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

Brasília 2010

FEDERATIVE REPUBLIC OF BRAZIL

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Ministry of Science and Technology
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Foreword

This Second National Communication to the United Nations Framework Convention on Climate Change describes initiatives and government programs that are helping to reduce greenhouse gas emissions in a consistent manner. As a result of some of these programs and initiatives, Brazil has a comparatively "clean" energy mix, with low greenhouse gas emission levels per energy unit produced or consumed. Other initiatives, such as the fight against deforestation, as well as the case for biofuels and energy efficiency, also help to achieve development goals, with a sharp deviation in the trend of greenhouse gas emissions curve in Brazil.

Brazil has historically been doing its fair share in combating climate change, and is prepared to sustain its leading role in the context of the global effort to tackle the problem. Brazil was the first country to sign the United Nations Framework Convention Climate Change, resulting from the United Nations Conference on Environment and Development - Rio-92, held in Rio de Janeiro, in June 1992. The Framework Convention is considered to be one of the most balanced, universal and relevant multilateral instruments of our time. It was ratified by the Brazilian National Congress in 1994.

The latest and one of the most effective initiatives by Brazil in this arena was the establishment of the National Policy on Climate Change - PNMC, by means of Law no 12,187/09. The voluntary mitigation actions at national level included in it had been announced by the President of the Republic, Mr. Luiz Inácio Lula da Silva, in Copenhagen, in December 2009, during the High Level Segment of the 15th Conference of the Parties to the Convention on Climate Change - COP-15 and the 5th Conference of the Parties serving as the Meeting of the Parties to the Kyoto Protocol - CMP-5. In accordance with this law, Brazil will pursue voluntary actions for the mitigation of greenhouse gas emissions with a view to reducing its projected emissions by 36.1%-38.9% by 2020. This law also provides that this projection, as well as the detailed actions to achieve the voluntary reduction objective mentioned above, will be based on the Second Brazilian Inventory of Anthropogenic Emissions by Sources and Removals by Sinks of Greenhouse Gases not Controlled by the Montreal Protocol, which is an integral part of this Second National Communication.

The necessary actions to achieve the national voluntary mitigation actions undertaken by Brazil will derive from the effort to be made by federal and state government bodies, as well as the society as a whole.

As it is known, the responsibility for coordinating implementation of commitments resulting from the Convention was assigned to the Ministry of Science and Technology - MCT soon after Rio-92, which reflects the importance that Brazil attaches to the science and the technologies associated to climate change. The issue of global climate change is of an eminently scientific and technological nature in the short and medium term. It is a scientific issue as it involves defining climate change, its causes, intensity, vulnerabilities, impacts and reduction of inherent uncertainties. It is a technological issue because the measures to combat global warming lead to actions that aim at promoting development, application, diffusion and transfer of technologies and processes to prevent the problem and its adverse effects.

The 2007-2010 Action Plan of Science, Technology and Innovation for National Development - PACTI includes a specific program on climate change in its strategic component entitled Research, Development and Innovation in Strategic Areas. The program has been called the "National Climate Change Program," and its purpose is to expand Brazil's scientific, technological and institutional capacity in the field of climate change so as to increase knowledge on the issue, identify the impacts on the country, and support public policies to address the problem both at national and international level. Specific actions have been designed to be implemented throughout the duration of the Plan. These include an action to support preparation of the Second National Communication of Brazil.

Just like Brazil's Initial National Communication, the work on the Second National Communication was guided by the principles of commitment, scientific rigor, decentralization, and transparency. The experience gained in the development of the first document allowed significant improvements, which are reflected in this document.

The MCT engaged a broad-based network of partners to prepare the Second National Communication. This network started taking shape in the mid-1990s and became stronger since then. Over 600 institutions and 1,200 experts with recognized competence in their respective areas of expertise from a variety of sectors (energy, industry, forestry, agriculture/livestock, waste treatment, etc.) were involved, coming from the public and private sectors, as well as from the academia.

The Second Brazilian Inventory of Anthropogenic Emissions by Sources and Removals by Sinks of Greenhouse Gases not Controlled by the Montreal Protocol is an integral part of this Communication, and it required intense work and significant human, technical and financial resources. It shows significant achievements, especially because it is based on a complex and detailed methodology. For example, the information on Brazil's land-use change and forestry sector relied heavily on satellite imagery and a sophisticated digital information processing system. Considerable progress has been made in this assessment in the country, although it is recognized that some challenges are yet to be solved. It is necessary to keep moving forward in terms of ensuring information quality and maintaining the structure for the preparation of the national inventory on sustainable bases.

A detailed review of the contents of the Second National Communication, and the results of the Inventory in particular, was sought to ensure reliability and transparency of information. The reference reports were made available on the worldwide web. A broad review process was undertaken by experts from various fields and through a comprehensive public consultation process from April to September 2010.

One of the pillars of the Convention is the principle of common but differentiated responsibilities. Although Brazil does not have – according to the international regime on climate change – any quantified emission limitation or reduction obligations, the country is playing a critical role and making tangible contributions to the combat against climate change.

Submission of this document is yet another decisive institutional step made by President Lula's administration in order to honor one of the country's most important commitments under the Convention, contributing for a better understanding of the global problem and advancing the science of climate change, taking into consideration the national reality, described through national programs and actions developed in the country.

Brazil's Second National Communication to the Convention reaffirms the country's commitment to strengthening the role of multilateral institutions that are the adequate framework for solving problems of a global nature that will affect the international community.

The contents of this document illustrate how Brazil has been making a relevant contribution for the achievement of the objective of the Convention on Climate Change, thus showing that mitigation of this phenomenon and adaptation to its effects are possible without compromising those actions aimed at addressing socioeconomic growth and poverty eradication, which are the first and overriding priorities of developing countries.

Sergio Machado Rezende
Minister of Science and Technology
Brasília, October 2010

Introduction

The commitments undertaken by Brazil under the United Nations Framework Convention on Climate Change - UNFCCC include development and periodical update of national inventories of anthropogenic emissions by sources and removals by sinks of greenhouse gases not controlled by the Montreal Protocol; submission of a general description of steps taken or envisaged to implement the Convention; and submission of any other information that the Party considers relevant for achieving the objective of the Convention. The document containing such information is called National Communication in the jargon of the Convention.

The format of the National Communication of Brazil follows the guidelines contained in Decision 17 of the 8th Conference of Parties to the Convention (document FCCC/CP/2002/7/Add.2, of March 28, 2003) – Guidelines for the preparation of national communications of the Parties not included in Annex I to the Convention. The structure of each chapter was based on this decision, and this structure was obviously adapted to the national circumstances and to the programs and actions developed in the country.

The Second National Communication of Brazil now being submitted to the Convention by the Brazilian government is composed of five parts. The first part introduces the national circumstances and special arrangements of Brazil, and is intended to provide an overall picture, taking into account the complexity of this vast country, as well as its development priorities. The second part comprises the Brazilian Inventory of Anthropogenic Emissions by Sources and Removals by Sinks of Greenhouse Gases not Controlled by the Montreal Protocol, covering the period 1990-2005. This is the result of the consolidation of 18 sectoral reference reports developed by institutions recognized for their excellence in the country, as well as by experts with recognized competence on climate change, and additional information obtained from various organizations. The third part presents the measures taken or envisaged to implement the Convention in the country, and is divided into two subparts: A) Programmes that include Measures relating to Climate Change Mitigation, and B) Programmes containing Measures to Facilitate Adequate Adaptation to Climate Change. These measures contribute directly or indirectly to the achievement of the objectives of the Convention. The fourth part provides other information deemed relevant to the achievement of the objective of the Convention, including transfer of technology; research and systematic observation; education; training and public awareness; capacity building at national and regional level; and information and networking. Finally, the fifth part describes the contraints and gaps, as well as related financial, technical and capacity building needs involved in the preparation of the Second National Communication.

In spite of the fact that the various institutions in Brazil had acquired some experience with the process of preparation of the Initial National Communication of Brazil, the preparation of a National Communication is extremely complex in a continent-sized country such as Brazil, and requires considerable effort. An ongoing challenge is to increase the number of experts on the subject in Brazil. Although the issue of climate change has gained increasing importance, especially after the release of the Fourth Assessment Report of the Intergovernmental Panel on Climate Change - IPCC, the number of publications available in Portuguese in the relevant areas is still limited, and the human and financial resources to develop more comprehensive studies are still scarce.

In order for Brazil to fulfill its commitments under the Convention, an institutional framework in the form of a program was established, under the coordination of the Ministry of Science and Technology, with funds provided by UNDP/GEF. It is important to point out, however, that these resources were instrumental in leveraging contributions from several partner institutions participating directly in the achievement of each project outcome. The budget originally available was only sufficient for the achievement of the core expected results, without any expansion of its content or further details, which often proved to be necessary in view of the highly complex nature of the technical studies involved, for which the expansion of content and further detailing contribute greatly to the quality of the final result.

Because of its scope and specificity, during the preparation of the inventory an effort was made to engage various entities from different sectors and specialists from a number of ministries; federal and state institutions; industry associations; public and private companies; non-governmental organizations; universities; and research centers.

As it was the case in the Initial National Communication of Brazil, considering that in many cases IPCC's default emission factors for estimating anthropogenic greenhouse gas emissions are not suitable for developing countries, a great effort was made to obtain relevant information that would reflect national conditions, such as in the case of the Land-Use Change and Forestry sector. Particularly for this sector in Brazil, preparation of the Inventory is always an exercise that entails considerable effort, given the complexity of the methodology, which involves the interpretation of a very large number of satellite images. As a result of the decision to use parts of previous works, also due to fund limitations, there was a delay in the timetable after ascertaining the need to correct and adapt these works. There was also an unexpected delay in the Agriculture Sector due to the fact that the 2006 Agriculture and Livestock Census results – a source of essential information for the detailed methodologies adopted in the Inventory – had not been published until October 2009.

Pioneering studies were conducted as part of the Inventory in order to increase scientific knowledge on emissions from the conversion of forest lands to other uses. To this end, a complex, sophisticated and detailed method was developed for the assessment of land use change and forestry, which is expected to be replicated in other countries around the world.

The Brazilian government objects to the use of the Global Warming Potential - GWP for the comparison of greenhouse gases. The option for aggregating the reported emissions into carbon dioxide equivalent units using the GWP for a period of 100 years was not adopted by Brazil, which reported its emissions just in units of mass for the individual greenhouse gases, as presented in its Initial National Inventory. In Brazil's view, the GWP does not adequately represent the relative contribution of the various greenhouse gases to climate change. Its use would overemphasize and erroneously stress the importance of greenhouse gases that remain in the atmosphere for only short periods of time, such as methane.

In this Inventory, a decision was made to continue reporting the anthropogenic emissions by sources and removals by sinks of greenhouse gases not controlled by the Montreal Protocol simply in units of mass for each greenhouse gas. However, in order to make it clear that using the GWP leads to an overestimation of the share of methane, the results of the Inventory using different CO_2 equivalent conversion metrics are described in a box, just for information purposes. This box provides the net anthropogenic emissions of greenhouse gases using the GWP, but emissions based on another metric – the Global Temperature Potential - GTP – are also reported. The GTP compares greenhouse gases through their contributions to the change in the average temperature of the Earth surface in a given future time period and better reflects the real contribution of the various greenhouse gases to climate change. Despite greater uncertainty in its calculation due to the need to use climate system sensitivity, the use of GTP allows for more appropriate mitigation policies.

It is worth recalling that while the assessment of annual emissions for the individual countries is important for quantifying global emissions and understanding the evolution of climate change (current and future evolution), annual emissions of greenhouse gases do not represent adequately and fairly the responsibility of a country in causing global warming, since the temperature increase is due to the accumulation of the countries' historical emissions, which in turn increase concentrations of greenhouse gases in the atmosphere. For every different level of concentration of each greenhouse gas, there is an accumulation of energy on the Earth's surface over the years. As mentioned in Brazil's proposal submitted during the negotiations of the Kyoto Protocol (document FCCC/AGBM/1997/MISC.1/Add.3), the responsibility of a country can only be correctly assessed from the perspective of double accumulation, which entails taking all of its historical emissions in a comprehensive manner, and the resulting accumulation of greenhouse gases in the atmosphere and increase in the average surface temperature resulting therefrom. Hence, the industrialized countries, which started emitting greenhouse gases from the Industrial Revolution, have a greater responsibility for climate change. In addition to the responsibility for climate change mentioned earlier, historic emissions data indicate that these countries will continue to be the primary responsible for a few more decades.

Although developing countries – such as Brazil – have no quantified emission limitation or reduction commitments for their anthropogenic greenhouse gas emissions, as established under the international regime of global climate change, the Second National Communication also highlights that several programs and actions that result in a significant reduction in these emissions are developed in the country. Some of these initiatives are responsible for the fact that renewable resources account for a relevant share of Brazil's energy mix, resulting in lower greenhouse gas emissions per unit of energy produced or consumed. In comparison with the Initial National Communication, the Second National Communication clearly reflects the increased number of initiatives in various stages of implementation that contribute and/or will contribute to the inflection in the growth rate of the greenhouse gas emissions curve in the country.

Another important factor to be noted in relation to this Second National Communication is the large number of institutions and authors and/or contributors involved in its preparation. In addition, all texts have been made available online as part of a policy of transparency and public participation that characterizes the administration of the Hon. Minister of Science and Technology, Dr. Sergio Rezende.

The Second National Communication presents the "state of the art" of the implementation of the Convention in the country, in relation to the Inventory of greenhouse gases by the end of 2005, and in relation to the numerous programs and actions that Brazil undertook by 2010, which reflect its commitment to combating climate change.

José Domingos Gonzalez Miguez
General-Coordinator on Global Climate Change

Executive Summary

Submission of this Second National Communication of Brazil to the United Nations Framework Convention on Climate Change - UNFCCC (hereinafter Convention on Climate Change, or simply the Convention) confirms the importance Brazil attaches to the commitments it undertook under this treaty, which is the adequate institutional framework through which the international community should combat climate change. Moreover, it is a clear signal that Brazil will make every effort to enhance understanding of the global problem and to advance the science of climate change based on the national circumstances described in this Communication by means of the actions and programs developed in the country.

Even with the lessons learned with the Initial Communication, the preparation of a National Communication is extremely complex in a continent-sized country such as Brazil, and requires considerable effort. An ongoing challenge is to increase the number of experts on the subject in Brazil. Despite the paucity of human and financial resources to develop more comprehensive studies, an extensive network of partnerships was put in place for the completion of this work. A significant number of institutions and authors and/or contributors with recognized competence in their respective areas of expertise were engaged in its preparation in a wide range of sectors (energy, industry, forestry, agriculture/livestock, waste treatment, etc.) from both the public and private sectors.

Following the "Guidelines for the preparation of national communications from Parties not included in Annex I to the Convention" (Decision 17/CP. 8), the Second National Communication of Brazil to the UNFCCC is comprised of five parts. The first part introduces the national circumstances and special arrangements of Brazil, and it is intended to provide an overall picture, taking into account the complexity of this vast country, as well as its development priorities. The second part comprises the Brazilian Inventory of Anthropogenic Emissions by Sources and Removals by Sinks of Greenhouse Gases not Controlled by the Montreal Protocol, which covers the period 1990-2005, although according to the guidelines contained in Decision 17/CP. 8 and to the GEF project signed by the Brazilian government the Inventory should only cover the period 1990-2000. Nevertheless, it has sought to present the preliminary data for 2005, which will be reviewed in the next National Communication. The Inventory is the culmination of the consolidation of 18 reference reports from different sectors developed by institutions renowned for their excellence in the country, as well as by experts of great distinction, and additional information obtained from various organizations. The third part presents the steps taken or envisaged to implement the Convention in the country, and it is divided into two subparts: A) Programmes containing measures to mitigate climate change, and B) Programmes containing measures to facilitate adequate adaptation to climate change. These measures contribute directly or indirectly to the achievement of the objectives of the Convention. The fourth part provides other information considered relevant to the achievement of the objective of the Convention, including transfer of technologies; research and systematic observation; education, training and public awareness; capacity building at national and regional level; and information and networking. Finally, the fifth part describes the financial, technical and capacity needs associated with the implementation of activities related to the elaboration of the Second National Communication.

National Circumstances

The Federative Republic of Brazil is divided into 26 states, 5,565 municipalities – according to the Brazilian Institute of Geography and Statistics (IBGE, 2009a) – and the Federal District, where the capital of the Republic, Brasília, seat of the government and the Executive, Legislative and Judicial Branches, is located. 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. It has 186 million inhabitants, according to data from the 2008 Demographic Census. The country had an average population growth of 1.15% per year over the 2000-2008 period. In 2008, most of the population (84.4%) lived in urban centers.

Brazil is also home to an extremely rich flora and fauna. In addition to harboring over a third of the Earth's tropical forests – the Amazon Forest –, there are ecological regions of great extent in the country, such as the Cerrado, the Atlantic Forest, the Caatinga, and the Pantanal wetlands. The country has extremely varied vegetation and flora resources, and contains one of the richest flora in the world with 41,123 known and registered species (FORZZA *e t al.*, 2010). The Brazilian fauna is also quite rich, although knowledge about its diversity is still incomplete. It is estimated that less than 10% of the existing total is actually known.

Since Brazil is a country with large territorial extensions, it has differentiated rainfall and temperature regimes. From north to south, a great variety of climates with distinct regional characteristics can be found, which has shaped the occupation of its territory and partly justifies socioeconomic differences.

Brazil has abundant water resources. Endowed with a vast and dense river watershed network, many of its rivers stand out due to their extension, width or depth. As a result of the nature of the relief, plateau rivers predominate, whose characteristics give them high potential for electric power generation, although these very characteristics, however, make navigation difficult. Although only 36% of the country's estimated hydroelectric power has been harnessed, 84% of Brazil's power was generated by hydroelectric power plants in 2009.

Brazil is a developing country with a complex and dynamic economy, which is ranked eighth in the world. It is an urban-industrial country, with food exports as its main connection to global capitalism. Brazil is the main exporter of several agricultural products: sugarcane, beef, chicken, coffee, orange juice, tobacco, and alcohol. Also, it comes second in soy bean and corn exports, and is ranked as the fourth largest exporter of pork. However, it is not the biggest food exporter in the world, as is widely believed. Brazil is also among the largest and most efficient producers of various manufactured products, including cement, aluminum, chemicals, petrochemical feedstock, and oil.

Regarding the share of economic sectors in the Gross Domestic Product - GDP, in 2006, the distribution was as follows: 65.8% for the service business, 28.8% for industry and 5.5% for agriculture.

In 2008, Brazil's GDP was US$ 1,406.5 billion, and the GDP *per capita* was US$ 7,420.00. Between 1990 and 2005, Brazil's economic growth exceeded population growth, and the population grew at an annual rate of 1.5% during this period, while GDP reported an annual growth rate of 2.6% during the same period.

It should be recognized that a significant portion of its population (about 30 million people) is still in poverty, lacking access to quality healthcare services, water supply and education, despite efforts by the government and society to reverse this situation. Great regional disparities still exist. Thus, the national priorities are to meet the pressing social and economic needs, such as eradicating poverty, improving health conditions, combating hunger, ensuring decent housing, among others. These elements are fully consistent with the Convention on Climate Change, which recognizes that mitigation of global climate change and adaptation to its effects are possible without compromising those actions to address socioeconomic growth and poverty eradication, which remain as first and overriding priorities for developing countries.

Despite improved social and economic indicators, especially over the past decade, the country still has a long way to go. Brazil is a country with a growing population, where most of the population's basic needs have yet to be met, infrastructure is still incipient and substantial improvements are required. All this justifies the fact that Brazil is still a developing country.

National Inventory of Anthropogenic Emissions by Sources and Removals by Sinks of Greenhouse Gases not Controlled by the Montreal Protocol

Estimates for 1990-2005

Brazil, as a Party to the Convention on Climate Change, assumed, based on its Article 4, paragraph 1 (a), the commitment to "develop, periodically update, publish and make available to the Conference of the Parties, in accordance with Article 12, national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, using comparable methodologies to be agreed upon by the Conference of the Parties."

This inventory covers carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6). The emissions of so-called indirect greenhouse gases such as nitrogen oxides (NO_x), carbon monoxide (CO) and other non-methane volatile organic compounds (NMVOC) have also been estimated. The emissions or removals of above gases were estimated according to the sources, which are called sectors: Energy; Industrial Processes; Use of Solvents and Other Products; Agriculture; Land-Use Change and Forestry; and Waste.

The preparation of the Inventory was based on the following technical guidelines of the Intergovernmental Panel on Climate Change (IPCC): "Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories", published in 1997; "Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories", published in 2000; and "Good Practice Guidance for Land Use, Land-Use Change and Forestry", published in 2003. Some of these estimates already take into account information found in "2006 IPCC Guidelines for National Greenhouse Gas Inventories", published in 2006.

Preparation of the inventory involved a significant portion of the Brazilian business and scientific community, and various government sectors. The results of this effort are shown in Table I, which summarizes the estimates of anthropogenic greenhouse gas emissions, for four years – 1990, 1994, 2000, and 2005 –, thus covering the year 2000, as required by Decision 17/CP.8 for the Second National Communication. With regard to 1990 to 1994, this Inventory updates the information presented in the Inventory of Anthropogenic Emissions and Removals of Greenhouse Gases not Controlled by the Montreal Protocol (BRASIL, 2004) - the Initial National Inventory.

Table I - Estimates for greenhouse gas emissions in Brazil – 1990, 1994, 2000, and 2005

Sector	Year	Unit	CO_2	CH_4	N_2O	HFC-23	HFC-125	HFC-134a	HFC-143a	HFC-152a	CF_4	C_2F_6	SF_6	NO_x	CO	NMVOC
Energy	1990	Gg	179,948	427	8.5									1,781	14,919	1,022
	1994		206,250	382	9.0									1,996	14,438	974
	2000		289,958	388	9.6									2,334	11,415	860
	2005		313,695	541	12.1									2,388	11,282	958
	Var. 90 / 00	%	61	-9	14									31	-23	-16
	Var. 90 / 05		74	27	43									34	-24	-6
Industrial Processes	1990	Gg	45,265	5.1	10.7	0.120	-	0.0004	-	-	0.302	0.026	0.010	8	365	322
	1994		48,703	6.5	16.3	0.157	-	0.0685	-	-	0.323	0.028	0.014	11	510	382
	2000		63,220	8.9	19.9	-	0.0071	0.4713	0.0075	0.0001	0.147	0.012	0.015	14	542	474
	2005		65,474	9.2	22.8	-	0.1249	2.2819	0.0929	0.1748	0.124	0.010	0.025	18	626	599
	Var. 90 / 00	%	40	73	87	-100	NA	108,876	NA	NA	-52	-56	54	69	48	47
	Var. 90 / 05		45	79	114	-100	NA	527,498	NA	NA	-59	-61	153	128	71	86
Solvent and Other Product Use	1990	Gg														350
	1994															435
	2000															473
	2005															595
	Var. 90 / 00	%														35
	Var. 90 / 05															70
Agriculture	1990	Gg		9,539	334									219	2,543	NE
	1994			10,237	369									233	2,741	NE
	2000			10,772	393									181	2,131	NE
	2005			12,768	476									237	2,791	NE
	Var. 90 / 00	%		12.9	17.6									-17		
	Var. 90 / 05			33.9	42.7									8		
Land-Use Change and Forestry	1990	Gg	766,493	1,996	13.7									496	17,468	NE
	1994		830,910	2,238	15.4									556	19,584	NE
	2000		1,258,345	3,026	20.8									752	26,476	NE
	2005		1,258,626	3,045	20.9									757	26,641	NE
	Var. 90 / 00	%	64	52	52									52	52	
	Var. 90 / 05		64	53	53									53	53	
Waste	1990	Gg	24	1,227	9.0											
	1994		63	1,369	10.8											
	2000		92	1,658	12.4											
	2005		110	1,743	14.0											
	Var. 90 / 00	%	276	35	37											
	Var. 90 / 05		349	42	54											
TOTAL	1990	Gg	991,731	13,195	376	0.120	-	0.000	-	-	0.302	0.026	0.010	2,504	35,296	1,693
	1994		1,085,925	14,233	421	0.157	-	0.068	-	-	0.323	0.028	0.014	2,797	37,273	1,791
	2000		1,611,615	15,852	455	-	0.007	0.471	0.007	0.0001	0.147	0.012	0.015	3,280	40,563	1,807
	2005		1,637,905	18,107	546	-	0.125	2.282	0.093	0.175	0.124	0.010	0.025	3,399	41,339	2,152
	Var. 90 / 00	%	63	20	21	-100	NA	108,876	NA	NA	-52	-56	54	31	15	7
	Var. 90 / 05		65	37	45	-100	NA	527,498	NA	NA	-59	-61	153	36	17	27
Memo Items (for information only – emissions not included in the inventory)																
International Bunkers	1990	Gg	5,231	0.01	0.15									23	NE	NE
	1994		4,339	0.01	0.12									19	NE	NE
	2000		14,627	0.60	0.23									201	118	24
	2005		15,759	0.66	0.24									221	132	26
	Var. 90 / 00	%	NA	NA	NA									NA	NA	NA
	Var. 90 / 05		NA	NA	NA									NA	NA	NA
CO_2 Emissions from Biomass	1990	Gg	187,962													
	1994		190,896													
	2000		180,471													
	2005		243,606													
	Var. 90 / 00	%	-4													
	Var. 90 / 05		30													

Emissions of the Main Greenhouse Gases

Brazil's emissions profile is different from that of developed countries, where emissions from fossil fuel combustion are the most significant. In most relevant sectors in Brazil, such as agriculture and land-use change and forestry, there are no methodologies that could be straightforwardly applied to the country, given that IPCC's default emission factors largely reflect the conditions of developed countries and countries with a temperate climate and do not necessarily fit Brazilian reality. Therefore, a great effort has been undertaken to collect data corresponding to Brazilian circumstances, making possible to apply higher tier IPCC methodologies and obtain more accurate and precise results.

Year 2000

The analysis of results is presented in two sections: the first one covers the year 2000, pursuant to the guidelines of the Convention on Climate Change for the Second National Communication; the second covers 2005, where the most up-to-date data for all sectors are considered.

In 2000, CO_2 emissions were estimated at 1,612 Tg, with the Land-Use Change and Forestry sector as the major contributor, accounting for 78% of emissions, followed by the Energy sector, with a share of 18% of total emissions.

Also in 2000, CH_4 emissions were estimated at 15.9 Tg, with the Agriculture sector accounting for 68% of total emissions, followed by the Land-Use Change and Forestry sector, with 19% of emissions, and the Waste sector, with 10%. The two most important sub-sectors were enteric fermentation in livestock, accounting for 61%, and forest conversion to other uses in the Amazon biome, accounting for 13%.

N_2O emissions were estimated at 455 Gg, basically because of the Agriculture sector, which accounted for 86% of total emissions. Within this sector, emissions from soils contributed with 83%, including, among others, grazing animal manure emissions, which accounted alone for 40% of the total.

Estimates by sector are analyzed below.

Energy Sector

This sector encompasses estimates of anthropogenic emissions caused by energy production, transformation, transportation, and consumption. It includes both emissions resulting from fuel combustion and fugitive emissions resulting from leaks in the production, transformation, distribution, and consumption chain.

The most relevant emissions refer to CO_2, with 290 Tg, driven by the road transport (38%) and the industrial subsector (24%). CH_4 emissions totaled 388 Gg, and were primarily released by the energy sub-sector (32%), which includes charcoal plants, and by fugitive emissions from oil and natural gas activities (27%). N_2O emissions were estimated at 9.6 Gg, primarily due to the road transport (23%) and the food and beverage sub-sector (19%).

Industrial Processes Sector

This sector entails estimates of anthropogenic emissions resulting from production processes in industries that do not result from fuel combustion.

The most relevant emissions also refer to CO_2, totaling 63 Tg, basically as a result of pig iron and steel (56%), cement (25%) and lime production (8%). N_2O emissions were estimated at 20 Gg, primarily due to adipic acid production (88%). CH_4 emissions were estimated at 8.9 Gg, caused by the chemical industry.

Solvent and Other Product Use Sector

For this sector, direct greenhouse gas emissions were not estimated.

Agriculture Sector

In this sector, CH_4 emissions totaled 10.8 Tg, driven by the enteric fermentation of ruminant herds (89%), which includes cattle herd, the second largest in the world. N_2O emissions totaled 393 Gg and derived from various sources, especially grazing animal manure (46%) and indirect soil emissions (32%).

Burning of sugarcane was responsible for indirect greenhouse gas emissions in this sector, given that the burning of cotton crop residues was virtually suspended in 1995.

Land-Use Change and Forestry Sector

Because of Brazil's vast territory, estimating figures for this sector was one of the most complex tasks in preparing the Inventory; it involved extensive survey and processing of remote sensing, statistical and forest inventory data.

The entire national territory was subdivided into spatial units in the form of polygons that resulted from the integration of various data sources: biome, municipal boundaries, vegetation profile, type of soil, land use in 1994, and land use in 2002. 75 possible transitions and their corresponding changes to carbon stock were analyzed, with changes being observed in 14.2% of the country's surface between 1994 and 2002. Based on the results of anthropogenic emissions and removals for 1994-2002, the emission factors for the Initial Inventory were updated for the years 1990 to 1994 and a preliminary estimation for the years 2003 to 2005 was conducted, based on activity data for *Prodes* and *PPCerrado*.

According to IPCC's latest guidelines, and in order to improve comparability between the various countries, only the emissions and removals occuring in managed areas were considered, i.e., the areas included in the planning process and where implementation of land-use management practices, with a view to performing important ecological, economic and social functions, is undertaken. In Brazil, these managed areas include all forest and native non-forest vegetation areas (Grassland) contained in Indigenous Lands and in the National System of Protected Areas - SNUC (Law nº 9,985/2000). Private Reserves of Natural Heritage – RPPNs were not considered due to insufficient adequate information. This option is different from the one used for Brazil's Initial Inventory, where all areas under natural forests (primary forests) were not considered to estimate average CO_2 removals.

Net emissions for this sector totaled 1,258 Tg CO_2, driven by the Amazon biome (65%) and *Cerrado* biome (24%). Emissions related to application of limestone to soils, which was responsible for 8.7 Tg CO_2, were also accounted for in this sector total emissions. CH_4 emissions were estimated at 3.0 Tg, and N_2O emissions were estimated at 21 Gg. In both cases, emissions derived from burning of the biomass left in the field after forest conversion. 68% of which were produced in the Amazon biome and 22% in the *Cerrado* biome.

Waste Sector

Waste disposal in landfills or open dumps generates CH_4. The emission potential for this gas increases the better the landfill control conditions are and the greater the depth of open dumps. Waste incineration, like every combustion, generates CO_2 and N_2O emissions, depending on the composition of the waste. However, this practice is not widespread in Brazil.

Treatment of wastewater with high degree of organic content, such as those from the residential and commercial sectors, from the food and beverage industries and those from the pulp and paper industry have significant potential for CH_4 emissions.

CH_4 emissions for this sector were estimated at 1.7 Tg. The majority of CH_4 emissions is generated by waste disposal (64%). CO_2 emissions in this sector were estimated at 92 Gg, due to the incineration of non renewable waste.

In the case of household sewage, as a result of nitrogen content in human food, N_2O emissions also occur, which were estimated at 12 Gg.

Year 2005

The analysis for 2005 emissions presented below takes into account the explanations previously provided in the analysis for the year 2000, except for the figures.

In 2005, CO_2 emissions were estimated at 1,638 Tg, with the Land- Use Change and Forestry sector as the main contributor, accounting for 77% of emissions, followed by the Energy sector, which was responsible for 19% of total emissions.

Also in 2005, CH_4 emissions were estimated at 18.1 Tg, driven by the Agriculture sector, accounting for 70% of total emissions, followed by the Land-Use Change and Forestry sector, accounting for 17% of emissions, and the Waste sector, accounting for 10% of emissions. The two most important sub-sectors were enteric fermentation in livestock, accounting for 63%, and forest conversion to other uses in the Amazon biome, which accounted for 12% of emissions.

N_2O emissions were estimated at 546 Gg, basically because of the Agriculture sector, which accounted for 87% of total emissions. Within this sector, emissions from soils were responsible for 84%, including, among others, grazing animal emissions, which accounted alone for 40% of the total.

Estimates by sector are analyzed below.

Energy Sector

The most relevant emissions refer to CO_2, which accounted for 314 Tg, mainly due to road transport (39%) and the industrial sub-sector (27%). CH_4 emissions totaled 541 Gg, and were primarily released by fugitive emissions from oil and natural gas activities (24%) and by the energy sub-sector (31%), which includes charcoal plants. N_2O emissions were estimated at 12.1 Gg, primarily due to road transport (22%) and food and beverage sub-sector (22%).

Industrial Processes Sector

The most relevant emissions refer to CO_2, which accounted for 65 Tg, basically as a result of pig iron and steel (58%), cement (22%) and lime production (8%). N_2O emissions accounted for 23 Gg, mainly due to adipic acid production (89%). CH_4 emissions were estimated at 9.2 Gg, generated by the chemical industry.

Solvent and other Product Use Sector

For this sector, direct greenhouse gas emissions were not estimated.

Agriculture Sector

In this sector, CH_4 emissions totaled 12.8 Tg, driven by the enteric fermentation of ruminant herds (90%), which includes cattle herd, the second largest in the world. N_2O emissions totaled 476 Gg and derived from various sources, especially grazing animal manure (46%) and indirect soil emissions (32%).

Land-Use Change and Forestry Sector

Net emissions for this sector totaled 1,259 Tg CO_2, driven by the Amazon biome (67%) and *Cerrado* biome (22%). Emissions related to application of limestone to soils, which was responsible for 7.5 Tg CO_2, were accounted for in this sector total emissions. CH_4 emissions were estimated at 3.0 Tg, and N_2O emissions were estimated at 21 Gg. In both cases, emissions derived from the burning of biomass left in the field after forest conversion, 70% of which being produced in the Amazon biome and 20% in the *Cerrado* biome.

Waste Sector

CH_4 emissions for this sector were estimated at 1.7 Tg. The majority of CH_4 emissions is generated by waste disposal (63%). CO_2 emissions in this sector were estimated at 110 Gg, due to the incineration of non renewable waste.

In the case of household sewage, as a result of nitrogen content in human food, N_2O emissions also occur, which were estimated at 14 Gg.

Box 2. For Information only

Greenhouse Gas Emissions in CO_2eq

In this Inventory, a decision was made to continue reporting the anthropogenic emissions by sources and removals by sinks of greenhouse gases not controlled by the Montreal Protocol simply in units of mass for each greenhouse gas. However, the results of the inventory using different CO_2 equivalent conversion metrics for the conversion of emissions of the various greenhouse gases are described in a box, just for information purposes. Thus, this Box describes net anthropogenic emissions of greenhouse gases using the GWP metric, as suggested by the guidelines, but also reports emissions using another metric, the Global Temperature Potential - GTP, which Brazil considers to be a more appropriate indicator of the relative importance of different greenhouse gases in terms of their contribution to global warming. The GTP compares greenhouse gas emissions by means of their contributions to the change in the average temperature of the Earth surface in a given future time period and better reflects the real contribution of the various greenhouse gases to climate change. GTP would, thus, allow for more appropriate mitigation policies.

GWP does not appropriately represent the relative contribution of the different greenhouse gases to climate change. Its use would overemphasize and erroneously stress the importance of greenhouse gases that remain in the atmosphere for only short periods of time, such as methane, leading to erroneous and inappropriate mitigation strategies in the short and long terms and erroneously driving mitigation priorities. Exaggerated importance has been assigned to methane emission reduction and to some industrial gases that remain in the atmosphere for a short period of time, thus shifting the focus away from the need to reduce CO_2 emissions from fossil fuels and to control some of the industrial gases that remain in the atmosphere for a long period of time.

A summary of greenhouse gas emissions in CO_2 equivalents using GWP and GTP metrics is provided in Figure I and Table I.

Table II compares the growth of net anthropogenic emissions of greenhouse gases with the growth of population and GDP in Brazil for the period 1990-2005.

Figure I - Differences between two possible metrics for estimating Brazilian greenhouse gas emissions in CO_2e in 2005

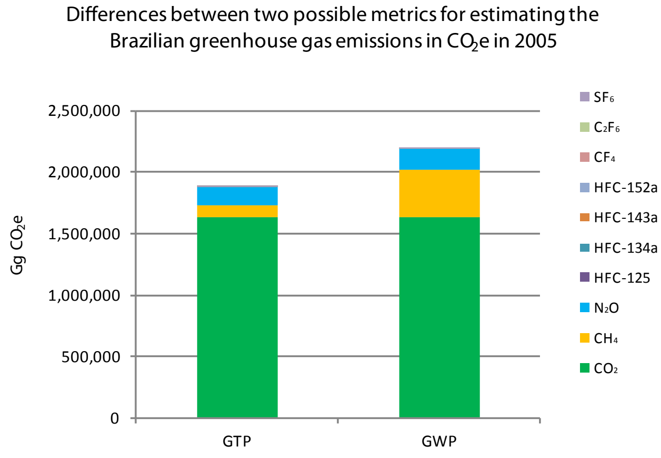

Table I - Anthropogenic emissions by sources and removals by sinks of greenhouse gases in CO_2e using GWP and GTP metrics, in 2005 and by gas

Gas	GTP		GWP	
	2005	Share 2005	2005	Share in 2005
	Gg	%	Gg	%
CO_2	1,637,905	87.2	1,637,905	74.7
CH_4	90,534	4.8	380,241	17.3
N_2O	147,419	7.8	169,259	7.7
HFC-125	139	0.0	350	0.0
HFC-134a	126	0.0	2,966	0.1
HFC-143a	398	0.0	353	0.0
HFC-152a	0.0175	0.0	24	0.0
CF_4	1,245	0.1	805	0.0
C_2F_6	233	0.0	95	0.0
SF_6	1,031	0.1	602	0.0
Total	**1,879,029**	**100**	**2,192,601**	**100**

Table II - Net anthropogenic greenhouse gas emissions, population and GDP growth in Brazil in the period 1990-2005

Item	Unit	1990	2005	Variation 1990-2005 %
GDP	Billion US$ 2007/year	830.5	1,218.3	46.69
Population	Million of inhab.	144.8	179.9	24.24
Emission	Gg CO_2e GWP	1,389,123	2,192,601	57.84
Emission	Gg CO_2e GTP	1,163,166	1,879,029	61.54

Description of Steps Taken or Envisaged to Implement the Convention in Brazil

Each non-Annex I Party shall, pursuant to Article 12, paragraph 1(b) of the UNFCCC, submit to the Conference of the Parties a general description of the steps taken or envisaged by the Party to implement the Convention, taking into account its common but differentiated responsibilities and its development priorities, its objectives and specific national and regional circumstances.

Decision 17/CP.8 divided this part into two large subsections. Non-Annex I Parties may provide information about programs containing measures to mitigate climate change, either by reducing anthropogenic emissions by sources or by increasing removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, in addition to measures to facilitate adequate adaptation to climate change, including information on specific concerns arising from adverse effects.

Programs Containing Measures to Mitigate Climate Change

According to the principle of common but differentiated responsibilities, only countries included in Annex I to the United Nations Framework Convention on Climate Change have undertaken quantified commitments for reducing or limiting their anthropogenic emissions of greenhouse gases not controlled by the Montreal Protocol.Under the Convention, countries not included in that group (Parties not included in Annex I), including Brazil, have no quantified emission limitation or reduction commitments for these emissions. After all, the Convention reflects the recognition that the relative contribution of these countries to global emissions of these gases will grow to meet their social and development needs.

Despite the fact that Brazil is a developing country, however, there is an array of programs in the country that promote a significant reduction in such emissions. Some of these programs are responsible for the fact that Brazil has a relatively "clean" energy mix, specifically in terms of low levels of greenhouse gas emissions per unit of energy produced or consumed. Many other initiatives that are being implemented also contribute to the inflection in the growth rate of the greenhouse gas emissions curve in the country.

Programs and Actions Related to Sustainable Development

Some of the programs and actions related to sustainable development are related to the use of renewable energy and energy conservation and/or efficiency. These programs contribute towards Brazil having a "clean" energy mix, with low greenhouse gas emissions in the energy sector, to stabilize the concentrations of these gases in the atmosphere and for long-term sustainable development.

Major programs related to sustainable development include use of ethanol as vehicle fuel. The National Alcohol Program - Proálcool was originally developed to avoid increasing dependence on foreign oil and foreign currency evasion during the oil price shocks. Although the program had great success in the 1970s and 1980s, the ethanol supply crisis in the late 1980s, together with the reduction of incentives for its production and use in the following years, led to a significant decrease in demand and, therefore, a drop in the sales of cars running on this fuel. Over the past few years, the technology for flex fuel motors has breathed new energy into domestic ethanol production. Vehicles running on gasoline, ethanol or any mixture of the two fuels were introduced in the country in March 2003, and they quickly attracted consumers. Their sales took over the sales for vehicles running on gasoline in the domestic market. It is important to point out that reduction of direct emissions from ethanol fuel use in Brazil has been approximately 600 million tons of CO_2 since 1975.

In the beginning of the 2000s, the Federal Government started viewing incorporation of biodiesel to Brazil's energy mix as strategic since this fuel was proving to be an alternative for reducing dependence on oil products and as a driving force for a new market for oilseeds. In addition, the intention was to add it to the domestic offer of fuels in a sustainable manner (socially, environmentally and economically), in order to make production of this feedstock a development driver, generating jobs and income, especially in the neediest regions of the country. Thanks to Probiodiesel, a program supported by the government, Brazil is among the largest producers and consumers of biodiesel in the world, with an annual production of 1.6 billion liters in 2009, and an installed capacity for nearly 4.7 billion liters in January 2010 (ANP, 2010a), thus increasing its share in Brazil's renewable energies.

Other important programs aim at reducing losses and eliminating wastage in energy production and use, in addition to adoption of enhanced energy-efficient technologies, and they help postpone investments in new power plants or oil refineries. Major programs include the National Electric Energy Conservation Program - Procel, a government program that has been developing a series of activities to combat electricity wastage since 1985. Moreover, the National Program on the Rationalization of the Use of Oil and Natural Gas Products - Conpet was established in 1991 in order to develop and bring together actions to rationalize the use of oil and natural gas products.

In Brazil, it is always important to bear in mind the contribution of hydroelectric power generation for the reduction of GHG emissions. In 2009, the Brazilian electric energy market required production of 466.2 TWh in public service and self-producing electric power plants. Of this production, 391 TWh, or 84%, was from hydroelectric sources. As a result of these figures, the Brazilian electrical sector takes on special characteristics, not only as one of the largest hydroelectric power producers in the world, but also for the exceptional participation of hydroelectric power in meeting its electric power needs. If the electricity generated by the non CO_2 emitting sources were produced by fossil fuel sources, emissions in the electrical sector would be much higher.

Significant growth is expected for the share of new renewable energy sources in Brazil's energy mix in the coming years. The new sources of renewable energy include the "modern use of biomass," small hydroelectric plants - SHPs, wind energy, solar energy (including photovoltaic energy), tidal power, and geothermal power. The "modern use of biomass" excludes the traditional uses of biomass, such as wood, and includes the use of agricultural and forest residues, as well as solid waste (garbage), for generating electricity, producing heat and liquid fuels for transportation. There is a great expectation especially in relation to cogeneration and use of agricultural residues. For example, it is estimated that agricultural residues – not including those from sugarcane – accounts for an energy availability of around 37.5 million toe per year, which is equivalent to 747 thousand barrels of oil per day, and this is virtually untapped.

Brazil is one of the few countries in the world that maintain the use of charcoal from planted forests in the metallurgical sector's production process, especially in the steel industry, with a focus on pig iron and steel. It is important to highlight the environmental gain resulting from mitigation of greenhouse gas emissions through emission reductions and net removals (during the 2001-2006 period, emission reductions of approximately 100 thousand tons of CO_2e were reported), as it creates a buffer that prevents pressure to deforest native forests.

Programs and actions that contain measures to mitigate climate change and its adverse effects

Brazil's demand for electricity has been growing much faster than the production of primary energy and the country's economy, a trend that should persist over coming years, thus calling for new energy planning strategies. While emissions tend to grow, because of the priority the country places on its development, several programs are underway in Brazil that seek to replace fossil fuel-based energy sources, with high carbon content per unit of energy generated, by other sources with a lower content, or by sources that generate greenhouse gas emissions with lower global warming potential. These programs and activities are designed to assist climate change mitigation and contribute towards achieving the Convention's ultimate objective. This is the case of natural gas, whose conversion efficiency is better than that for other fossil fuels. This results in lower CO_2 emissions per unit of energy generated. Compared to burning fuel oil, the option for natural gas enables a 27% reduction in total CO_2 emissions in plants designed with generation technology based on the conventional steam cycle, a 31% reduction in gas-powered turbines, and a 28% reduction in thermal power generation from combined cycle.

With regard to nuclear energy, from 1984 (the year the first nuclear power plant in operation in the country began to generate electricity) to 2009, 152 TWh were generated, which is equivalent to 32.7 million toe, considering a thermal efficiency of 40%. If this energy had been generated by coal, the use of nuclear energy in Brazil would have avoided the emission of 127 million tons of CO_2, which corresponds to 37% of total emissions for 2009 from energy use.

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

Raising awareness of environmental issues in the medium and long terms is essential to sustainable development. Cognizant of this, in the process of preparing the national Agenda 21 the Brazilian government sought to establish strategies to ensure sustainable development in the country, recommending actions, partnerships, methodologies and institutional mechanisms for its implementation and monitoring.

Recently, several official measures have been pursued, which is an indication of the importance of the combat against climate change in Brazil. Early in this process, in 2008, the National Plan on Climate Change was approved with a view to identifying, planning and coordinating actions and measures that can be undertaken to mitigate greenhouse gas emissions generated in the country, as well as those necessary for the adaptation of society to the impacts arising from climate change.

On December 29, 2009, the National Policy on Climate Change was put in place, which established its own principles, objectives, guidelines, and instruments. The National Policy aims, inter alia, at the reconciliation of social and economic development with protection of the climate system; reduction of anthropogenic greenhouse gas emissions in relation to their various sources; strengthening of anthropogenic removals by sinks of greenhouse gases in the country; and implementation of measures to promote adaptation to climate change by the three levels of government, with the participation and collaboration of the economic and social stakeholders, particularly those especially vulnerable to its adverse effects.

As announced by the President of the Republic during the High Level Segment of the 15th Conference of the Parties to the Convention - COP-15 and the 5th Conference of the Parties serving as the Meeting of the Parties to the Kyoto Protocol - CMP-5, held in Copenhagen, the text of the law that established the National Policy on Climate Change provides that the country will adopt voluntary actions to mitigate greenhouse gas emissions at national level with a view to reducing its projected emissions by 36.1%-38.9% by 2020. The measures to implement the Policy have been launched, with a view to establishing sectoral plans to achieve the goal expressed in the Policy regarding mitigation actions. This is one of the most ambitious national voluntary mitigation actions in the world.

The Policy on Science, Technology and Innovation - ST&I is also being strengthened with regard to climate change. Examples include the fact that the 2007-2010 Action Plan (entitled Science, Technology and Innovation for National Development) has encompassed the National Program on Climate Change, and the fact that there is a program entitled Meteorology and Climate Change under the Federal Government's 2008-2011 Multi-Annual Plan with a view to providing insight into the mechanisms that determine global climate change and to improving weather, climate, hydrological, and environmental forecasting capacities.

Many of the programs implemented in the country do not directly intend to reduce greenhouse gas emissions, but they will have impacts on emissions originating from different sources. One of the most important factors is the finding that not only the federal government is involved, but also states and municipalities.

At the federal level, the National Air Quality Control Program – Pronar seeks to control air quality by establishing national emission limits. There is also the Motor Vehicle Air Pollution Control Program – Proconve, which has the same goal, but covers specifically air pollution by automotive vehicles. This is certainly one of the most successful environmental programs ever implemented in Brazil.

Article 4.1 (d) of the United Nations Framework Convention on Climate Change provides that the Parties shall "(p)romote 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."

Much progress has been made in recent years regarding the combat against deforestation, particularly in the Amazon. Administrative, economic and legal measures have been adopted, according to a political action strategy (among such instruments is the Action Plan for the Prevention and Control of Deforestation in the Legal Amazon - PPCDAM). With the series of measures adopted, the deforestation area was significantly reduced by 73%, from 27,772 km^2 in 2004 to 7,464 km^2 in 2009.

Much of the success in the implementation of these measures is due to the fact that Brazil has one of the most modern systems for monitoring forest areas in the world, such as is the case of the remote sensing-based monitoring system for the Amazon by the National Institute for Space Research - INPE, which has four operating and complementary systems: Prodes, Queimadas, Deter, and Degrad.

Brazil has also been a pioneer in the use of meteorological satellite data to monitor burning in the country, which culminated in the creation of the Program for the Prevention and Control of Burnings and Forest Fires – Proarco, implemented by the Brazilian Institute of the Environment and Natural Resources – Ibama in collaboration with the National Institute for Space Research - INPE, with a view to preventing and controlling fires burnings in the country, thus avoiding forest fires.

In addition, there is a large number of Federally Protected Areas - PAs in the country to protect and conserve the existing flora and fauna. These PAs cover 44,835,960.84 hectares (448.35 thousand km^2) in total. Adding up all Protected Areas in Brazil – federal and state PAs, full protection and sustainable use PAs, in addition to indigenous lands –, the total is 238,627,268 ha, which accounts for 27.98% of the country's territory. This figure does not include Municipally Protected Areas; Permanent Preservation Areas; Private Natural Heritage Reserves and military areas, plus a large area of native forest (mainly in the Amazon) that is not included as protected areas.

Financial and tax measures (the Green Protocol, environmental responsibility of banks, rural credit restrictions on environmental offenders, ecological ICMS, among others) have also proven to be of great importance in promoting sustainable development.

The National Fund on Climate Change and the Amazon Fund are recent examples of attempts to find financial resources in innovative ways to address challenges posed by climate change.

Clean Development Mechanism Project Activities in Brazil

The success of Clean Development Mechanism - CDM – which is an instrument under the Kyoto Protocol – in Brazil is unquestionable and it has undoubtedly contributed to mitigating greenhouse gas emissions in the country. In August 2010, the potential of annual greenhouse gas emission reduction from 460 CDM project activities in Brazil under validation or in a subsequent stage in the CDM pipeline represented 8% of emissions from sectors other than land use, land use change and forestry - LULUCF (only afforestation and reforestation are eligible for CDM as LULUCF activities), which accounted for about 59% of Brazil's emissions in 1994. Two relevant examples of significant results from CDM in terms of reducing greenhouse gas emissions in Brazil are the following: five CDM project activities related to the production of adipic acid and nitric acid alone have reduced N_2O emissions virtually to zero in the Brazilian industrial sector, and 25 registered CDM project activities accounted for a reduction of approximately 47% of methane emissions in landfills in 1994.

Regarding CDM Programme of Activities - PoA, the first Brazilian PoA is another relevant example in terms of greenhouse gas emission reduction. This programme promotes CH_4 capture and combustion from Animal Waste Management System in swine farms in Brazil. 961 small-scale CDM programme activities have been included in the registered PoA by the coordinating/managing entity. The inclusion of these small swine farms in this PoA clearly indicates the relevance of the CDM to make feasible initiatives that would not occur in the absence of the Kyoto Protocol.

In terms of number of CDM project activities, Brazil ranks third, corresponding to 7% of the worldwide total. In terms of expected greenhouse gas emission reduction, CDM project activities in Brazil are responsible for a reduction of 393 million tons of carbon dioxide equivalent during the first crediting period. This period could vary between 7 and 10 years. On an annual basis, the expected greenhouse gas emission reduction is around 50 million tons of carbon dioxide equivalent. Considering US$ 15/tCO_2e, the amount of external financial resources to flow into the country during the first crediting period is approximately US$ 5.8 billion or US$ 750 million per year. In 2009, Certified Emission Reductions - CERs (known as "carbon credits") from CDM project activities would be ranked 16th if considered as part of the Brazilian export portfolio.

Programs Containing Measures to Facilitate Adequate Adaptation to Climate Change

One of the main objectives of the Second National Communication project was to "elaborate a methodological approach regarding vulnerability assessment and adaptation measures," which contained two results: elaboration of regional modeling of the climate and climate change scenarios; and vulnerability and adaptation research and studies concerning strategic sectors that are vulnerable to the impacts associated with climate change in Brazil.

The first result is related to the need for downscaling methods (scale reduction, that is, improved resolution) for Brazil, applicable to global climate change impact studies that require more detailed climatic projections, i.e., with better spatial resolution than that provided by a global climate model.

Hence, the Regional Climate Model - RCM, which is called Eta-CPTEC, was validated and then used to produce regional scenarios for future climate change for the Second National Communication of Brazil to the Convention. The Eta-CPTEC regional model featured new lateral conditions of the coupled ocean-atmosphere global model HadCM3 kindly provided by the Hadley Centre, UK. The study related to downscaling methods for Brazil was applied to climate change scenarios from the global model HadCM3 to obtain more detailed climate projections (2010-2040, 2040-2070, 2070-2100) with improved spatial resolution under scenario A1B. According to the model runs, the annual projections for 2010-2100 for temperature and rainfall derived from the Eta-CPTEC model for South America show increases in rainfall in Brazil's South region, and reductions in rainfall in the Northeast region and the Amazon, while temperatures rise throughout Brazil, and they are higher in the mainland area (MARENGO *et al.*, 2010).

The second result aims at developing a preliminary analysis of the impacts associated with climate change in the main areas in accordance with Brazil's national circumstances, especially in those areas where vulnerability is influenced by physical, social and economic factors. The initial goal was to analyze the areas considered to be strategically relevant, where impacts associated with climate change may be important for Brazil, and which could be studied in an independent manner, while future climate scenarios for Brazil had not yet been concluded. However, additional development of some studies from this result would depend on future results obtained from regional climate models, which would provide more reliable scenarios for South America in relation to the impacts of climate change on average surface temperature or on rainfall patterns.

Thus, studies were conducted on the semi-arid region, urban areas, coastal zones, human health, energy and water resources, forests, agriculture and livestock, and prevention of disasters, under the coordination of the Center for Strategic Studies and Management in Science, Technology and Innovation - CGEE, in collaboration with the Ministry of Science and Technology - MCT. Renowned Brazilian scientists in the area were mobilized for this task, each responsible for addressing specific issues. These studies were comprised of papers and debated by representatives from public and private organizations, in workshops for each of the thematic areas held in 2008 and 2009.

Additionally, with the runs of the regional model and with the availability of regionalized climate change scenarios until 2100, it was possible to conduct in-depth studies in the areas of health, energy and water resources, agriculture, and coral bleaching.

Other Information Considered Relevant to the Achievement of the Objective of the Convention

Transfer of Technologies

It must be recognized that a quick and effective reduction in greenhouse gas emissions and the need to adapt to the adverse effects of climate change require access to and diffusion and transfer of environmentally sound technologies.

Brazil considers the expression "transfer of technology" to have a more comprehensive meaning, encompassing the different stages of the technological cycle, including research and development - R&D, demonstration, increase in scale (deployment), diffusion and the transfer of technology *per se*, in relation to both mitigation and adaptation.

Brazil believes that the development and transfer of technologies related to global climate change should support mitigation and adaptation actions in order to achieve the Convention's ultimate objective. In the quest for this objective, identification of technological needs must be determined at national level, based on national circumstances and priorities.

Brazil has been seeking to identify the country's technological needs in relation to energy in a manner that reconciles meeting growing demands with the use of sources that emit fewer greenhouse gases. However, the intention is not merely to seek to identify the technologies the country needs to receive, but also the great potential for endogenous technologies that could be diffused and/or transferred to other countries, especially developing countries, through South-South (especially with Portuguese-speaking and/or African countries) or triangular cooperation. Ethanol produced from sugarcane is one of these examples, as well as technological advances achieved in the agriculture sector.

Research and Systematic Observation

Various research studies and systematic observation activities related to the global climate change problem have been carried out in the country. In this context, teams of Brazilian researchers are participating in the international effort of research programs related to global climate change, such as the Global Climate Observation System - GCOS, Global Oceanic Observation System - GOOS and the Pilot Research Moored Array in the Tropical Atlantic - Pirata, among others.

Among the research initiatives led by Brazil, the Large Scale Biosphere-Atmosphere Experiment in Amazonia - LBA deserves special mention. It aims at expanding understanding of the climatological, ecological, biogeochemical and hydrological functioning of the Amazon region; of the impact of land use changes on this functioning; and of the interactions between the Amazonia and the global biogeophysical system of the Earth. In 2007, the LBA became a government program and refreshed the research agenda launched in 1998, when it was under international cooperation agreements.

A major scientific contribution by Brazil to the negotiations of the international regime on global climate change was the so-called "Brazilian Proposal", put forward by the country in response to the "Berlin Mandate", and submitted in May 1997. The proposal intends to promote a change in paradigm by defining objective criteria to evaluate each country's responsibility for global climate change. It is based on each country's historical and differentiated contributions towards the increase in global mean surface temperatures caused by the accumulation of anthropogenic greenhouse gases since the Industrial Revolution.

Thus, the country is promoting and cooperating in scientific research and in systematic observations aimed at explaining, reducing or eliminating uncertainties that still exist regarding the causes, the effects, the magnitude and the evolution of climate change over time.

Education, Training and Public Awareness

Although the issues related to climate change are complex and difficult to be understood by lay persons, and in the light of the limited reading material on the subject available in Portuguese, an effort has being made to expand education, public awareness and training on issues related to climate change.

Several educational programs implemented in Brazil are in accordance with the Convention's objectives. In particular, the following should be highlighted:

- The Brazilian Internet site on climate change of the Ministry of Science and Technology - MCT (http://www.mct.gov.br/clima) has contributed towards an increase in public awareness on the matter, as it provides information about the entire negotiation process under the Convention, the main references about climate science and the preparation of the National Communication. On September 27, 2010, the total number of pages available exceeded the figure for 2000 more than tenfold, since the website had 35,363 pages online, in four languages (Portuguese, English, Spanish, and French). Furthermore, it is worth noting that, according to Google, the Ministry homepage's PageRank is 8, i.e., every ten searches conducted on the Internet on the topic of global climate change, eight are directed to the Brazilian homepage. Also, publications in Portuguese (such as the official version of the Convention and Kyoto Protocol), articles from newspapers, magazines and journals, radio and TV shows, as well as the organization of seminars and debates, have helped in generating awareness of an issue that was relatively unknown in the country in 1994.

- Established in 2000 and chaired by the President of the Republic, the Brazilian Climate Change Forum - FBMC has helped to promote awareness and engagement of the society regarding the issue of global climate change, together with numerous other public and private organizations.

- The *Procel nas Escolas* (Procel at Schools) and Conpet *nas Escolas* (Conpet at Schools) programs are especially geared towards children and adolescents through partnerships with learning institutions, and they are also of great importance. They aim at expanding teacher and student awareness about the importance of using electric energy, oil byproducts and natural gas in the most sustainable way possible and to broadly promote such attitudes. It is estimated that between 1990 and 2008, thanks to the achievements by the Procel project, an accumulated savings of energy of 2,841,912 MWh was achieved.

National and Regional Capacity Building

Brazil has special needs related to the institutional structure required to deal with climate change related issues. Building national and regional capacity is one of the primary objectives of developing countries, considering that climate change is a new field of study and there are few specialized courses on the subject.

At regional level, the work of the Inter-American Institute for Global Climate Change Research - IAI, an intergovernmental organization dedicated to research, deserves special mention. In relation to research at national level, activities by the Brazilian Research Network on Global Climate Change - Climate Network, established at the end of 2007, and the National Institute of Science and Technology for Climate Change are to be highlighted. Another aspect to be pointed out is the increasing participation of Brazilian scientists in the IPCC process, as well as the recent creation of the Brazilian Panel on Climate Change, based on the IPCC. Efforts are being made in the country in relation to the improvement of future climate change scenarios on the part of the Center for Weather Forecasting and Climate Studies - CPTEC/INPE and the newly created Earth System Science Center - CCST/INPE.

There are also cooperation initiatives in relation to national and regional capacity building with other developing countries (South-South cooperation) and triangular cooperation initiatives, involving both developed and developing countries (North-South-South cooperation). Training on modeling future regional scenarios of climate change for Latin American and Caribbean countries is reported as an example of regional capacity building. As far as national capacity building is concerned, Brazil has also collaborated with other developing countries in building capacity related to the Clean Development Mechanism and the preparation of National Communications.

Financial, Technical and Capacity Needs Difficulties Associated with the Preparation of the National Communication

The appreciation of Brazil's currency – the *real* – was a major concern in executing the project of the Second National Communication of Brazil. The dollar exchange rate at the time the project was negotiated with the GEF was R$ 3.15. Under those circumstances, the approved budget for the project (US$ 3,400,000 from GEF plus the original national contribution of US$ 4,175,600) would certainly be sufficient for carrying out all the planned basic studies, and the expansions and details, that is, the additional activities that would be implemented, at the expense of the contributions that would be negotiated during the project execution, with each partner.

However, the dollar exchange rate, according to the official United Nations exchange rate for October 2010, was at R$ 1.71, having oscillated throughout execution of the project (2006-2010) at rates lower than those considered when the project was proposed. This caused several financial difficulties for the project to comply with its basic commitments, since all of its expense commitments were paid in *reais*.

In the specific case of the Second National Communication of Brazil, the executing agency of this project, i.e., the MCT, had to make additional efforts in relation to financial execution of the project, since besides those contributions that are normally expected for expanding and detailing results, additional funds were necessary to make it possible to carry out some studies, given the *real*'s appreciation in relation to the dollar.

The efficient completion of the Second National Communication of Brazil, with the proper expansions and details of those studies deemed necessary by the technical area, as well as the solution of the difficulties faced with the exchange appreciation, demanded funds worth US$ 10,604,222.

Of these funds, US$ 3,400,000 were provided by GEF and US$ 7,204,222 came from national contributions. Initially, this contribution was US$ 4,175,600. However, given the exchange rate appreciation and the determined need for additional activities during the execution of the project, this contribution was not sufficient, which forced the MCT to work with several of the Ministry's institutions and entities in order to obtain additional funds, without which the work would not be finalized.

Through active participation and thanks to a solid construction of partnerships by the MCT, it was possible to leverage additional contribution funds of US$ 3,028,622 to complete the project in an efficient manner, maintaining the expected quality of the results.

In addition, another major concern in relation to the permanent arrangements for the preparation of National Communications is the lack of a stable team with expertise in global climate change, dedicated to the planning and supervision of actions that is not outsourced or hired as consultants for the delivery of products.

The acquisition of sophisticated equipment for processing data derived from interpretation of satellite imagery and auxiliary data (cartographic maps, etc.) was a concern in the project due to the delay in hiring and lack of experience in the preparation of this type of bidding by the United Nations agency.

Summing up, the contents of this document are an indication that Brazil has been doing its fair share to combat climate change, and is prepared to sustain this leading role in the context of the overall effort needed to address the problem, pursuant to the Convention's objective and principles.

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Juliano Mota Lazaro
Júlio Noronha
Júlio Palhares
Jurandir Falas Berbel
Jussara Haruco Miaira
Jussara Starling de Medeiros
K. P. G. Alekseev
Karen Suassuna
Kelma Maria Nobre Vitoriano
Kênio Franklin de Freitas
Kennedy Gomes de Souza
Kleber Covas Martinez
Konnie Peuker
Laércio de S. Campos
Laís Roberta Galdino de Oliveira
Laline Ramirez Nunes
Lani Tardin
Leda Christiane de F. Lopes Lucena
Larissa Schmidt
Laryssa Lilian Lopes Sbruzzi
Laura Kikue Kumazawa
Laura Maria Regina Tétti
Laura Porto
Laura Silvia Valente de Macedo
Laura Tetti
Lauro Eduardo de Souza Pinto
Lauro José Scholer
Lázaro de Godoy Neto
Leandro Batista Yokomizo
Leandro do Prado Wildner
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Leandro Waldvogel
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Lidia Harue Hanada,
Lidiane Barroso
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Lindemberg Bezerra
Lindon Fonseca Matias
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Lorenza Alberici da Silva
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Luana de Rosa
Lucas Assunção
Lucas dos Santos Lôbo Takahashi
Lúcia H. Ribas Machado
Luciana Mara Corrêa
Luciana Medeiros de Carvalho Brant
Luciana O. Queiroz Ribeiro
Luciana Omena dos Santos
Luciana Spinneli Araújo
Luciane Garavaglia
Luciane R. dos Anjos
Luciano Chagas Barbosa
Luciano dos Santos Martins
Luciano Fonseca Coppola
Luciano Freire Maia
Luciano Lellis Miranda
Luciano Nobre Varella
Luciano Quintans
Luciano Rodrigues
Lucila Maria Teixeira Caselato
Ludmila de Oliveira Ferreira
Luís Antônio Martinelli
Luis Carlos Leonardelli
Luís Fernando Stone
Luis Gustavo Moraes Ferraz
Luis Henrique Sartorlli
Luis Salazar
Luiz Alberto Figueiredo Machado
Luiz Alberto Oliva Monte
Luiz Antônio Antunes de Oliveira
Luiz Augusto Horta Nogueira
Luiz Augusto S. de Azevedo
Luiz Carlos B. Biasi
Luiz Carlos Hermes
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Luiz Cláudio Padiar
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Luiz Gylvan Meira Filho
Luiz Kazuiko Maebara
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Luiz Mário Baccarin
Luiz Pereira Ramos
Luiz Pinguelli Rosa
Luiz R. A. Cunha
Luiz Renha
Luiz Soares
Luiz Soresini
Luiz Varela Guimarães
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Manoel Fernandes Martins Nogueira
Manoel Régis Lima Verde Leal
Manuel Eduardo Ferreira
Manuel Jerez Orozco
Manuella Santos Barbosa
Manyu Chang
Mara Lorena Maia Fares

Marçal José Rodrigo Pires
Marcela Cardoso Guilles da Conceição
Marcela Ohira Schwarz
Marcelo Consiglio
Marcelo Drügg Barreto Vianna
Marcelo Francisco Sestini
Marcelo Khaled Poppe
Marcelo Meirinho Caetano
Marcelo Pisetta
Marcelo Rodolfo Siqueira
Marcelo Teixeira Pinto
Marcelo Theoto Rocha
Márcia Amorim Soares Amaral
Marcia Andréa Dias Santos
Marcia Chame
Márcia Cristina Pessoa Fonseca
Márcia Drachmann
Márcia Janeiro Pereira
Márcia Macul
Márcia Simão Macul
Márcia Valéria Ferraro Gomes
Márcia Valle Real
Marcia Zenobia de Lima Oleari
Marcio Guimarães
Márcio M. Santos
Márcio Nogueira Barbosa
Márcio Schetinni
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Marco Antônio Machado
Marco Antonio Sanchez Artuzo
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Marco Aurélio de Sousa Martins
Marco Aurélio dos Santos Bernardes
Marco Aurélio Freitas
Marco Túlio Scarpelli Cabral
Marco Ziliotto
Marcos Antonio Vieira Ligo
Marcos Aurélio Vasconcelos de Freitas
Marcos Buckeridge
Marcos Corrêa Neves
Marcos Eduardo de Souza
Marcos Escaldelai
Marcos Freitas
Marcos Jank
Marcos Otávio Prates
Marcos Pellegrini Bandini
Marcos Sampol
Marcos Santos Ferreira
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Margareth Watanabe
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Maria Clara Tavares Cerqueira
María Cleofé Valverde Brambila
Maria Conceição Peres Young Pessoa
Maria Cristina Maciel Lourenço
Maria Cristina Yuan
Maria da Conceição Peres Young
Maria da Conceição Santana Carvalho
Maria de Fátima Salles de Abreu Passos
Maria do Carmo Carvalho da Silva
Maria do Socorro B. Nascimento
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Maria Feliciana de Ortigão Sampaio
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Maria Isabel Sobral Escada
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Maria Luiza de Araújo Gastal
Maria Netto
Maria Rita Fontes
Maria Sílvia Muylaert
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Mariana Regina Zechin
Mariana Sigrist
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Maurício D'Agostini Silva
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Maurício Silva Andrade
Maurício Tiomno Tolmasquim
Maurik Jehee
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Mauro Gebrim
Mauro Kazuo Sato
Mauro Luiz Brasil
Mauro Mansur
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Milton Cezar Ribeiro
Milton Eduardo Giancoli
Milton Marques
Milton Nogueira
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Miuzael Frazão Freire
Moacir Marcolin
Mohamed E. E. Habib
Moisés Antonio dos Santos
Mônica de Queiroz Santos
Moyzés dos Reis Amaral
Myrthes Marcelle Santos
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Nádima de Macedo Paiva Nascimento
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Nadja N. Marinho Batista
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Nelson Machado Guerreiro

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Nilson Clementino Ferreira
Niro Higushi
Nivaldo Silveira Ferreira
Nuri Oyamburo de Calbete
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Odemar Rosa Pereira
Odo Primavesi
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Oliveira Santos
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Orivaldo Brunini
Orlando Cristiano da Silva
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Osvaldo Soliano Pereira
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Oswaldo dos Santos Lucon
Oswaldo M. Albino Neto
Oswaldo Polizio Júnior
Oswaldo Velinho
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Roberto Bertelli
Roberto da Rocha Brito
Roberto de Aguiar Peixoto
Roberto de Moura Campos
Roberto dos Santos Vieira (*in memoriam*)
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Roberto Godinho
Roberto Moreira
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Rodolfo Nicastro
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Rodrigo de Matos Moreira
Rodrigo Hemerhy
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Ronaldo Seroa da Motta
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Rosana Faria Vieira
Rosana Tiyomi Kirihara
Rosane Castiglioni Pereira
Rosangela Silva
Rosaura Garcia Zucolo
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Sebastião Costa Guedes
Sebastião Renato O. Fortes
Sebastião Sérgio Faria
Segen Farid
Semida Silveira
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Sérgio Antônio Perassa
Sérgio Besserman Vianna
Sérgio Calbete
Sérgio Lopes Dousseau
Sérgio Maia
Sérgio Peres Ramos da Silva
Sérgio Raposo de Medeiros
Sérgio Serra
Sheila da Silva Souza
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Sidney Abreu
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Silvia Martarello Astolpho
Sílvio Arfeli
Silvio Manoel Silva Gonçalves
Silvio Pereira Coimbra
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Sizuo Matsuoka
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Sônia Maria Manso Vieira
Sônia Seger P. Mercedes
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Sourak Aranha Borralho
Suani Teixeira Coelho
Suleima Santos
Suzana Kahn Ribeiro
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Taiana Nunes dos Santos
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Tamara Vigolo Trindade
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Tereza Cristina Pinto
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Thaylini Cristine Luz Belino Bonfin
Tsutomu Morimoto
Thelma Krug
Themis Piazzetta Marques
Thiago de Araújo Mendes
Tiago Massao Matsumoto
Tomás Caetano Rípoli
Torello Redi Neto
Túlio César Mourthé de A. Andrade
Ubirajara Moura de Freitas
Ulf Walter Palme
Ulisses Eugenio Cavalcanti Confalonieri
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Valdete Duarte
Valdo da Silva Marques
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Valquíria Pereira Cabral da Silva
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Vanderlei Perez Canhos
Vania Elisabete Schneider
Vanildes Oliveira Ribeiro
Vera Lúcia Castro
Vera Lúcia de Abreu Vilela
Vicente Schmall
Victor Bonesso Júnior
Victor Ferreira de Souza
Victorio L. Furlani Neto
Vilma de Jesus Rodrigues
Vilson Fontana Bastos
Vilson Rodrigues Aguiar
Virgílio Bandeira
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Volnei Peruchi
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Wagner Costa Ribeiro
Wagner Fisher
Wagner Moreira
Wagner Soares

Waldir B. Silva
Waldir Stumpf
Waldomiro Paes
Walmir Costa da Roda
Walmir Fernando G. da Rocha
Walnir Ferro de Souza
Warwick Manfrinato
Weber Amaral
Wellington B. C. Delitti
Wellington Costa Freitas
Werner Eugênio Zulauf (*in memoriam*)
Werner Kornexl
William Frasson
Wilson Roberto Soares Mattos
Wolmir Pereira Andrade
Yara Campos Almeida
Yuri Andres de Jesus Moraes
Yushiro Kihara
Zelinda Leão
Zilmar de Souza
Zulcy Souza

Participating Institutions

3M do Brasil - Regional de Meio Ambiente, Segurança e Higiene Industrial - América Latina
ABAL - Associação Brasileira do Alumínio
ABCM – Associação Brasileira do Carvão Mineral
ABCP - Associação Brasileira de Cimento Portland
ABEMA - RN – Associação Brasileira de Entidades Estaduais de Meio Ambiente
ABES - Associação Brasileira de Engenharia Sanitária e Ambiental
ABESCO - Associação das Empresas de Serviços de Conservação de Energia
ABETRE - Associação Brasileira de Empresas de Tratamento de Resíduos
ABIA - Associação Brasileira das Industrias Alimentícias
ABIQUIM - Associação Brasileira da Indústria Química
ABL - Incinerador de Antibióticos do Brasil
ABLP - Associação Brasileira de Resíduos Sólidos e Limpeza Pública
ABNT - Associação Brasileira de Normas Técnicas
Aborgama do Brasil Ltda
ABPC - Associação Brasileira de Cimento Portland
ABRELPE - Associação Brasileira de Empresas de Limpeza Pública e Resíduos Especiais
ABS Quality Evaluations
Açúcar e Álcool Oswaldo Ribeiro de Mendonça Ltda
Açúcar Guarani S/A.
Açucareira Quatá S/A
Açucareira Zillo Lorenzetti S/A.
ADEMA - Administração Estadual do Meio Ambiente SE
AES Sul Distribuidora Gaúcha de Energia S/A
AES Uruguaiana Empreendimentos S/A
Afluente Geração e Transmissão de E.E. S/A
Agência Goiana de Meio Ambiente
Agência Nacional de Energia Elétrica - ANEEL
AGESPISA - Águas e Esgotos do Piauí S/A
AIDIS - Associação Interamericana de Engenharia Sanitária e Ambiental
AINEP - Assessoria e Intermediação de Negócios Especiais e Participação
ALBRAS - Alumínio Brasileiro S/A
ALCOA
ALLMA - Gestão em Agronegócios
Alpina Ambiental S/A
ALSTOM POWER - Sistemas de Controle Ambiental
ALUMAR - Consórcio de Alumínio do Maranhão
Alves & Trancho – Assessoria e Consultoria em Informática Ltda.
Amapari Energia S.A
Amazonas Distribuidora de Energia S/A
Amazônia Eletronorte Transmissora de Energia S/A
AmBev - Companhia de Bebidas das Américas
Ambiental ECOPAM
Ambiental Saneamento e Concessões Ltda
AMESC - Associação dos Municípios do Extremo Sul Catarinense
Ampla Energia e Serviços S/A
ANAC - Agência Nacional de Aviação Civil
Anaconda Ambiental e Empreendimentos Ltda.
Antonio Ruette Agroindustrial Ltda
APETRES - Associação Paulista das Empresas de Tratamento e Destinação de Resíduos Urbanos
Araputanga Centrais Elétricas S/A
ArcellorMittal
ArcelorMittal Cariacica
ArcelorMittal Itaúna
ArcelorMittal Juiz de Fora
ArcelorMittal Monlevade
ArcelorMittal Piracicaba
ArcelorMittal Sabará
Artemis Transmissora de Energia S/A
ASEMG – Associação Suinocultores do Estado de Minas Gerais
Associação Mineira de Silvicultura - AMS
ATE II Transmissora de Energia S/A
ATE III Transmissora de Energia S/A
ATE Transmissora de Energia S/A
ATT Ambiental Tecnologia e Tratamento Ltda
BAESA - Energética Barra Grande S/A
Bahia Pulp S/A
Baixada Santista Energia S/A
Banco Nacional de Desenvolvimento Econômico e Social – BNDES
Bandeirante Energia S/A
Belgo Bekaert Arames Contagem
Belgo Bekaert Arames Hortolândia
Belgo Bekaert Arames Osasco
Belgo Bekaert Arames Sabará
Biogás Energia Ambiental S/A.
BIOTECS - Águas e Efluentes - Engenharia de Sistemas de Tratamento
Boa Hora Central de Tratamento de Resíduos
Boa Hora Central de Tratamento de Resíduos Ltda
Boa Sorte Energética S/A
Boa Vista Energia S/A
Bonfante Energética S/A
Bons Ventos Geradora de Energia
Brascanenergética Minas Gerais S/A
BRASECO - Tratando do Lixo, Cuidando de Você
Brasil Central Energia S/A

Breitener Jaraqui S/A
Breitener Tambaqui S/A
Brentech Energia S/A
BT Geradora de Energia Elétrica S/A
Bunge Fertilizantes S/A
Caçador Energética S/A
CAEMA - Companhia de Águas e Esgoto do Maranhão
CAER - Companhia de Águas e Esgotos de Roraima
CAERD - Companhia de Águas e Esgotos de Rondônia
CAERN - Companhia de Águas e Esgotos do Rio Grande do Norte
CAESA - Companhia de Água e Esgotos do Amapá
CAESB - Companhia de Saneamento Ambiental do Distrito Federal
CAGECE - Companhia de Água e Esgoto do Ceará
CAGEPA - Companhia de Água e Esgoto da Paraíba
Caiuá Distribuidora de Energia S/A
Calheiros Energia S/A
Capuava Energy
Carangola Energia S/A
Casa Civil da Presidência da República
CASAL - Companhia de Saneamento de Alagoas
CASAN - Companhia Catarinense de Águas e Saneamento
Cavo-Serviços e Meio Ambiente S/A
CBA – Companhia Brasileira de Alumínio
CDSA - Centrais Elétricas Cachoeira Dourada S/A
CEAL – Companhia Energética de Alagoas
CECLIMA - Centro Estadual de Mudanças Climáticas/AM
CEDAE - Companhia Estadual de Águas e Esgotos
CEEE-GT – Companhia Estadual de Energia Elétrica
CEESAM Geradora S/A
CELESC Distribuição S/A
CELG Distribuição S/A
CELG Geração e Transmissão
Celulose Nipo-Brasileira S/A
CEMAR – Companhia Energética do Maranhão
CEMIG Companhia de Energia de Minas Gerais
CEMIG Geração e Transmissão S/A
CEMPRE - Compromisso Empresarial para Reciclagem
CENBIO - Centro Nacional de Referência em Biomassa
Censtroeste Construtora e Participações Ltda
Centrais Elétricas Brasileiras S.A. - ELETROBRÁS
Centrais Elétricas do Pará S/A
Centrais Elétricas Matogrossenses S/A
Centrais Hidrelétricas Grapon S/A
Centro de Ciência do Sistema Terrestre – CCST/INPE
Centro de Estudos em Sustentabilidade _ Centro de Gestão e Estudos Estratégicos - CGEE
Centro de Previsão do Tempo e Estudos Climáticos do INPE – CPTEC/INPE
Centro Nacional de Referência de Biomassa – CENBIO
CEPEA - Center for Advanced Studies on Applied Economics - ESALQ/USP
CERAN - Companhia Energética Rio das Antas
CERPA - Central Energética Rio Pardo Ltda
CES - Centro de Estudos em Sustentabilidade da FGV - EAESP
CESA - Castelo Energética S/A. CE
CESAN - Companhia Espírito Santense de Saneamento
CESP - Companhia Energética de São Paulo
CETESB - Companhia Ambiental do Estado de São Paulo
Cetrel - Camaçari - BA
Cetrel Lumina Com. E Adm.
Cetrel Lumina Comercial em São Paulo
CETREL S/A. - Empresa de Proteção Ambiental
CGEE - Centro de Gestão e Estudos Estratégicos
CGTF - Central Geradora Termelétrica Fortaleza S/A
CIEN – Companhia de Interconexão Energética
CJ Energética S/A
Clariant - Blumenau/SC
Clean CTTR (Central de Tratamento Térmico de Resíduos) - Belém - PA
Clean Service Serviços Gerais Ltda
CNPGL - Embrapa Gado de Leite
CNPSA - Embrapa Suínos e Aves
CODEMA Campinas - Conselho Municipal de Meio Ambiente
CODESP - Companhia Docas do Estado de São Paulo
COELBA – Companhia de Eletricidade do Estado da Bahia
COGEN - SP - Associação Paulista de Cogeração de Energia
Columbian Chemicals Brasil Ltda.
COMGAS - Companhia de Gás de São Paulo
Companhia Ambiental do Estado de São Paulo - CETESB
Companhia Brasileira de Estireno
Companhia Cervejaria Brahma - Cervejarias Reunidas Skol Caracu S/A - Sub -Produtos
Companhia de Energia Elétrica do Estado de Tocantins
Companhia de Gás de São Paulo
Companhia Energética Chapecó
Companhia Energética de Brasília
Companhia Energética de Pernambuco
Companhia Energética de Petrolina
Companhia Energética do Ceará
Companhia Energética Santa Clara
Companhia Estadual de Distribuição de Energia Elétrica
Companhia Força e Luz do Oeste
Companhia Hidrelétrica do São Francisco
Companhia Hidroelétrica São Patrício
Companhia Jaguari de Energia
Companhia Luz e Força Santa Cruz
Companhia Nacional de Energia Elétrica
Companhia Nitro Química Brasileira
Companhia Paulista e força e Luz

Companhia Siderúrgica Nacional
Companhia Transirapé de Transmissão
Companhia Transleste de Transmissão
Companhia Transudeste de Transmissão
COMPESA - Companhia Pernambucana de Saneamento
Compromisso Empresarial para a Reciclagem – CEMPRE
Concessionária Mosquitão
Conselho Nacional da Pecuária de Corte
Consórcio Aproveitamento Hidrelétrico Porto Estrela
Consórcio Capim Branco Energia -UHE AmadorAguiar I
Consórcio Capim Branco Energia -UHE AmadorAguiar II
Consórcio Dona Francisca (CEEE-GT e DFESA)
Consórcio Ecocamp
Consórcio Itá
Consórcio Machadinho
Construtora Marquise S/A
Coordenação dos Programas de Pós Graduação em Engenharia/Universidade Federal do Rio de Janeiro - COPPE/UFRJ
COPASA - Companhia de Saneamento de Minas Gerais
COPEL – HOLDING – Companhia Paranaense de Energia
COPERSUCAR - Centro Tecnológico Copersucar
COPPE/UFRJ – Instituto Alberto Luiz Coimbra de Pós-Graduação e Pesquisa de Engenharia
Corpus Saneamento e O Brasileiro Ltda
CORSAN - Companhia Riograndense de Saneamento
Corumbá Concessões S/A
COSAN Alimentos S.A FILIAL TARUMÃ
COSAN Alimentos S.A UNIDADE MARACAÍ
COSAN Centro Oeste S.A Açúcar e Álcool Filial Jataí
COSAN S.A Bionergia Filial UTE Costa Pinto
COSAN S.A Bionergia Filial UTE GASA
COSAN S/A Bionergia Filial UTE RAFARD
COSANPA - Companhia de Saneamento do Pará
COSE - Companhia Energética do Rio Grande do Norte
Costa Rica Energética Ltda
Cotiporã Energética S/A
CPFL Piratininga
CPPSE - Embrapa Pecuária Sudeste
CPPSUL - Embrapa Pecuária Sul
CPRH - Agência Estadual de Meio Ambiental e Recursos Hídricos/PE
CRA - Centro de Recursos Ambientais/BA
CSN - Cia. Siderúrgica Nacional
CST - Companhia Siderúrgica de Tubarão
CTEEP
Curuá Energia S/A.
CVRD - Companhia Vale do Rio Doce - Departamento de Gestão Ambiental e Territorial
Da Ilha Energética S/A
DAE S/A. - Água é Esgoto
Dambiental
Dana Indústrias Ltda.
DANONE Ltda.
Dedini S/A Indústria de Base
Departamento Municipal de Energia de Ijui
DESO - Companhia de Saneamento de Sergipe
Destilaria Água Bonita Ltda
DME Energética Ltda.
DMEPC
DNA Consultoria, Planejamento, Gestão Urbana e Ambiental
e&e Economia e Energia
ECO - PROCESSA Arcos/MG
ECO - PROCESSA Cimpor - Cajati/SP
ECO - PROCESSA Cimpor - Campo Formoso/BA
ECO - PROCESSA Cimpor - Candiota/RS
ECO - PROCESSA Cimpor - Cezarina/GO
ECO - PROCESSA Cimpor - João Pessoa/PB
ECO - PROCESSA Cimpor - São Miguel dos Campos/AL
ECO - PROCESSA Lafarge Cantagalo
ECO - PROCESSA Matosinhos/MG
Economia e Energia - e&e
ECTE – Empresa Catarinense de Transmissão de Energia
ELEKTRO – Eletricidade e Serviços S/A
ELETRAM - Eletricidade da Amazônia S.A.
Eletro Primavera Ltda
ELETROCAR Centrais Elétricas de Carazinho S/A
ELETRONORTE _ Centrais Elétricas do Norte do Brasil S/A
ELETROSUL - Centrais Elétricas S/A
EMAE - Empresa Metropolitana de Águas e Energia S/A
EMBASA - Empresa Baiana de Águas e Saneamento S/A.
Embralixo Empresa Bragantina de Varrição e Coleta de Lixo Ltda
Empreiteira Pajoan - Central de Tratamento de Resíduos (Associada APETRES)
Empresa Amazonense de Transmissão de Energia S/A
Empresa Brasileira de Pesquisa Agropecuária - Embrapa
Empresa de Distribuição de Energia Vale Paranapanema S/A
Empresa de Transmissão de Energia de Santa Catarina
Empresa de Transmissão de Energia do Rio Grande do Sul
Empresa de Transmissão do Alto Uruguai S/A
Empresa de Transmissão do Espírito Santo S/A
Empresa Elétrica Bragantina S/A
Empresa Energética de Mato Grosso do Sul S/A
Empresa Energética Porto das Pedras S/A
Empresa Luz e Força Santa Maria S/A
Empresa Norte de transmissão de energia S/A
Empresa Tejofran de Saneamento e Serviços Ltda
ENERCAN- Campos Novos Energia S/A
Energética Campos de Cima da Serra
Energética Ponte Alta S/A
Energética Salto Natal S.AENERGISA Borborema
ENERGISA Minas Gerais Distribuidora de Energia S/A
ENERGISA Nova Friburgo Distribuidora de Energia S/A

ENERGISA Paraíba
ENERGISA Sergipe Distribuidora de Energia S/A
Energyworks do Brasil Ltda
Enerpeixe S.A
Enge - Aplic Montagens Industriais Ltda
ENGEPASA Ambiental Ltda
Engetécnica Ltda
Enob Ambiental Ltda
ENTERPA Ambiental S/A.
Eólica Formosa Geração e Comércio de Energia S/A
Eólica Icaraizinho Geração e comércio de Energia S/A
Eólica Paracuru Geração e Comércio de Energia S/A
EPAGRI - Empresa de Pesquisa Agropecuária e Extensão Rural de Santa Catarina
EPE – Empresa de Pesquisa Energética
EPESA – Centrais Elétricas de Pernambuco S/A
Eppo Ambiental Ltda
Equipav S/A - Açúcar e Álcool
ERM Brasil Ltda.
ERTE - Empresa Regional de Transmissão de Energia
Espírito Santo Centrais Elétricas S/A
Espora Energética S/A
Essencis Administração
Essencis Co - Processamento
Essencis CTR Betim
Essencis CTR Caieiras
Essencis CTR Curitiba
Essencis CTR Itaberaba
Essencis CTR Joinville
ESSENCIS Incineração - (Fonte:Abetre e Cenbio)
Essencis Soluções Ambientais S/A.
ESTRE - Empresa de Saneamento e Tratamento de Resíduos Ltda.
ESTRE CDR Pedreira
ESTRE CGR Guatapará
ESTRE CGR Itapevi
ESTRE CGR Paulínia
ESTRE CGR Piaçaguera
ESTRE CGR Romeiros
ETEO - Empresa de Transmissão de Energia do Oeste
ETEP - Empresa Paraense de Transmissão de Energia S/A
Eucatex S/A Indústria e Comércio
Evrecy Participações Ltda
Faculdade SENAI de Tecnologia Ambiental
FATMA - Fundação do Meio Ambiente/SC
FBOMS - Fórum Brasileiro de ONG's e Movimentos Sociais para o Meio Ambiente e Desenvolvimento
FEAM - Fundação Estadual de Meio Ambiente/MG
Federação das Indústrias do Estado de Minas Gerais - Gestão e Tecnologia - Gerência de Meio Ambiente
FEEMA - Fundação Estadual de Engenharia do Meio Ambiente/RJ
FEMACT - Fundação do Meio Ambiental, Ciência & Tecnologia/RR
FEPAM - Fundação Estadual de Proteção Ambiental/RS
Ferrari Termoelétrica S/A
FIESP - Federação das Indústrias do Estado de São Paulo
FIRJAN - Federação das Indústrias do Rio de Janeiro
Forty Construções e Engenharia LTDA
Fórum Baiano de Mudanças Climáticas Globais e de Biodiversidade
Fórum Brasileiro de Mudanças Climáticas
Fórum Capixaba de Mudanças Climáticas
Fórum Catarinense de Mudanças Climáticas Globais e de Biodiversidade
Fórum Cearense de Mudanças Climáticas
Fórum Estadual de Mudanças Climáticas e Biodiversidade Tocantins
Fórum Gaúcho de Mudanças Climáticas
Fórum Mineiro de Mudanças Climáticas Globais
Fórum Paranaense de Mudanças Climáticas
Fórum Paulista de Mudanças Climáticas e Biodiversidade
Fórum Rio de Mudanças Climáticas Globais
FOSFERTIL – Fertilizantes Fosfatados S/A
Foz do Chopim Energética Ltda.
FUNCATE - Fundação para a Ciência Aeroespacial, Aplicações e Tecnologia
Fundação Oswaldo Cruz - Fiocruz
Fundação Getúlio Vargas - FGV
Funil Energia S.A.
FURNAS Centrais Elétricas S/A
GALERA Centrais Elétricas S/A
GEOKLOCK - Consultoria e Engenharia Ambiental Ltda. - Departamento de Engenharia Ambiental
Geomap Ltda.
GERA - Geradora de Energia do Amazonas S/A
Geraoeste Usinas Elétricas do Oeste S/A
Gerdau Aço Minas
Global Defense Systems Ltda
Goiasa Goiatuba Álcool Ltda
Governo do Estado da Bahia- Secretaria de Meio Ambiente e Recursos Hídricos
Governo do Estado de Minas Gerais - Fundação Estadual do Meio Ambiente
Governo do Estado do Espírito Santo- Secretaria do Meio Ambiente e Recursos Hídricos - Instituto Estadual de Meio Ambiente e Recursos Hídricos - IEMA
Governo do Estado do Paraná-secretaria de Estado do Meio Ambiente e Recursos Hídricos
Governo do Estado do Rio de Janeiro-secretaria de Estado do Ambiente - Fundação Estadual de Engenharia do Meio Ambiente - Grupo Leão & Leão
Grupo Plantar
Guarantã Energética Ltda

Hidroluz Centrais Elétricas Ltda
Hidropower Energia S/A
HIDROSSOL – Hidroelétricas Cassol Ltda.
HOLCIM
HPT - Torres de Resfriamento - Tratamento de Água e Efluentes
IABr - Instituto Aço Brasil
IAP - Instituto Ambiental do Paraná/PR
IBAM - Instituto Brasileiro de Administração Municipal - Área de Desenvolvimento Urbano e Meio Ambiente
IBGE - Instituto Brasileiro de Geografia e Estatística
IDEMA - Instituto de Defesa do Meio Ambiente/RN
IEA - Instituto de Estudos Avançados da Universidade de São Paulo
IEE - Instituto de Eletrotécnica e Energia
IEF - Instituto Estadual de Florestas/RJ
IEF – Instituto Estadual de Florestas/MG
IEMA - Instituto de Energia e Meio Ambiente
Iguaçu Energia
IMA - Instituto do Meio Ambiente/AL
IMASUL - Instituto de Meio Ambiente do Mato Grosso do Sul
Inidiavai Energética S/A
Instituto Alberto Luiz Coimbra de Pós - graduação e Pesquisa de Engenharia - Universidade Federal do Rio de Janeiro - Programa de Planejamento Energético – PPE/COPPE/UFRJ
Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis - Ibama
Instituto de Eletrotécnica e Energia - IEE/USP
Instituto de Energia e Meio Ambiente - IEMA
Instituto de Estudos Avançados - IEA/USP
Instituto de Física - IF/USP
Instituto de Pesquisa Econômica Aplicada – IPEA
Instituto de Zootecnia – APTA (Centro de Pesquisa e Desenvolvimento em Nutrição Animal e Pastagens)
Instituto Estadual de Meio Ambiente e Recursos Hídricos - IEMA
Instituto Interamericano para Pesquisas em Mudanças Globais - IAI
Instituto Nacional de Ciência e Tecnologia para Mudanças Climáticas – INCT/Clima
Instituto Nacional de Meteorologia - INMET
Instituto Nacional de Pesquisas da Amazônia - INPA
Instituto Nacional de Pesquisas Espaciais - INPE
Instituto Virtual de Mudanças Globais - IVIG/UFRJ
Interligação Elétrica de Minas Gerais S/A
International Council for Local Environmental Initiatives - ICLEI Brasil
International Paper do Brasil Ltda
INVESTCO S/A
IPAAM - Instituto de Proteção Ambiental do Amazonas
IPT - Instituto de Pesquisa Tecnológica
Irara Energética S/A
Isamu Ikeda Energia S/A
Itaipu Binacional
Itamarati Norte S/A Agropecuária
ITAMBÉ - Cia. de Cimento Itambé
Itapebi Geração de Energia S/A
Itiquira Energética S/A
Jaguari Energética S/A
Jataí Energética S/A.
Jotagê Engenharia Comércio e Incorporações Ltda
Klabin S/A
Konus Icesa S/A
LACTEC - Instituto de Tecnologia para o Desenvolvimento
LDC Bioenergia S/A., Unidade Giasa
LDC Bioenergia S/A., Unidade Lagoa da Prata
LDC Bioenergia S/A., Unidade Leme
LDC Bioenergia S/A., Unidade Rio Brilhante
Light Energia
Light Serviços de Eletricidade S/A.
LIMPEC - Limpeza Pública de Corações
Limpel Limpeza e Engenharia Ltda
Linha Emília Energética S/A
Litucera Limpeza e Engenharia Ltda
Locanty Com. Serviços Ltda
Locavargem Ltda
Logos Engenharia S/A.
Ludesa Energética S/A.
Luftech - Soluções Ambientais
Lumbrás Energética S/A
LUMITRANS Companhia de Transmissão de Energia Elétrica
Lwarcel Celulose Ltda
Macedo Passos Consultoria em Informática Ltda.- ME
Maqbrit Comércio e Indústria de Máquinas Ltda
Marca Ambiental Ltda. - Gerenciamento e Tratamento de Resíduos
MAUÊ S/A Geradora e Fornecedora de Insumos
MB Engenharia e Meio Ambinete Ltda
Mega Automação Industrial Ltda
Millennium Central Geradora Eólica S/A
Ministério da Agricultura, Pecuária e Abastecimento - MAPA
Ministéio de Minas e Energia - MME
Ministério da Ciência e Tecnologia – MCT
Ministério da Defesa - MD
Ministério da Fazenda - MFaz
Ministério da Integração Nacinal – MI
Ministério da Saúde - MS
Ministério das Cidades - MCid
Ministério das Relações Exteriores – MRE
Ministério do Desenvolvimento, Indústria e Comércio Exterior - MDIC

Ministério do Meio Ambiente – MMA
Ministério do Planejamento, Orçamento e Gestão - MPOG
Ministério dos Transportes – MT
Miranda & Miranda – Assessoria e Consultoria em Informática Ltda.
MIZUME - Tecnologia de Tratamento de Esgoto
Monte Serrat Energética S/A.
Mosca Grupo Nacional de Serviços Ltda
Multi Serviços Tecnologia Ambiental Ltda
NATURATINS - Instituto Natureza do Tocantins
NEPA/UNICAMP - Núcleo de Estudos em Proteção Ambiental
Nordeste Transmissora de Energia
Novatrans Energia S/A.
NOVELIS DO BRASIL LTDA
Novo Mundo Energética SA
OMBREIRAS Energética S/A
Ônix Geração de Energia S/A
Ouro Energética S/A
P&D Consultoria
Pampeana Energética S/A
Pantanal Energética Ltda.
Paranatinga Energia S/A
PePeC Ambiental - Consultoria em Meio Ambiente
Petróleo Brasileiro S.A. – PETROBRAS
Pilkington Brasil Ltda.
Pioneira Saneamento e Limpeza Urbana Ltda
Pioneiros Termoelétrica Sud Mennucci S.A.
Planalto Energética S/A
Plena Transmissoras
Ponta Grossa Ambiental Ltda
PRANA - Assessoria e Gestão Ambiental
Prefeitura da Cidade de Nova Iguaçu - EMLURB - Empresa Municipal de Limpeza Urbana
Prefeitura da Estância Turística de Ibiúna
Prefeitura da Estância Turística de Salto-Secretaria da Indústria, Comércio e Agricultura
Prefeitura Municipal de Marília-secretaria Municipal do Verde e do Meio Ambiente
Prefeitura Municipal de Saltinho
Prefeitura Municipal de São Paulo-Secretaria Municipal do Verde e do Meio Ambiente
Prefeitura Municipal de Volta Redonda - Coordenadoria de Defesa do Meio Ambiente
Primaverda Energia S/A
PROCLIMA RN
Programa Nacional de Conservação de Energia Elétrica - PROCEL/ELETROBRÁS
Programa Nacional do Uso Racional de Derivados de Petróleo e do Gás Natural - CONPET/PETROBRAS
PROGUIMA Processamento de dados Ltda. – ME
PROSAB - Programa de Pesquisas em Saneamento Básico (Instituição FINEP)
PUC-RS Pontifícia Universidade Católica do Rio Grande do Sul
QUALIX - Aterro Sanitário Sítio São João
QUALIX Serviços Ambientais Ltda.
Queiroz Galvão Energética SA
Quimatec Produtos Químicos
Quitaúna-Serviços S/C Ltda
Raia & Coelho Ltda. - Consultoria em Tratamento de Lixo
Rede Brasileira de Pesquisa sobre Mudanças Climáticas Globais - Rede Clima
REFAP S.A
RENOVA Soluções - Centro de Tratamento de Resíduos de Nova Iguaçu
Retiro Velho Energética S.A.
RGE - Rio Grande Energia S/A
Riachão Energética S/A
Riacho Preto Energética S.A
Rialma Companhia Energética III S/A
Rialma Companhia Energética S/A
RIMA Industrial S.A
Rio do Sangue Energia S/A
Rio Glória Energética S/A
Rio Manhuaçu Energética S/A
Rio PCH – Neoenergia
Rio Pomba Energética S/A
Rio Sucuriu Energia S/A
Rio Verde Energia S/A
Rodnei Cassiano Todorow – ME
S/A
SABESP - Companhia de Saneamento Básico do Estado de São Paulo
SADIA S/A. - Sustentabilidade
Salto Jauru Energética S/A
Samarco Mineração
SANEAGO - Saneamento de Goiás S/A.
SANEATINS - Companhia de Saneamento do Tocantins
SANEPAR - Companhia de Saneamento do Paraná
Sanepav Engenharia, Saneamento e Pavimentação Ltda
SANESUL - Empresa de Saneamento do Mato Grosso do Sul S/A.
SANSUY S/A. Indústria de Plásticos
Santa Candida Açúcar e Alcool Ltda.
Santa Cruz Geração de Energia S/A.
Santa Cruz Power Corporation Usinas Hidroelétricas
Santa Cruz S.A. Açúcar e Álcool
Santa Fé Energética S/A.
Santa Gabriela Energética S/A
São Joaquim Energia S/A
São Pedro Energia S/A
São Simão Energia S/A
SAR - Superintendência de Aeronavegabilidade
Sarpi - Sistemas Ambientais Comercial Ltda

SASA - Sistemas Ambientais - ONYX
SATC - Associação Beneficente da Indústria Carbonífera de Santa Catarina
Scheide & Costa Ltda.
SDS - Secretaria de Estado de Desenvolvimento Sustentável/SC
SDS - Secretaria de Meio Ambiente e Desenvolvimento Sustentável/AM
SEA - Secretaria de Estado do Ambiente/RJ
SEAMA - Secretaria de Estado de Meio Ambiente e Recursos Hídricos/ES
Secretaria de Meio Ambiente e Recursos Hídricos
Secretaria de Meio Ambiente, Cidades, Planejamento e Tecnologia MS
Secretaria do Meio Ambiente do Estado de São Paulo - Instituto Geológico
SECTMA - Secretaria Ciência& Tecnologia e Meio Ambiente/PE
SECTMA - Secretaria de Ciência & Tecnologia e do Meio Ambiente/ PB
SEDAM - Secretaria de Desenvolvimento Ambiental/RO
SELURB - Sindicato Nacional das Empresas de Limpeza Urbana
SEMA - Secretaria de Estado de Meio Ambiente e Recursos Naturais/AC
SEMA - Secretaria de Meio Ambiente e Recursos Naturais MA
SEMA - Secretaria Estado de Meio Ambiental e Recursos Hídricos/PR
SEMA - Secretaria Estadual de Meio Ambiente/AP
SEMA - Secretaria Estadual de Meio Ambiente/MT
SEMA - Secretaria Estadual do Meio Ambiente/RS
SEMA - Secretaria Executiva Ciência & Tecnologia e Meio Ambiental/PA
SEMACE - Superintendência do Meio Ambiente/CE
SEMAD - Secretaria de Meio Ambiente e Desenvolvimento Sustentável/MG
SEMAR - Secretaria Meio Ambiental e Recursos Hídricos/PI
SEMARH - Secretaria de Estado do Meio Ambiente/SE
SEMARH - Secretaria de Meio Ambiente e Recursos Hídricos/BA
SEMARH - Secretaria de Meio Ambiente e Recursos Hídricos/GO
SEMARHN - Secretaria de Meio Ambiente Recursos Hídricos/AL
SEMASA-Serviço Municipal de Saneamento Ambiental de Santo André - Departamento de Resíduos Sólidos
SENAI CIC/CETSAM PR (Centro de Tecnologia em Saneamento e Meio Ambiente)
SEPLAN - Secretaria Recursos Hídricos e Meio Ambiente/TO
SERQUIP Serviços, Construções e Equipamentos Ltda
Serra Negra Energética S/A
Sestini & Sestini Ltda. – ME
Siderúrgica Barra Mansa S/A
SIECESC - Sindicato da Indústria da Extração do Carvão de Santa Catarina
SIIF Cinco Geração e Comércio de Energia S/A
Silcon Ambiental Ltda
SILCON Comercial em Santos
SILCON PTR Comércio e Administração
SILCON PTR Esprírito Santo
SILCON PTR Juquiá
SILCON PTR Mauá
SILCON PTR Paulínia
SILCON PTR Santos
SIR - Sindicato Nacional da Indústria de Refratários
Sistema de Transmissão Nordeste
SMA - Secretaria Estadual de Meio Ambiente/ SP
SNIC – Sindicato Nacional da Indústria do Cimento
SNIS - Sistema Nacional de Informações sobre Saneamento
SOMA - Secretaria da Ouvidoria - Geral e do Meio Ambiental/CE
SPE Alto Irani Energia S/A
SPE Plano Alto Energia S/A
STC - Sistema de Transmissão Catarinense S/A.
Stemag Engenharia e Construções Ltda
STERLIX Ambiental Tratamento de Resíduos Ltda
SUDEMA - Superintendência de Administração do Meio Ambiente/PB
SUEZ AMBIENTAL
Sul Transmissora de Energia
Suzano Papel e Celulose
Tangará Energia S/A.
TB Serviços, Transporte, Limpeza, Gerenciamento e Recursos Humanos Ltda
TECIPAR
TECIPAR Com. e Adm.
Tecipar Engenharia e Meio Ambiente Ltda
Tecna Sistemas Ltda.- ME
Tecno Lara Tratamento de Efluentes
Tecnometal Engenharia e Construções Mecânica Ltda
Termocabo S/A.
Termoelétrica Itaenga Ltda
Termopernambuco S/A
Terraplena Ltda
The Nature Conservancy - TNC
Tocantins Energética S/A
Torre Empreendimento Ltda
Tractebel Energia S/A
TRANSFORMA - Engenharia do Meio Ambiente
Trans-lix Transportes e Serviços Ltda
Transmissora Sudeste Nordeste S/A.
Transresíduos Transportes de Resíduos Industriais Ltda
TRIBEL
TRIBEL Comercial em São Paulo

Tribel Tratamento de Resíduos Industriais de Belford Roxo Ltda
Tupan Energia Elétrica S/A
UGMC-Unidade Gestora de Mudanças Climáticas e Unidades de Conservação
Uirapuru Transmissora de Energia S/A.
UNESP - Universidade Estadual Paulista (Faculdade de Ciências Agrárias e Veterinárias)
União da Indústria de Cana-de-açúcar – Única
UNICAMP - Universidade Estadual de Campinas
UNICAMP - Universidade Estadual de Campinas - Instituto de Geociências - Departamento de Geografia - LECLIG - Laboratório de Estudos Climáticos IG/UNICAMP
UNIFACS - Universidade Salvador - Bahia
Unileste Engenharia S/A
Universidade de Campinas – Unicamp
Universidade de São Paulo – Pirassununga
Universidade de São Paulo - USP
Universidade Federal de Minas Gerais – UFMG
Universidade Federal do Rio de Janeiro – UFRJ
Universidade Federal do Rio Grande do Sul – UFRGS
URBAM - Urbanizadora Municipal S/A.
Usian Barralcool S/A
Usian Cururipe açúcar e Álcool S/A
Usian de Açúcar Santa Terezinha – Tapejara
USIMINAS-Usinas Siderúrgicas de Minas Gerais S/A
Usina Alta Mogiana S/A Açúcar e Álcool
Usina Alto Alegre S/A
Usina Barra Grande de Lençóis S.A.
Usina Boa Vista
Usina Cerradinho Açúcar e Álcool
Usina Colombo S/A Açúcar e Álcool
Usina Mandu S/A
Usina Petribú S/A
Usina Santa Adélia S/A
Usina Santa Isabel
Usina São Domingos-Açúcar e Álcool S/A
Usina São Luiz S/A.
Usina São Martinho
Usina Termelétrica Norte Fluminense S/A.
Usina Termo Elétrica Iolando Leite Ltda
USP - Faculdade de Saúde Pública
USP - Universidade de São Paulo (Escola Superior de Agronomia “Luiz de Queiroz” – ESALQ - Departamento de Produção Animal)
UTE Termocabo
V&M -Vallourec e Mannesmann Tubes
Vale dos Ventos Geradora Eólica S/A
VALE SUL
Várzea do Juba Energética S/A
Vega Engenharia Ambiental S/A
Vêneto Energética S/A
VEOLIA Administração
VEOLIA Resicontrol
VEOLIA Sasa
Veracel Celulose S/A
Viasolo Engenharia Ambiental S/A
Vista Alegre Açúcar e Álcool Ltda
Vital Engenharia Ambiental S/A
Viva Ambiental e Serviços Ltda
Votorantim Cimentos Brasil
Votorantim Cimentos N/NE S.A.
Votorantim MetaisVotorantim Metais Zinco S.A.
VSB -Vallourec & Sumitomo Tubos do Brasil
WHITE MARTINS/PRAXAIR
Zona da Mata Geração S.A.

Symbols, acronyms and abbreviatons

AAE – Energy Application Agency (*Agência para Aplicação de Energia*)
ABAL – Brazilian Aluminum Association (*Associação Brasileira do Alumínio*)
ABC – Brazilian Academy of Sciences (*Academia Brasileira de Ciências)*
ABC – Brazilian Cooperation Agency (*Agência Brasileira de Cooperação*)
ABCM – Brazilian Coal Association (*Associação Brasileira do Carvão Mineral*)
ABCP – Brazilian Association of Portland Cement (*Associação Brasileira de Cimento Portland)*
ABEER – Brazilian Association of Renewable Energy Companies and Energy Efficiency (*Associação Brasileira de Energia Renovável e Eficiência Energética*)
ABEGÁS – Brazilian Gas Distribution Companies Association (*Associação Brasileira das Empresas Distribuidoras de Gás Canalizado*)
ABEMA - Brazilian Association of Environmental Entities (*Associação Brasileira das Entidades de Meio Ambiente)*
ABETRE - Brazilian Association of Waste Treatment Companies (*Associação Brasileira de Empresas de Tratamento de Resíduos*)
ABIA - Brazilian Food Industry Association (*Associação Brasileira das Indústrias de Alimentação*)
ABIC - Brazilian Association of Coffee Industry (*Associação Brasileira da Indústria do Café*)
ABIOVE – Brazilian Association of Vegetable Oil Industries (Associação Brasileira das Indústrias de Óleos Vegetais)
ABIP – Brazilian Association of the Bakery and Confectionery Industry (*Associação Brasileira da Indústria de Panificação e Confeitaria*)
ABIQUIM – Brazilian Chemical Industry Association (*Associação Brasileira da Indústria Química*)
Abn Amro Real - Algemene Bank Nederland; Amsterdam-Rotterdam Bank (*Banco Geral dos Países Baixos*)
ABNT - Brazilian Association of Technical Standards (*Associação Brasileira de Normas Técnicas*)
ABPC – Brazilian Lime Producers Association (*Associação Brasileira dos Produtores de Cal*)
ABRABE – Brazilian Association of Beverages (*Associação Brasileira de Bebidas*)
ABRAFE - Brazilian Association for Iron-Alloys Producers (*Associação Brasileira dos Produtores de Ferroligas e de Silício Metálico*)
ABRASCO – Brazilian Graduate Association for Collective Health (*Associação Brasileira de Pós-Graduação em Saúde Coletiva*)
ABRELPE - Brazilian Association of Public Cleaning and Special Waste Companies (*Associação Brasileira de Empresas de Limpeza Pública e Resíduos Especiais*)
AC – state of Acre
ACSYS - Arctic Climate System Study *(Estudo do Sistema do Clima Ártico)*
AEG - applied intersectoral overall balance model
AIA – Environmental Impact Assessment/EIA (*Avaliação de Impacto Ambiental*)
AIACC - Assessment of Impacts and Adaptation to Climate Change *(Avalição de Impactos e Adaptação à Mudança do Clima)*
AIDS - Acquired Immune Deficiency Syndrome *(Síndrome da Imunodeficiência Adquirida)*
AL – state of Alagoas
Al_2O_3 - alumina or aluminium oxide
ALADI – Latin American Integration Association *(Associação Latino-Americana de Integração)*
ALALC – Latin American Free Trade Association *(Associação Latino-Americana de Livre Comércio)*
Albras – Brazilian Aluminum (*Alumínio Brasileiro S.A*)
Alumar – Aluminum Consorcium of the state of Maranhão (*Consórcio de Alumínio do Maranhão*)
AM - Amanã Sustained Development Reserve
AM – state of Amazonas
AMC - Atmospheric Mesoscale Campaign
AMS – Medical-Health Assistance Survey (*Assitência Médico Sanitarista*)
ANA – National Waters Agency (*Agência Nacional de Águas*)
ANAC - National Civil Aviation Agency (*Agência Nacional de Aviação Civil*)
ANAMMA - National Association of Municipalities and Environment (*Associação Nacional de Municípios e Meio Ambiente*)
ANEEL – National Electrical Energy Agency (*Agência Nacional de Energia Elétrica*)
Anfavea – National Association of Motor Vehicle Manufacturers (*Associação Nacional de Fabricantes de Veículos Automotores*)
ANP - National Agency of Petroleum, Natural Gas and Biofuels (*Agência Nacional do Petróleo, Gás e Biocombustíveis*)
ANTAQ – National Water Transport Agency (*Agência Nacional de Transportes Aquaviários*)
ANTP - National Public Transport Association (*Associação Nacional de Transportes Públicos)*
ANTT - National Ground Transport Agency (*Agência Nacional de Transportes Terrestres*)
AP – state of Amapá

APAs – Environmental Protection Areas (*Áreas de Proteção Ambiental*)
AR4 – IPCC Fourth Assessment Report
Arebop – National Association of Tire and Rubber Artifact Recycling Companies (*Associação Nacional das Empresas de Reciclagem de Pneus e Artefatos de Borrachas*)
ARGOS - Advanced Research and Global Observation Satellite (*Satélite de Pesquisa Avançada e Observação Global*)
ARIEs – Areas of Relevant Ecological Interest (*Áreas de Relevante Interesse Ecológico*)
ARPA – Amazon Region Protected Areas (*Áreas Protegidas da Região Amazônica*)
ASTM - American Society for Testing Materials (*Sociedade Americana para Ensaio de Materiais*)
Atlas - Autonomous Temperature Line Aquisition System
B2 – Biodiesel 2% (concentration)
B5 – Biodiesel 5% (concentration)
B100 – Pure biodiesel
BA – state of Bahia
BAMS - Bulletin of the American Meteorological Society (*Boletim da Sociedade Americana de Meteorologia*)
BANIF – Funchal International Bank (*Banco Internacional do Funchal*)
BASA – Bank of Amazônia (*Banco da Amazônia S.A.)*
BB – Bank of Brazil (*Banco do Brasil S.A.*)
bbl – barrel of oil (*barril de petróleo*)
BCCF - Brazilian Climate Change Forum
BEN – National Energy Balance (*Balanço Energético Nacional*)
bep – barrel of oil equivalent (*barril equivalente de petróleo*)
BEU – Useful Energy Balance (*Balanço de Energia Útil*)
BHC – Breast Height Circumference
BIG - Generation Information Database (*Banco de Informações de Geração*)
BIG-GT - Biomass Integrated Gasification - Gas Turbine (*Gaseificação Integrada de Biomassa - Turbina a Gás*)
BM – World Bank (*Banco Mundial*)
BM&F – Brazilian Mercantile & Futures Exchange (*Bolsa de Mercadorias & Futuros*)
BNB – Bank of the Northeast of Brazil (*Banco do Nordeste do Brasil S. A.*)
BNDES – Brazilian Development Bank (*Banco Nacional de Desenvolvimento Econômico e Social*)
BOD - biochemical oxygen demand (*demanda bioquímica de oxigênio*)
Bovespa – São Paulo Stock Exchange (*Bolsa de Valores de São Paulo*)
BPCC – Brazilian Panel on Climate Change
BR – Brazil
BRACELPA – Brazilian Association of Pulp and Paper (*Associação Brasileira de Celulose e Papel*)
Bradesco – a Brazilian Bank (*Banco Brasileiro de Descontos*)
BRAMS - Brazilian Regional Atmospheric Modelling System (*Sistema Brasileiro de Modelagem Atmosférica Regional*)
BTU - British Thermal Unit (*Unidade térmica Britânica*)
C – carbon
C_2F_6 – hexafluoroethane
C40 – Group of large cities in the world committed to combat climate change (*Grupo de grandes cidades mundiais comprometidas a combater a mudança do clima*)
CaC_2 - calcium carbide (*carbureto de cálcio*)
$CaCO_3$ – calcium carbonate (*carbonato de cálcio*)
CAF – Andean Promotion Corporation (*Corporação Andina de Fomento)*
CAN – Andean Community (*Comunidade Andina)*
CANAMBRA - Consortium of Canadian, American and Brazilian consultants (*Consórcio de Consultores Canadenses, Norte-americanos e Brasileiros*)
$Ca(OH)_2$ – hydrated lime
CAPES – Coordinating Foundation of Personnel Improvement for Higher Education (*Coordenação de Aperfeiçoamento de Pessoal de Nível Superior*)
CAR - Rural Environmental Registry (*Cadastramento Ambiental Rural*)
CARBONCYCLE - Brazilian-European Study of the Carbon Cycle of Amazônia
CATHALAC - Water Center for the Humid Tropics of Latin America and The Caribbean *(Centro del Agua del Trópico Húmedo para América Latina y el Caribe)*
CATIE – Tropical Agricultural Research and Higher Education (*Centro Agronômico Tropical de Investigación y Enseñanza*)
CATT - Coupled Aerosol and Tracer Transport model
CBA – Aluminum Brazilian Company (*Companhia Brasileira de Alumínio*)
CBD – circumference at breast height
CBERS - China-Brazil Earth Resources Satellite
cc – cubic centimeter
CC – Scientific Committee (*Comitê Científico*)
CCC – Fuel Consumption Bill (*Conta de Consumo de Combustíveis*)
CCD - charge-coupled device
CCD - INPE CBERS satellites
CCIR - Rural Property Registry Certificate (*Certificado de Cadastro de Imóvel Rural*)
CC-LBA – Large Scale Biosphere-Atmosphere Program in the Amazon Scientific Committee (*Comitê Científico do LBA)*
CCP - Cities for Climate Protection (*Cidades pela Proteção do Clima*)
CCS - Carbon Capture and Storage (*Captura e armazenamento de carbono*)
CCST – Earth System Science Center (*Centro de Ciência do Sistema Terrestre*)
CDB – Bank Deposit Certificate (*Certificado de Depósito Bancário*)
CDE – Energy Development Bill (*Conta de Desenvolvimento Energético*)

CDM - Clean Development Mechanism
CE – state of Ceará
CEBDS - Brazilian Business Council of Sustainable Development (*Conselho Empresarial Brasileiro para o Desenvolvimento Sustentável*)
CEF – a Brazilian Bank (*Caixa Econômica Federal*)
CEFET – Federal Centers of Technological Education (*Centro Federal de Educação Tecnológica)*
CEMIG – Minas Gerais Electrical Utility (*Centrais Elétricas de Minas Gerais*)
CEMPRE – Business Commitment for Recycling (*Compromisso Empresarial para a Reciclagem*)
CENAL - National Executive Commission on Alcohol (*Comissão Nacional do Álcool*)
CENBIO – Reference Center on Biomass (*Centro de Referência em Biomassa*)
CENPES – Petrobras' Leopoldo Américo Miguez Research and Development Center (*Centro de Pesquisas e Desenvolvimento Leopoldo Américo Miguez*)
CEPAC – Thematic Network for Sequestering Carbon and Climate Change and set up the Carbon Storage Research Center (*Centro de Pesquisas sobre Armazenamento do Carbono)*
CEPED – Center for Research and Development (*Centro de Pesquisas e Desenvolvimento)*
CEPEL – Center for Electrical Energy Research (*Centro de Pesquisas de Energia Elétrica*)
CERPCH – Reference Center on Small Hydroelectric Plants (*Centro de Referência em Pequenas Centrais Hidrelétricas*)
CERs - Certified Emission Reductions
CESP – São Paulo Electrical Company (*Companhia Energética de São Paulo*)
CET - Common External Tariff
CET - Traffic Engineering Company (*Companhia de Engenharia de Tráfego*)
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
CFE – Final Energy Consumption (*Consumo Final de Energia*)
CFL - compact fluorescent lamp
CGEE – Center for Strategic Studies and Management in Science, Technology and Innovation (*Centro de Gestão e Estudos Estratégicos*)
CGMC – General Coordination on Global Climate Change (*Coordenação Geral de Mudanças Globais de Clima*)
CH_4 – methane
CHO – aldehydes
CI – Conservation International (*Conservação Internacional*)
CICE - Internal Committee for Energy Conservation (*Comitê Interno de Conservação de Energia*)
CIDE – Contribution for Intervention in the Economic Domain (*Contribuição de Intervenção no Domínio Econômico*)
CIDES – Interministerial Comission on Sustainable Development (*Comissão Interministerial para o Desenvolvimento Sustentável)*
CIIFEN – International Research Center on the *El Niño* Phenomenon *(Centro Internacional para la Investigación del Fenómeno de El Niño* – *Centro Internacional para a Investigação do Fenômeno El Niño*)
CIM – Interministerial Committee on Climate Change (*Comitê Interministerial de Mudança Global do Clima*)
CIMA – Interministerial Sugar and Alcohol Council (*Conselho Interministerial do Açúcar e do Álcool*)
CIMGC – Interministerial Commission on Global Climate Change (*Comissão Interministerial de Mudança Global do Clima)*
CIRM – Interministerial Commission for Sea Resources (*Comissão Interministerial para os Recursos do Mar*)
CITES - Convention on International Trade in Endangered Species of Wild Fauna and Flora (*Convenção sobre o Comércio Internacional de Espécies Ameaçadas da Fauna selvagem e Flora*)
CLAIRE - Cooperative LBA Airborne Regional Experiment
CLIMAPEST – Global Climate Change Impacts on Phytosanitary Problems (*Impactos das Mudanças Climáticas Globais sobre Problemas Fitossanitários*)
Climate Network - Brazilian Research Network on Global Climate Change (*Rede Brasileira de Pesquisas sobre Mudanças Climáticas Globais – Rede Clima*)
CLIVAR - Research Program on Climate Variability and Predicability for 21st Century – (*Programa de Pesquisa sobre Variabilidade e Previsibilidade Climática para o Século 21*)
cm - centimeter
CMN – National Monetary Council (*Conselho Monetário Nacional*)
CMP - Conference of the Parties serving as the Meeting of the Parties to the Kyoto Protocol – (*Conferênica das Partes na qualidade de Reunião das Partes no Protocolo de Quioto*)
CNAL – National Alcohol Council (*Conselho Nacional do Álcool*)
CNEN - National Nuclear Power Commission (*Comissão Nacional de Energia Nuclear*)
CNFP - National Registry of Public Forests (*Cadastro Nacional de Florestas Públicas*)
CNIJMA – National Conference on Children and Youth for the Environment (*Conferência Nacional Infanto-juvenil pelo Meio Ambiente*)
CNMA – National Conference on the Environment (*Conferência Nacional de Meio Ambiente*)
CNP – National Petroleum Council (*Conselho Nacional do Petróleo*)
CNPE - National Energy Policy Council (*Conselho Nacional de Política Energética*)
CNPE – National Committee on Energy Policy (*Conselho Nacional de Política Energética*)

CNPq – Council of Scientific and Technological Development (*Conselho Nacional de Desenvolvimento Científico e Tecnológico*)
CNT - National Transport Confederation (*Confederação Nacional do Transporte*)
CO – carbon monoxide
CO_2 – carbon dioxide
CO_2e - CO_2 equivalent
COELBA – Bahia Electrical Company (*Companhia Elétrica da Bahia*)
COELCE – Ceará Electrical Company (*Companhia Elétrica do Ceará*)
COFA – Amazon Fund Steering Committee (*Comitê Orientador do Fundo Amazônia*)
Cofins – Tax for Social Security Financing (*Contribuição para o Financiamento da Seguridade Social*)
COGEN – Energy Co-generation Industry Association (*Associação da Indústria de Cogeração de Energia*)
COIAB – Coordination of Indigenous Organizations of the Brazilian Amazon (*Coordenação das Organizações Indígenas da Amazônia Brasileira*)
Comar – Metropolitan Clean Air Committee (*Comitê Metropolitano do Ar Limpo*)
Comgas – São Paulo Gas Company (*Companhia de Gás de São Paulo*)
CONAB – National Supply Company (*Companhia Nacional de Abastecimento*)
CONAMA – National Environmental Council (*Conselho Nacional de Meio Ambiente*)
Conapa – National Committee on Antartic Research (Comitê Nacional de Pesquisas Antárticas)
Confea – Federal Council of Engineering, Architecture and Agronomy (*Conselho Federal de Engenharia, Arquitetura e Agronomia*)
CONPET – National Program on the Rationalization of the Use of Oil and Natural Gas Products (*Programa Nacional da Racionalização do Uso dos Derivados do Petróleo e do Gás Natural*)
CONSERVE – Program for the Efficient Use of Energy (*Programa de Uso Eficiente da Energia*)
CONTRAN – National Traffic Council (*Conselho Nacional de Trânsito)*
COP - Conference of the Parties (*Conferência das Partes da Convenção-Quadro das Nações Unidas sobre Mudança do Clima*)
COPEL – Paraná Electrical Company (Companhia Elétrica do Paraná)
Copersucar – Sugarcane, Sugar and Alcohol Producers Cooperative of the State of São Paulo (*Cooperativa dos Produtores de Cana, Açúcar e Álcool do Estado de São Paulo*)
COPPE/UFRJ – Alberto Luiz Coimbra Institute of Graduate Studies and Research in Engineering at the Federal University of Rio de Janeiro (*Instituto Alberto Luiz Coimbra de Pós-Graduação e Pesquisa em Engenharia - UFRJ*)
COPPETEC – Project Coordination, Research and Technological Studies (*Coordenação de Projetos, Pesquisas e Estudos Tecnológicos*)
COr – revised carbon monoxide (*monóxido de carbono corrigido*)
CORINAIR – Core Inventory of Air Emissions
CP - Conference of the Parties (*Conferência das Partes*)
CPC – Polar and Climate Center (*Centro Polar e Climático*)
CPDS - Commission on Sustainable Development Policies and the National Agenda 21 (*Comissão de Políticas de Desenvolvimento Sustentável da Agenda 21 Nacional*)
CPFL – São Paulo Power and Light Company (*Companhia Paulista de Força e Luz*)
CPLP – Community of Portuguese-Speaking Countries (*Comunidade de Países de Língua Portuguesa*)
CPTEC – Center for Weather Forecasting and Climate Studies (*Centro de Previsão do Tempo e Estudos Climáticos*)
CREA - Regional Council of Engineering, Architecture and Agronomy (*Conselho Regional de Engenharia, Arquitetura e Agronomia*)
CRESESB – Reference Center on Solar and Wind Energy (*Centro de Referência em Energia Solar e Eólica*)
CRN - Collaborative Research Network Program (*Rede Colaborativa de Pesquisa*)
CSI - Cement Sustainability Initiative
CSIR - Council for Scientific and Industrial Research (*Conselho para a Pesquisa Científica e Industrial*)
CSP - Concentrated Solar Power – (*Energia Solar Concentrada*)
CTA - Technical Aerospace Center (*Centro Técnico Aeroespacial*)
CTB - Brazilian Traffic Code (*Código de Trânsito Brasileiro*)
CTBE – Center for Bioethanol Science and Technology (*Centro de Ciência e Tecnologia do Bioetanol*)
CTC – Center of Sugarcane Technology (*Centro de Tecnologia Copersucar*)
CTFA – Amazon Fund Technical Committee (*Comitê Técnico do Fundo Amazônia*)
CTL - Coal-to-liquid
CT-Petro - Oil and Natural Gas Sector Fund (*Fundo Setorial de Petróleo e Gás Natural*)
CVI - Climatic Vulnerability Index
CW - Curb Weight
d – day
DBH – diameter at breast height
DBMS - Database Management Systems
DEA - diethanolamine
Degrad - Mapping of forest degradation in the Brazilian Amazon (*Mapeamento de Áreas Degradadas*)
DEPV – Airforce's Department of Air Space Control (*Departamento de Controle do Espaço Aéreo*)
DETER – Real Time Deforestation Detection System (Sistema de Detecção de Desmatamento em Tempo Real)

DETEX – Mapping Project of Selective Logging Activities (*Projeto de Mapeamento de Ocorrências de Exploração Seletiva de Madeira*)
DETRAN – State Transit Department (*Departamento Estadual de Trânsito*)
DF – Federal District (*Distrito Federal*)
DHN – Navy's Directorate of Hydrography and Navigation
DIS - Data and Information Sytem (*Sistema de Dados e Informações*)
DMC - Disaster Monitoring Constellation satellites
DNA - Designated National Authority
DNAEE – National Department of Waters and Electrical Energy (*Departamento Nacional de Águas e Energia Elétrica*)
DNPM – National Department of Mineral Production (*Departamento Nacional de Produção Mineral*)
DOE - Designated Operational Entity
DPA – Political/Administrative Division of Brazil (*Divisão Político-Administrativa do Brasil*)
DVI - Desertification Vulnerability Index
DSS – decision support system
e&e – Economy and Energy (*Economia e Energia*)
E&P – Exploitation and Production (Exploração e Produção)
E.L.R. - European Load Response Cycle (*Ciclo Europeu de Resposta em Carga*)
E.S.C - European Stationary Cycle (*Ciclo Europeu em Regime Constante*)
E.T.C. - European Transient Cycle (*Ciclo Europeu em Regime Transiente*)
E22 - 22% ethanol and 78% gasoline
EAP - Economically Active Population
EC – European Community
ECLAC - Economic Commission for Latin America and the Caribbean (*Comissão Econômica para América Latina e Caribe*)
ECMWF - European Centre for Medium-Range Weather Forecasts
ECO – LBA-ECO Module (*Módulo LBA-ECO*)
EIA – Environmental Impact Assessment (*Estudo de Impacto Ambiental*)
EIRD – International Disaster Reduction Strategy (*Estratégia Internacional de Redução de Desastres*)
EJA – Teen and Adult Education (*Educação de Jovens e Adultos*)
ELETROBRAS – Brazil's Electrical Utility (*Centrais Elétricas do Brasil S.A.*)
ELETRONORTE – Electrical Utility of the North of Brazil (*Centrais Elétricas do Norte do Brasil S.A.*)
Eletronuclear - Eletrobras Termonuclear S.A.
ELETROPAULO – São Paulo Electricity S.A. (*Eletricidade de São Paulo S.A.*)
EMBC - Economy of Climate Change in Brazil (*Economia da Mudança do Clima no Brasil*)
EMBRAPA – Brazilian Agricultural Research Corporation (*Empresa Brasileira de Pesquisa Agropecuári*a)
EMTU/SP - São Paulo Metropolitan Urban Transport Company (*Empresa Metropolitana de Transporte Urbano de São Paulo*)
ENSO - El Niño Southern Oscilation (*El Niño Oscilação Sul/ ENOS*)
EOD – Designated Operational Entity/DOE (*Entidade Operacional Designada*)
EPAGRI – Santa Catarina Agriculture Research and Rural Extension Company (*Empresa de Pesquisa Agropecuária e Extensão Rural de Santa Catarina*)
EPE – Energy Research Company (*Empresa de Pesquisa Energética*)
EPS – expandable polystyrene foam
ES – state of Espírito Santo
ESCO's - Energy Saving Companies (*Empresas de Serviços de Conservação de Energia*)
EsEc – Ecological Stations (*Estações Ecológicas*)
ESF - Family Health Strategy (*Estratégia Saúde da Família*)
ESSP - Earth System Science Partnership (*Parceria do Sistema de Ciências da Terra*)
ETA – η (greek letter)
Ethanol E100 - 100% Hydrated Ethanol
EU – European Union
EUSTACH - European Studies on Trace Gases and Atmospheric Chemistry
EVAP - Evaporative Emission Control
FAB – Brazilian Air Force (*Força Aérea Brasileira*)
FAO - Food and Agriculture Organisation (*Organização das Nações Unidas para a Agricultura e a Alimentação*)
FAPERJ – Rio de Janeiro Research Foundation (*Fundação de Amparo à Pesquisa do Estado do Rio de Janeiro*)
FAPESP – São Paulo Research Foundation (*Fundação de Amparo à Pesquisa do Estado de São Paulo*)
FAPESPA – Pará Research Foundation (*Fundação de Amparo à Pesquisa do Estado do Pará*)
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 Forum on Climate Change (*Fórum Brasileiro de Mudanças Climáticas*)
FBOMS - Brazilian Forum of NGOs and Social Movements for the Environment and the Development (*Fórum Brasileiro de ONG's e Movimentos Sociais*)
FBPN – "O Boticário" Nature Protection Foundation (*Fundação O Boticário de Proteção à Natureza*)
FCCC - Framework Convention on Climate Change (*Convenção-Quadro sobre Mudança do Clima*)
FEALQ – Luiz de Queiroz Agrarian Studies Foundation (*Fundação de Estudos Agrários Luiz de Queiroz*)
Febraban – Brazil's Federation of Banks (*Federação Brasileira de Bancos*)

FEEMA - State Environmental Engineering Foundation (*Fundação Estadual de Engenharia do Meio Ambiente*)
Fetranspor – Urban Passenger Transportation Federation of the state of Rio de Janeiro (*Federação de Transportes de Passageiros Urbanos do Estado do Rio de Janeiro*)
FGV/SP – Getulio Vargas Foundation/Sao Paulo (*Fundação Getulio Vargas/São Paulo*)
FIESP - Federation of Industries of the State of São Paulo (*Federação das Indústrias do Estado de Sao Paulo)*
FIFA - Fédération Internationale de Football Association (*Federação Internacional de Futebol*)
FINEP - Financing Agency for Studies and Projects (*Financiadora de Estudos e Projetos*)
FIOCRUZ – Oswaldo Cruz Foundation (*Fundação Oswaldo Cruz*)
Flonas – National Forests (*Florestas Nacionais*)
FNDE – National Fund for the Development of Education (*Fundo Nacional de Desenvolvimento da Educação*)
FNDF - National Fund for Forest Development (*Fundo Nacional de Desenvolvimento Florestal*)
FNMA – National Environment Fund (*Fundo Nacional do Meio Ambiente*)
FNMC – National Fund for Climate Change (*Fundo Nacional sobre Mudança do Clima*)
FOB - Free on Board (*Livre a Bordo*)
FPSO - Floating Production Storage and Offloading
Funai – National Indian Foundation (*Fundação Nacional do Índio*)
Funasa - National Health Foundation (*Fundação Nacional de Saúde*)
Funatura - Pro–Nature Foundation (*Fundação Pró-Natureza*)
Funbio - Brazilian Biodiversity Fund (*Fundo Brasileiro para a Biodiversidade*)
Funcate – Foundation for Space Science, Technology and Applications (*Fundação de Ciência, Aplicações e Tecnologia Espaciais*)
FUNCEME – Cearense Meteorology Foundation (*Fundação Cearense de Meteorologia)*
Fundo InfraBrasil – Fund for investment in infrastructure with an environmental management system (*Fundo de investimento em infra-estrutura com sistema de gestão ambiental*)
FURNAS – Furnas Electrical Utility (*Furnas Centrais Elétricas S.A.*)
g – gram
G7 – Group of the Seven
G77 – Group of Seventy-seven
GAIM - Global Analysis, Integration and Modelling (*Análise Global, Interpretação e Modelagem*)
Gasoline E22 - Gasoline mixed with 22% of ethanol
GCD - greatest common divisor
GCE – Electrical Energy Crisis Management Chamber (*Câmara de Gestão da Crise de Energia Elétrica*)
GCM - General Circulation Models (*modelos de circulação geral*)
GCOS - Global Climate Observing System (*Sistema Mundial de Observação do Clima*)
GCTE – Global Change and Terrestrial Ecosystems (*Mudança Global e Ecossistemas Terrestres*)
GDP – Gross Domestic Product
GDP/Capita – Gross Domestic Product *per capita*
GEF - Global Environment Facility (*Fundo Global para o Meio Ambiente*)
GESis - Strategic Management of Agribusiness Systems (*Gestão Estratégica de Sistemas Agroindustriais*)
GEWEX - Global Energy and Water Cycle Experiment (*Experimento dos Ciclos Globais de Água e Energia*)
GEx – Executive Group on Climate Change (*Grupo Executivo sobre Mudança do Clima*)
Gg – gigagram (10^9 g or a thousand tonnes)
GHG - greenhouse gas
GISS - Goddard Institute for Space Studies (*Instituto Goddard de Estudos Espaciais*)
Gj – Gigajoule
GNP – Gross National Product
GO – state of Goiás
GOALS – Global Ocean-Atmosphere-Land System (*Sistema Global Oceano-Terra-Atmosfera*)
GOES - Geostationary Operational Environmental Satellite
GOF-UK – British Government
GOOS - Global Ocean Observing System (*Sistema de Observação Oceânica Global*)
GPC - Global Producing Center (*Centro Produtor Global*)
GPM - Global Precipitation Measurement (*Mensuração de Precipitação*)
GPMC - Climate Change Research Group (*Grupo de Pesquisa em Mudanças Climáticas*)
GT – Working Group (*Grupo de Trabalho*)
GTA – Amazonian Working Group (*Grupo de Trabalho Amazônico*)
GTI - Interministerial Work Group (*Grupo de Trabalho Interministerial*)
GTL - Gas-to-Liquid
GTP - Global Temperature Potential
GTZ - German Agency for Technical Cooperation (*Deutsche Gesellschaft für Technische Zusammenarbeit*)
GW – gigawatt
GWh – gigawatt hour
GWP - Global Warming Potential (*Potencial de Aquecimento Global*)
GWSP - Global Water System Project (*Projeto sobre o Sistema Global da Água*)
h – hour
H_2SO_4 - sulphuric acid (*ácido sulfúrico*)
ha – hectare

HadCM3 - Hadley Centre Global Model (*Modelo global do Hadley Center*)
H-Bio – Petrobras Technology for the Production of Renewable Diesel (*Tecnologia Petrobrás para Produção de Óleo Diesel Renovável*)
HC – hydrocarbons
HCFC – hydrochlorofluorocarbon
HCFC-22 – hydrochlorofluorocarbon-22
HDI - Human Development Index
HDT - Hydrotreatment Units (*Unidades de Hidrotratamento*)
HEAT - Harmonized Emissions Assessment Tool
HFC-134a - hydrofluorocarbon-134a
HFC-23 – hydrofluorocarbon-23
HFCs – hydrofluorocarbons
HNO_3 - nitric acid (*ácido nítrico*)
HRC - High Resolution Camera
HS – Southern Hemisphere (*Hemisféro Sul*)
HSBC - Hong Kong and Shangai Banking Corporation (*Corporação Bancária de Hong Kong e Xangai*)
HVI - Health Vulnerability Index
I/M – Inspection and Maintenance Program for Vehicles in Use (*Inspeção e Manutenção de Veículos*)
IABr – Brazilian Steel Institute (*Instituto Aço Brasil*)
IAC - Agronomy Institute of Campinas (*Instituto Agronômico de Campinas*)
IAEA - International Atomic Energy Agency
IAG – Institute of Astronomy, Geophysics and Atmospheric Sciences (*Instituto de Astronomia, Geofísica e Ciências Atmosféricas*)
IAI – Inter-American Institute for Global Change Research (*Instituto Interamericano para Pesquisas em Mudanças Globais*)
IAP - Independent Autonomous Producers
IAPAR – Agricultural Research Institute of the state of Paraná (*Instituto Agronômico do Paraná*)
IBAMA – Brazilian Institute for the Environment and Renewable Nature Resources (*Instituto Brasileiro do Meio Ambiente e Recursos Naturais Renováveis*)
IBAS – India, Brazil and South Africa/ IBSA (*Índia, Brasil e África do Sul*)
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*)
IBIS - Integrated Biosphere Simulator
IBSA - India, Brazil and South Africa
ICLEI - International Council for Local Environmental Initiatives (*Conselho Internacional para as Iniciativas Ambientais Locais*)
ICMBio - Chico Mendes Institute on Biodiversity Conservation (*Instituto Chico Mendes de Conservação da Biodiversidade*)
ICMS – Value Added Tax on Sales and Services (*Imposto sobre Circulação de Mercadorias e Serviços*)
ICP – International Comparison Programme
ICSU – International Council of Scientific Unions
IDB – Brazilian Basic Data and Indicators (*Indicadores e Dados Básicos do Brasil*)
IDB - Inter-American Development Bank (*Banco Interamericano de Desenvolvimento*)
IDB/SUS - Single Health System Database (*Indicadores e Dados Básicos do Sistema Único de Saúde*)
IDH – Human Development Index/ HDI (*Índice de Desenvolvimento Humano*)
IEA - International Energy Agency (*Agência Internacional de Energia*)
IEA/USP – Institute for Advanced Studies of the University of São Paulo (*Instituto de Estudos Avançados da Universidade de São Paulo*)
IES – Institutions of Higher Education (*Instituições de Ensino Superior*)
IFC - International Finance Corporation (*Coorporação Financeira Internacional*)
IGAC - International Global Atmospheric Chemistry (*Química Atmosférica Global Internacional*)
IGBP - International Geosphere-Biosphere Programme
IGCC - Integrated Gasification Combined Cycle
inhab. – inhabitants
ILAFA –Latin American Institute of Iron and Steel (*Instituto Latinoamericano del Fierro y el Acero*)
IMAZON – Amazon Human and Environmental Institute (*Instituto do Homem e Meio Ambiente da Amazônia*)
INB - Nuclear Industries of Brazil (*Indústrias Nucleares do Brasil*)
INCRA – National Institute of Colonization and Agrarian Reform (*Instituto Nacional de Colonização e Reforma Agrária*)
INCT – National Institute of Science and Technology (*Instituto Nacional de Ciência e Tecnologia*)
INEA - State Institute for the Environment (*Instituto Estadual do Ambiente*)
INEP – Anísio Teixeira National Institute of Educational Studies and Research (*Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira*)
INLAND - Integrated Land Model (*Modelo componente de superfície*)
INMET – National Institute of Meteorology (*Instituto Nacional de Meteorologia*)
Inmetro - National Institute of Metrology, Standardization and Industrial Quality (*Instituto Nacional de Metrologia, Normalização e Qualidade Industrial*)
INPA – National Institute for Research in Amazonia (*Instituto Nacional de Pesquisa na Amazônia*)
INPE – National Institute on Space Research (*Instituto Nacional de Pesquisas Espaciais*)
IOS – South Oscillation Index (*Índice de Oscilação Sul*)
IOUSP – Oceanographic Institute of the University of São Paulo (*Instituto Oceanográfico da Universidade de São Paulo*)

IPAM – Amazon Environmental Research Institute (*Instituto de Pesquisa Ambiental da Amazônia*)
IPCC - Intergovernmental Panel on Climate Change
IPEA – Institute for Applied Economic Research (*Instituto de Pesquisa Econômica Aplicada*)
IPEN - Institute of Energy and Nuclear Research (*Instituto de Pesquisas Energéticas e Nucleares*)
IPI – Tax on Industrialized Products (*Imposto sobre Produtos Industrializados*)
IQE – Municipal Index on Educational Quality (*Índice Municipal de Qualidade Educacional*)
IQM - Municipal Index on Environmental Quality (*Índice Municipal de Qualidade do Meio Ambiente*)
IQS - Municipal Index on Health Quality (*Índice Municipal de Qualidade da Saúde*)
IRD - French Research Institute for Development *(Institut de recherche pour le développement)*
ISA – Socio-Environmental Institute (*Instituto Sócio Ambiental*)
ISE – Business Sustainability Index (*Índice de Sustentabilidade Empresarial*)
ITCZ - Intertropical Convergence Zone
ITR – Rural Property Tax (*Imposto Territorial Rural*)
IVC – Climate Vulnerability Index (*Índice de Vulnerabilidade Climática*)
IVD – Desertification Index (*Índice de Desertificação*)
IVED – Econono-Demographic Vulnerability Index (*Índice de Vulnerabilidade Econômico-Demográfico*)
IVG – General Vulnerability Index (*Índice de Vulnerabilidade Geral*)
IVS – Health Vulnerability Index (*Índice de Vulnerabilidade de Saúde*)
IVSE – Socioeconomic Vulnerability Index/SEVI (*Índice de Vulnerabilidade Socioeconômica*)
JBIC - Japan Bank for International Cooperation (*Banco Japonês para Cooperação Internacional*)
JMA - Japan Meteorological Agency (*Agência Meteorológica Japonesa*)
kcal – kilocalorie
KfW - German Bank for Reconstruction and Development (*Kreditanstalt für Wiederaufbau*)
kg – kilogram
km – kilometer
km^2 – square kilometers
kmLC – kilometer of coast line (*quilômetro de linha de costa*)
kW – kilowatt
kWh – kilowatt-hour
kWp – kilowatt-peak
KWU - Kraftwerk Union A.G.
l. or L. – liter
LAMEPE – Pernambuco Meteorology Laboratory (*Laboratório de Meteorologia de Pernambuco*)
LANDSAT – Land Remote Sensing Satellite
lb - pound
LBA – Large Scale Biosphere-Atmosphere Experiment in Amazonia (*Programa de Grande Escala da Biosfera-Atmosfera na Amazônia*)
LC – coast line (*linha de costa*)
LDB - National Education Guidelines and Bases Law (*Lei de Diretrizes e Bases da Educação Nacional*)
LDCs - Least Developed Countries (*Países de Menor Desenvolvimento Relativo*)
LDPE - low-density polyethylene (*Polietileno de Baixa Densidade*)
LFC – compact fluorescent lamp (*lâmpadas fluorescentes compactas*)
LGN – liquefied natural gas (*líquido de gás natural*)
LHV - lower heating value
LLDPE - linear low-density polyethylene
LNG - liquefied natural gas
LPB - La Plata watershed (*Bacia do Prata*)
LPG - Liquefied Petroleum Gas
LVH - Loaded Vehicle Weight (*Massa do Veículo para Ensaio [= CW+136 kg]*)
LUCF - Land-use change and forestry
LULUCF – Land use, Land-use change and forestry
m – meter
M – million
m^2 – square meter
m^3 – cubic meter
MA – state of Maranhão
MAA – annual arithmetic average (*média aritmética anual*)
MAPA – Ministry of Agriculture, Livestock and Food Supply (*Ministério da Agricultura, Pecuária e Abastecimento*)
MBSCG – Brazilian Global Climate System Model (*Modelo Brasileiro do Sistema Climático Global*)
MCid – Ministry of Cities (*Ministério das Cidades*)
MCR – Regional Climate Model (*Modelo Climático Regional*)
MCT – Ministry of Science and Technology (*Ministério da Ciência e Tecnologia*)
MDA – Ministry of Agrarian Development (*Ministério do Desenvolvimento Agrário*)
mdc – greatest common divisor/gcd (*máximo divisor comum*)
MDIC – Ministry of Development, Industry and Foreign Trade (*Ministério do Desenvolvimento, Indústria e Comércio Exterior*)
MDG - Millenium Development Goal
MDL – Clean Development Mechanism/ CDM (*Mecanismo de Desenvolvimento Limpo*)
MDT – Digital Land Model (*Modelo Digital de Terreno*)
MEA – monoethanolamine
MEC – Ministry of Education (*Ministério da Educação*)
MERCOSUR - Southern Common Market (*Mercado Común del Sur*)

METEOSAT – Geostationary Meteorological Satellites operated by EUMETSAT (*Satélites Meteorológicos Geoestacionários Operados por EUMETSAT*)
MF – Ministry of Finance (*Ministério da Fazenda*)
mg – miligram
MG – state of Minas Gerais
MGA – annual geometric average (*média geométrica anual*)
$MgCO_3$ - magnesium carbonate
MI – Ministry of National Integration (*Ministério da Integração Nacional*)
MIC – Ministry of Industry and Commerce (*Ministério da Indústria e Comércio*)
MICT - Ministry of Industry, Commerce and Tourism (*Ministério da Indústria, do Comércio e do Turismo*)
MJ – megajoules
MJ – Ministry of Justice (*Ministério da Justiça*)
mm – millimeter
mm/day – millimeters per day (milímetros por dia)
MMA – Ministry of Environment (*Ministério do Meio Ambiente*)
MME – Ministry of Mines and Energy (*Ministério de Minas e Energia*)
MN - Natural Monuments (*Monumentos Naturais*)
MODIS - Moderate Resolution Imaging Spectroradiometer
MPEG – Emilio Goeldi Museum of Pará state (*Museo Paraense Emílio Goeldi*)
MPOG – Ministry of Planning, Budget and Management (*Ministério do Planejamento, Orçamento e Gestão*)
MRE – Ministry of Foreign Relations (*Ministério das Relações Exteriores*)
MS – dried matter (*matéria seca*)
MS – state of Mato Grosso do Sul
MT – state of Mato Grosso
MT – Ministry of Transportation (*Ministério dos Transportes*)
MVC - monomeric vinyl chloride (*cloreto de vinila*)
MW – megawatt
MWh – megawatt hour
N - nitrogen
N – North
n.a. - not available (*não disponível*)
n° - number
N_2O – nitrous oxide
Na_2CO_3 – neutral carbonate of soda or soda ash
Na_3AlF_6 – cryolite
NAE - Nucleus of Strategic Affairs of the Presidency of the Republic (*Núcleo de Assuntos Estratégicos da Presidência da República*)
NAMAs - Nationally Appropriate Mitigation Actions (*Ações de Mitigação Nacionalmente Apropriadas*)
NASA - National Aeronautics & Space Administration
NBR – Brazilian Norm (*Norma brasileira*)
NE – Northeast
NGO – Non-governmental organization
NGV - Natural Gas Vehicle
NH_3 – ammonia
Nm3 - normal cubic meter (metro cúbico normal)
NMVOC – Non-Methane Volatile Organic Compounds (*Compostos Orgânicos Voláteis Não Metânicos*)
NNW – North-northwest (*norte-noroeste*)
NO – nitrogen oxide (*óxido de nitrogênio*)
NO_2 - nitrogen dioxide (*dióxido de nitrogênio*)
NOAA - National Oceanic and Atmospheric Administration (*Administração Nacional Atmosférica e Oceânica dos EUA*)
NO_x – nitrogen oxides
Nuclen – Nuclebras Engineering (*Nuclebras Engenharia*)
NUCLEP – a Brazilian manufacturer of heavy components (*Nuclebras Equipamentos Pesados S.A.*)
NV - Normative Values
NW - Northwest
O_3 - ozone
ºC – Celsius degrees (*graus Celsius*)
ODM – Millenium Development Goal/ MDG (*Objetivo de Desenvolvimento do Milênio*)
OECD - Organisation for Economic Co-operation and Development (*Organização para Cooperação e Desenvolvimento Econômico*)
OEG - Government's Strategic Guidelines (*Orientações Estratégicas do Governo*)
OEMA – State and Municipal Environmental Agencies (*Órgãos Executivos Estaduais e Municipais de Meio Ambiente*)
OIE – Domestic Energy Supply (*Oferta Interna de Energia*)
OIEE – Domestic Electric Energy Supply (*Oferta Interna de Energia Elétrica*)
OMM – World Meteorological Organization/ WMO (*Organização Meteorológica Mundial*)
OMS – World Health Organization/ WHO (*Organização Mundial da Saúde*)
ONG – non-governmental organization/ NGO (*organização não-governamental*)
ONS – National Electrical System Operator (*Operador Nacional do Sistema*)
ONU – United Nations/UN (*Organização das Nações Unidas*)
OOCP - Oceans Observations Climate Panel
OVEG Project – National Program for Vegetable Oil Energy (*Programa Nacional de Energia de Óleos Vegetais*)
P & D – research and development/R & D (*Pesquisa e Desenvolvimento*)
P, D & I - research, development and innovation/ R, D & I (*pesquisa, desenvolvimento e inovação*)
P.E.A. – economically active population/EAP (*população economicamente ativa*)
PA – state of Pará
PA – Protected Area
PAC - Growth Acceleration Program (*Programa de Aceleração do Crescimento*)

PACD – Plan of Action to Combat Desertification (*Plano de Ação e Combate à Desertificação)*
PAGES - Past Global Changes (*Mudanças Globais Passadas*)
PAN-Brasil - National Action Program to Combat Desertification and Mitigate the Effects of Drought (*Programa Nacional de Combate à Desertificação e Mitigação dos Efeitos da Seca*)
PARNAs – National Parks (*Parques Nacionais*)
PB – lead
PB – state of Paraíba
PBE - Brazil's Labeling Program (*Programa Brasileiro de Etiquetagem)*
PBMC – Brazilian Panel on Climate Change (*Painel Brasileiro de Mudanças Climáticas*)
PCD – Data Collection Platform (*Plataforma de Coletas de Dados*)
PCH – small hydroelectric plant (*Pequena Central Hidrelétrica*)
PCPV – Vehicle Pollution Control Plans (*Planos de Controle da Poluição Veicular*)
PCS - higher calorie power (*poder calorífico superior)*
PD – Demonstration Projects (*Projetos Demonstrativos*)
PD/A – Type A Demonstration Projects (*Projetos Demonstrativos Tipo A*)
PD/I – Indigenous Demonstration Projects (*Projetos Demonstrativos Indígenas*)
PDE – Education Development Plan (*Plano de Desenvolvimento da Educação*)
PDEE – Expansion Decennial Plan for Electric Power Systems (*Plano Decenal de Expansão de Energia Elétrica*)
PE – state of Pernambuco
PEAD – polyethylene (*polietileno*)
PEBD – low-density polyethylene (*Polietileno de Baixa Densidade*)
PELBD - linear low-density polyethylene/ LLDPE (*Polietilenos lineares de baixa densidade*)
PEM - Proton Exchange Membrane (*Membrana para Troca de Prótons*)
PEMFC - Proton Exchange Fuel Cell (*Célula a Combustível tipo Membrana Condutora de Prótons*)
PER - perchloroethylene
PET – polyethylene terephthalate
PETROBRAS – Brazilian Petroleum S.A. (*Petróleo Brasileiro S.A.*)
PFC – perfluorocarbons
PFMCG – Program for Global Climate Change Research (*Programa da Fapesp de Pesquisas em Mudanças Climáticas Globais*
pH - potentia hydrogenii
PI – state of Piauí
PIA – Annual Industrial Research (*Pesquisa Industrial Anual)*
PIA – Independent Autonomous Producers (*Produtores Independentes Autônomos*)
PIB – Gross Domestic Product (*Produto Interno Bruto*)
PIB/Capita – Gross Domestic Product *per capita* (*Produto Interno Bruto per capita*)
PICE – Program for Integration and Economic Cooperation (*Programa de Integração e Cooperação Econômica*)
PIN - Program for National Integration (*Programa de Integração Nacional*)
PIRATA - Pilot Research Moored Array in the Tropical Atlantic (*Rede Piloto de Pesquisa no Atlântico Tropical*)
PIS – Social Integration Program Tax (*Programa de Integração Social*)
PLC - Population per Length of Coastline (*Comprimento da Linha da Costa*)
PM - particulate matter (*material particulado*)
PMEL - Pacific Marine Environmental Laboratory (*Laboratório Ambiental Marinho do Pacífico*)
PNA - Pacific North America (*América do Norte/Pacífico*)
PNAD – National Household Sample Survey (*Pesquisa Nacional por Amostra de Domicílios*)
PNE – National Energy Plan (*Plano Nacional de Energia*)
PNEA – National Environmental Education Policy (*Política Nacional de Educação Ambiental*)
PNGC – National Plan of Coastal Management (*Plano Nacional de Gerenciamento Costeiro*)
PNLT - National Logistics and Transportation Plan (*Plano Nacional de Logística de Transportes*)
PNMC - National Policy on Climate Change (*Política Nacional sobre Mudança do Clima*)
PNPB - National Biodiesel Production and Use Program (*Programa Nacional de Produção e Uso de Biodiesel*)
PNQA – National Air Quality Assessment Program (*Plano Nacional da Qualidade do Ar)*
PNSB – National Survey of Basic Sanitation Study (*Pesquisa Nacional de Saneamento Básico*)
PNUD – United Nations Development Programme/ UNDP (*Programa das Nações Unidas para o Desenvolvimento)*
PoA - Program of Activities
POAG – Plan for the Optimization of Natural Gas Use in the Campos Basin (*Plano de Otimização de Gás*)
Poloamazônia - Programs for Agriculture, Livestock and Agromineral Hubs in the Amazon (*Programas de Pólos Agropecuários e Agrominerais na Amazônia*)
PPA – Multi-Annual Plan (*Plano Plurianual*)
PPC – Purchasing Power Parity/ PPP (*Paridade de Poder de Compra*)
PPCDAM - Action Plan for the Prevention and Control of Deforestation in Legal Amazon (*Plano de Ação para a Prevenção e Controle do Desmatamento na Amazônia Legal*)
PPCerrado – Action Plan for the Prevention and Control of Deforestation and Burning in *Cerrado* (*Plano de Ação para a Prevenção e Controle do Desmatamento e das Queimadas no Cerrado*)

PPDC - Civil Defense Preventive Plan
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 (*partes por milhão)*
ppmv – parts per million in volume (*partes por milhão em volume)*
PPP - Purchasing Power Parity
PPT – Priority Thermoelectric Generation Plan (*Plano Prioritário de Geração Termelétrica*)
PQZ - Zero Burning Project
PR – state of Paraná
PRECIS - Providing REgional Climates for Impacts Studies
PREVFOGO - National System for Preventing and Combating Forest Fires (*Sistema Nacional de Prevenção e Combate aos Incêndios Florestais*)
PRI - Principles for Responsible Investment (*Princípios do Investimento Responsável*)
Proalcool – National Alcohol Program (*Programa Nacional do Álcool*)
PROANTAR – Brazilian Antarctic Program (*Programa Antártico Brasileiro*)
Proarco – Program for the Prevention and Control of Burning and Forest Fires in the Arc of Deforestation (*Programa de Prevenção e Controle de Queimadas e Incêndios Florestais no Arco do Desflorestamento)*
PROBIO – Conservation and Sustainable Use of Biological Diversity Project (*Projeto de Conservação e Utilização Sustentável da Diversidade Biológica*)
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*)
Pro-Biodiesel – Brazilian Biofuels Program (*Programa Brasileiro de Biocombustíveis*)
ProCaC - Brazilian Hydrogen and Fuel Cell Systems Program (*Programa Brasileiro de Hidrogênio e Sistemas de Células a Combustível)*
PROCEL – National Program of Electric Energy Conservation (*Programa Nacional de Conservação de Energia Elétrica*)
Proclima - Real Time Climatic Monitoring Program in the Northeast region (*Programa de Monitoramento Climático em Tempo Real da Região Nordeste*)
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*)
PRODEEM – Program for State and Municipal Energy Development (*Programa de Desenvolvimento Energético de Estados e Municípios*)
PRODES - Project for Estimating Gross Deforestation of the Brazilian Amazon (*Projeto de Estimativa do Desflorestamento Bruto da Amazônia Brasileira*)
PROEÓLICA – Emergency Wind Energy Program (*Programa de Incentivo às Fontes Alternativas de Energia Elétrica*)
$ProH_2$ - Science, Technology and Innovation Program for Hydrogen Economy (*Programa de Ciência, Tecnologia e Inovação para a Economia do Hidrogênio*)
Proinfra - Incentive of Alternative Sources of Electric Energy (*Programa de Incentivo às Fontes Alternativas de Energia Elétrica*)
Promot - Program for Controlling Air Pollution from Motorcycles and Similar Vehicles (*Programa de Controle da Poluição do Ar por Motociclos e Veículos Similares)*
Pronacop - National Industrial Pollution Control Program (*Programa Nacional de Controle da Poluição Industrial*)
Pronaf - National Program for the Strengthening of Family Agriculture (*Programa Nacional de Agricultura Familiar)*
Pronar – National Air Quality Control Program (*Programa Nacional de Controle da Qualidade do Ar*)
Pronea – National Environmental Education Program (*Programa Nacional de Educação Ambiental*)
Pro-Renova – Structured Program to Support other Emerging Countries in the Area of Renewable Energies (*Programa Estruturado de Apoio aos demais Países em Desenvolvimento na Área de Energias Renováveis*)
Proterra - Program for Land Redistribution and Incentives for Agroindustry in the North and Northeast regions (*Programa de Redistribuição de Terras e Estímulos à Agroindústria do Norte e Nordeste*)
PROZON – Brazilian Program for the Elimination of Substances that Deplete the Ozone Layer (*Programa Brasileiro de Eliminação das Substâncias que Destroem a Camada de Ozônio*)
PTS – Total Suspended Particulates/TSP (*partículas totais em suspensão*)
PUC/MG – Pontifical Catholic University of Minas Gerais (*Pontifícia Universidade Católica de Minas Gerais*)
PY – Paraguay
R & D – research and development (*Pesquisa e Desenvolvimento*)
R$ - real (Brazilian national currency)
RAINFOR – Amazon Network of Forestry Inventories (Rede Amazônica de Inventários Florestais)
RAL – Mining Annual Report (Relatório Anual de Lavra)
RCCS - Renewable Carbon Capture and Storage (*Captura e armazenamento de carbono renovável*)
RCEs – Certified Emission Reductions/ CERs (*Redução Certificada de Emissões)*
RCM - Regional Climate Model (*Modelo Climático Regional*)
RD&I - research, development and innovation
REBIO – Biological Reserves (*Reservas Biológicas*)

REDD - Reduction of Emissions from Degradation and Deforestation (*Redução de Emissões de Degradação e Desmatamento*)
Rede Elo – Local Renewables Model Communities Network in Brazil (*Rede de Cidades e Comunidades Modelo em Energias Renováveis Locais no Brasil*)
RegCM3 – a regional climate model
Rejuma – Youth Network for Environment and Sustainability (*Rede da Juventude pelo Meio Ambiente e Sustentabilidade*)
RELAC – Portuguese-Speaking Network of Specialists in Climate Change (*Rede Lusofônica de Especialistas em Alterações Climáticas)*
Reluz - National Program for Efficient Public Lighting (*Programa Nacional de Iluminação Pública Eficiente*)
Res - reservoirs (managed area)
Resex - Extractivist Reserves (*Reservas Extrativistas*)
Reuni – Support Program for the Restructuring and Expansion of Federal Universities (*Programa de Apoio a Planos de Reestruturação e Expansão das Universidades Federais*)
ReViS - Wildlife Refuges (*Refúgios da Vida Silvestre*)
RGR – Global Reversion Reserve (*Reserva Global de Reversão*)
RIMA – Environmental Impact Report (*Relatório de Impacto do Meio Ambiente*)
Rio-92 – United Nations Conference on Environment and Development (*Conferência das Nações Unidas sobre Meio Ambiente e Desenvolvimento*)
RIOCC – Ibero-American Network on Climate Change (*Red Iberoamericana de Oficinas de Cambio Climático / Rede Iberoamericana de Mudança do Clima*)
RJ - state of Rio de Janeiro
RL – Legal Reserve (*Reserva Legal*)
RN – state of Rio Grande do Norte
RO – state of Rondônia
RPPN – Private Reserve of Natural Heritage (*Reserva Particular de Patrimônio Natural*)
RR – state of Roraima
RS – state of Rio Grande do Sul
RTF - Rain Forest Trust Fund (*Fundo Fiduciário para Florestas Tropicais*)
s – second
S – South
SACC – International Consortium for the Study of Oceanic Related Global and Climate Changes in South America (*Consórcio internacional para o estudo das mudanças globais dos oceanos e do clima na América do Sul*)
SACZ - South Atlantic Convergence Zone
SAE – Secretariat of Strategic Affairs (*Secretaria de Assuntos Estratégicos da Presidência da República*)
SAEMC - South American Emissions, Megacities and Climate (*Emissões, Megacidades e Clima da América do Sul*)
SBF - Brazilian Forest Service
SBI - Subsidiary Body for Implementation (*Órgão Subsidiário de Implementação*)
SBPC – Brazilian Society for the Progress of Science (*Sociedade Brasileira para o Progresso da Ciência*)
SBR - styrene-butadiene-rubber (*borracha de butadieno estireno*)
SBSTA - Subsidiary Body for Scientific and Technological Advice (*Órgão Subsidiário de Assessoramento Científico e Tecnológico da Convenção*)
SC – state of Santa Catarina
SC – connective systems (*sistemas conectivos*)
SCAF – Simulation of Future Agricultural Scenarios based on Regional Climate Change Projections (*Simulação de Cenários Agrícolas Futuros a partir de Projeções de Mudanças Climáticas Regionalizadas*)
SCAR - Scientific Committee on Antarctic Research (*Comitê Científico de Pesquisa Antártica*)
SCD – Data Collecting Satellite (*Satélite de Coleta de Dados*)
SCOPE - Scientific Committee on Problems of the Environment (*Comitê Científico sobre Problemas do Meio-Ambiente*)
SE – state of Sergipe
SE – Southeast
SECAD – Secretariat of Continuing Education Literacy, and Diversity (*Secretaria de Educação Continuada, Alfabetização e Diversidade*)
SECIRM – Secretary of the Interministerial Commission for Sea Resources (*Secretaria da Comissão Interministerial para os Recursos do Mar*)
SEMA – Special Environment Secretariat (*Secretaria Especial do Meio Ambiente*)
SENAC – National Service for Commercial Apprenticeship (*Serviço Nacional de Aprendizagem Comercial*)
SENAI – National Service for Industrial Apprenticeship (*Serviço Nacional de Aprendizagem Industrial*)
SEVI - Socioeconomic Vulnerability Index
SF_6 – sulfur hexafluoride
SFB - Brazilian Forest Service (*Serviço Florestal Brasileiro)*
SGBD – Database Management Systems/ DBMS (*Sistemas Gerenciadores de Bancos de Dados*)
SHP - Small Hydroelectric Plant
Si – silicon (*silício*)
SIDRA – IBGE's Automatic Recovery System of Aggregated Databases (*Sistema IBGE de Recuperação Automática*)
SIG – Geographic Information System/GIS (*Sistema de Informações Geográficas*)
SIGEA – Computerized System for Air Emissions Management (*Sistema Informatizado de Gestão de Emissões Atmosféricas*)
Silviminas - Silviculture Association of Minas Gerais (*Associação Mineira de Silvicultura*)
SIN - National Integrated System (*Sistema Integrado Nacional*)
SINDIFER – Iron Industry Union of the state of Minas Gerais (*Sindicato da Indústria do Ferro no Estado de Minas Gerais*)

SINDIPAN – São Paulo Bakery and Confectionery Industry Union (*Sindicato da Indústria de Panificação e Confeitaria de São Paulo*)
SIPOT – Brazilian Hydroelectric Potential Information System (*Sistema de Informações do Potencial Hidrelétrico Brasileiro*)
SisFogo - National System for Information on Fires (*Sistema Nacional de Informações Sobre Fogo*)
SISMADEN – Natural Disaster Monitoring and Warning System (*Sistema de Monitoramento e Alerta de Desastres Naturais)*
SISNAMA – National Environmental System (*Sistema Nacional do Meio Ambiente*)
SLAPR – Environmental Licensing System for Rural Properties (*Sistema de Licenciamento Ambiental de Propriedades Rurais*)
SNIC – National Cement Industry Union (*Sindicato Nacional da Indústria do Cimento*)
SNIS - National Sanitation Information System (*Sistema Nacional de Informações sobre Saneamento*)
SNUC – National System of Protected Areas (*Sistema Nacional de Unidades de Conservação*)
SO_2 – sulfur dioxide
SO_3 - sulfur trioxide
SOFC - Solid Oxide Fuel Cell (*Células a Combustível de Óxidos Sólidos*)
SOSMA – SOS Mata Atlântica
SO_X – sulphur dioxides
SP – state of Sao Paulo
SPARC - Stratospheric Processes and their Role in Climate (*Processos Estratosféricos e seu Papel no Clima*)
SPC&T – Subprogram on Science and Technology (Subprograma Ciência e Tecnologia)
SPE/WSP - Society of Petroleum Engineers/ World Petroleum Congress
SREX - Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (*Relatório de Extremos Climáticos e Gerenciamento de Riscos*)
SRHU - Secretariat of Water Resources and Urban Environment (*Secretaria de Recursos Hídricos e Ambiente Urbano*)
SSE – South-Southeast
ssp – species (*espécies*)
ST – science and technology
ST&I - science, technology and innovation
START – Analysis, Research and Training (*Sistema de Mudança Global para Análise, Pesquisa e Treinamento*)
SUDAM – Superintendent of Amazon Development (*Superintendência de Desenvolvimento da Amazônia*)
Sudene – Northeast Development Superintendence (*Superintendência do Desenvolvimento do Nordeste*)
SUS – Single Health System (*Sistema Único de Saúde*)
SW – southwest
t – tonne
T&D – Transmission & Distribution (*Transmissão e Distribuição*)
TCA - Amazon Cooperation Treaty (*Tratado de Cooperação Amazônica*)
tCO_2e/year – tonnes of CO_2 equivalent per year
TERRA - Satellilte from The Earth Observing System (*Satélite do Sistema de Observação da Terra*)
Tg – teragram (10^{12} g or one million tonnes)
TGW - Total Gross Weight
Tj – Terajoule
TM/Landsat – Thematic mapping sensor of the Landsat satellite (*Sensor de mapeamento temático do satélite Landsat*)
TNC - The Nature Conservancy (an NGO)
TO – state of Tocantins
toe – tonne of oil equivalent
TOGA - Tropical Ocean Global Atmosphere (*Experimento Oceano Tropical e Atmosfera Global*)
ton - tonne
TRMM - Tropical Rainfall Measuring Mission
TWh – terawatt-hour
U_3O_8 – uranium (urânio)
UAM - Unibanco Asset Management
UE – European Union/EU (União Européia)
UF – Unity of Federation (state)
UFES – Federal University of the state of Espirito Santo (*Universidade Federal do Espírito Santo*)
UFF – Federal Fluminense University (*Universidade Federal Fluminense)*
UFJF – Federal University of Juiz de Fora (*Universidade Federal de Juiz de Fora)*
UFMG – Federal University of the state of Minas Gerais (*Universidade Federal de Minas Gerais*)
UFPB - Federal University of the state of Paraíba (*Universidade Federal da Paraíba*)
UFPE – Federal University of the state of Pernambuco (*Universidade Federal de Pernambuco)*
UFPR – Federal University of the state of Paraná (*Universidade Federal do Paraná*)
UFRGS – Federal University of the state of Rio Grande do Sul (*Universidade Federal do Rio Grande do Sul*)
UFRJ – Federal University of the state of Rio de Janeiro (*Universidade Federal do Rio de Janeiro*)
UFRRJ – Federal Rural University of Rio de Janeiro (*Universidade Federal Rural do Rio de Janeiro)*
UFSC – Federal University of the state Santa Catarina (*Universidade de Santa Catarina*)
UFSCar - Federal University of São Carlos (*Universidade Federal de São Carlos)*
UGH – Hydrogen Generation Units (*Unidades de Geração de Hidrogênio*)
UHE – Hydroelectric Power Plant (*Usina Hidrelétrica de Energia*)

UN – United Nations
UnB – University of Brasilia (*Universidade de Brasília*)
UNCED - United Nations Conference on Environment and Development (*Conferência das Nações Unidas sobre Meio Ambiente e Desenvolvimento*)
UNDP - United Nations Development Programme
UNEP - United Nations Environment Programme (*Programa das Nações Unidas para o Meio Ambiente*)
UNESCO - United Nations Educational, Scientific and Cultural Organization (*Organização das Nações Unidas para a Educação, a Ciência e a Cultura*)
UNFCCC - United Nations Framework Convention on Climate Change (*Convenção-Quadro das Nações Unidas sobre Mudança do Clima*)
Unibanco – a Brazilian Bank (*União de Bancos Brasileiros S/A*)
Unica – Sugarcane Industry Union (*União da Indústria de Cana-de-Açúcar*)
UNICAMP – University of Campinas (*Universidade de Campinas*)
UNIFEI – Federal University of Itajubá (Universidade Federal de Itajubá)
UPE – State University of Pernambuco (*Universidade do Estado de Pernambuco*)
UPGN - Natural Gas Processing Unit (*Unidade de Processamento de Gás Natural*)
US - United States (*Estados Unidos da América*)
USA - United States of America (*Estados Unidos da América*)
US$ – US Dollar (*dólar norte-americano*)
USP – University of São Paulo (*Universidade de São Paulo*)
UTE – Thermoelectric plant (Usina Termo Elétrica)
UVIBRA - Brazilian Vitiviniculture Union (*União Brasileira de Vitivinicultura*)
VIA – vulnerabilities, impacts and adaptation (Vulnerabilidade, Impactos e Adaptação)
VOC – Volatile organic compound (*Composto Organico Volátil*)
VS – volatile solids (sólidos voláteis)
VSE – Socioeconomic Vulnerability (Vulnerabilidade Socioeconômica)
W – West (Oeste)
WB – World Bank
WCRP - World Climate Research Program
WG - Working Group
WIFI - Wireless Fidelity
WMO – World Meteorological Organization
WHO - World Health Organization
WSA – World Steel Association
WSP - World Petroleum Congress (Congresso Mundial de Petróleo)
ZEE – Ecological and Economic Zoning (*Zoneamento Econômico Ecológico)*
µ – micro

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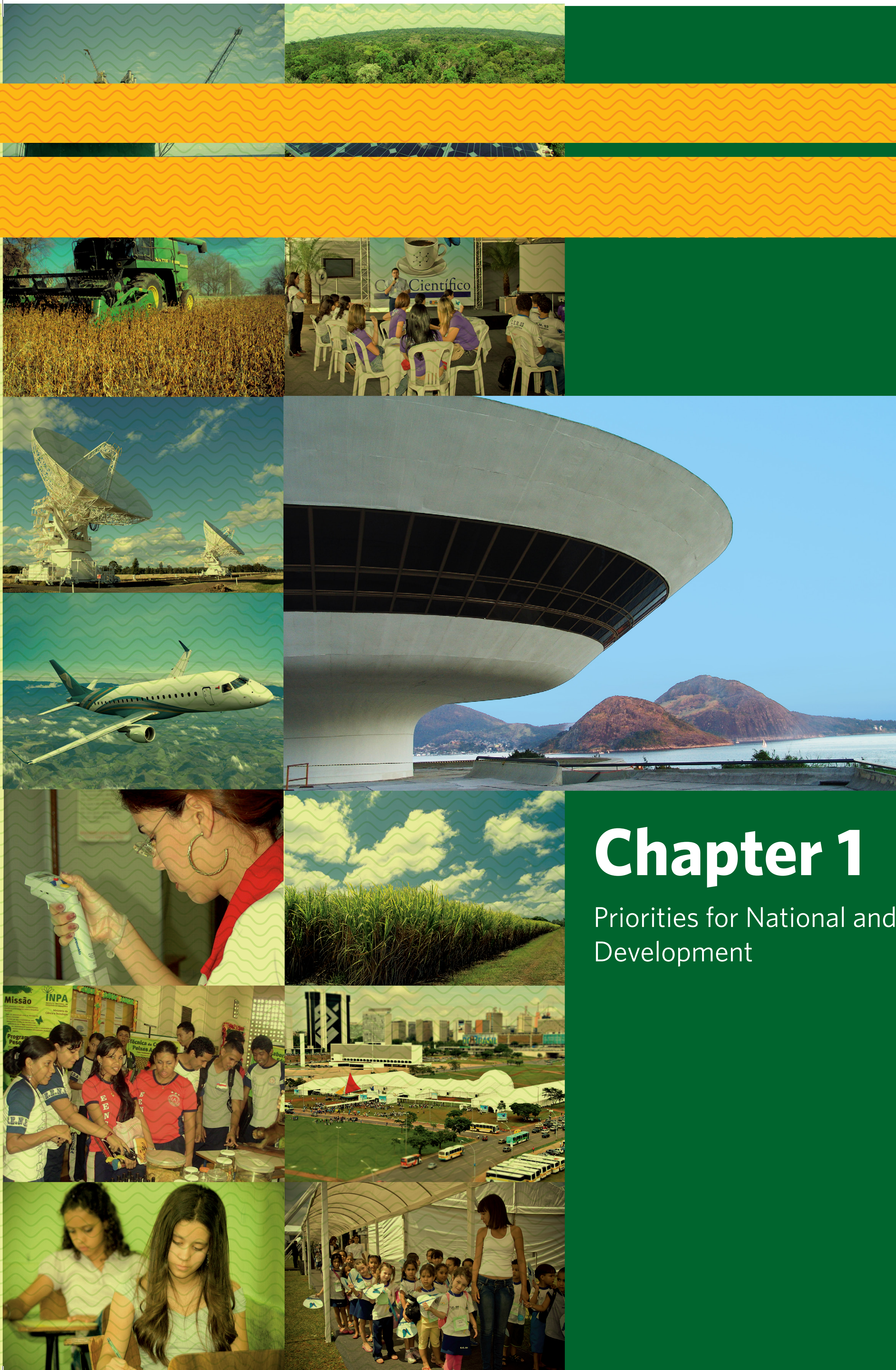


Chapter 1

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. Its geodesic center is located at the coordinates 10°35' south latitude and 52°40' west of Greenwich. The eastern limit is the coast of the Atlantic Ocean, and it has several oceanic islands, with a special mention to Fernando de Noronha, Abrolhos and Trindade. To the north, west and south, Brazil borders all South American countries, with the exception of Chile and Ecuador. The country is crossed by the Equator and the Tropic of Capricorn, with most of its lands 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 in the world. Its territorial dimension characterizes it as a continental country, since its territory occupies 1.6% of the earth's land mass, 5.7% of the planet's emerged lands and 20.8% of the American continent's surface.

The Federative Republic of Brazil is divided into 26 states, 5,565 municipalities (IBGE, 2009a) and the Federal District, where the capital of the Republic, Brasília, seat of the government and the executive, legislative and judicial branches, is located. The country is governed under the Federal Constitution of 1988.

Brazil has a presidential system where the President of the Republic is elected by direct and secret ballot for a four year term. Re-election for a single consecutive term is permitted for the President of the Republic, governors and mayors. It has a bicameral system exercised by the National Congress, with two representative houses: the Chamber of Deputies, with 513 federal deputies, who represent the population; and the Federal Senate, with 81 senators of the Republic, who represent the states (the units of the Federation).

The vastness of Brazil's territory, in latitude as well as longitude, is home to an extraordinary mosaic of ecosystems, along with extensive climatic and topographic diversity. Throughout its history, these characteristics have determined the various forms of occupation and use by society of the spaces shaped by the country's tropical and subtropical nature, forming, in general terms, five large geographic regions: North, Northeast, Southeast, South and Central-West (Figure 1.1). Each is cited below with their respective states or districts:

- North Region – occupies 45% of national territory, and it is comprised of the following states: Acre - AC, Amapá - AP, Amazonas - AM, Pará - PA, Rondônia - RO, Roraima - RR and Tocantins - TO.

- Northeast Region – occupies 18% of national territory, and it is comprised 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.

- Central-West Region – occupies 19% of national territory, and it is comprised of the following states: Goiás - GO, Mato Grosso - MT, Mato Grosso do Sul - MS and Distrito Federal - DF.

- Southeast Region – occupies 11% of national territory, and it is comprised of the following states: Espírito Santo - ES, Minas Gerais - MG, Rio de Janeiro - RJ and São Paulo - SP.

- South Region – occupies 7% of national territory, and it is comprised of the following states: Paraná - PR, Santa Catarina - SC and Rio Grande do Sul - RS.

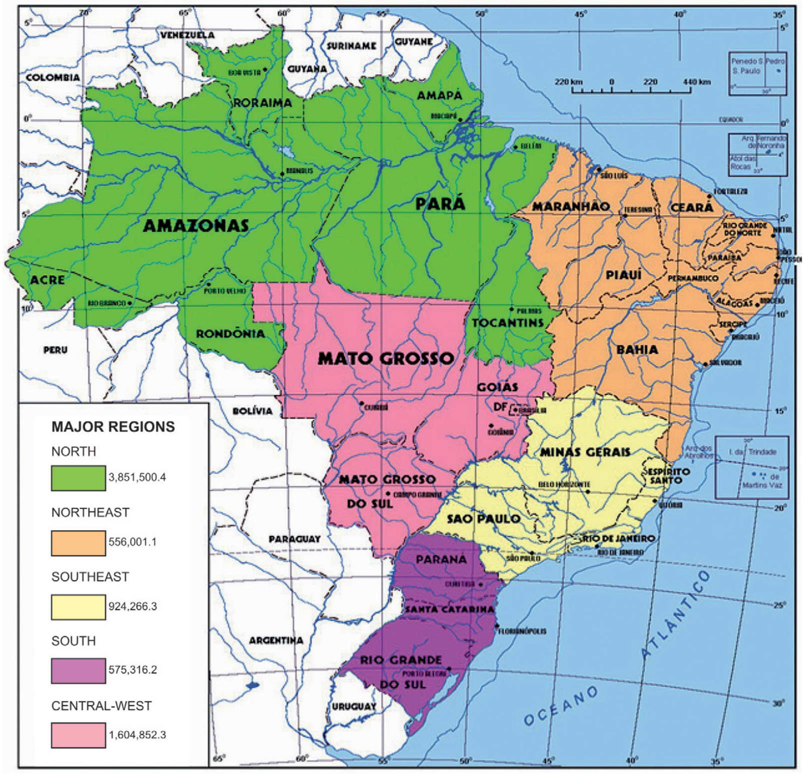
The 2007 Population Count (IBGE, 2007a) provided greater visibility regarding the demographic transformations that have occurred in the country since the 2000 Demographic Census, when Brazil had a population of 169.8 million inhabitants (IBGE, 2000b). During this period, Brazil's population grew 9.5%, at an average annual rate of 1.15%, reaching approximately 186 million inhabitants in 2008, of which 48.8% were men and 51.2% were women[1]. The Southeast is the country's most populous region, with about 42.0% of the total number of inhabitants. The Northeast region is ranked second, with approximately 28.0%, followed by the South region, with 14.5%; North region, with 8.0%; and Central-West region, which is home to only about 7.5% of the population. The urbanization rate jumped from 77.3% in 1970 to 84.4% in 2008[2].

Figure 1.2 provides the distribution of the population across the country's territory, and the map shows Brazil's demographic density.

1 Data re-weighted based on the weight defined by the 2007 Population Count. Available at <http//:www.sidra.ibge.br>.

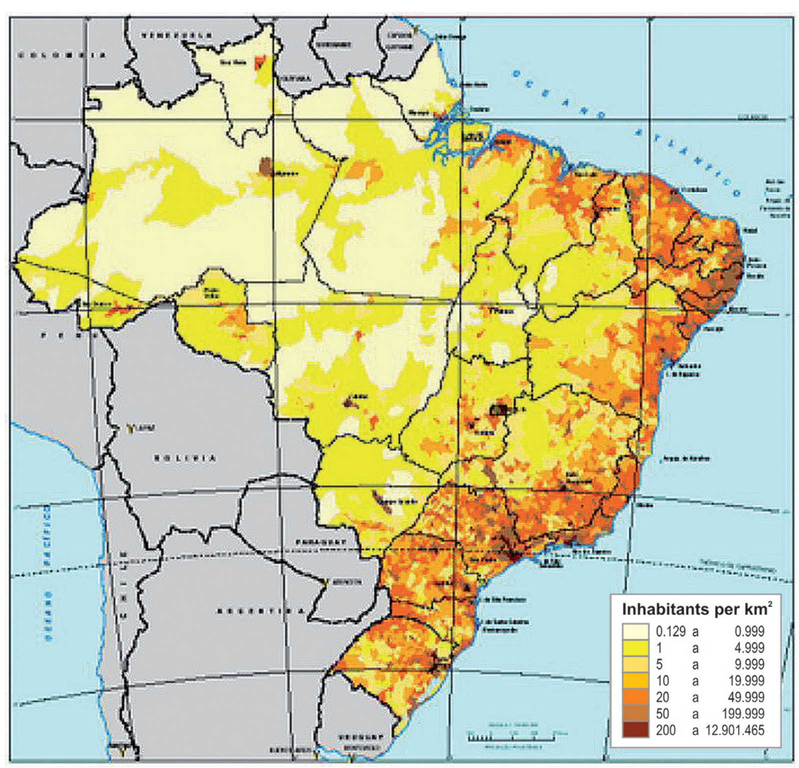
2 Due to the lack of an urban population estimate in the 2007 Population Count, this was estimated at 84% of the total, based on the evolution of the urban fraction from previous official numbers, allowing an estimate of the same fraction for 2005 and 2008.

Figure 1.1 Brazil's political-administrative division



Source: IBGE, 2000a.

Figure 1.2 Demographic Density in Brazil



Source: IBGE, 2000a.

1.1.1 Vegetation and Flora Resources

In 2004, the Brazilian Institute of Geography and Statistics – IBGE introduced a new classification and division of Brazil's vegetation and flora resources. In such a new classification and division, a revision, in terms of concept and design, of phytoecological regions (*regiões fitoecológicas*) classification was undertaken (Figure 1.3). A phytoecological region can be defined as an area covered by flora of typical genera and characteristic biological forms that repeat themselves within a given climate and may occur in areas of different soils, but with well-defined relief. These revisions were based on the interpretation of images obtained from the Landsat 5-TM satellite, along with new techniques and bibliographic and field research. This justifies the changes in the map featured in Brazil's Initial National Communication to the United Nations Framework Convention on Climate Change (BRASIL, 2004).

According to this new classification, the vegetation mapping was based on ecological profiling criteria, following a hierarchy of formations delimited by vegetation ecology and environmental parameters, according to a classification key based on two big formations: forest and field-like (*campestre*) vegetation.

The forest formations were subdivided according to topographic criteria, establishing three large latitude ranges: the first from 5° N to 16° S; the second from 16° S to 24° S; and the third above 24° S. The formations were distributed according to the altitude:

- Lowlands (*Terras baixas*): (1) from 5m to 100m, (2) from 5m to 50m, and (3) from 5m to 30m;
- Sub-montane (*Submontana*): (1) from 100m to 600m, (2) from 50m to 500m and (3) from 30m to 400m;
- Montane (*Montana*): (1) from 600m to 2,000m, (2) from 500m to 1,500m, and (3) from 400m to 1,000m; and
- Upper-Montane (*Altomontana*): (1), (2) and (3) above the maximum limits of montane formations.

The field-like formations were subdivided based on profiling criteria (vegetation density and size) into forested, wooded, park, and wooded-grassland (*gramíneo-lenhosas*) formations.

According to the new classification, in terms of Brazil's phytogeographic conceptualization, Brazilian vegetation is mainly distributed in the neotropical zone which, for geographic purposes, can be divided into two territories: the Amazonian (equatorial rainforest) and the extra-Amazonian (intertropical) area.

In the Amazonian territory (equatorial rainforest area), the vegetation ecological system develops in a climate with an average temperature around 25 ° C, with rainfall well distributed throughout the year, without any monthly water deficit in the annual rainfall and temperature balance (*balanço ombrotérmico*).

In the extra-Amazonian territory (intertropical area), the vegetation ecological system is associated with two climates: a tropical climate, with average temperatures around 22 °C and seasonal rainfall for a period, and a water deficit for more than 60 days in the annual rainfall and temperature balance; and a subtropical climate, with mild temperatures in the winter that soften the annual average to around 18 °C, with moderate and well-distributed rainfall throughout the year, without any monthly water deficit in the annual rainfall and temperature balance, but with thermal seasonality caused by the coldest days of the year.

The following phytoecological regions have been defined in Brazil:

- Savannah Region (*Cerrado*) – vegetation found predominantly in the Central-West region. Discontinuous areas of Cerrado are also found in the Amazon, and in the Northeast, Southeast and South regions of the country. The Brazilian Cerrado includes various field-like formations, with low wooded grassland vegetation alternating with small isolated and grouped trees, and riparian forest formations (riverside vegetation), thus revealing great structural variability and, as a consequence, big differences in size and density.
- Savannah Steppe Regions (*Caatinga, Campos de Roraima, Pantanal* wetlands in Mato Grosso, and the Quaraí River sand bar's Espinilho Park) – type of neotropical vegetation, generally with tree cover containing elements of *phanerophyte*, thorny *Chamaephyte* and a variety of cactus , covering a *hemicryptophyte* grassland stratum, interwoven with some *therophytes.*
- Steppe Region – encompasses the Prairies of Rio Grande do Sul, with discontinuous areas in Uruguaiana - RS and southern Brazil *Campos Gerais*). It is characterized by an essentially field-like vegetation. Cespitose and rhizomatous grasses are predominant, with rare annual and *oxalidaceae* grasses, as well as leguminous and compound grasses. The *phanerophytes* are represented by thorny and deciduous species.

- Campinarana Region – vegetation restricted to areas in the Upper Negro River and adjacent to its tributaries, extending into Colombia and Venezuela, where there are similar areas. It covers lowlands, almost always flooded areas, with groupings of thin and tall trees, which results from the soil's poor nutrient contents.

- Dense Tropical Rainforest Region (*Floresta Ombrófila Densa*) – This covers part of the Amazon area and extends along the Atlantic Coast, from the states of Rio Grande do Norte to Espírito Santo, in areas found between the coast and the pre-Cambrian coast mountains, extending along the mountain slopes to the state of Rio Grande do Sul. It consists of large trees in the alluvial terrace and in the tertiary plateaus, as well as medium-sized trees along the coastal slopes.

- Open Tropical Rainforest Region (*Floresta Ombrófila Aberta*) – type of vegetation located between the Amazon and the Extra-Amazonian area. Forest profile consists of widely spaced trees and sparse shrubby stratum. This is found in climate conditions where the dry season may last from 2 to 4 months, with average temperatures between 24 °C and 25 °C.

- Mixed Tropical Rainforest Region (*Floresta de Araucária*) – This is typical of Brazil's southern plateau, although there are also isolated areas in higher altitudes of the Serra do Mar and Mantiqueira mountain ranges.

- Semi-Evergreen Tropical Forest Region (*Floresta Estacional Semidecidual*) – the ecological concept for this phytoecological region is related to the two-season climate (dry and rainy) in the tropical area (average temperatures around 21 °C), with a short dry season accompanied by an pronounced drop in temperature in the subtropical region (average temperatures around 15 °C). The predominant tree elements, which are adapted to the unfavorable season (cold or dry), undergo foliar seasonality. In both cases, the percentage of deciduous trees found in this sort of forest is between 20% and 50%.

- Seasonal Deciduous Forest Region (*Floresta Estacional Decidual*) - This features a predominantly deciduous tree stratum with more than 50% of the individual trees dropping their leaves during the unfavorable season. This is found in a dispersed and discontinuous manner in Brazil: from the north to the southeast, it can be found between the Open Tropical Rainforest and Savannah regions; from east to west, between the Steppe Savannah and the Semi-Evergreen Tropical Forest; and, in the south, in the subtropical area of the Uruguay River Valley, between the Mixed Tropical Rainforest in the southern plateau and the Steppe.

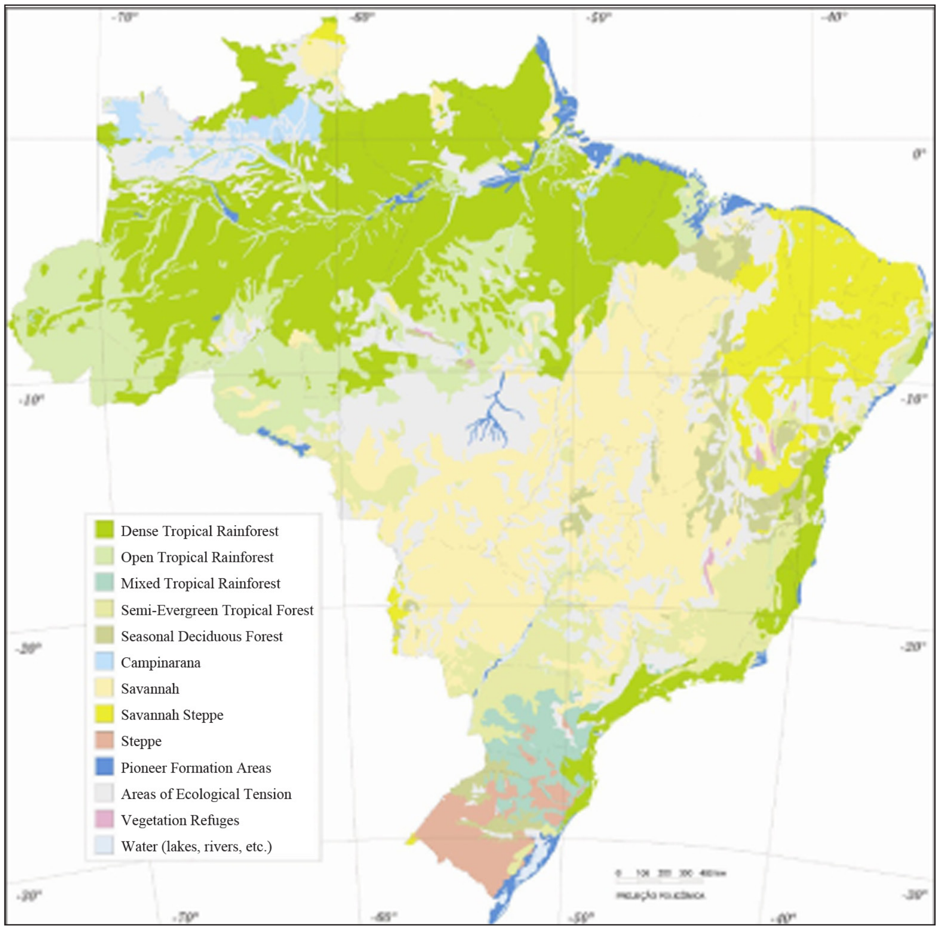
The areas of vegetation should not be taken for the phytoecological regions, because they represent a broader concept and they can encompass various environments and integrate more than one trophic system. These are:

- Pioneer Formation Areas (*Área de Formações Pioneiras - First Occupation of Soil System*) – areas along the coast, water courses and even around lowlands that accumulate water (swamps and lagoons) where field-like wooded grassland vegetation is found. They are pedologically unstable areas, with unconsolidated or poorly consolidated sediment under the influence of different accumulation processes.

- Areas of Ecological Tension (contacts between different types of vegetation) – where these flora come in contact between two or more phytoecological regions either by overlapping or merging, these interactions are called enclaves and ecotones, respectively. In the first case, each vegetation mosaic keeps its flora identity and profile without mixing, and it is possible to distinguish the predominant formation or area under formation. In the case of ecotones, the flora identity assumes a species level, where one region does not prevail over the other. Endemisms that can be better identified frequently occur. Areas of ecological tension can occur in the same area with the contact of two geological formations and with climate transition ranges.

- Vegetation Refuges (*Refúgio Ecológico* - Relic Vegetation Communities) – this is any different vegetation and flora from the general context of the region's flora, translated into a relic vegetation community. There are montane and high montane refuges with shrubby and/or grass-like structures. The profiles are complex, because although limited to small areas, vegetation refuges are significantly diversified.

Figure 1.3 Regional distribution of Brazil's natural vegetation



Source: IBGE, 2004.

Considering the extension and characteristics of its territory, Brazil has a great variety of vegetation and flora resources, which is home to one of the richest flora in the world, with 41,123 known and catalogued species, 3,633 fungi, 3,521 algae, 1,522 bryophytes, 23 gymnosperms and 31,248 angiosperms, according to Brazil's recently updated "List of Brazilian Flora Species" (FORZZA *et al*., 2010).

1.1.2 Fauna

Brazil is one of the richest countries in number of animal species, with about 13% of all the amphibian species described in the world (SILVANO & SEGALLA, 2005); 10% of all mammals (COSTA *et al*., 2005); 17.8% of all butterflies (BROWN & FREITAS, 1999) and 21% of all the continental water fish on the planet (AGOSTINHO *et al.,* 2005). Of the 624 *taxa*[3] of existing primates in the world, 133 species and subspecies live in the Brazilian territory, representing 21% of all *taxa* found on the planet (CHIARELLO *et al.,* 2008).

Moreover, Brazil is ranked fourth in relation to the total number of reptiles, trailing only Australia, Mexico and India (MARTINS & MOLINA, 2008).

According to the most recent compilation available on the number of Brazilian fauna species – the "Red Book of the Brazilian Endangered Fauna Species" (MACHADO *et al.,* 2008), within the universe of species known by science, Brazil has 652 species of mammals, 800 amphibians, 1,800 birds, 641 reptiles, 2,300 freshwater fish, 1,298 saltwater fish and more than 100,000 species of land invertebrates. However, knowledge about the diversity of Brazilian fauna is still incomplete. It is estimated that less than 10% of the existing total is actually known.

In order to have an idea about the potential of the still unknown fauna, in just 17 years, from 1978 to 1995, 7,320 species of Metazoan animals were described. In just over 10 years, 18 new species of mammals and 19 species of birds were described. In two years of studies in remaining forest areas of the Atlantic Forest in the south of Bahia, researchers identified 14 new species of amphibians (DRUMMOND, 2008).

3 *Taxon*, with Latin plural *taxa*, is a taxonomic unit essentially linked to a classification system. *Taxa* can be at any level of a classification system, thus, an order is a *taxon*; a genus, as a specie, is also a *taxon*, or any other unit for classifying living beings.

1.1.3 Water Resources

In Brazil, there are abundant available water resources. Endowed with a vast and dense hydrological network, many of its rivers are noted for their lenght, width and/or depth. Brazilian territory has eight large watersheds: the Amazon River, the Tocantins River, and the South Atlantic — north and northeast sections, the São Francisco River, and the South Atlantic — east section, the Paraná River, the Uruguay River and the South Atlantic — southeast section (Figure 1.4). As a result 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, among other characteristics that give them high potential for electric power generation. However, these same characteristics make navigation difficult. Among the great national rivers, only the Amazon and the Paraguay are predominantly lowland rivers and are extensively used for navigation. The main plateau rivers are the São Francisco and Paraná.

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

Brazil's hydroelectric potential by watershed, shown in Table 1.1, shows the contrast between demand — primarily as a result of industrial, residential, commercial and public use — and the real supply capacity. Thus, it is a fact that in the Amazon River watershed, with a potential for 89,738 MW, only 5.3% is in operation/construction.

In 2009, the Paraná, Uruguay, São Francisco, South Atlantic — east section and South Atlantic — southeast section watersheds were responsible for supplying hydroelectric power to the country's areas with the greatest demographic and industrial concentration. Among those, the Paraná watershed stands out, not only because of its potential, but also as having the highest percentage in operation or under construction (69.4% of 61,744 MW).

In terms of depletion of the potential, the most saturated watershed are the Paraná, the Uruguay, the Tocantins and the São Francisco, with usage indexes (ratio between potential used and existing potential) of 69.4%, 50.2%, 50.1% and 41.2%, respectively. The lowest usage rates are seen in the Amazon and the South Atlantic — north and northeast sections. At a national level, about 36.9% of estimated hydroelectric power has already been harnessed. In terms of inventoried potential, this rate increases to 47%.

Figure 1.4 Brazil's watersheds

Source: ANEEL, 2010.

Table 1.1 Brazil's hydroelectric potential by watershed (MW) – December, 2009

Stage/Watershed	Amazonas	Tocantins	North and Northeast Atlantic	São Francisco	East Atlantic	Paraná	Uruguay	Southeast Atlantic	Totals by Stage
Remaining	17,919	1,846	525	760	784	3,697	12	996	26,539
Individualized	24,773	128	182	907	704	2,946	862	1,090	31,592
Estimated Total	42,693	1,974	707	1,667	1,489	6,643	874	2,086	58,131
Inventory	25,842	7,166	1,611	7,339	5,594	7,764	4,404	1,544	61,264
Viability	11,988	3,738	6	6,140	895	2,432	292	2,218	27,709
Basic Design	4,474	190	56	109	760	2,065	1,054	432	9,140
Construction	3,693	1,142	0	107	572	1,950	1,035	105	8,605
Operation	1,047	11,960	320	10,579	4,674	40,890	5,657	3,376	78,502
Total Inventoried	47,045	24,197	1,993	24,273	12,496	55,101	12,442	7,675	185,221
Grand Total	**89,738**	**26,170**	**2,699**	**25,940**	**13,984**	**61,744**	**13,316**	**9,761**	**243,352**

Source: SIPOT, 2009.

The low utilization rates for the Amazon River watershed are due to the predominantly lowland relief, its huge biological diversity and its distance from the main power consumption centers. In the central-south area of the country, the more rapid economic development and the predominant relief (plateaus) made it possible to utilize more of its hydraulic potential. However, with the country's population moving inland and the depletion of the most potential in the South and Southeast regions, it has become necessary to develop hydroelectric power in more remote and economically less developed regions.

In the Northeast region of Brazil, 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 view of this climatic peculiarity, ponds are used for water storage and distribution, both for household consumption and for developing irrigated agriculture.

1.2 Climate

The location of Brazil's territory along 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 the equatorial to the subtropical, with gradation of types and subtypes produced by the geoecological variability that exists in the country.

South America extends from the tropics to the mid-latitudes and it is affected by tropical, subtropical and mid-latitude regimes. One of the main characteristics of South America's tropical region is the Amazon forest, which contributes to the region's humidity and rainfall as well as the planet's energy balance. In the summer in the Southern Hemisphere, this region has strong convection, especially in the Central Amazonia; in the winter, convection activity shift northwest, reaching Central America.

South America's climate has interannual variability, as shown by the differences in wind flow, cloudiness, rainfall and behavior of synoptic systems. One of the large-scale factors responsible for climate variability is the *El Niño* Southern Oscillation – ENSO phenomenon (warming of Pacific Ocean waters). South America is directly influenced by ENSO and indirectly influenced by the variation in atmospheric circulation. The direct influence is by the increase in convection in the Eastern Equatorial Pacific region, which affects the continent's western tropical area. The displacement and 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 Brazil's Northeast region. Intensification of the subtropical jet stream increasing frontal system convection and blocking situations are related to flooding in Brazil's South and Southeast regions. Other large-scale anomalies affect South America, such as persistent wave trains and patterns with wave number three and four around the Southern Hemisphere.

Convection activity over South America's central and western regions is associated with high level anticyclonic circulation, which, in the summer (Southern Hemisphere) is called the Bolivian High. It is associated with strong warming on the surface, an upward movement, and upper level divergence. In some periods of summer and spring, convection over this region is also associated to a persistent northwest-southeast band of cloud cover, called the South Atlantic Convergence Zone.

The northeast portion of the continent has high interannual and annual variability in terms of rainfall. This region is affected by the Intertropical Convergence Zone – ITCZ, upper level cyclonic vortices, disturbances from the east, instability lines associated with the sea breeze, and by the approach of frontal systems over the ocean. South and southeast 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.

1.2.1 Rainfall and Temperature Climatology

Since Brazil is a country with large territorial extension, it has differentiated rainfall and temperature regimes. From north to south, a great variety of climates with distinct regional characteristics can be found. In the North of the country, there is a rainy equatorial climate, with virtually no dry season. In the Northeast region, the rainy season, with low rainfall levels, is restricted to a few months, characterizing a semi-arid climate. The Southeast and Central-West regions suffer the influence of tropical and mid-latitude systems, with a well-defined dry season in the winter and a rainy season in the summer with convective rains. Due to its latitudinal location, Brazil's South region suffers greater influence from mid-latitude systems, where the frontal systems are the main causes of rains during the year.

High temperatures are observed in the North and Northeast regions, with little variability during the year; this combination is responsible for the hot climate in these regions. In the mid-latitudes, temperature variation during the year has a major influence on the climate. During winter, there is greater penetration of upper latitude cold air masses, which contributes to the predominance of low temperatures.

It should be noted that modern technology has made it possible, to some extent, to overcome the climatic conditioning factors, enabling the expansion of temperate crops to areas with higher temperatures and lower rates of rainfall.

North Region

The North region has spatial and seasonal temperature homogeneity, which does not occur in relation to rainfall. This region has the highest total annual rainfall, most notably at the coast of Amapá, at the mouth of the Amazon River and in the west of the region, where rainfall exceeds 3,000 mm. This region has three centers with abundant rainfall. The first is located in the Amazon's northwest, with rainfall above 3,000 mm/year. The existence of this center is associated with the condensation of humid air brought by easterly winds from the Intertropical Convergence Zone – ITCZ winds, 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 5° S, with 2,500 mm/year of rainfall; and the third, is in the eastern part of the Amazonia, close to the city of Belém, with rainfall 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 subcontinent, where the rain is abundant throughout the year, reaching its peak in April-May-June, with more than 3,000 mm/year; a second in a zone-oriented band extending to the central part of Amazon, where the rainy season occurs in March-April-May; and the third in the southern part of Amazonia, where the rainfall peak occurs in January-February-March. Rainfall 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 & HASTENRATH, 1993).

The rainy season of the North region (December-January-February) changes progressively from January-February-March, in the south of the Amazonia, to April-May-June in the northwest of the Amazon watershed. This variation seems to be related to the ITCZ position, because the rainfall nuclei migrate from the central part of the country, in the austral summer, to the northwest of South America in the austral winter, following the annual migration of deep convection. Weather stations located in the Northern Hemisphere, such as Oiapoque (3° N 60° W), see maximum rainfall in the austral winter (June-July-August) and minimum in the austral summer (December-January-February)(RAO & HADA, 1990).

With regard to temperatures, during the Southern Hemisphere's winter, the entire southern portion of the North region, especially the southwest area (Acre, Rondônia and part of Amazonas state), is frequently invaded by upper latitude anticyclones that cross the Andes Mountains in the south of Chile. Some of them are exceptionally intense and may even cause sudden drops of temperature, known as *friagem* (NIMER, 1979). Because of the relative high humidity and intense cloud cover that are typical of the region, excessive maximum daily temperatures are not recorded during the year.

Northeast Region

Taking into account the rainfall regime, there is a great climatic variety over the Northeast region – NE, ranging from a semi-arid climate inland, with an annual rainfall of less than 500 mm/year, to a rainy climate mainly observed in the eastern coast of the region, with an annual rainfall of more than 1,500 mm (KOUSKY & CHU, 1978). The northern part of the region receives between 1,000 and 1,200 mm/year (HASTENRATH & HELLER, 1977).

Similar to the North region, a large part of the Northeast region also has a great seasonal and spatial temperature homogeneity. Only in the south of the state of Bahia is there a greater seasonal temperature variability as a result of the penetration of relatively cold air masses in winter months.

Different rainfall regimes are identified in the Northeast region. In the north of the Northeast region, the main rainy season is from March to May; in the south and southeast regions, rains occur mainly from December to February; and in the eastern part of the region, the rainy season is from May to July. The Northeast region's main rainy season, including the north and east of the region, which explains 60% of annual rainfall, is from April to July, while the dry season for most of the region occurs from September to December (RAO *et al.*, 1993). Satellite images suggest the importance of easterly disturbances in the rainfall of the Northeast region (YAMAZAKY & RAO, 1977). These disturbances propagate over the Atlantic Ocean, towards the continent, during fall and winter (CHAN, 1990).

Rainfall interannual variations in the east of the Northeast region can be attributed to anomalies in the position and intensity of the ITCZ, caused by positive anomalies in the South Atlantic sea surface temperature (MOURA & SHUKLA, 1981; NOBRE, 1994), and by the occurances of the El Niño in the Equatorial Pacific.

South Region

Annual rainfall distribution over Brazil's South region occurs in a quite uniform manner. Throughout almost the entire region, annual average rainfall ranges between 1,250 and 2,000 mm. Only a few areas are outside of this rainfall range. The coast of the state of Paraná, western section the state of Santa Catarina and the area around São Francisco de Paula, in the state of Rio Grande do Sul, receive above 2,000 mm/year. The southern coast of the state of Santa Catarina and the North of the state of Paraná see less than 1,250 mm/year (NIMER, 1979). It can be thus concluded that the relief, due to its generally smooth characteristics, does not exert any great influence on rainfall distribution. The temperature, in turn, plays a similar role to rainfall, reinforcing the uniform climate in the south of the country. However, this is the region of Brazil with the greatest thermal variability throughout the year.

Some atmospheric phenomena affecting this region are essential in determining temperature and rainfall climatology. Key among these is the movement of frontal systems over the region, which are responsible for much of the total recorded rainfall (OLIVEIRA, 1986). The trajectory of these systems is closely linked to the position and intensity of South America's subtropical jet. Some studies (KOUSKY & CAVALCANTI, 1984) emphasize the importance of the jet stream to rainfall.

The inverted troughs are situated, on average, over the states of Rio Grande do Sul and Santa Catarina, extending to Argentina and Paraguay, and are more frequent in the summer and spring in the Southern Hemisphere (FERNANDES & SATYAMURTY, 1994), with a northwest-southeast (NW-SE) oriented axis, parallel to the frontal surface, and are responsible for the severe weather over the affected regions.

Mesoscale convective systems are also responsible for great amounts of rainfall over this region, as well as in the south of the Southeast and Central-West regions (CUSTÓDIO & HERDIES, 1994).

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

The occurrence of cyclogenesis and frontogenesis over the South region of Brazil is also a critical factor determining the rainfall and temperature climatology of this region. Statistical studies (GAN & RAO, 1991) show that the highest frequency of cyclogenesis occurs over Uruguay during the winter in the Southern Hemisphere. On average, there are 60 cyclogenesis over the South region every year.

With regard to temperature, frost can be considered one of the main atmospheric phenomena in Brazil's South region, given that it is associated with air temperatures below 0°C with the formation of ice on exposed surfaces.

Southeast and Central-West Regions

Due to their latitudinal locations, the Southeast and Central-West regions are characterized by being transition regions between low-latitude hot climates and mid-latitude temperate mesothermal climates (NIMER, 1979). The southern Southeast and Central-West regions are affected by most of the synoptic systems that reach the south of the country, with some differences in terms of system intensity and seasonality. The inverted troughs mainly act during the winter (FERNANDES & SATYAMURTY, 1994), causing moderate weather conditions, especially over the states of Mato Grosso do Sul and São Paulo. Upper level cyclonic vortices from the Pacific organize with intense convection associated with the instability caused by the subtropical jet. Pre-frontal lines of instability, generated from the association of large-scale dynamic factors and mesoscale characteristics, are responsible for intense rainfall (CAVALCANTI *et al.*, 1982).

Especially over the Central-West region, the Bolivian High, generated from strong convective warming of the atmosphere (release of latent heat) during the summer months in the Southern Hemisphere (VIRJI, 1981), is considered a typical semi-stationary system of the region. Stationary large-scale circulation in mid-latitudes can directly influence rainfall and temperature in the Southeast, whether or not the region is being affected by systems associated with the atmospheric wave flow. This kind of situation is called blocking and it affects not only the South region of Brazil but also the Southeast region.

The Southeast and Central-West regions are characterized by the action of systems that associate 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 most important phenomena that influence the rainfall regime of these regions (QUADRO & ABREU, 1994). The fact that the band of cloud cover and rainfall remain semi-stationary for consecutive days favors the occurrence of flooding in affected areas.

In general, rainfall is evenly distributed in these regions, with average annual accumulated rainfall ranging from 1,500 and 2,000 mm. Two maximum spots exist in the Central-West region and on the coast of the Southeast region of Brazil, whereas in the north of the state of Minas Gerais rainfall is relatively scarce throughout the year.

1.3 Economy

Table 1.2 shows Gross Domestic Product figures and the population in Brazil in 1970, 1980 and during the 1990-2008 period.

Table 1.2 Gross domestic product - GDP and population in Brazil, 1970-2008

	GDP		Population		GDP/inhab.	
	Billion US$ 2007/ year	Annual rate	Millions of inhabitants	Annual rate	thousand US$ 2007/ inhab.	Annual rate
1970	310.5		93.1		3.33	
1980	710.4		119.0		5.97	
1990	830.5		144.8		5.74	
1991	839.1	1.0%	146.8	1.4%	5.71	-0.4%
1992	835.1	-0.5%	148.9	1.4%	5.61	-1.8%
1993	874.1	4.7%	150.9	1.4%	5.79	3.2%
1994	920.7	5.3%	153.0	1.4%	6.02	3.9%
1995	961.4	4.4%	155.0	1.3%	6.20	3.0%
1996	982.1	2.2%	157.1	1.3%	6.25	0.8%
1997	1015.2	3.4%	160.3	2.0%	6.34	1.3%
1998	1015.6	0.0%	163.4	2.0%	6.21	-1.9%
1999	1018.2	0.3%	166.6	1.9%	6.11	-1.7%
2000	1062.0	4.3%	169.8	1.9%	6.25	2.3%
2001	1075.9	1.3%	171.8	1.2%	6.26	0.1%
2002	1104.5	2.7%	173.9	1.2%	6.35	1.5%
2003	1117.2	1.1%	175.9	1.2%	6.35	0.0%
2004	1181.0	5.7%	177.9	1.2%	6.64	4.5%
2005	1218.3	3.2%	179.9	1.1%	6.77	2.0%
2006	1266.7	4.0%	182.0	1.1%	6.96	2.8%
2007	1338.5	5.7%	184.0	1.1%	7.27	4.5%
2008	1406.5	5.1%	186.0	1.1%	7.56	3.9%
1990/ 2005	-	3.6%	-	1.5%	-	-

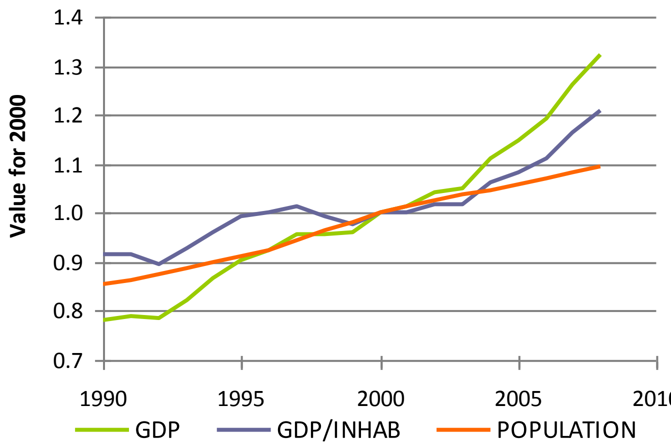
Source: Elaborated from IBGE data, 2009b.

The 1990s saw low economic growth rates and actually reported a 5.74% drop in GDP per inhabitant in its first year. The first years of this decade were marked by high inflation, with double-digit average monthly rates, which was not reverted until July 1994 with the adoption of the Real Plan, which created a new currency, the *real*, and instituted a new monetary and exchange regime. The Federal Government simultaneously conducted a successful deindexation process of the economy with a view to eliminating the inflationary memory of the economic players.

However, this new phase of Brazil's economic history was not problem free. A series of external shocks placed the sustainability of the Real Plan at risk, forcing the government to make use of monetary and exchange policies to slow down domestic consumption and to raise the exchange rate (NEUTZLING, 2007). In 1999, Brazil enters the floating exchange age, beginning to officially adopt the inflation goal system, which consists of an institutional arrangement where the commitment to price stability is monetary policy's main objective. The country thus abandoned strict control over evolution of the exchange rate, a policy known as "exchange anchor" (*âncora cambial*) that was pursued during the first phase of the Real Plan.

GDP growth data in Brazil are highly volatile, despite growing dynamism of the economy. From 2003, there has been a trend in GDP and GDP per capita growth that greatly exceeds population growth, as shown in Figure 1.5.

Figure 1.5 GDP, population and GDP/inhabitant growth in Brazil



Source: Elaborated from IBGE data, 2009b.

During the 1990-2005 period, the Brazilian population grew by 24.3%, which corresponds to an annual rate of 1.5%. During the same period, the country's GDP jumped from US$ 830.5 billion to US$ 1,218.3 billion, i.e., a growth rate of 46.7%, which represents an annual rate of 3.6%.

The IBGE National Accounts have undergone important changes that also alter annual GDP growth figures (IBGE, 2009b). The IBGE published the figures starting in 2000 and conducted what it called a "retropolation"[4] until 1995.

4 See:< http://www.ibge.gov.br/home/estatistica/indicadores/pib/pdf/22_retropolacao.pdf>.

It should also be underscored that the regional accounts, which are calculated on a quarterly basis, also changed in relation to the previous period, in the subdivision by activities starting in 2002 (IBGE, 2009b). The figures for the previous series are available from 1985 to 2003, and thus there is an overlay between the two criteria for 2002 and 2003.

In the evaluation of energy consumption and greenhouse gas emissions, it is always useful to compare the estimated figures to the economic activity indicators in the same sectors or activities. This makes sense when a long time series is available.

Another important factor that must be considered is that the classifications for IBGE's quarterly balance, as well as for some state balances, do not make it possible to establish a more open correlation between economic and energetic data than in the three macro-sectors shown.

Table 1.3 shows a significant change in the calculation method for the share of individual sectors of the economy in Brazil's GDP, especially for those related to industry and services. With regard to annual behavior, a reduction can be observed in the agriculture and livestock share, with a growth in the service sector.

Table 1.3 Tables for "retropolated" shares

	"Retropolated" Values (standardized) (%)			
	Agriculture and Livestock	Industry	Services	Total
1990	5.4	26.8	67.8	100
1991	4.9	25.1	70.0	100
1992	4.4	24.9	70.7	100
1993	4.4	24.0	71.6	100
1994	6.7	26.1	67.3	100
1995	5.7	24.5	69.8	100
1996	5.5	24.7	69.9	100
1997	5.2	24.9	70.0	100
1998	5.3	24.0	70.7	100
1999	5.3	25.1	69.6	100
2000	5.1	26.9	68.0	100
2001	5.7	27.0	67.4	100
2002	6.6	27.1	66.3	100
2003	7.4	27.8	64.8	100
2004	6.9	30.1	63.0	100
2005	5.7	29.3	65.0	100
2006	5.5	28.8	65.8	100

Source: Elaborated by e&e from IBGE data, National Accounts 2009b.

Brazil's macroeconomic and trade balance data make it an urban-industrial country with food exports as its connection to global capitalism. In 2008, Brazil's agribusiness trade balance closed at US$ 60 billion, representing 36.3% of exports, while employing 37% of Brazilian workers (GIRARDI, 2008).

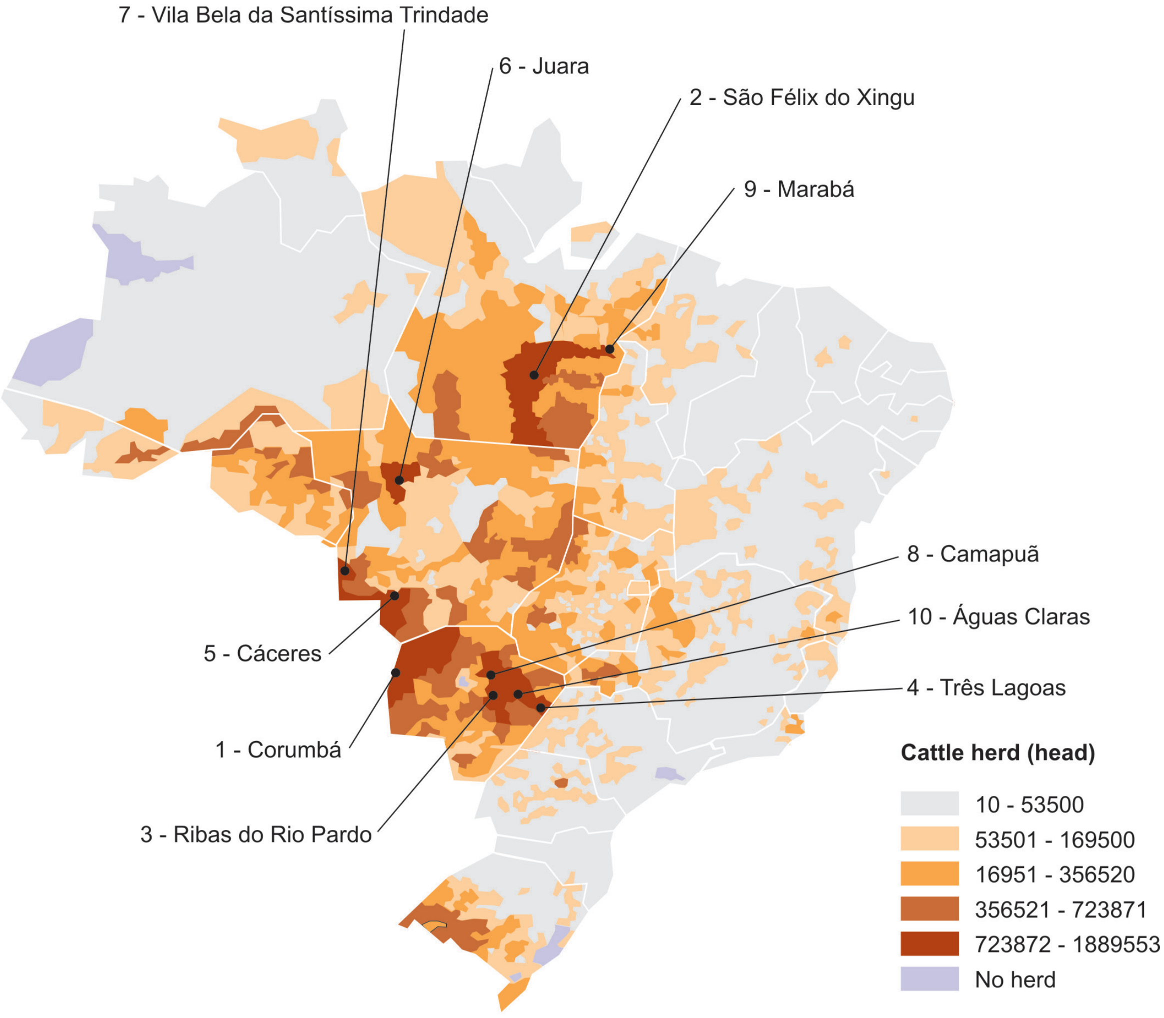
In 2008, Brazil's foreign trade continued to grow, ranking it 22nd among the main global exporters and 24th among the main importers. This includes the fact that the final two months of 2008 witnessed a reduction in export and import trade flows compared to the growth seen until October, due to the international financial crisis, which led to a reduction in international food and mineral commodity prices and in the demand for goods (DANTAS *et al.*, 2009).

Brazil is ranked first in the world in terms of the exportation of several agriculture products: sugarcane, beef, chicken, coffee, orange juice, tobacco, and alcohol. It is also second in soy bean and corn exports and is ranked the fourth largest exporter of pork. However, the country is still far from being the biggest food exporter in the world, as is widely believed.

In the agriculture and livestock sector, animal production growth stands out, and it should be noted that in 2005 the main herd was that of cattle, with 207.2 million head (Figure 1.6); followed by the swine herd, with 34.1 million head; sheep, with 15.6 million head; goat, with 10.3 million head; equine, with 5.8 million head; and bubaline, with 1.2 million head. The total number of hens, roosters, broilers, and chicks in the same year reached 812.5 million.

A series of factors ensured the achievements of the agriculture sector in Brazil over recent years: abundant natural resources (soil, water and sunlight); product diversity; and a relatively favorable exchange rate until 2006 (after which the appreciation of the real jeopardized profitability); increasing demand from Asian countries; and growth in agricultural productivity.

Figure 1.6 Spatial distribution of cattle herd across the Brazilian territory, with an emphasis on the ten top municipalities 2005



Source: IBGE. Available at: <http://www.ibge.gov.br/home/presidencia/noticias/noticia_visualiza.php?id_noticia=499&id_pagina=1>

1.4 Social Development

This section examines the status of social development in the country, based on the variation in the human development index - HDI according to the following data: 2009 Human Development Reports, issued by UNDP (PNUD, 2009); an analysis by the Institute of Research in Applied Economics of the IBGE's 2008 National Household Sample Survey (IPEA, 2009); and the Fourth Brazilian Monitoring Report on Millennium Development Goals (IPEA, 2010a).

The human development index - HDI is a summary measure of human development in a country. More precisely, it is an index that measures the progress achieved by a country, on average, in terms of three basic dimensions: a long and healthy life, based on average life expectancy; access to knowledge, based on adult literacy rates and the combined gross enrollment rate; and a dignified standard of living, based on purchasing power parity - PPP of GDP per capita[5], in U.S. dollars.

These three dimensions are standardized in values between 0 and 1, and by calculating its simple average it is possible to determine the final HDI score. Countries are then ranked based on this score, where a classification of 1 represents the maximum HDI score.

Compared with other countries in South America, in 1980 Brazil had one of the worst Human Development Indexes, ahead of only Paraguay and Bolivia, without considering Su-

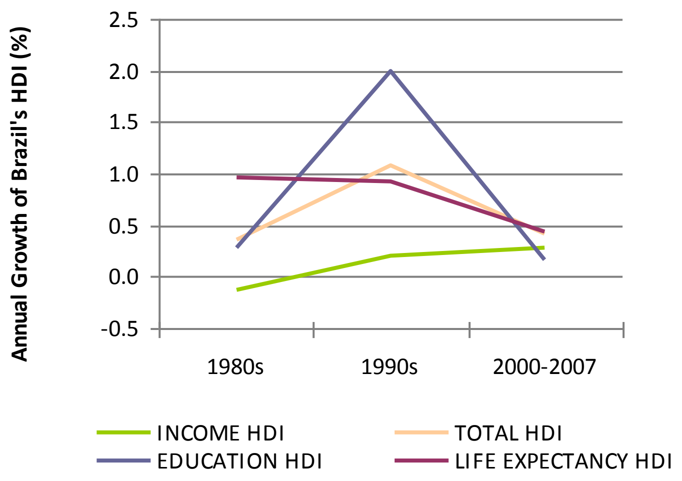
5 Purchasing power parity - PPP is an alternative method to exchange rate for calculating the purchasing power in two countries. PPP measures how much a certain currency can buy in international terms (normally the dollar), since goods and services have different prices from one country to the other. PPP is necessary because a comparison of gross domestic products - GDP in a common currency does not precisely describe the differences in material prosperity. PPP, on the other hand, takes into account the differences in earnings as well as cost of living differences.

riname and Guyana, for which data was not available. Ten years later, it had overtaken only Peru. In 2000, however, Brazil saw the quickest progress, and was ranked ahead of Colombia, Peru, Paraguay, and Bolivia, with an index approaching Venezuela's. From the turn of the millennium on, Brazil's HDI growth slowed down, allowing Peru, Colombia and Ecuador to once again approach Brazil's level. The HDI for Chile, Argentina, Uruguay, and Venezuela during the period considered was always higher than Brazil's (Table 1.4).

Brazil's HDI saw rapid growth in the 1990s, especially the second half of that decade, and then slowed-down growth after the turn of the century (Figure 1.7). Of the three dimensions measured by the HDI, there was a reduction in the pace of improvements in education and life expectancy at birth. The education sub index, which was growing at a clip of 1.99% per year last decade, has seen annual growth of 0.16% this decade. Life expectancy was reporting annual increases of 0.91% in the 1990s, and this decade this rate has fallen to 0.43%. The third dimension, income, saw slight improvements this decade, with annual growth going from 0.22% to 0.29%.

In 2007, Brazil remained among those countries classified as having high human development (HDI between 0.800 and 0.899), a group it joined in 2005. The 2007 HDI leaders were Norway (0.971), Australia (0.970), Iceland (0.969), Canada (0.966), and Ireland (0.965), which are among the 38 countries or territories classified as having very high human development levels by the UNDP. With an HDI of 0.813, Brazil is ranked 75 in the world, among 182 countries and territories considered.

Figure 1.7 Brazil's HDI annual growth rate (%)



Source: Elaborated from data presented by MALI.

A breakdown of HDI (Table 1.5) shows that Brazil had a lower sub index for income than that of Latin America and the Caribbean, and that of the world average. In terms of life expectancy (longevity), Brazil exceeds the global average, but not Latin America's. Education is Brazil's indicator that most approaches a score of 0.900 (very high HDI) and that has most distanced itself from the world average. Therefore, reduced growth in this index was already somewhat expected, taking into account that it is impossible to see great proportional improvements in indicators that increasingly get closer to 100%. Nevertheless, there is still room for growth in terms of the criteria used to measure education (literacy rate and gross school enrollment).

Table 1.4 Variation in the Human Development Index in South America (1980 – 2007)

Countries	1980	1985	1990	1995	2000	2005	2006	2007
Chile	0.748	0.762	0.795	0.822	0.849	0.872	0.874	0.878
Argentina	0.793	0.797	0.804	0.824	.....	0.855	0.861	0.866
Uruguay	0.776	0.783	0.802	0.817	0.837	0.855	0.860	0.865
Venezuela	0.765	0.765	0.790	0.793	0.802	0.822	0.833	0.844
Brazil	0.685	0.694	0.710	0.734	0.790	0.805	0.808	0.813
Colombia	0.688	0.698	0.715	0.757	0.772	0.795	0.800	0.807
Peru	0.687	0.703	0.708	0.744	0.771	0.791	0.799	0.806
Ecuador	0.709	0.723	0.744	0.758	....	....	0.805	0.806
Suriname	....	....	....	....	....	0.759	0.765	0.769
Paraguay	0.677	0.677	0.711	0.726	0.737	0.754	0.757	0.761
Bolivia	0.560	0.577	0.629	0.653	0.699	0.723	0.726	0.729
Guyana	....	....	....	....	....	0.722	0.721	0.729

Source: Elaborated from the 2009 Human Development Report, issued by UNDP (PNUD, 2009).

Table 1.5 Human Development Index (2007) and its components

	2007 HDI	HDI Life Expectancy	HDI Education	HDI Income
Brazil	0.813	0.787	0.891	0.761
Latin America and Caribbean	0.821	0.806	0.886	0.770
Countries with very high HDI	0.955	0.918	....	0.988
Countries with high HDI	0.833	0.790	0.902	0.807
Countries with medium HDI	0.686	0.698	0.744	0.614
Countries with low HDI	0.423	0.434	0.477	0.359
World	0.753	0.708	0.784	0.768

Source: Elaborated from the 2009 Human Development Report, issued by UNDP (PNUD, 2009).

The average life expectancy data shown in Table 1.6 refer to the number of years a new-born is expected to live if the specific mortality rate patterns for each existing age at the time of its birth are maintained. The average life expectancy for a Brazilian in 2007 was 72.2 years, higher than the global average; however, it is 7.9 years lower than the average for countries with a very high HDI, and also lower than the average for Latin American countries. Life expectancy at birth has a positive correlation with infrastructure, a requirement that still needs to be much improved in Brazil for this indicator to grow.

Table 1.6 Average life expectancy and Purchasing Power Parity - PPP of Gross Domestic Product per capita - 2007

	Average life expectancy (years)	GDP per capita (PPP in US$)
Brazil	72.2	9,567
Latin America and Caribbean	73.4	10,077
Countries with very high HDI	80.1	32,272
Countries with high HDI	72.4	12,569
Countries with medium HDI	66.9	3,963
Countries with low HDI	51.0	862
World	67.5	9,972

Source: Elaborated from the 2009 Human Development Report, issued by UNDP (PNUD, 2009).

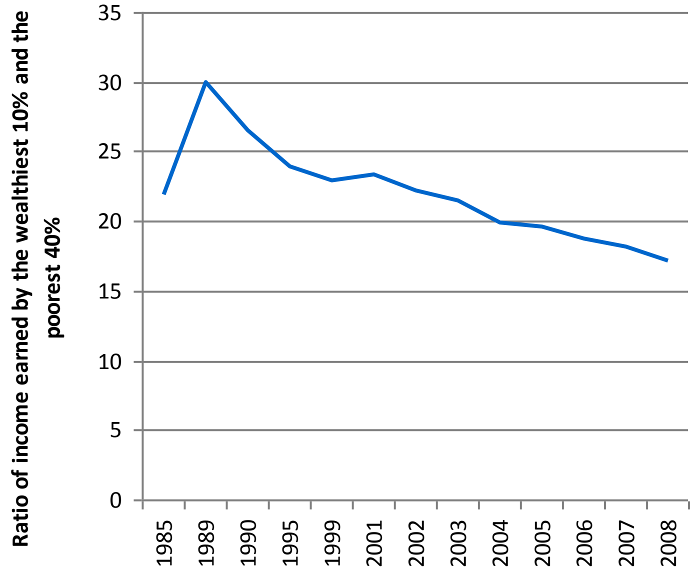
The data in Table 1.6 also shows that in 2007 Brazil's Gross Domestic Product per capita (US$ 9,567, in PPP) was lower than the average for its group, i.e., high HDI countries (US$ 12,569), and much lower than that for the group of very high HDI countries (US$ 32,272), and even lower than the average for Latin America and the Caribbean and the world average.

1.4.1 Degree of Inequality: Brazil and the World

In the beginning of the 1990s, Brazil had one of the highest degrees of inequality in the world, where the average income of the richest 10% was almost thirtyfold greater than the average income of the poorest 40% (BRASIL, 2004). Starting in 2001, the degree of income inequality in Brazil began to fall sharply and continuously, reaching a reduction of 6.21 percentage points in 2008 (Figure 1.8).

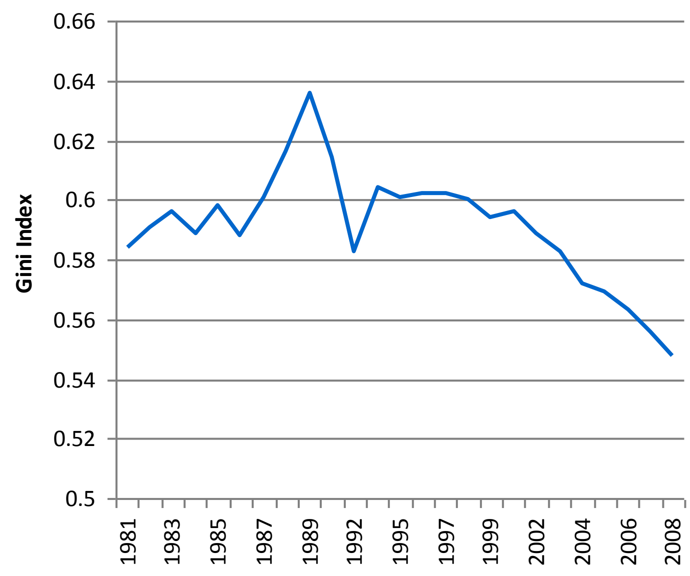
The results obtained from another indicator, the Gini index, which is the most commonly used measure of income inequality in the world, show the same sharp decline in income distribution inequalities between 2001 and 2008 (Figure 1.9). The degree of income concentration in Brazil fell 8.1% between 2001 and 2008, from 0.596 to 0.548, when it reached the lowest recorded value in the country since 1977, corresponding to an average annual reduction rate of 1.2%. From the beginning of the 1980s to 2001, the Gini index oscillated around 0.600, which kept Brazil among the countries with the greatest income inequality in the world.

Figure 1.8 Evolution of inequality in household per capita income in Brazil, according to the ratio of the richest 10% and poorest 40%, 1985-2008



Source: Elaborated from IPEADATA data. Available at: <http://www.ipeadata.gov.br>.

Figure 1.9 Evolution of inequality in household per capita income in Brazil according to the Gini Index, 1985-2008



Source: Elaborated from IPEADATA data. Available at: <http://www.ipeadata.gov.br>.

Despite this sharp drop, the inequality of Brazil's income distribution is still extremely high. According to the United Nations Development Programme's 2009 Human Development Report, in 2007, Brazil was ranked 10th in most unequal income distribution out of a list of 182 countries and territories considered, only better than Colombia, Bolivia, Haiti, Honduras, Botswana, Namibia, South Africa, Comoros, and Angola.

However, it is necessary to explain that, as mentioned in a document published by the United Nations Development Programme (PNUD, 2010), inequality is not only a problem in developing countries.

1.4.2 Evolution in the Proportion of Poor, Hunger and Child Malnutrition in Brazil

The first and primary Millennium Development Goal - MDG[6] is the eradication of extreme poverty and hunger in the world. In order to meet this goal, the Millennium Summit[7] established two targets to be met by 2015. The first is the reduction of extreme poverty levels in the world's population to half the level in the 1990s; the second is to halve the proportion of people living in hunger.

The extreme poverty and hunger reduction goals do not apply to countries individually, but to the entire world. They can be met even if some countries are unable to achieve them, so long as others have an optimal performance and exceed them. In this context, Brazil has tried to do more than just its part for the world to achieve the first Millennium Development Goal, establishing more ambitious targets than those agreed upon by the international community, and which are to reduce extreme poverty to one fourth of 1990's level and to eradicate hunger by 2015.

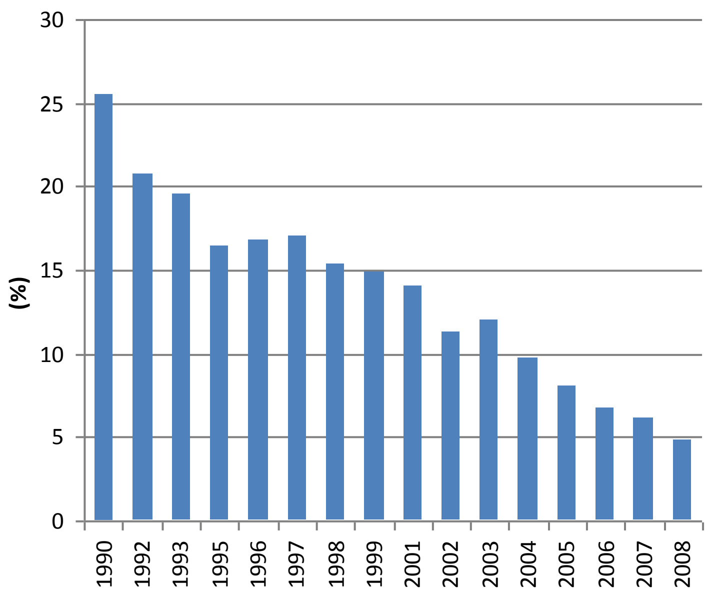
According to the Fourth Brazilian Monitoring Report on Millennium Development Goals (IPEA, 2010a), Brazil's goal to cut extreme poverty to one fourth of 1990's level was achieved in 2007 and exceeded in 2008.

6 The Millennium Development Goals - MDG derive from the United Nations Millennium Declaration, adopted by 191 Member States on September 8, 2000. The Millennium Declaration brings a series of firm commitments that, if fulfilled by the established deadlines, according to the quantitative indicators that accompany them, shall improve humanity's destiny in the 21st Century. Eradicate extreme poverty and hunger; achieve universal primary education; promote gender equality and empower women; reduce child mortality; improve maternal health; combat HIV/AIDS, malaria and other diseases; ensure environmental sustainability; and develop a global partnership for development are the eight Development Goals presented in the Millennium Declaration, and which are to be met by 2015.

7 The Millennium Summit refers to the meeting of the 191 Heads of the Members States of the United Nations, held on September 6-8, 2000, in which the Millennium Development Goals were established.

In 1990, 25.6% of Brazilians' household per capita income was under the international poverty line of US$1.25 PPP/day, that is, one out of every four Brazilians had a daily income whose purchasing power in the local market was less than the purchasing power of US$1.25 in the USA. The reduction in extreme poverty since 1990 was such that in 2008 only 4.8% of the population (one out of every 20 Brazilians) was poor according to international criteria (Figure 1.10).

Figure 1.10 Percent of the population living on less than US$1.25 PPP per day in Brazil*, 1990-2008

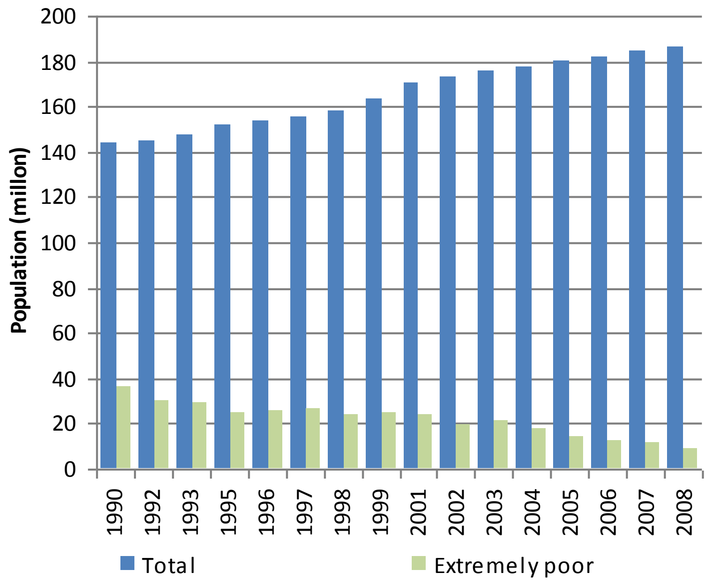


*Excluding the rural population of the states of RO, AC, AM, RR, PA and AP. Sources: Income: IBGE, National Household Survey, PNAD.
PPP Factors: United Nations, Statistics Division (World Bank, ICP 2005). Average annual inflation for Brazil and the USA: International Monetary Fund, World Economic Outook, 2009.
Source: IPEA, 2010a.

The sharp drop in extreme poverty is better understood when expressed in terms of population (Figure 1.11). From 1990 to 2008, while Brazil's population grew from 141 million to approximately 186 million, the extremely poor population decreased from 36.2 to 8.9 million. In 2008, only one fourth of the population that was poor in 1990, and just of over one third of those who were poor in 1995, remained so.

The main indicator for the second goal — reducing world hunger — is the percentage of children from zero to four years of age considered underweight for their age using the growth curves of healthy and well-fed children used as a reference by the World Health Organization. In 1996, 4.2% of Brazilian children from zero to four years of age were under the expected weight for their age. In 2006, this percentage had been halved, to 1.8% (IPEA, 2010a).

Figure 1.11 Total population and population living on less than US$1.25 PPP per day (in millions) in Brazil*, 1990-2008



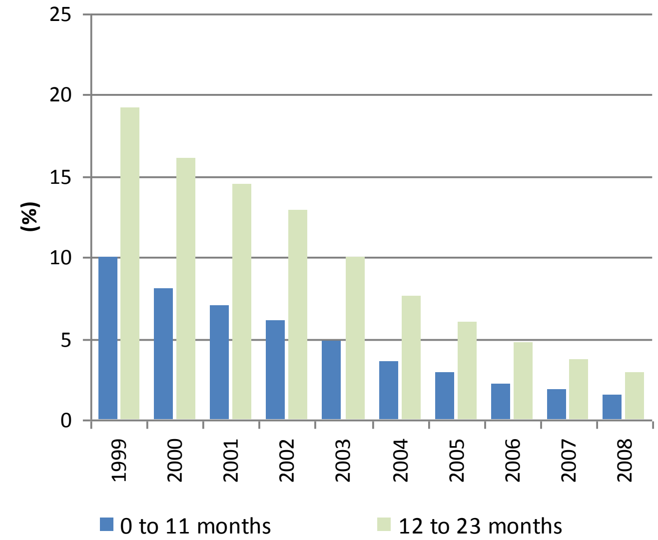
*Excluding the population of the states of RO, AC, AM, RR, PA and AP. Sources: IBGE Income, National Household Survey, PNAD.
PPP Factors: United Nations, Statistics Division (World Bank, ICP 2005). Average annual inflation in Brazil and the USA: International Monetary Fund, World Economic Outook, 2009.
Source: IPEA, 2010a.

Information on children under two years of age and cared for by the Family Health Strategy teams - ESF[8] also show sharp reductions in protein-energy malnutrition in childhood. This is relevant data because although it does not refer to all the children in the country, a great part of those whose socioeconomic profile implies greater risk of malnutrition is cared for by the ESF. Among those children cared for up to 11 months of age, only 1.5% was considered malnourished in 2008. In the next age group — 12 to 23 months of age —, 2.9% were malnourished (Figure 1.12).

Hospital admissions of children up to 11 months of age solely due to malnutrition, vitamin deficiencies and their sequella are less frequent events, and have been reduced from 9.6 per thousand in 1999 to 5.3 per thousand in 2008 (Figure 1.13).

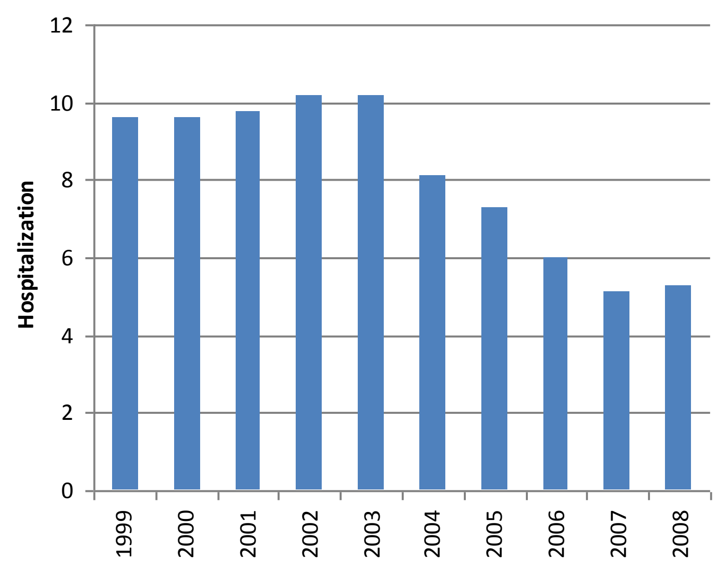
8 In 1994, the Ministry of Health created the Family Health Strategy - ESF with the main objective of reorganizing health care on new foundations, that is, take healthcare closer to families. ESF prioritizes health prevention, promotion and recovery actions in a complete and continuous manner. Care is provided at the basic healthcare unit or at home by professionals (doctors, nurses, nursing aides, and health community agents) who comprise the Family Health Strategy teams. These professionals and the population that participates in the project create ties of co-responsibility, which facilitates the identification and care for community health problems.

Figure 1.12 Percentage of children up to 23 months of age cared for by the Family Health Strategy with lower than expected weight for their age in Brazil*, 1999-2008



* Only children cared for by the Family Health Strategy. Ministry of Health, Secretary of Health Care, Basic Care Information System.
Source: IPEA, 2010a.

Figure 1.13 Hospital admissions due to malnutrition out of every 1,000 admissions of children aged 0 to 11 months in Brazil*, 1999-2008



*Only children cared for by the Family Health Strategy. Ministry of Health, Secretary of Health Care, Basic Care Information System.
Source: IPEA, 2010a.

Considering the reduction in the national percentage of children under expected weight during the period 1996-2006, Brazil has already exceeded the international goal of halving hunger by 2015. More detailed analyses of the nutritional status of children from zero to four years of age, from National Demographic and Health Survey information and other administrative surveys and records, including additional indicators such as the adjustment of weight to height, and height to age, revealed that Brazil is close to eradicating child malnutrition and achieving its own goal.

1.4.3 National Social Policies System

Since the end of the 1980s, new social concepts became part of the Brazilian public agenda and began to guide the development of social policies in the country, especially the following:

- Reinforcement of selectivity and focus – priority in the agenda, resources and social actions to programs for the poor sectors, focusing expenses and actions on basic needs for the most vulnerable groups based on age and spatial location.

- Combination of universal and selective programs – differently from universalism versus selectivity, an understanding seems to have grown in Brazil that public networks of basic education and healthcare are crucial and strategic both because of their services and because they can hold mass programs. This way, focused programs would complement universal programs, with mutual support.

- Minimum income programs – monetary transfers to guarantee minimum individual or family income levels became part of a list of anti-poverty programs, especially through formulas that establish a link between minimum income targets and targets for improving school and health performances for younger children.

- Public-private partnership – greater acceptance of non-governmental organization participation in offering social services, based on the understanding that, alone, the government is unable to respond to the huge challenge posed by poverty, which makes it necessary, therefore, to expand on initiatives by the various segments of society to provide social services.

- Expansion of production programs – in designing new programs, there is also growing concern for those that may contribute towards reinforcing the capacity and productivity of poor segments in generating income, such as training programs, support for micro and small enterprises and job creation.

- Expansion of access to food programs – the purpose is to increase the supply of high nutritious foods and to improve the living conditions of families living in situations of food insecurity. When designing these programs, food and nutritional security are considered to be the guarantee of access to food on a daily basis, in sufficient quantities and with the necessary quality.

- Job and income generation programs – these are actions to generate jobs and income in a sustainable manner for needy, vulnerable families, who benefit from social programs.

In this context, and with the intent of eliminating extreme poverty, in 2004 the Federal Government created the Family Allowance Program ("*Programa Bolsa Família*"), with a view to guaranteeing the right to food, health, education and achieving citizenship to the population most vulnerable to hunger. In this program, the government transfers funds directly to the families and they assume the commitment to keep their children in school and to monitor the health of children, adolescents and pregnant women.

The main social policies currently in place are those geared towards combating poverty and hunger; universal and qualified education; job and income generation for the poorest; expansion and improvement of health services; combating socioeconomic inequalities and those inequalities resulting from race and gender. In summary, they are policies focused on improving the quality of life of Brazilians, especially those in a situation of social vulnerability (IPEA, 2010a).

1.4.4 Human Development and Changes in the Demographic Pattern

One of the most important structural transformations of Brazilian society in recent decades was the change in its demographic pattern. This change has been underway in a rapid pace since the end of the 1960s.

Despite the immense regional and social inequalities, Brazilian population mortality rates have had a rapid and sustained decline since the beginning of the 1940s, entailing an increase in the population's life expectancy, which jumped from 41 to 54 between the 1930s and 1960s. However, the level of fecundity remained high until the mid 1960s, only declining in the South and Southeast regions (although slightly) and remaining constant, or even increasing in the North, Northeast and Central-West regions. Thus, the total fecundity rate only fell from 6.5 to 5.3 children per woman during this period. The result of this evolution was a significant increase in the average population growth rate, which went up from 2.4% in the 1940s to 3.0% in the 1950s and 2.9% in the 1960s.

Since the Brazilian population has remained basically closed, that is, without significant migratory flows, and with high and quite stable levels of fecundity, its age group distribution remained relatively constant and young from 1940 to 1970, despite the sharp decline in mortality rates and rapid growth. Thus, throughout that entire period, 52% of the population was under the age of 20.

The country underwent a rapid and widespread decline in fecundity at the end of the 1960s. Previously limited to more privileged urban social groups from more developed regions, this process soon extended to every social class and various regions. Thus, the total fecundity rate fell from 5.8 in 1970 to 4.3 in 1975, and 3.6 in 1984, which corresponds to a decline of more than 37% over only 15 years.

Census data from 1991 confirm the tendency for a sharp drop in fecundity in Brazil. Brazil's population grew below expectations, and in 1991 there were only about 147 million inhabitants, with an average annual growth rate between 1980 and 1991 falling to 1.9%, compared to the 2.4% seen in 1980.

Indeed, it can be affirmed that the decline in fecundity in Brazil is not a situational phenomenon, but rather an irreversible process that has come to be called a demographic transition in the demographic jargon. Information on use of contraceptive in Brazil corroborates this assertion.

According to 1980, 1991 and 2000 Census data, this change in the demographic growth pattern has produced some significant consequences in the short term: the average annual growth rate of the population, which in the 1960s was 2.9%, fell to 2.5%, 1.9% and 1.6% over the next three decades, respectively; and the percentage of the population under 10 years of age fell significantly. These data show that Brazil's population underwent continuous decline in growth rates and a destabilization in age group distribution.

A fundamental aspect evidenced by these data is the expressive "aging" of the population, that is, the progressively smaller weight of youths as a result of the decline in fecundity rates that occurred between 1970 and 1991. In the population's age group profile, the 2000 Demographic Census revealed that for every 100 children, Brazil had 30 elderly. This survey showed that, out of the total elderly population, women were the majority. On average, the elderly were 69 years old and had 3.4 years of education, and the majority lived in big cities.

According to the Social Indicators Synthesis (IBGE, 2008), based on the National Household Sample Survey - PNAD, which covered the entire country, in 2008 Brazil's average demographic density was 22 inhabitants/km^2. The population under one year of age declined 27.8%, from 1.8% of the total population in 1998 to 1.3% in 2008; the number of children and adolescents up to 14 years of age represented 24.7% of total population, whereas in 1998 this percentage was 30.0%, representing a 17.7% decline in the previous 10 years. The PNAD was also able to identify a considerable increase in the elderly population aged 70 or more, indicating a total of 9.4 million people in that age group, corresponding to 4.9% of the total population.

Considering continuity in the tendencies for fecundity and life expectancy rates for the Brazilian population, the estimates for the next 20 years indicate that the elderly population could exceed 30 million people in 2020, thus representing nearly 13% of the population.

Fecundity continued to be a fundamental demographic factor for characterizing the evolution of Brazil's population. In 2008, the total fecundity rate was 1.9, compared to 3.6 in 1984, an indication of the continued intense and rapid decline in fecundity that has been taking place in Brazilian society over recent decades.

1.4.5 Profile of Education

Educational indicators in Brazil saw significant improvement over recent decades, with a reduction in illiteracy rates, an increase in enrollments at every level of education and growth in the population's average level of education. Nevertheless, the situation of education in the country is still unsatisfactory both from a quantitative and a qualitative perspective. Some of the main indicators for education in Brazil in the past decades are shown in Table 1.7.

Table 1.7 Main indicators for education in Brazil over the past decades

Education Indicators in Brazil - 1960 to 2006						
Indicators	1960	1970	1980	1991	2000	2006
Adult Literacy Rate (*)	60.4	66.4	74.5	79.9	86.8	89.3
Illiterates	39.6	33.6	25.5	20.1	13.2	10.7
Population's Level of Education (**)						
First phase of elementary (1-4)	41.0	40.0	40.0	38.0	43.0	NA
Second phase of elementary (5-8)	10.0	12.0	14.0	19.0	13.0	NA
High School	2.0	4.0	7.0	13.0	16.0	NA
Higher Education	1.0	2.0	5.0	8.0	7.0	NA
Average Number of Years of Study	2.1	2.4	3.6	5.0	5.7	NA

(*) People 15 years of age or older. (**) People 25 years of age or older, by level of education completed.

Source: IPEA/PNUD, 1996; IBGE, 1960; IBGE, 2000b; IBGE, 2006a.

An appropriate level of education for the population is an essential requirement for the country's development to guarantee the exercise of citizenship and promote equal opportunities in society. Expanding education levels and education quality in Brazil is still a major challenge, especially because of the persistent teaching and learning problems (IPEA, 2006a).

An analysis of the increase in education levels over past decades reveals that, despite the growth reported, from an average of two years of study in 1960 to nearly six years in 2000, this increase is lower than expected as a result of the growth in income per capita over the same period.

In 2000, 86.8% of those people aged 15 or more were literate, and this percentage increased to 89% in 2005. The South region has the lowest illiteracy rate for those 15 years of age or older (5.9%) and the Northeast region has the highest (21.9%) rate. Brazil's illiteracy rate fell from 20.1% in 1990 to 13.6% in 2000, and to 11% in 2005. There has been significant improvement in education level rates due to robust policies geared towards this area. In relation to states, the Federal District has the lowest illiteracy rate in the country: 4.7%. The other states with the best rates are Rio de Janeiro, with 4.8%; Santa Catarina and Rio Grande do Sul, with 5.2%, and São Paulo, with 5.4%. Alagoas has the highest rate of illiteracy in the country: 29.3%. The rural area saw an increase in literacy rates, from 72.4% in 2000 to 75% in 2005. The South region, with 9.8%, has the lowest percentage of illiterates in the rural area. The Northeast region has the worst performance in the country, with 36.4% of all those aged 15 or more unable to read and write.

In the group of people between 7 and 14 years of age, which corresponds to the age group where the vast majority of children should be in elementary school, 2.7% were not enrolled in schools. The lowest figure for this indicator was the Southeast region (1.8%), followed by the South region (2.1%). At the other extreme, 4.3% of that age group was not in school in the North region, and in the Northeast region that percentage was 3.5%. In the Central-West region, the indicator was at 2.4%.

According to the IBGE (2006a), the illiteracy rate for people aged 10 or more fell from 14.7% to 11.4% from 1995 to 2001, and in 2005 it was 10.1%. In the 10-14 age group, when it is expected that a child should at least be able to read and write, the illiteracy rate fell from 9.9% in 1995 to 4.2% in 2001, and finally to 3.2% in 2005. In the Northeast region, this indicator was at 23.9% in 1995, falling to 9.5% in 2001 and 7.0% in 2005. Despite this progress, this final result is still far from the level achieved in the South, Southeast and Central-West regions.

Between 1991 and 2005, 4.6 million students joined elementary education and another 5.2 million entered high school in public education networks. Although illiteracy in Brazil mainly affects the adult population, especially the elderly, the Brazilian education system has been unable to eradicate this problem among the young, as demonstrated in the rates shown above.

There has been a significant improvement in education level rates as a result of education policies. In 2005, 79.8% of the students attended public schools. School attendance improved in all age groups. The highest percentage of children in school (97.3%) is from the 7-14 age group. However, the percentage of slow students or students who drop out of school is still very high.

But the poor quality of the education system is less related to a shortage of resources than to their inefficient distribution and use. This inefficiency results largely from the system's institutional format, which is marked by strong fragmentation, lack of effective jurisdictions for coordination and precarious mechanisms of information and evaluation. However, Brazil has sought to conduct programs with a view to improving Brazil's educational system as well as the progressive universalization of access to basic education.

Basic education

Brazil has virtually universalized access to school for the population aged 7-14. Between 1992 and 2005, it expressively increased the percentage of youths in school (school attendance rates), and there was also a significant reduction in several types of inequality (Table 1.8).

Table 1.8 School attendance rates for people aged 7-17 by level of education, according to gender and household status, 1992 and 2005 (%)

Selected Characteristics	Elementary 7 to 14 years old		High School 15 to 17 years old	
	1992	2005	1992	2005
Total*	81.4	94.5	18.2	46.0
North*	82.5	93.9	11.7	35.4
Northeast	69.7	92.4	9.5	30.1
Southeast	88.0	95.8	24.3	57.4
South	86.9	95.9	23.1	53.6
Central-West	85.9	94.7	17.5	45.9
Gender				
Men	79.9	94.3	15.1	41.2
Women	82.7	94.8	21.3	50.7
Household situation				
Rural	66.5	92.5	5.3	25.7
Urban	86.2	95.0	22.3	50.4

*Excluding the rural population of the states of RO, AC, AM, RR, PA and AP.
Source: IPEA, 2007.

A comparison between the attendance rates at elementary schools in Brazil's regions shows that there has been a reduction in disparity in this regard. Between 1992 and 2005, the difference between the regions with the highest and lowest rates fell from about 20% to under 4%. High school has seen a similar trend: over the same period, asymmetry between the attendance rates in the Northeast and Southeast regions fell from 61% to 48%.

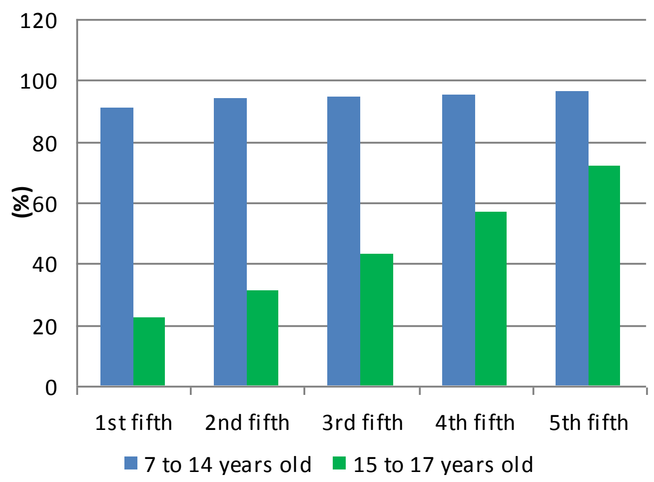
Another great achievement is seen in the rural and urban indicators between 1992 and 2005. While at the beginning of the period, 66.5% of all children aged 7 to 14 from the rural area attended that level of education, by the end of the period this had increased to 92.5%.

However, the comparison of students according to family income shows persistent inequality (Figure 1.14). In elementary education, the difference between school attendance rates for the richest and the poorest is 5 percentage points; in high school, this disparity is nearly tenfold more.

The low attendance rate for high school in the 15-17 age group is mainly due to the enormous age-grade distortion that affects most of these youths, especially those who belong to low-income groups. In 2005, nearly 82% of Brazilians aged 15 to 17 attended school, but only 45% of them were in high school. Among those in the poorest 20% group, attendance rates were half the national average.

Despite the progress made by the Brazilian society, the percentage of slow students or students who drop out of school is still very high. This contributes towards the low conclusion rates for elementary education.

Figure 1.14 Attendance rate (%) of people aged 7-17, by age group, according to the fifths16 of monthly family income per capita in 2005



Source: Elaborated based on data from IPEADATA. Available at: < http://www.ipeadata.gov.br/>

Technical education

There is a great deficiency in technical education in the Brazilian educational system. The total supply for technical education does not reach 1 million enrollments per year, even after the 20% growth reported between 2003 and 2005. Most of this growth occurred in the private sector.

Despite the weight of the private sector, the best-known and consolidated feature of this group is the federal technical school network, with 138 units and nearly 80 thousand students throughout the country. However, the largest slice of the public supply is in the state technical school network, with 553 units and 165 thousand students.

Technical school enrollment represents approximately 10% of all regular high school students (9.2 million in 2005, as per data from the Ministry of Education - MEC/ Anísio Teixeira National Institute of Educational Studies and Research – INEP, 2008) and falls short of 2% of the working population with eight years of education or more (46 million workers), who would be potential candidates for technical courses.

Adolescent and adult education

The growth in Adolescent and Adult Education - EJA has mainly occurred at the elementary level, which is consistent with the fact that nearly half of the working population has at least eight years of education. For this group of adolescents and adults who are employed or looking for a job, EJA is not only the fastest path, but it is also more attractive than regular high school, due to environments, times and, in some cases, methodologies that are more adjusted to their profile, such as the *Novo Telecurso* and *Telecurso 2000*[9]; *Tecendo o Saber*[10] and *Escola da Juventude*[11].

9 These programs are updated continuously. In 1978, *Telecurso 2° grau* was created, which was a pioneer project in Brazilian distance education. In 1981, *Telecurso 1° grau* became available. In 1994, the Roberto Marinho Foundation, in a partnership with the Federation of Industries of the State of São Paulo - FIESP, launched *Telecurso* 2000, which consisted of an innovative educational proposal geared towards people who had not completed elementary and high school education. Nowadays, *Telecurso* is recognized around the world as a methodology that promotes a quality leap in education, and it has benefited more than 5.5 million people. In 2006, *Telecurso* began a new virtuous cycle. Its partners launched a set of measures to enlarge its scope: expanding content and including new actions, subjects and technologies. And thus Novo *Telecurso* came into being: an enormous investment with social relevance for another 10 years.

10 *Tecendo o Saber* is a project that offers teens and adults an opportunity to study first phase elementary education content, which corresponds to grades 1-4. The *Tecendo o Saber* programs are broadcast by TV Globo, on Canal Futura and TV Escola. They are also made available to all the other educational, community and university TV stations.

11 The *Escola da Juventude* is a state government program for adolescents and adults to attend High School for a shorter period of time than the conventional program through weekend classes and technologies that accelerate the learning process, such as computer laboratories and video rooms.

In general, the current supply of EJA (around 6 million enrollments) is still small, considering its market potential of 45 million adolescents and adults who are in the working population (whether employed or not) and who have not completed elementary school.

It is estimated that between 2003 and 2004 nearly 8 million adolescents and adults were theoretically taught to read and write, which would have been sufficient to cover nearly 90% of the working population with less than one year of education. At this pace, absolute illiteracy (i.e., total inability to read and write) could be eradicated in a short period of time.

However, this issue is more complex since there are doubts as to the efficacy of shortduration adult literacy programs, without any follow-up in high school equivalency programs or vocational courses. Furthermore, the problem of functional illiteracy persists.

Higher Education

From 2002 to 2007, Brazil saw big improvements in various higher education indicators, such as the increase in courses offered (Table 1.9), increase in openings (Table 1.10) and increase in enrollments (Table 1.11). In relation to classroom-based undergraduate education, the 2007 National Household Sample Survey revealed that there were 23,488 courses throughout Brazil, thus representing a 6.3% increase compared to 2006. The lowest growth in course numbers was reported by the Northeast region (0.5%), although other regions with poor higher education coverage saw above-average growth for Brazil, such as the North (8.7%) and Central-West (7.2%) regions. As in previous years, the private Higher Education Institutions - IES were responsible for offering the highest number of courses in 2007, in a total of 16,892. However, federal higher education institutions saw the highest percentage growth (8.8%) in the number of courses compared to 2006 (IBGE, 2007b).

Table 1.9 Evolution in the number of courses, according to administrative category, 2002 to 2007

Year	Total	%Δ	Public						Private	%Δ
			Federal	%Δ	State	%Δ	Municipal	%Δ		
2002	14,399	-	2,316	-	2,556	-	380	-	9,147	-
2003	16,453	14.3	2,392	3.3	2,788	9.1	482	26.8	10,791	18
2004	18,644	13.3	2,450	2.4	3,294	18.1	518	7.5	12,382	14.7
2005	20,407	9.5	2,449	0	3,171	-3.7	571	10.2	14,216	14.8
2006	22,101	8.3	2,785	13.7	3,188	0.5	576	0.9	15,552	9.4
2007	23,488	6.3	3,030	8.8	2,943	-7.7	623	8.2	16,892	8.6

Source: INEP, 2008.

Table 1.10 Evolution in the number of openings, according to administrative category, 2002 to 2007

Year	Total	%Δ	Public						Private	%Δ
			Federal	%Δ	State	%Δ	Municipal	%Δ		
2002	1,773,087	-	124,196	-	132,270	-	38,888	-	1,477,733	-
2003	2,002,733	13	121,455	-2.2	111,863	-15.4	47,895	23.2	1,721,520	16.5
2004	2,320,421	15.9	123,959	2.1	131,675	17.7	52,858	10.4	2,011,929	16.9
2005	2,435,987	5	127,334	2.7	128,948	-2.1	57,086	8	2,122,619	5.5
2006	2,629,598	7.9	144,445	13.4	125,871	-2.4	60,789	6.5	2,298,493	8.3
2007	2,823,942	7.4	155,040	7.3	113,731	-9.6	60,489	-0.5	2,494,682	8.5

Source: INEP, 2008.

Table 1.11 Evolution in the number of enrollments, according to administrative category, 2002 to 2007

Year	Total	%Δ	Public						Private	%Δ
			Federal	%Δ	State	%Δ	Municipal	%Δ		
2002	1,205,140	-	122,491	-	125,499	-	32,501	-	924,649	-
2003	1,262,954	4.8	120,562	-1.6	108,778	-13.3	37,741	16.1	995,873	7.7
2004	1,303,110	3.2	122,899	1.9	125,453	15.3	38,890	3	1,015,868	2
2005	1,397,281	7.2	125,375	2	122,705	-2.2	40,601	4.4	1,108,600	9.1
2006	1,,448,,509	3.7	141,989	13.3	117,299	-4.4	38,119	-6.1	1,151,102	3.8
2007	1,481,955	2.3	151,640	6.8	109,720	-6.5	37,131	-2.6	1,183,464	2.8

Source: INEP, 2008.

The student population in higher education has tripled since 1980 — from 1.4 million to 4.2 million —, the number of institutions has doubled and the predominance of private institutions has grown. Today, they represent virtually 90% of the IES in the country, and offer 88% of the openings.

In this context of higher education expansion, it is important to recognize that Brazil's graduate study system is still markedly public. It is by far the best segment of higher education in Brazil, and it adequately supplies undergraduate studies with professors with Masters and PhDs.

It could be argued whether Masters use their potential and whether the per hour wage system, which prevails in private institutions, is a good solution. But it is impossible not to appreciate the huge progress of private sector faculty members since 70% of the teachers with a Master Degree work at these institutions. This shows that even with the recent major expansion, faculty staff is increasingly more qualified, that is, there are no problems in supplying teachers or in offering openings in the undergraduate segment.

The Federal Government has been pursuing initiatives in recent years to extend the coverage of higher education to every social class. These measures include the Support Program for the Restructuring and Expansion of Federal Universities - Reuni[12] , which is one of the actions in the Education Development Plan - PDE, and it was instituted in recognition of the strategic role of universities — especially in the public sector — for economic and social development.

With Reuni, the Federal Government adopted a series of measures to resume growth of public higher education, creating a program that is both multidimensional and academic, political and strategic. The effects of the initiative are reflected in the significant expansion in the number of openings, initiated in 2008 and expected to end in 2012, and the opportunity this represents for academic restructuring with innovation, which in the short term will mean a true revolution in the country's public higher education.

Below is a description of the three cycles of recent expansion undergone by Brazil's federal universities:

- First Cycle – Expansion towards the Countryside (2003/2006): creation of ten new federal universities in every region; consolidation of two federal universities; creation and consolidation of 49 university campuses, taking free and public education to smaller cities with immediate effects on meeting the existing strong demand; positive impact on physical, political, social, cultural, economic, environmental levels; creation and expansion of new local and regional opportunities available; and fight against regional and spatial inequalities.

12 See: <http://reuni.mec.gov.br/>.

- Second Cycle - Expansion with Restructuring (2007/2012): adherence by all 54 federal institutions of higher education (existing as of December 2007); 26 projects with innovation components; consolidation and establishment of 95 university campuses; apparent increase in the number of openings for higher education, especially night courses;

- Third Cycle - Expansion with an emphasis on international linkages (2008): creation of federal universities in strategic territorial regions for education, research and extension purposes within the scope of international integration and cooperation under Brazilian leadership.

Reuni's general objectives, goals and guidelines are to create conditions (through allocation of resources) for expanding access to and staying in higher education; increase the quality of education through academic innovation and adaptation, with integration between professional and technological undergraduate, graduate and basic education; improve the use of human resources and physical infrastructure of federal universities; gradually increase the average conclusion rate for classroom-based undergraduate courses to 90% and achieve the student/teacher ratio of 18 in classroom-based undergraduate courses; increase enrollments in undergraduate courses by at least 20%; create a five-year deadline, counted from the start of each plan, to comply with the goals established by federal higher education institutions.

The desired quality for higher education begins to become a reality as federal universities join the program and adopt its guidelines, according to six components: expansion of the offer of public higher education; academic-curriculum restructuring; pedagogical renewal of higher education; intra and inter-institutional mobility; institutional social commitment, and; graduate studies support for the qualitative development and improvement of undergraduate courses.

Expansion and restructuring are pressing needs of the country's public higher education. Expansion is necessary because on the national average only 12% of Brazilian youths between 18 and 24 years of age have access to university education, and restructuring is necessary as a means to ensure the academic, political and strategic responses to the 21st Century's new challenges, i.e., academically adapting universities in their qualitative (essence and structure) and quantitative (expansion of supply) aspects to the new demands and new roles and global contexts that stem from a society of knowledge that is getting stronger and stronger at the beginning of this century; strategically preparing qualified labor to meet the country's social, economic and ecological needs of this new cycle of growth and development currently underway in Brazil; producing scientific, technological and innovative knowledge to insert the country in a sovereign manner in the new global order of knowledge that is arising in the 21st Century.

Graduate studies

In terms of performance, graduate studies are incredibly robust. In 15 years, the number of enrollments in Masters programs doubled, and for PhDs they grew fivefold. In 2004, there were 66,306 Masters and 39,948 PhD enrollments. The search for graduate studies continues to report rapid growth, as do the requests for Coordination for the Improvement of Higher Level Personnel — Capes authorization for the creation of new Masters programs. The result is that scientific production is now growing continuously. In 50 years, Brazil shifted from a production that virtually equaled zero to a 1.7% share in global science, ahead of virtually every non-industrialized country (except for China and India).

1.4.6 Profile of Healthcare

The objective of this section is to introduce Brazil's health profile, focusing on epidemiological characteristics, the demand and supply of health services and the expenses at different levels of public administration.

Infant mortality

Based on 1991 Demographic Census data, it is possible to estimate the child mortality rate tendencies in the 1980s. This rate has been seeing a significant reduction, and it fell from 163/1,000 in 1940 to 73/1,000 in 1980, to 47.2/1,000 in 1990, and to 21.7/1,000 in 2005.

A reduction in child mortality is a tendency that has been ongoing since the beginning of the 1990s. The rate fell from 31.9 per thousand live births, in 1997, to 21.17 in 2005. Child mortality has fallen in every region, with the Northeast region reporting the greatest reduction (37%). However, according to IPEA (2010b), even with reductions in every state, regional differences are the factor of greatest concern and reveal the inequalities in the Brazilian population's living conditions. In the Northeast region, with 31.6 per thousand live births, and North region, with 23.35 per thousand, the rates were much higher than those seen in the South (13.8), Southeast (14.20) and Central-West (17.80) regions.

Available data suggests a strong drop in child mortality over the past decade, reflecting improved living conditions as a result of an increase in spending on health, sanitation, food and nutrition, since 1986. It is worth pointing out that the reduction in child mortality in Brazil between 1990 and 2005 was only possible through the adoption of various actions, such as an increase in vaccination coverage for the population; increased prenatal care; expansion of health services; continued reduction in fecundity; improvement in the population's environmental conditions and nutrition; improvements in basic sanitation and the increase in mother education.

Changes in the profile of child mortality causes over recent decades basically reflect the transformations resulting from the urbanization process and the weight of health institutions in relation to births and primary child health care. Although most births occur in hospitals and there has been an considerable increase in medical care for the population, quality is still precarious, which is reflected in the high incidence of diseases stemming from the perinatal period in the child mortality structure, which in recent years has become the main cause of deaths for children up to one year of age. In 2005, infectious diseases accounted for 7.6% of mortality, but mortality from perinatal causes was 61%.

Over the past ten years, living conditions for Brazilians and access to basic health service have improved considerably. However, compared to other South American countries, like Argentina and Chile, Brazil still has a high rate of child mortality. Even with the increase in health services, quantitative improvements are necessary in the care given to pregnant women, at birth and new-borns.

Overall mortality

According to the Unified Health System Database (IDB/SUS, 2008), the gross mortality rate in Brazil in 2004 was 6.29/1,000. The major cause of death in the country is related to circulatory diseases, which were responsible for 31.5% of deaths in 2005. Neoplasia (cancer) comes second, responsible for 16.3%; external causes, with accidents as a major cause, mainly traffic accidents, come third, with 14.1%; respiratory tract diseases are ranked fourth, with 10.8%; in fifth, infectious and parasitic diseases, with 5.2%; the sixth position is held by diseases stemming from the perinatal period (3.3%); and other causes with 18.8%.

According to the IPEA (2010b), the tendency towards a reduction in mortality, which was already the case in the 1990s, has been maintained, thanks to socioeconomic development, aging of the population and increase in coverage by health and sanitation actions. The profile of mortality has been changing in the country: mortality from non-transmissible diseases, such as neoplasia, has increased from 14.9% in 2000 to 16.3% in 2005. These causes are associated with life style and working conditions, and can be reduced with measures to control risk factors. A mortality profile where non-transmissible diseases predominate is an indicator of a population at a higher socioeconomic stage. However, in Brazil's case, there is still an uncomfortable percentage of deaths from infectious and parasitic diseases (5.2%), especially in the North and Northeast region, where this indicator is approximately 8% in some states. Although the participation of infectious and parasitic diseases fell from 6.23% in 1990, to 5.1% in 2004 of total deaths with known causes, the absolute number of deaths by this group of diseases grew from 41,676 in 1990 to 46,628, in 2005.

Demand and supply of health services

The demand for health services is associated with the level of development and the actual supply of these services. Health care use rates grow according to income levels. Furthermore, it has been ascertained that the higher the family income per capita, the higher the percentage of people who pay for the health services used, which is close to 60% in classes with family income per capita greater than two monthly minimum salaries.

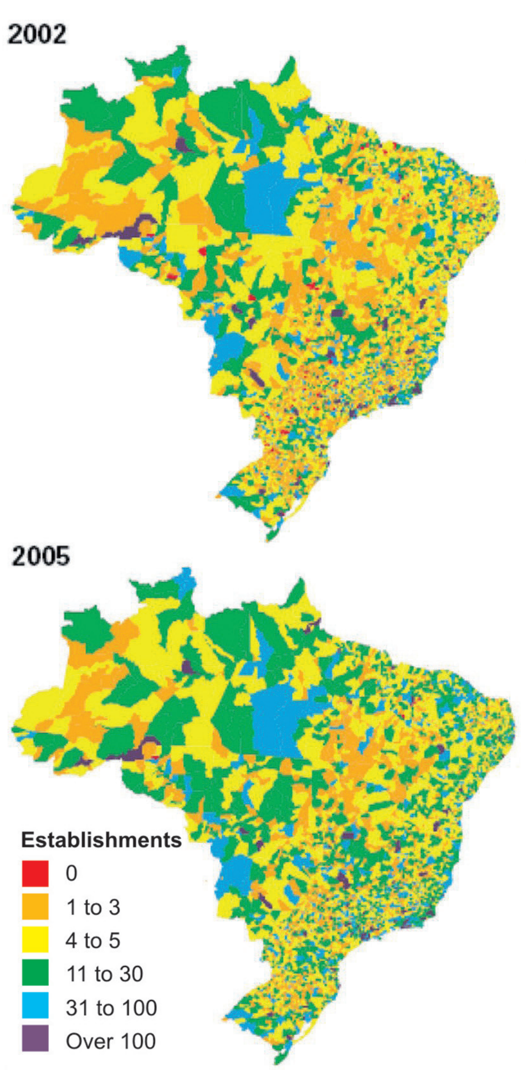
In 2006, IBGE's Medical-Health Assistance Survey - AMS revealed a total of 83,379 health care establishments, 3,606 of which were out of service, 2,769 had been shut down and 77,004 were in full or partial operation. The public and private sectors had differentiated behaviors by region. The public sector saw most growth in the North (2.7% per year), Northeast (7.0% per year) and Southeast (5.8% per year) regions, whereas the private sector saw most growth in the South (5.0% per year) and Central-West (15.2% per year) regions, as shown in Figure 1.15.

According to IBGE (2006b), the number of beds had jumped from 443,888 in 1976 to 544,357 in 1992, which meant an increase of 22.6%, or 1.3% per year, and fell to 443,210 in 2005, representing an 18.6% reduction (1.6% p.a.). In 2005, the bed per 1,000 inhabitants ratio was 2.4. In 2002, this ratio was 2.7 per 1,000 inhabitants. The private sector was responsible for the biggest decline in this rate (4.9% p.a.). The decline was 1.2% in the public sector.

The supply of beds is distributed as follows around Brazil's major regions: the North region has 6.1% of the total number of beds (27,163); the Northeast region, 26.1% (115,857); the Southeast region, 43.2% (191,453); the

South region, 16.8% (74,558); and the Central-West region, 7.7% (34,179). But the North region has the highest percentage of public beds (57.7%) followed by the Northeast (45.3%) and the Central-West (36.6%) regions. In the Southeast region, the percentage is 27.9% and in the South region, the lowest, at 19.9%.

Figure 1.15 Health establishments by municipality



Source: IBGE, 2006b.

1.4.7 Access to Urban Sanitation Services

This item discusses the data on sanitary sewage[13], water supply and garbage collection in urban and rural zones, divided by geographical region, in 1991 and 2006, which are summarized in Table 1.12.

In general, access to sanitary sewage services in Brazil reveals significant discrepancies among the different social classes. Sanitary sewage is the service with the lowest rate of public service, being offered to only 68.24% (20.27% in the rural zone and 77.85% in the urban zone) of Brazilian municipalities in 2005, and where the Central-West region has the lowest rate, 43.83% for the same year. Four out of five cases of disease are caused by water contamination and the lack of appropriate sewage treatment.

From 2001 to 2005, in the total number of permanent private households the proportion of dwellings with proper sanitary sewage grew from 66.8% to 70.4%. The proportion of houses served by a sewage collection network grew continuously, from 45.4% to 49.0%, from 2001 to 2005.

Water supply is another major urban sanitation problem in the country. The geographical regions display enormous differences, as do the rural and urban zones. The proportion of homes served by a general network went up from 81.1% in 2001 to 83.4% in 2005.

Another source of problems in major urban centers is urban solid waste from the household and industrial sectors. Garbage collected and improperly disposed of in open air landfills and in marsh areas causes health problems and water contamination. When a toxic load is involved, generally from industrial and agricultural settings, environmental consequences for human health and for the preservation of fauna and flora are more significant. Disposal is a problem: incineration is expensive and also poses risks of contamination; recycling is not always possible, given the quality of the waste or collection and transportation costs. Only 8% of Brazil's municipalities maintain selective garbage collection programs; 62% collect hospital waste; however, 34% of those do not submit it to any treatment. From 2001 to 2005, the percentage of homes with garbage collection service grew from 83.2% to 86.8%.

Access to proper basic sanitation makes the population less vulnerable to water-transmitted diseases. There is a high correlation between child mortality rates and the lack of sanitation services.

Despite the increase in the percentage of people with simultaneous access to proper water, sewage and garbage collection, the lack of proper basic sanitation still afflicted 28.7% of Brazil's urban population in 2004. Coverage levels are lower in Brazil's North and Central-West regions. Among Brazil's

13 Sanitary sewage consists of an appropriate system for collecting, treating and disposing of dejects generated by human, commercial and industrial activities.

states, the biggest declines in population numbers with improper basic sanitation were reported in the states of Tocantins, Amazonas, Espírito Santo, Paraná, and Rio Grande do Sul. In turn, the states of Amapá and Alagoas had the worst performances, with an increase of more than 12 percentage points in the number of people dwelling in homes with inadequate basic sanitation between 2001 and 2004. The pollution potential from this lack of sewage treatment is worsened by the lack of proper disposal for a great part of collected solid waste. Despite the improvement in the indicators, access to proper basic sanitation is still very unequal in both regional and social terms.

Table 1.12 Proportion of sanitary sewage, water supply and garbage collection in urban and rural zones, divided by geographical region, in 1991 and 2006.

	Proportion of sanitary sewage (%)				Proportion of water supply (%)				Proportion of garbage collection (%)			
	1991		2006		1991		2006		1991		2006	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
Brazil	8.84	61.8	20.27	77.85	9.31	86.98	29.01	97.03	5.29	77.98	24.63	97.15
Southeast	15.63	79.57	30.57	91.52	11.71	93.17	29.01	97.03	8.16	85.77	41.77	99.04
South	16.55	63.2	45.17	83.3	7.37	90.26	31.92	95.04	5.05	86.44	39.42	99.23
Northeast	3.88	35.3	9.76	61.51	9.53	78.39	29.32	90.85	3.69	62.56	14.51	92.96
North	8.26	34.83	19.67	60.31	8.52	67.99	15.57	89.33	7.83	52.9	19.2	92.82
Central-West	3.35	40.85	6.71	49.64	5.05	78.97	16.92	69.02	3.27	75.08	20.14	98.72

Source: Elaborated from SIDRA/IBGE data. Available at: <http://www.sidra.ibge.gov.br/>.

1.5 Summary of National Circumstances

Overall, despite its progress in economic and social indicators in recent years, Brazil is a country with a growing population, where most of the population's basic needs have yet to be met, infrastructure is still incipient and substantial improvements are required. All this justifies the fact that Brazil is still a developing country.

Table 1.13 Summary of National Circumstances

Criteria	1994	2000	2005	2008
Population (millions of inhabitants)	153.0[1]	169.8[2]	179.9[3]	186.0[3]
Corresponding surfaces (km^2)	8,514,876.6	8,514,876.6	8,514,876.6	8,514,876.6
GDP (billion US$ 2007/year)[4]	920.7	1,062.0	1,218.3	1,406.5
GDP per capita (thousand US$ 2007/inhab.)[4]	6.02	6.25	6.77	7.56
Informal sector's share of GDP (%)	NA	12.98%	NA	NA
Industry's share of GDP (%)[4]	26.1	26.9	29.3	28.8 (2006)
Services' share of GDP (%)[4]	67.3	68.0	65.0	65.8 (2006)
Agriculture's share of GDP (%)[4]	6.7	5.1	5.7	5.5 (2006)
Surface for agricultural use (km^2)[5]	2,206,790	2,190,883	2,186,818	NA
Urban population as a percentage of total population (%)	77.3[1]	81.2[2]	83.3[6]	84.4[6]
Number of head of cattle (millions) [7]	158.2	169.9	207.2	202.3
Forest surface (km^2) [8]	5,582,197	5,407,6747	5,247,288	5,121,048
Number of inhabitants in extreme poverty (millions)[9]	32	22	15	9
Life expectancy at birth (years)[10]	66.4	68.6	71.9	72.9
Literacy rate (%)[10]	84	86.4	86.8	89.3 (2006)

Notes:
NA: Not available.
1 – IBGE, linear interpolation between the 1991 Census and the 1996 Population Count.
2 - IBGE, 2000b.
3 – IBGE, linear interpolation between the 2000 Census and the 2007 Population Count.
4 – IBGE, 2009b.
5 – SIDRA. Municipal Livestock Survey (total area of farms by land use). Data for 1994, 2000 and 2005 obtained through interpolation.
6 – Due to the lack of an urban population estimate in the 2007 Population Count, this was estimated at 84% of the total, based on the evolution of the urban proportion from previous official figures, thus allowing for an estimate of the same fraction for 2005 and 2008.
7 – Available at: <http://www.sidra.ibge.gov.br>.
8 – FAO, 2010 (data for 1994 obtained through interpolation).
9 – IPEA, 2010a; IPEADATA (<http://ipeadata.gov.br>).
10 – IBGE, 2000b; 2006a; 2007a; 2007b; 2008; 2010 (<http://www.ibge.gov.br/home/mapa_site/mapa_site.php# populacao>).

Chapter 2

Mercosur

2 MERCOSUR

2.1 Background, Objectives and Main Characteristics

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

However, the greatest stimulus to integration occurred on March 26, 1991, with the creation of the Southern Common Market - Mercosur, which was the outcome of a long process of building closer relations between Brazil, Argentina, Paraguay, and Uruguay. Its objective was set out by the "Treaty of Asunción for the Constitution of the Southern Common Market," and reaffirmed in the Protocol of Ouro Preto, of December 17, 1994, which are the main legal instruments of the integration process.

The Treaty of Asunción constitutes a framework agreement, that is, an instrument to be continuously complemented by additional instruments, negotiated by the four member States, as a function of progress in integration. The Treaty fundamentally established the conditions for achieving the Common Market by December 31, 1994. In this regard, the Treaty establishes, among other aspects, the following:

- establishment of a free trade program, comprised of progressive, linear and automatic tariff reductions, accompanied by the elimination of non-tariff barriers;
- coordination of macroeconomic policies;
- establishment of a Common External Tariff – CET;
- establishment of a list of exceptions for the liberalization program for products considered sensitive; and
- creation of a general regime of origin and a dispute resolution system.

With the signing of the Protocol of Ouro Preto, the so-called Mercosur transition period came to an end. The Protocol gave to the integration process all the elements of a complete Customs Union. Mercosur gained a definitive institutional structure for the negotiation and deepening of the integration towards the desired Common Market.

2.2 Institutional Structure

At the Ouro Preto Summit, Mercosur's institutional structure was defined in more detail; in other words, besides the basic structure, the decision-making bodies, the specific attributions of each, and their decision-making system were established. Mercosur's current structure has about fifty negotiating *fora*, some exclusively technical in nature, and others with political or executive functions.

The Protocol of Ouro Preto also established Mercosur's international legal personality, which enables the block to acquire rights and be subject to obligations as an entity distinct from its member countries. In practice, this means that Mercosur can negotiate international agreements as a bloc.

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

2.3 Mercosur's Basic Indicators

Mercosur is now an economic reality on a continental scale: a total area of more than 11 million square kilometers (more than 58% of Latin America's territory); a market of more than 210 million inhabitants; and a cumulative GDP of more than 1.6 trillion dollars.

The region is one of the main centers for foreign investments in the world, an important reserve of the planet's natural resources, and a considerable source of energy resources. The bloc's agricultural potential is another striking characteristic. Mercosur figures among the largest global producers of wheat, coffee, cocoa, citrus, rice, soy, milk, and meat.

Since its foundation, Mercosur has been consolidating it operations and achieving significant results, contributing towards the creation of a receptive climate for trade expansion.

Chapter 3

Relevant Institutional Arrangements for Elaborating the National Communication on Permanent Bases

3 Relevant Institutional Arrangements for Elaborating the National Communication on Permanent Bases

3.1 Institutional Framework

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

Brazil was the first country to sign the United Nations Framework Convention on Climate Change – UNFCCC at Rio-92. Later, 193 other Parties (including the European Union) joined the Convention, which is an indication of its virtually universal nature. The Convention entered into force on March 21, 1994, ninety days after the deposit of the fiftieth instrument of ratification by the countries' parliaments. In Brazil, the UNFCCC was ratified by the National Congress on February 28, 1994, and it entered into force ninety days later, on May 29 of that same year.

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

3.1.1 The Interministerial Commission on Sustainable Development

In June 1994, the Brazilian government established an Interministerial Commission on Sustainable Development - CIDES[14]. CIDES was chaired by the Ministry of Planning and Budget and was composed of representatives from other ministries. The objective of the CIDES was to provide assistance to the President of the Republic in decision-making about national strategies and policies geared towards sustainable development, in a manner compatible with Agenda 21, in light of the complexity of this task and the need to involve a large number of institutions.

3.1.2 The General Coordination on Global Climate Change

The responsibility for coordinating the implementation of commitments resulting from the UNFCCC was given to the Ministry of Science and Technology – MCT by Presidential Decree nº 1.160/1994. Thus, in response to the mandate granted by CIDES, the General Coordination on Global Climate Change[15]- CGMC, was created, within the structure of the MCT, in August 1994, and to whom this responsibility was given.

During its first years of operations, the main task of the CGMC was to coordinate the preparation of Brazil's Initial National Communication to the United Nations Framework Convention on Climate Change, according to those commitments assumed under the Convention. The elaboration of the National Communication is a multidisciplinary effort, which involved in its first edition around 150 institutions and 700 specialists from every region of the country. The Communication poses a great challenge, taking into account the need to build national capacity in the area, since in many cases it represents pioneer and complex work.

Due to its scope and specificity, and considering that emissions of the main greenhouse gases (CO_2, CH_4, N_2O, HFCs, CF_4, C_2F_6, SF_6) from the energy, industrial, forestry, agricultural and livestock and waste treatment sectors are addressed, the preparation of Brazil's Inventory of Anthropogenic Greenhouse Gas Emissions by Sources and Removals by Sinks of Greenhouse Gases Not Controlled by the Montreal Protocol involves a number of ministries (Ministry of the Environment; Ministry of Agriculture, Livestock and Food Supply; Ministry of Mines and Energy; Ministry of Development, Industry and Foreign Trade - MIDIC, etc.), federal institutions (Petrobras, Eletrobrás, Embrapa, INPE, among others) and state institutions (Cetesb, Cemig, among others), trade associations (ABAL, ABEGÁS, ABIQUIM, Bracelpa, Unica, Copersucar, White Martins, among others), non-governmental organizations (Funcate, Fundação José Bonifácio, among others), universities and research centers (COPPE/UFRJ, USP, UFRS, UnB, among others).

Brazil concluded and published its initial inventory in 2004. National greenhouse gas emissions covering the 1990-1994 period were inventoried, and they were summarized based on 15 reference studies.

The International Energy Agency – IEA compared the inventories from the main developing countries. The IEA evaluation of Brazil's inventory was extremely positive, thus underscoring that the inventory's main qualities are transparency, development of time series (although short) and use of more elaborate national emission factors. From an institutional perspective, this reflects the fact that Brazil was able to set up a competent structure for elaborating inventories.

14 Presidential Decree nº 1,160, of June 21, 1994.

15 So called Coordination of Research on Global Changes, when it was created.

The CGMC was also in charge of coordinating activities related to Brazil's Second National Communication to the Convention. In terms of work division for the second inventory, the Ministry of Mines and Energy coordinated the energy sector; Funcate was in charge of the forestry and land use sector; EMBRAPA, the agriculture and livestock sector; CETESB, the waste treatment sector; and the coordination of the industrial sector was up to each of the main trade associations, such as aluminum (Brazilian Aluminum Association - ABAL), cement (National Cement Industry Union - SNIC), steel (Brazilian Steel Institute - IABr), chemical (Brazilian Chemical Industry Association - ABIQUIM) and coal (Brazilian Coal Association - ABCM).

Besides coordinating the implementation of Brazil's commitments under the Convention, the CGMC participates in negotiations on implementation issues and technical and scientific aspects that are discusses in the subsidiary bodies of the Convention (Subsidiary Body for Implementation - SBI and Subsidiary Body for Scientific and Technological Advice – SBSTA, and others).

Since 1995, the CGMC has actively participated in the discussions that led to the adoption of the Kyoto Protocol, in December 1997, in Japan, particularly in the document submitted by the Brazilian government to the Convention to subsidize the elaboration of the Protocol. Such a document proposed the creation of a Clean Development Fund, which was modified and then adopted as one of the Protocol's articles (Article 12, on the Clean Development Mechanism – CDM). It also proposed a new criteria for sharing the burden of mitigating climate change based on the historic responsibility of industrialized countries in causing the increase in temperature.

Since then, the CGMC has participated in discussions of technical and scientific issues related to the regulation and implementation of the Protocol, in conjunction with the Ministry of External Relations.

Additionally, Brazil's commitments under the Convention include promoting and cooperating in scientific, technological, technical, socioeconomic and other research, in systematic observations and in the development of a climate system database with a view to explaining and reducing or eliminating the remaining uncertainties related to the causes, effects, magnitude and changes over time of climate change and the economic and social consequences of various response strategies.

Within the scope of the Brazilian government, the CGMC coordinates the review of the scientific assessments conducted by the Intergovernmental Panel on Climate Change - IPCC with the growing support of the scientific community, and it also actively participates, together with the Ministry of External Relations, in the Panel's plenary sessions, providing the Brazilian government's perspectives in the discussion and approval of the IPCC reports.

Another important area of activities of the CGMC is building public awareness of climate change related issues. A homepage on climate change (http://www.mct.gov.br/clima) was created within the Ministry of Science and Technology's website to facilitate the integration of all the experts and institutions involved. This homepage serves as a forum for bringing together experts from different sectors that can accompany and contribute to the work, as well as opening up a space for society in discussing climate change related issues[16].

Furthermore, the CGCM promotes and supports events on global climate change in the various areas related to the issue, and publishes and disseminates relevant information, especially regarding the Convention, the Protocol and the IPCC. It thus seeks to develop and disclose legal, technical and scientific information, as well as participate in discussion on global warming, its causes and impacts, aimed at building awareness among opinion leaders, policy-makers, business leaders, students and the general public about the problem.

3.1.3 The Interministerial Commission on Global Climate Change

The perspective of the Kyoto Protocol entering into force and of the regulation of the Clean Development Mechanism – CDM highlighted the importance of establishing an entity within the Brazilian government that could channel this potential towards national development priorities. Furthermore, the concern for greater institutionalization of the climate change issue in the country due to its strategic characteristics, led to the creation[17] of the Interministerial Commission on Global Climate Change – CIMGC, aimed at 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 commitment related to the United Nations Framework Convention on Climate Change, this body was chosen to chair the Commission and to serve as its Executive Secretariat, since the scientific aspects of global climate change will continue, in the foreseeable fu-

16 See Part IV, Section 3.4.1, on Official Website on Climate Change.
17 By Presidential Decree of July 7, 1999, amended by the Decree of January 10, 2006.

ture, to dominate the political negotiations, and scientific knowledge necessary to subsidize 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 CGMC 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 External Relations - MRE and of Science and Technology - MCT, which are the political and technical focal points, respectively, on global climate change in Brazil; ministries with specific attributions and responsibilities over important sectors for greenhouse gas emission reduction activities in Brazil, such as Agriculture, Livestock and Food Supply - MAPA; Transportation - MT; Mines and Energy - MME; Environment - MMA; Development, Industry and Foreign Trade - MDIC; and Cities - MCid; as well as ministries with more strategic and long-term vision, such as Planning, Budget and Management - MPOG; Finance - MF; and the Executive Office of the Presidency of the Republic ("Casa Civil da Presidência da República"). The decree also 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 – issue opinions, when requested, about proposals for sectoral policies, legal instruments and regulations that contain any relevant component for mitigating global climate change and to the adaptation of the country to its effects;

II – provide support to the positions of the government in negotiations under the auspices of the Convention 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 Kyoto Protocol to the UNFCCC, according to national sustainable development strategies;

IV – consider opinions about projects that result in reduction of greenhouse gas emissions and that are considered eligible under the CDM, 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 Convention and the subsidiary instruments to which Brazil is a Party.

The Interministerial Commission thus represented an initial effort in the sense of bringing together government actions related to global climate change. Furthermore, it is important to highlight that the Interministerial Commission is Brazil's Designated National Authority - DNA[18], being in charge of evaluating and approving project activities under the Clean Development Mechanism - CDM in Brazil.

CDM project activities shall be elaborated in accordance with the rules defined by decision 17/CP.7 (later, ratified by decision 3/CMP.1) that establishes CDM's procedures and modalities, which were incorporated into the Brazilian legal system through resolution nº 01 of the Interministerial Commission on Global Climate Change on September 11, 2003. The CIMGC has developed and issued resolutions with the objective of incorporating approval requirements for CDM project activities in the country that have been internationally established by the decisions of the Conference of Parties serving as the Meeting of the Parties to the Kyoto Protocol and by its Executive Board, as well as establish additional criteria for approving CDM project activities in Brazil. It should be pointed that the CIMGC, considering that it was the CDM's first DNA to be created in the world, has served as a model for creating many other DNAs, which led to cooperation activities in this regard between Brazil and other developing countries[19].

All of the eligible CDM project activities are duly reviewed by the CIMGC in relation to the projects' contribution criteria towards the country's sustainable development.

All material related to the CIMGC, as well as about all CDM project activities in Brazil, is available on the Executive Secretariat's home page (http://www.mct.gov.br/clima), which is the CGMC. Information is also periodically published on CDM's status in Brazil and in the world[20].

3.1.4 The Interministerial Committee on Climate Change - CIM

In 2007, the Federal Government created the Interministerial Committee on Climate Change – CIM[21] with the task of steering the development, implementation, monitoring and evaluation of the National Plan on Climate Change, among other functions.

18 In accordance with Article 3, clause IV, of Presidential Decree of July 7, 1999, amended by the Decree of January 10, 2006.

19 See Part IV, Section 4.10, on South-South Cooperation.

20 See Part III, Section A.4, on the Current Status Of Project Activities Under The Clean Development Mechanism - CDM in Brazil and in the World.

21 Presidential Decree nº 6,263, of November 21, 2007.

The CIM is coordinated by the Executive Office of the Presidency of the Republic and it is composed of seventeen federal bodies and the Brazilian Forum on Climate Change - FBMC[22]. The federal bodies are as follows: Ministry of Agriculture, Livestock and Food Supply; Ministry of Science and Technology; Ministry of Defense; Ministry of Education; Ministry of Finance; Ministry of National Integration; Ministry of Health; Ministry of Cities; Ministry of External Relations; Ministry of Mines and Energy; Ministry of Agrarian Development; Ministry of Development, Industry and Foreign Trade; Ministry of Environment; Ministry of Planning, Budget and Management; Ministry of Transportation; and the Center of Strategic Affairs of the Presidency of the Republic.

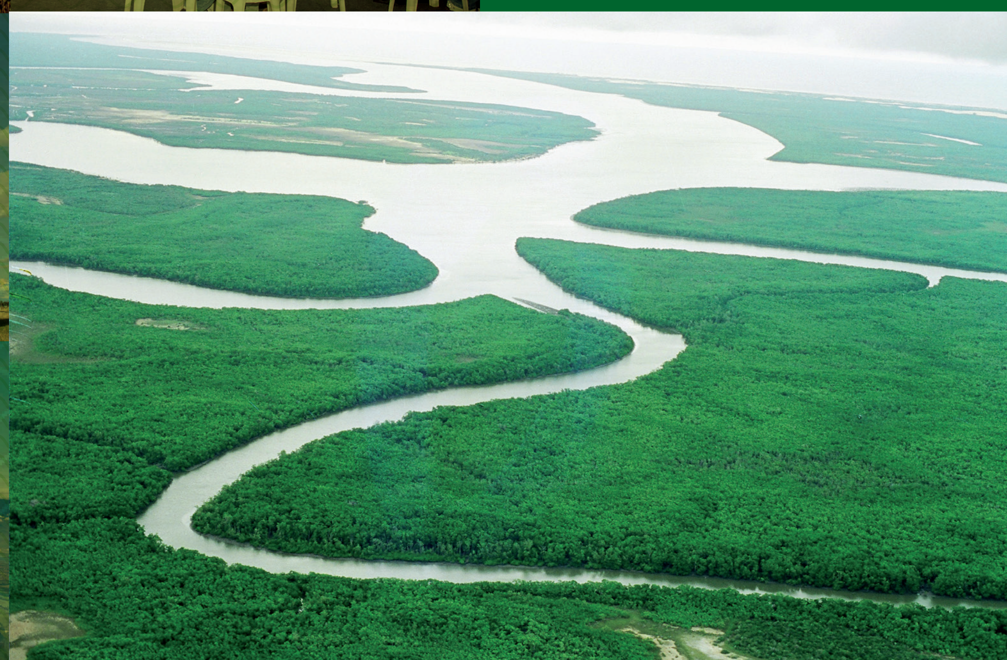
The Executive Group on Climate Change - GEx, under the CIM, which is coordinated by the Ministry of Environment, was in charge of developing, implementing, monitoring and evaluating the National Plan on Climate Change.

22 See Part IV, section 3.3, on the Brazilian Climate Change Forum.

The GEx was given the task of drafting the preliminary proposal of general objectives, principles and guidelines for the National Policy on Climate Change, as well as the preliminary version of the National Plan on Climate Change, following the guidelines established by the CIM. After extensive public consultation, the National Plan on Climate Change was launched in December 2008. The National Policy on Climate Change was enacted into law[23] in December 2009[24].

It is worth highlighting that Brazil's National Communication to the United Nations Framework Convention on Climate Change, according to the criteria established by this Convention and by its Conference of Parties, is considered one of the instruments of the National Policy on Climate Change[25].

23 Law nº 12,187, of December 29, 2009.
24 See Part III, Section A.3.4, on the National Policy on Climate Change.
25 Article 6, clause IV, of Law nº 12.187, of December 29, 2009.



Chapter 4

Special Circumstances

4 Special Circumstances

The objective of this section is to examine 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, paragraph 8 of the United Nations Framework Convention on Climate Change.

4.1 Brazilian Biomes

4.1.1 Coastal Ecosystems

Brazil's Coastal Zone encompasses various climatic environments (wet equatorial, tropical, semi-arid and subtropical), from latitude 5º16′ North to latitude 33º44′ South. It has a diversified geological formation and various geomorphological shapes. The coastline changes direction significantly (from SW-NE in the South, to W-E in the state of Rio de Janeiro, S-N from Espírito Santo to Rio Grande do Norte, ESE-WNW in the Northeast and NNW-SSE in the state of Amapá), with a total extension of approximately 12,400 km considering the boundaries of the main bays, the large islands of the Marajó archipelago, São Luís and Santa Catarina, and the boundaries of Lagoa dos Patos. The watersheds that feed the Coastal Zone have several geographical dimensions and characteristics, such as the Amazon River Basin, the seasonal rivers in the Northeast, the São Francisco, Doce, Jequitinhonha and Paraíba do Sul Rivers, the Atlantic watersheds, limited by the Serra do Mar mountains, and the Lagoa dos Patos basin. Thus, climate changes that occur on the continent as well as in the Atlantic Ocean (extratropical cyclones in the South, the Intertropical Convergence Zone, tropical storms and extratropical cyclones in the Northern Hemisphere) will potentially have important consequences in the coastal region. For legal purposes, the Coastal Zone is comprised of a maritime band that is 12 nautical miles wide, and a land band limited by the municipalities washed by the sea or estuary environments, corresponding to an average width of 50 km and surface of 535,000 km^2 (VIDIGAL, 2006 *apud* NEVES & MUEHE, 2008). Therefore, the effects of climate change on the Coastal Zone are much broader than those caused by the thermal/eustatic rise in sea level.

Brazil has 17 states washed by the sea (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). This extensive coastline is home to a rich mosaic of ecosystems – estuaries, islands, mangroves, shoals, dunes, beaches, sea cliffs, rocky coasts and coral reefs. The Coastal Zone is a privileged portion of Brazilian territory in relation to natural, economic and human resources.

The Brazilian coast can be divided into four major areas:

- The Amazonian coast, which stretches from the Oiapoque River to the Parnaíba River delta. It has a long extension of exuberant mangroves as well as tidal floodplain forests, dune fields and beaches. It has a rich biodiversity in crustacean, fish and bird species.

- The northeastern coast begins at the mouth of the Parnaíba River and continues to the Bahia Bay. It is marked by limestone and sandstone reefs, as well as dunes, which move with the wind when they lose the vegetation cover that secures them. There are also mangroves, shoals and forests in these areas. The waters of the northeast coast are home to the manatee and turtles, both endangered species.

- The southeastern coast goes from Bahia Bay to the estate of São Paulo. It is the most densely populated and industrialized part of the country. Its features include sea cliffs, reefs and beaches with monazitic sands. It is bounded by the Serra do Mar mountains and it has a very jagged coastline, with several bays and small coves. The most important ecosystem in this area is the shoal forest. This part of the coast is inhabited by the maned sloth and the golden lion tamarin, two more endangered species.

- The south coast begins in the state of Paraná and ends at Arroio Chuí, in the state of Rio Grande do Sul. With many grassy marshes and mangroves, this ecosystem is very rich in birds, but it is also home to other species, like the coypu, otter (also an endangered species) and capybaras.

In the following subsections, emphasis shall be given to the oceanic islands and mangroves, since they are extremely vulnerable ecosystems to global climate change, as well as issues related to human interference in these ecosystems, such as ports and terminals and human occupation along the coast. In Part III of this Communication, some of the effects of global climate change on sea and land ecosystems will be discussed.

Maritime Islands

Considering the length of the Brazilian coast, the number of existing islands is significant. From an environmental perspective, the islands are known for their unique flora and fauna, which are particularly vulnerable to disturbances and destruction of anthropogenic nature. The islands are particularly vulnerable to climate change due to the potential sea level rise resulting from global warming.

The study of islands is still little disseminated in Brazil. Little information on animals and vegetation is available, and so is specific data on island geomorphology and geology. Studies on the vulnerability of Brazilian islands to sea level rise resulting from climate change have yet to be developed.

In future studies, criteria related to population, area and altitude for preliminary profiling of the Brazilian coastal islands should be combined with the classification of the coast. With regard to the population, all of the islands with urban centers shall be especially considered (high risk is involved). It is also important to consider the type of coast on which the island is located to infer important geological and geomorphological information for ascertaining floodable areas. The tidal regime is a factor of great importance against the altitude. For example, the islands at low altitudes in the macrotidal regime are more compromised than islands at the same altitude with a mesotidal regime.

The Brazilian coast can be divided in terms of three types of tidal regimes, encompassing the states below:

- macrotide: from Amazonas to Rio Grande do Norte;
- mesotide: from Rio Grande do Norte to Bahia; and
- microtide: from Espírito Santo to Rio Grande do Sul.

The main Brazilian maritime islands are listed in Table 4.1, with information about its area and location.

Table 4.1 Main Brazilian maritime islands

Name	Area	Location		
	(km^2)	States	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.

Mangroves

Mangroves are widely 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 in the North) using Landsat images, nautical charts and several maps. Studies have identified five main tree species in these areas: *Rhizophora mangle, Avicennia schaueriana, Avicennia nitida, Laguncularia racemos*, and *Conocarpus erectus.* These species extend from Cape Orange, located at 4º N, to latitude 28º 20' S.

This ecosystem represents 8% of the planet's total coastline and one-fourth of the tropical zone coastline, for a total of 181,077 km^2. It must be pointed out that Brazil is ranked second in mangrove area extension (13,400 km^2), only trailing Indonesia, which has 42,550 km^2, distributed over its archipelagos (SPALDING *et al*., 1997 *apud* SOUZA FILHO, 2005).

The mangroves support the biological chain of marine fauna and also retain sediment, frequently preventing or reducing sedimentation problems at ports (MUEHE & NEVES, 1995). Depending on the relationship between topography, sediment supply and sea level, the communities that inhabit mangroves can diminish or grow, while the proportion of different species can vary. These variations can be investigated for different scenarios using a combination of physical and biological models, but insufficient data and knowledge currently hamper their application in Brazil. Simple methods are thus recommended, such as continuous mapping of mangrove areas and adoption of legislation to protect and study the evolution of these areas.

Ports and Terminals

Port services seek to essentially meet the demand generated by flows resulting from Brazil's foreign trade. Nearly 90% of the freight commercialized with other countries flow through the ports. Ports not only represent the point of entry and exit of merchandise, but they are also drivers of development in their areas of coverage, and are therefore strategic to the country.

The growth of general freight activity at Brazil's organized (public) ports and private terminals between 2003 and 2007 reveals an average annual growth of 7.2%, and total freight activity at Brazil's ports/terminals in 2007 was 754,716,655 tons. Private terminal share in 2007 represented 63.1%, while for organized (public) ports this was around 36.9%, therefore maintaining their same shares since 2003. Greater concentration at terminals stems from bulk activity, especially iron ore and oil byproducts.

The map in Figure 4.1 shows the geographic position of all of the country's ports (coastal and inland ports) in 2007.

Figure 4.1 Map of Brazil's main ports (coastal and inland ports)

Source: ANTAQ, 2007.

Variations in sea level can entail consequences in port structures (for example, breakwaters, mooring buoys, dikes), just like in port operations (for example, time between drags, extent of oscillations in mooring areas, frequency of flooding).

When considering a hypothetical one-meter increase in sea level, several ports would be flooded or their freeboard (height above high tide level) would be reduced to less than 0.5 m. In Macapá, which is influenced by the Amazon River discharge and the high oceanic tides, flooding in the port area already poses a problem. In the North and Northeast regions, three ports (Macapá, Itaqui and Cabedelo) could be flooded and five ports (Belém, Fortaleza, Recife, Maceió, and Salvador) have reduced their freeboards; all of these handle all types of freight and, with the exceptions of Fortaleza and Maceió, are located in bays or estuaries. In the South and Southeast regions, three ports (Vitória, Angra dos Reis and Paranaguá) could flood and four ports (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 sort of improvement would most probably be needed. Considering the location of these ports and their economic importance for the region, it seems clear that the North and Northeast regions are more vulnerable than the South and Southeast regions.

The Suape port, 35 km south of Recife, is the first example in Brazil where a potential rise in the sea level was considered during its construction. An additional elevation of 0.25 m was included in the port structure design based on the preliminary results of variations in sea level in Recife, considering a 50-year horizon.

Other effects should also be considered. Higher sea levels allow waves to reach the coast at greater heights due to less friction with the bottom. Wave force is proportional to the second or third order of wave height. Thus, a 10% increase in wave height increases the stress on pillars by 20%, and increases the weight of rock blocks used in breakwater constructions by 30%. These changes would be particularly important for ports located on the open sea coast, such as Recife and Suape, Ilhéus, Praia Mole, and Imbituba, or on artificial islands, such as Areia Branca and Sergipe.

Changes in sediment flows and deposition patterns also interfere with port operations. Santos, located in an estuary, has a long history of problems with saline intrusion, estimated at 1.5 million m^3/year of fluvial sediment and 0.3 million m^3/year of marine sediment. Belém and Itaqui are both located in estuaries with high tidal variations and significant movement of sediment. In Belém, the average annual volume of dredged sediment is around 1.0 million m^3, while there seems to be no problem in Itaqui. Rio Grande is at the mouth of Lagoa dos Patos, where astronomical tide is negligible and flow conditions are determined by meteorological conditions in the ocean and lagoon, and saline intrusion is around 0.35 million m^3/year. Sedimentation rates and places can vary with changes in sea level. Along the open sea coast, an increase in sand transport rates along the coast should be expected as a consequence of bigger waves, where Recife is an example. Three locations where severe deposition can already be seen in the access channel are: Fortaleza (0.6, 1.6 and 2.5 million m^3/year in 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 watershed evolution).

Increases in wave heights have already been described in the North Atlantic. Similar changes in the South Atlantic would be reason for concern for the off-shore oil industry that supplies most of the oil and natural gas produced in Brazil, as well as for all coastal structures.

Human Occupation along the Coast

The population's geographical distribution along the coastal states is quite diversified. Taking into consideration only the micro regions located in the Coastal Zone considered by IBGE, and in those the municipalities that are washed by the sea or are located in estuary environments, the percentage of the Brazilian population actually living in the Coastal Zone is around 22% to 25%, a figure that has remained stable since the 1980 Census. This goes against the usually accepted notion of a country whose population is concentrated along the coast. Three categories of Brazilian states can be identified: those with less than 10% of the population in coastal municipalities (São Paulo, Paraná and Piauí); those with more than 60% (Rio de Janeiro and Amapá); and those with 20%-50% (others). In order to plot human occupation along the coast, one can adopt spatial demographic density or the index called "Coastline Extension Population - PLC," which consists of the ratio between the population in coastal municipalities in a micro region and the coastline extension (in kilometers) of that micro region. According to the 2007 population count, approximately 7,100 km of Brazil's coast has PLC values under 1,000 inhabitants/kmLC. i.e., uninhabited regions, and thus vulnerable to improper or environmentally fragile occupation. Nearly 3,700 km is occupied by 1,000-5,000 inhabitants/kmLC, which corresponds to small municipalities; approximately 500 km have a PLC value of 5,000-10,000 inhabitants/kmLC, which corresponds to medium–sized cities and only about 1,000 km has a PLC value above 10,000 inhabitants/kmLC, a category that encompasses the major state capitals along the country's coastline.

Data from the 2000 Demographic Census indicates that the Coastal Zone had 395 municipalities (IBGE, 2000b). Of the total number of coastal municipalities, 179 (45.3%) were classified as small (populations under 20 thousand inhabitants). These were primarily located in the South (57.33%) and Northeast (47.9%) regions, forming dozens of traditional clusters with economies based on agriculture, livestock, fishing and, more recently, shrimp farming[26] and tourism and leisure activities.

Mid-sized cities, with populations between 20 and 100 thousand inhabitants, predominated in the Northeast (56.8%) and the Southeast (19.3%) regions, the two regions that were historically occupied during the colonial period. These municipalities revealed a still incipient urban socioeconomic profile, which has intensified in recent years due to tourism and real estate developments along the coast. On the other hand, municipalities with more than 100 thousand inhabitants, which are considered large, are primarily located in the Southeast (40.9%) and Northeast (39.3%) regions, thus forming a complex network of highly urbanized spaces, but lacking in socio-environmental quality. In these populated urban systems, industrial, commercial and service activities predominate. They are thus the places of greatest socioenvironmental vulnerability (STROHAECKER, 2008).

The Brazilian Coastal Zone can thus be considered to be a region of contrasts. There one can find areas with intense urbanization, important port and industrial activities and large scale tourism (cases of the coastal cities and regional centers located largely in estuary and bay regions, areas that saw the early moves of Brazil's occupation). On the other hand, there are also areas of low density occupation and ecosystems with great environmental significance, which, however, have been subject to an rapid occupation process.

In this context, the Ministry of Environment, in cooperation with the Interministerial Sea Council, state governments, the Brazilian Institute of the Environment and Renewable Natural Resources - Ibama and other institutions, seeks to organize and protect the ecosystems by implementing the National Plan of Coastal Management - PNGC[27].

26 Shrimp farming is the cultivation of shrimp in hatcheries for human consumption.

27 The PNGC was constituted by means of Law nº 7.661, of May 16, 1988. Its details and operationalization were the object of Resolution nº 01 of the Interministerial Commission for Sea Resources - CIRM, of November 21, 1990, approved after a National Council for the Environment hearing - Conama. See: <http://www.mma. gov.br/estruturas/sqa/_arquivos/pafzc_out2005.pdf>.

4.1.2 Amazon

In Brazilian territory, the Amazonian ecosystems cover the states of Acre, Amapá, Amazonas, Pará, Rondônia, and Roraima, and part of the states of Maranhão, Tocantins and Mato Grosso. The Amazon is recognized as the largest existing tropical forest, totaling 1/3 of the tropical rainforest reserves and the largest genetic bank on the planet. It has 1/5 of the world's freshwater and unmeasured mineral assets.

The great geological diversity, plus its unique relief, resulted in the formation of the most varied classes of soil under the influence of high temperatures and rainfall, which are typical of the warm super humid and humid equatorial climate. However, the natural fertility of the soil is poor, contrasting with the exuberance of the rainforests in which they grow.

The forest, despite being the most notable feature of the Amazon, does not hide its great variety of ecosystems, among which the most prominent are upland forests, flooded forests, flood plains, grasslands, and Cerrado. Consequently, the Amazon is home to countless vegetation and animal species.

Nowhere on earth do more animal and vegetation species exist than in the Amazon, in terms of species inhabiting the region as a whole as well as those coexisting in a single location. However, although the Amazon is the region with the greatest biodiversity on the planet, only a fraction of this biodiversity is known.

According to Museu Paraense Emílio Goeldi - MPEG[28] records, the wealth of Amazon flora encompasses nearly 30,000 species, nearly 10% of all vegetation species on the planet. Tree diversity ranges from 40 to 300 different species per hectare.

In relation to arthropods (insects, spiders, scorpions, millipedes, etc.), estimates by the Museu Emílio Goeldi team of researchers show that more than 70% of the Amazonian species do not yet have a scientific name, and considering the current pace of studies and taxonomy works, this situation will remain the same for long time. There are records of 1,800 species of butterflies and over 3,000 species of ants are estimated to exist, as well as something between 2,500 and 3,000 species of bees.

28 The Museu Paraense Emílio Goeldi - MPEG is a research institution under Brazil's Ministry of Science and Technology. It is located in the city of Belém, state of Pará, in the Amazon region. Since its foundation in 1866, its activities have focused on the scientific study of the Amazon's natural and sociocultural systems, as well as the diffusion of knowledge and collections related to the region. See: <http://www.museu-goeldi.br/institucional/ index.htm> and <http://www.museu-goeldi.br/biodiversidade/index.asp>.

The Museu Emílio Goeldi also estimates that there are 1,300 species of fish for the entire Amazon River watershed, where 450 different species have been identified in the Negro River alone. Records of 163 species of amphibians; 240 species of reptiles, many of which are restricted to the Amazon or part of it; more than 1,000 species of birds, of which 283 have restricted distribution or are very rare; and 311 species of mammals deserve special mention.

Several studies conducted in the Amazon, particularly under the Large Scale Biosphere-Atmosphere in the Amazon - LBA[29], reflect a unique dynamic in the Amazon forest that sometimes acts as a source of carbon and sometimes as a carbon sink. Some recent findings support the view that the Amazon forest is acting as a carbon sink, in particular the findings in the study in permanent parcels established at the Ducke Reserve[30]. This study has shown that even the natural forest is acting as a sink, although this is not consistent in all areas, depending on soil type and other variables.

Findings of studies in Brazil have also shown that an average temperature rise of 3ºC to 4ºC in the Amazon by 2100 would have a significant impact on the forest, which is not adapted to temperatures above 40ºC. It is estimated that the natural vegetation would be replaced by another vegetation similar to the Cerrado, which endures higher temperatures.

The use and occupation of land in the Amazon is characterized by plant and animal extractivism — including logging by lumber companies — by livestock and subsistence agriculture, as well as the growing of shrubby and tree species. Grain production covers significant continuous parcels. Mining and gold fields (sporadic activities) and regional infrastructure (sporadic and linear activities) are also responsible for alterations in natural ecosystems. In the areas surrounding urban centers and older occupation areas, a considerable part of the land, once deforested, is now covered by secondary vegetation or native forest in their various stages of growth and regeneration.

Nature's conservation instruments in the Amazon are ecosystem management, protected areas and the study and preservation of species of fauna and flora.

The Amazon plays a crucial role in controlling rainfall and moisture in most of the South American continent, and it holds a great portion of the planet's freshwater, while being home to immense biodiversity. All the reasons discussed here make this region especially sensitive to global climate change.

29 See Part IV, Section 2.3, on the Large Scale Biosphere-Atmosphere Program in the Amazon - LBA.

30 The Adolpho Ducke Forest Reserve is the property of the National Institute for Research in the Amazon - INPA. It is located in the east zone of Manaus and represents one of the most valuable environmental resources of the city, since it is home to extremely diverse fauna and flora and various sources of bayous, providing pure and clean water to the Reserve's neighboring area.

4.1.3 Atlantic Forest

The Atlantic Forest is a complex and exuberant set of highly important ecosystems that are home to a significant part of Brazil's biological diversity, recognized both by the national and international scientific communities. Unfortunately, it is also one of the most threatened biomes in the world due to the constant aggression or threat of destruction of its various habitats and associated ecosystems.

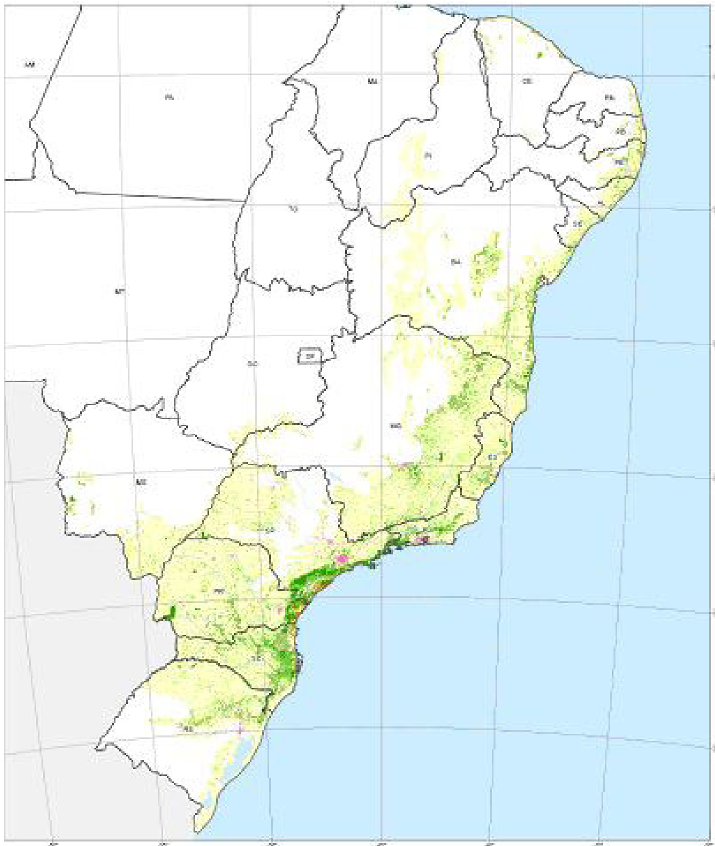
The Atlantic Forest is distributed along the country's Atlantic coast, reaching sections of Argentina and Paraguay in the Southeast and South. The Atlantic Forest originally encompassed 1,315,460 km² of Brazilian territory. Its original borders included areas in 17 states, (PI, CE, RN, PE, PB, SE, AL, BA, ES, MG, GO, RJ, MS, SP, PR, SC, and RS), which corresponded to approximately 15% of Brazil. However, about 70% of this area has now been deforested (ROMA, 2007).

Nearly 60% of Brazil's population currently lives in this extensive area. In other words, based on IBGE's 2007 Population Census, more than 112 million inhabitants live in the 3,222 municipalities, which correspond to the 58% that exist in Brazil. Of those municipalities, 2,594 are completely located in the biome and another 628 are partially included (IBGE, 2005).

The high degree of interference in the Atlantic Forest is well known. Since the beginning of European colonization, with the occupation of the first territorial spaces near the coastal region and the exploitation of Brazil wood — the tree from which a much used dye by the textile industry at the time was extracted — many raw materials began to be exploited. The impacts from the different cycles of exploration came later, such as the gold, sugarcane and then coffee cycles. New economic cycles of development and national integration emerged and firmly established an industrialization and, consequently, urbanization process, with Brazil's major cities and metropolises located today in the area originally occupied by the Atlantic Forest, thus drastically reducing its natural vegetation.

The destruction process has escalated over the past three decades, resulting in severe alterations in ecosystems due to the high fragmentation of the habitat and loss of its biodiversity. Figure 4.2 shows the remaining area of Atlantic Forest in the country in the most recent compilation of images produced by INPE and the SOS Mata Atlântica Institute.

Figure 4.2 Atlas of the Atlantic Forest areas



Source: SOSMA/INPE, 2008.

4.1.4 Southern Fields

The "Southern Fields" were so named by the MMA/Pronabio study of priorities for the conservation and sustainable use of Atlantic Forest and Southern Fields biodiversity elaborated by Conservation International - CI, Socio-Environmental Institute - ISA, WWF, and the Brazilian Institute of the Environment and Renewable Natural Resources – Ibama[31]. In generic terms, the fields in southern Brazil are called "pampas", an indigenous term for "flat region". However, this denomination only corresponds to one of the types of field, found more often in the south of the state of Rio Grande do Sul, and also reaching Uruguay and Argentina. Other known types, such as the fields in the high mountain ranges found in transition areas with a predominance of Brazilian pine (*araucárias*). In other areas there are fields similar to savannahs profiles.

This field vegetation initially seems to have an apparent uniformity, with low grassland landscapes, 60 cm to 1 m high, on the flatter surfaces, sparse and poor in species, and which becomes denser and richer along the mountain slopes, where grass, compound and leguminous vegetation are predominant. The most common genera are: *Stipa*, *Piptochaetium*, *Aristida*, *Melica*, and *Briza*. The alluvial forest has countless tree species of commercial interest.

The forte of the Campanha region, the largest extension of fields in the state of Rio Grande do Sul, lies in beef cattle. However, the management techniques adopted are not appropriate for the conditions of these fields, and all of the consequences of the small-scale practice of burning fields are still unknown. Most of the pasturelands are used with greater concerns, with the recovery and maintenance of the vegetation. Rio Grande do Sul's natural fields are generally exploited through continuous and extensive cattle-raising.

Other important economic activities, based on the use of these fields, include rice, corn, wheat and soy bean crops, often planted in association with cattle and sheep-raising. In the Upper Uruguay River and the Medium Plateau, the expansion of soy bean and wheat plantation has led to the disappearance of the fields and deforestation. These two crops currently occupy virtually the entire area, causing a gradual reduction in soil fertility. This also leads to erosion, compacting and loss of soil organic matter.

4.1.5 Pantanal Wetlands

In 1991, The Interministerial Commission for the Preparation of the United Nations Conference on Environment and Development defined the Pantanal wetlands in the state of Mato Grosso as "the largest continuous flooded plain on the planet". Its geographic location is of particular importance, since it represents the connection between the Cerrado, in Central Brazil, the Chaco, in Bolivia, and the Amazon region to the North, somewhat resembling the Upper Paraguay River watershed[32].

The Pantanal wetlands act as a great reservoir, with a gap of up to five months between water inflows and outflows. The summer regime dictates floods between November and March in the north, and May and August in the south, in the latter case due to the Pantanal's regulating influence.

As a transition area, the Pantanal region displays a mosaic of land ecosystems with similarities, most especially, with the Cerrado, and in part with the Amazon forest, as well as aquatic and semi-aquatic ecosystems that are interdependent to a greater or lesser degree. The upper watershed's plateaus and high lands are formed by bluffs and remnants of eroded plateaus, locally called mountain ranges. They are primarily covered by open vegetation, such as "clean fields" (*campos limpos*), "dirty fields" (*campos sujos*), "cerrados" and "cerradões", mainly determined by soil and cli-

31 See: <http://www.ibama.gov.br/ecossistemas/campos_sulinos.htm>

32 See: <http://www.ibama.gov.br/ecossistemas/pantanal.htm>.

mate factors, and also by humid forests, extensions of the Amazon ecosystem.

The floodable plain that forms the Pantanal is one of the most important wetlands in South America. This area also has low, medium and highly floodable plains, thus highlighting the widespread and prolonged fluvial flooding environments. These periodically flooded environments have high biological productivity, great density and diversity of fauna.

The agricultural frontier expansion process, which mainly occurred after 1970, was the key cause of the demographic growth in Brazil's Central-West region. The wetland plain region, with its land structure based on large properties geared towards cattle-raising in its swampy areas, was not affected by the population growth process. There was no significant increase in the number or population of wetland cities. However, there was fast urban growth on the plateau. Like all of the cities that emerged or expanded at that time, those in Mato Grosso and Mato Grosso do Sul did not and do not have the appropriate infrastructure to minimize the environmental impact of fast growth mainly caused by the discharging of household or industrial sewage into the watershed's watercourses. This type of pollution has a direct impact on the Pantanal's plain, which receives upper land sediment and residue.

The same frontier expansion process was responsible for using the "cerrados" for agriculture and livestock, which caused the deforestation of plateau areas to plant soy bean and rice crops, as well as to establish pasturelands.

4.1.6 Cerrado

The Cerrado biome is considered a tropical savannah ecosystem, with similarities to ecosystems in Africa and Australia. The core or central area of the Cerrado is mainly distributed along Brazil's Central Plateau, in the states of Goiás, Tocantins, Mato Grosso, Mato Grosso do Sul, a part of Minas Gerais, Bahia and the Federal District, covering 196,776,853 hectares. There are other Cerrado areas, called peripheral or ecotones, which are transitions with the Amazon, Atlantic Forest and Caatinga biomes.

The "cerrados" are recognized by their various ecosystem formations. From a ecological profile perspective, there is the "cerradão", the typical cerrado, the cerrado plain, the "dirty cerrado field" (*campo sujo de cerrado*) and the "clean cerrado field" (*campo limpo de cerrado*), which have vegetation height and biomass volume in descending order. The so-called "cerradão" is the only one to be considered a forest formation.

The typical vegetation found in the Cerrado is small in size, with twisted trees, twisted branches, thick bark and thick leaves. Studies conducted suggest that the Cerrado's native vegetations do not have this characteristic due to a lack of water — because there is a large and dense water network there — but rather because of soil factors, such as an imbalance of micro nutrients, such as aluminum.

Brazil's Cerrado is known as the richest savannah in the world in biodiversity, with the presence of several ecosystems and very rich flora and fauna.

The "cerrados" remained unaltered until the 1950s. Starting in the 1960s, with the country's move inland and the opening of a new highway network, large ecosystems made room for cattle-raising and extensive agriculture, such as soy bean, rice and wheat. These changes were mainly supported by the implementation of new road and energy infrastructures, as well as the discovery of new vocations for these regional soils, making new and profitable agrarian activities possible, which had an impact on the until then unaltered biodiversity.

Starting in the 1990s, governments and various segments of society began debates on how to preserve remaining Cerrado areas with the purpose of seeking technologies based on the proper use of water resources, the extraction of native vegetation products, the raising of wild animals, ecotourism and other initiatives that enable a model for sustainable development.

4.1.7 Caatinga

The Caatinga biome is the main ecosystem in the Northeast region, extending through the domain of semi-arid climates and occupying the states of Bahia, Ceará, Piauí, Pernambuco, Rio Grande do Norte, Paraíba, Sergipe, Alagoas, Maranhão, and Minas Gerais. The term Caatinga comes from Tupi-Guarani [33] and means "white forest". It is a unique biome despite being located in a semi-arid climate area, with a great variety of landscapes, relative biological wealth and endemism. Seasonal and periodic droughts create intermittent regimes in rivers and leave vegetation without leaves. Plant foliage sprouts and turns green again during the short rainy periods.

The Caatinga is dominated by vegetation with xerophytic characteristics — dry plant formations that comprise a hot and thorny landscape — with strata comprised of deciduous grasses, bushes and short or medium sized trees (3 to 7 meters tall), with a great number of thorny plants, mixed with other species like cacti and bromeliads.

33 A Brazilian indigenous language, general language spoken until the 19th Century along the coast (the generic name of the Tupi tribes on the coast), and currently still in some sparse areas in the Amazon under the name *nheengatu*.

Most of the local population survives off of nascent agriculture, poor plant extractivism and negligible livestock. There are cattle and goat herds, with the latter being more important than the former. Unwooled sheep are also raised as an alternative. Climate irregularity is one of the factors that most affects in the life of the population. Even when it rains, the shallow and rocky soil is unable to store the rainwater and the high temperatures (averages between 25 °C and 29 °C) cause intense evaporation. That is why agriculture is only possible in some areas near the mountains, where there is a greater amount of rain. There are some spots of land that can be used for farming, and nowadays with good irrigation and soil correction (because it is generally acidic) it is possible to successfully plant coffee, mangoes and other fruits[34].

The Caatinga biome ecosystems undergo intense changes with the replacement of native plant species with crops and pastures. Burning is still a common practice to prepare the land for crops and livestock. Approximately 80% of the original ecosystems have now been affected by human action[35].

4.2 Regions with Fragile Ecosystems

Fragile ecosystems include deserts, semi-arid lands, mountains, wetlands, islets and certain coastal areas, which are important due to their own characteristics and resources.

Brazilian territory consists of very old geological structures and it is very eroded. The country has modest altitudes, with 93% of Brazil's territory at altitudes below 900 meters. Thus, Brazil does not have high mountain ranges and the country's highest peaks are in national parks[36], as can be seen in Table 4.2.

Special attention has been given in the country to conservation of Serra do Mar, a mountainous system that extends from the state of Espírito Santo to the south of the state of Santa Catarina. Serra do Mar is home to the main remnants of the Atlantic Forest, which used to cover the entire eastern coast of Brazil, from the state of Rio Grande do Norte to the state of Rio Grande do Sul.

The Federal Constitution stipulates[37] that "the Brazilian Amazon forest, Atlantic Forest, Serra do Mar, Pantanal wetlands in Mato Grosso, and the Coastal Zone are national heritages, and they shall be used in compliance with the law, under conditions that ensure the preservation of the environment, including with regard to the use of natural resources."

Table 4.2 Brazilian mountains with altitudes that exceed 2,600 meters

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

Source: IBGE, 1996.

4.3 Desertification

Desertification is not a recent problem. In 1977, the United Nations Conference to Combat Desertification was convened in Nairobi, Kenya, where the guidelines for the Plan of Action to Combat Desertification - PACD were drawn up with the objective of developing actions on a global scale. However, progress has been extremely modest.

34 See: <http://www.vivaterra.org.br/caatinga.htm>.
35 See: < http://www.ibama.gov.br/ecossistemas/caatinga.htm>
36 On August 22, 2002, the Montanhas de Tumucumaque National Park was created by Presidential Decree, in northwestern Amapá, on the border with French Guyana. It has 3.8 million hectares of continuous and virtually untouched Amazon forest.
37 In its Article 225, paragraph 4.

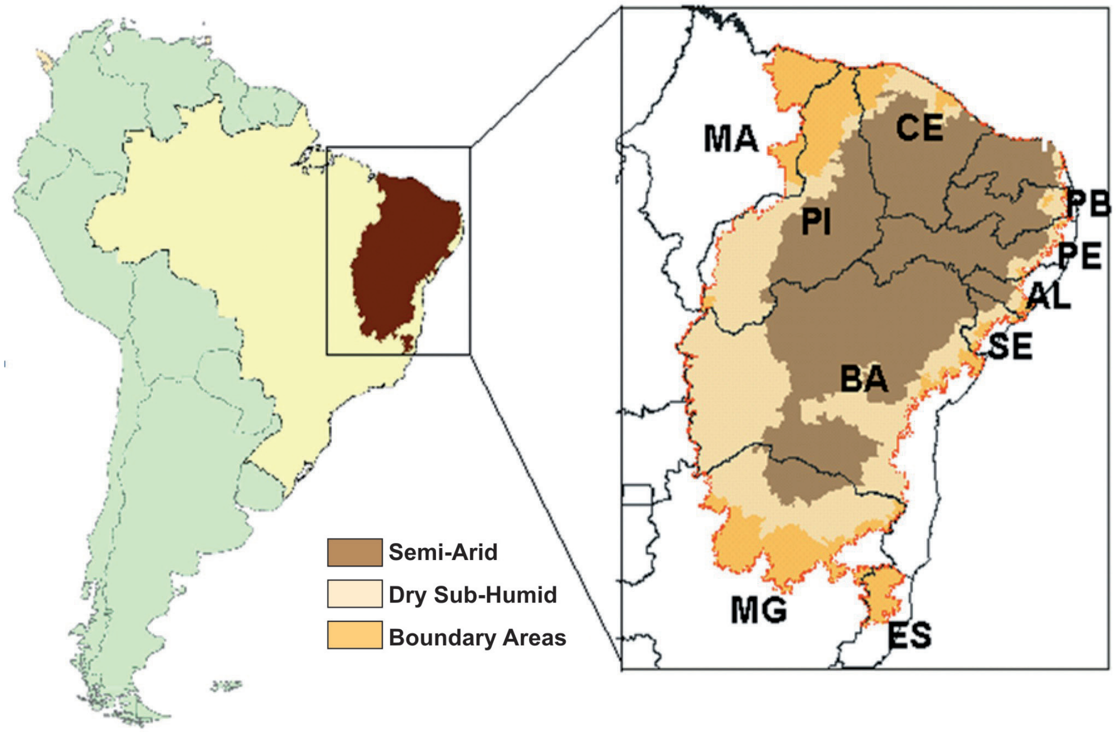
Under the United Nations Convention to Combat Desertification, those areas prone to desertification have arid, semi-arid and sub-humid dry climates. These climate classes, as far as the desertification issue is concerned, are determined according to the Aridity Index (THORNTHWAITE, 1941), adopted to stipulate prone areas and to develop the *World Atlas of Desertification* published by the *United Nations Environment Programme* (UNEP, 1997), a map which has served as a parameter around the world. This index is defined as the ration between the amount of rainfall and the potential evapotranspiration, that is, the maximum possible loss of water through evaporation and transpiration, and the following categories derive from it:

- Hyper-arid: < 0,03
- Arid: 0.03 – 0.20
- Semi-Arid: 0,21-0,51
- Dry Sub-Humid: 0.51-0.65
- Wet Sub-Humid: > 0.65

The areas prone to desertification correspond to more than 30% of the planet's land surface, where more than one billion people live. In Brazil, the prone areas are those covered by the semi-arid and dry sub-humid regions, mainly located in the Northeast region and in the north of the states of Minas Gerais and Espírito Santo (Figure 4.3).

Brazil's semi-arid region is characterized by high evapotranspiration, periods of drought, shallow soil, high salinity, low fertility and reduced capacity for water retention, which limits their production potential. Furthermore, the desertification process is intensified by poverty, and vice-versa. The most alarming social indicators in the country are seen in Brazil's semi-arid region. The areas prone to desertification cover between 940 thousand and 1.3 million km^2 in total, i.e., 1115.2% of Brazil's territory, concentrating 1,482 municipalities and nearly 32 million inhabitants (MMA, 2004). These numbers make this area the most populous dry region in the world.

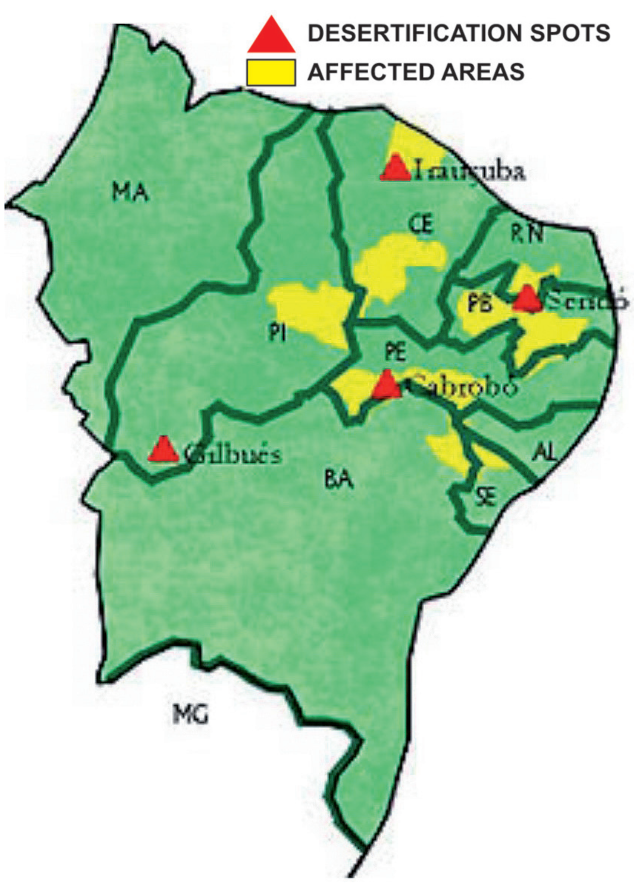
Figure 4.3 Areas of Brazilian territory prone to desertification



Source: MMA, 2004.

Data from the Ministry of Environment (MMA, 2004) indicate that 181,000 km^2 in the semi-arid region are being seriously affected by the desertification process, with the generation of diffused impacts encompassing different levels of soil, vegetation and water resource degradation. The most critical areas, with intense degradation of resources and producing considerable damage, the so-called “desertification spots”, were initially identified in four locations: Gilbués, Iraçuba, Seridó, and Cabrobó, totaling 18,743.5 km^2, as seen in Figure 4.4.

Figure 4.4 Affected areas and desertification spots in Brazil’s Northeast region.



The Brazilian Northeast region naturally has high potential for water evaporation as a result of the enormous availability of solar energy and high temperatures. Strong drought and dry cycles tend to afflict the region in intervals ranging from a few years up to decades. Temperature increases associated with climate change resulting from global warming, regardless of what may happen with the rains, would be sufficient to cause major evaporation of lakes, ponds and reservoirs, and greater evaporative demand of plants. In other words, unless there is an increase in rainfall volume, water will become a scarcer good, with serious consequences for the sustainability of regional development (MARENGO, 2008).

A study conducted by the Center of Strategic Affairs of the Presidency of the Republic, in 2005 (NAE, 2005), indicated the Northeast as the most vulnerable region to global climate change in the country, since water scarcity is already a problem in this region. At present, water availability per capita in the region is insufficient in the states of Rio Grande do Norte, Paraíba, Pernambuco, Alagoas and Sergipe, not to mention regional variations in the water deficit, which make the situation even more unsustainable for inhabitants of the semi-arid region affected by water stress.

It is important to point out that, in Brazil, areas prone to serious degradation of the soil, of water resources, of vegetation and a reduction in the quality of life of affected populations are not limited to the semi-arid and dry sub-humid regions. Soil degradation in other parts of the country, such as Rio Grande do Sul (especially the municipality of Alegrete), Paraná, São Paulo and Rondônia have been identified. The Cerrado region is of great concern in relation to degradation, because the quartzonite sand soil is by nature not robust enough and is poor in nutrients. Although the vegetation offsets the ecosystem’s fragility, maintaining a small layer of fertile soil, frequent burning and cattle activity, with the consumption of all the sprouts, weaken the land, and the layer of productive soil gives way to the sand. However, these areas are not included in the desertification concept according to the United Nations methodology.

Desertification has three major, interrelated impacts: environmental, social and economic. The environmental impacts include destruction of fauna and flora, a significant reduction in water resource availability (silting of rivers and reservoirs) and loss of the soil’s physical and chemical properties. These environmental impacts generate considerable loss of the soil’s production capacity, thus causing social change. With an increase in the aridization of the semi-arid and more frequent droughts, the basis of support for human activity diminishes, probably increasing the displacement of the population — mainly poor farmers, such as the subsistence farmers — to big cities in the region, or other regions, further increasing the social problems those big cities already have. The economic consequences of these impacts are also big. Estimates of soil and water resource losses represent an enormous economic loss that affects millions of people and contributes towards poverty and social vulnerability. In Brazil, the cost of soil and water resource losses reaches US$ 5 billion per year, which is equivalent to 0.8%

of Gross Domestic Product - GDP, and has a negative impact on more than 15 million people[38].

As stipulated in the United Nations Convention to Combat Desertification, Brazil developed the National Plan to Combat Desertification and to Mitigate the Effects of Drought - PANBrazil. The program is a plan that aims at defining the guidelines and the main actions to combat and prevent the desertification phenomenon in Brazilian regions with semi-arid and dry sub-humid climates.

The Brazilian government is creating a system to forecast the occurrence of long drought periods in the semi-arid and to identify the areas prone to desertification that can be exacerbated by global climate change. Called the Brazilian Early Warning System for Drought and Desertification, an initiative by the Ministry of Science and Technology and the Ministry of Environment, the project aims at creating and implementing a system that provides a more immediate prediction of major drought episodes that afflict the region. It also aims at creating a diagnostic tool to identify those areas most affected by environmental degradation and more prone to desertification. Irrigation areas have also been implemented in the semi-arid areas.

4.4 Areas with High Urban Air Pollution

In Brazil, as in most developing countries, urbanization rates are high. In the 1970s, the country had an urbanization rate of 55.9%, reaching 81.2% in 2000 and 84.4% in 2008. The Southeast, the country's most developed region, had an rate of 91.9% in 2007[39].

This accelerated — and for the most part unorganized — growth in recent decades, has exerted great pressure on urban zones. Together with industrialization, this process implies high urban air pollution rates.

Air pollution levels are determined by quantifying the polluting substances found in the air. "Any form of matter or energy with intensity and in quantity, concentration, time or characteristics in disagreement with stipulated levels, and that make or can make air improper, harmful or damaging to health, inconvenient to public well-being, harmful to materials, fauna and flora, or harmful to the safety, use and enjoyment of property and to the community's normal activities" shall be considered an air pollutant[40] .

38 See: < http://www.mma.gov.br/sitio/index.php?ido=ascom.noticiaMMA&idEstrutura=8&codigo=6027>

39 See: <http://www.sidra.ibge.go.br>

40 As per Conama Resolution nº 3, of June 28, 1990.

The most serious air pollution problem in Brazil is related to the emission of particulate matter - PM by industries and the transportation sector. Particulate matter consists of a mixture of particles in liquid or solid or both form, which remains in suspension in the air and represents a complex mixture of organic and inorganic substances. These particles vary in size, composition and origin. Their properties are summarized according to their aerodynamic diameters, which are called particle size.

The thick fraction is called PM_{10} (particles with aerodynamic diameters under 10 μm), which can reach the upper airways and lungs. Smaller or finer particles are called $PM_{2.5}$ (with aerodynamic diameters under 2.5 μm). These particles are more dangerous because they penetrate deeper into the lungs and can reach the alveolar region. Particle size also determines the amount of time they have been in the atmosphere. While sedimentation and precipitation remove PM_{10} from the atmosphere in a few hours after emission, $PM_{2.5}$ can remain in suspension for days, or even a few weeks, and can be transported for long distances (OMS, 2005).

Long exposure time to particulate matter can result in a substantial reduction in life expectancy. The long-term effects have a much more significant impact on public health than the short-term effect. $PM_{2.5}$ has a greater association with mortality, causing a 6% increase in risk of death by any disease with a 10-μg/m3 increase in the concentration. With a similar increase in concentration, the estimated relative risk increases by 12% for deaths by cardiovascular diseases and 14% for deaths by lung cancer.

The effects related to long-term exposure include: increase in respiratory problems and chronic obstructive pulmonary disease, reductions in pulmonary functions in children and adults, and reduction in life expectancy mainly due to cardiopulmonary mortality and probably lung cancer.

When the concentration of a pollutant in the air is determined, the degree of recipient exposure (humans, other animals, plants and materials) is measured as the final result of the discharging process of this pollutant into the atmosphere from its emission sources and its interactions in the atmosphere, from a physical (dilution) and chemical (chemical reactions) perspective.

It is important to underscore that, even with emissions maintained unchanged, air quality can change as a result of weather conditions that determine a greater or lesser dilution of these pollutants. That is why air quality worsens in relation to the carbon monoxide, particulate matter and sulfur dioxide parameters during winter months, when weather conditions are more unfavorable for dispersion of the pollutants. Ozone has higher concentrations in spring and summer because it is a secondary pollutant that depends on the intensity of sunlight to be formed.

The systematic determination of air quality should be, due to issues of a practical nature, limited to a restricted number of pollutants, defined as a result of their importance and of the available material and human resources. In general, the group of pollutants universally known as the most encompassing indicators of air quality is comprised of: carbon monoxide, sulfur dioxide, particulate matter, ozone, and nitrogen dioxide. The reason why these parameters are chosen as indicators of air quality is associated to their greater frequency and the adverse effects they have on the environment.

Air quality standards, as per a publication by the World Health Organization in 2005, vary according to the approach adopted to balance health risks, technical feasibility and economic considerations, as well as several other political and social factors, which in turn depend on the level of development and national capacity to manage air quality, among other things. WHO's recommended guidelines take this heterogeneity into account and, in particular, recognize that by developing air quality policies, governments should carefully consider their local circumstances before adopting the values proposed by the WHO as national standards.

In Brazil, current national air quality standards and the respective methods of reference have been stipulated by Ibama[41], which expanded the number of parameters previously regulated[42]. The standards stipulated in this administrative rule were submitted to the National Environment Council - Conama[43].

According to IPCC's Fourth Assessment Report (IPCC, 2007), a greater frequency of heat waves is expected in urban areas, with greater intensity and duration. A deterioration in air quality and an increase in risk areas can also be projected, especially in tropical cities, which are subject to increasingly more intense rainfall that can cause mudslides and flooding.

In view of global warming, some pollutants are expected to have increased environmental concentration, especially gases and particles generated from atmospheric photochemical processes. Thus, there may be an increase in general mortality as a result of the presence of secondary aerosols (nitrates and sulfates) and oxidant gases (ozone) (NOBRE *et al.*, 2010).

41 By means of Normative Rule nº 348, of March 14, 1990.

42 By means of GM Rule nº 231, of April 27, 1976.

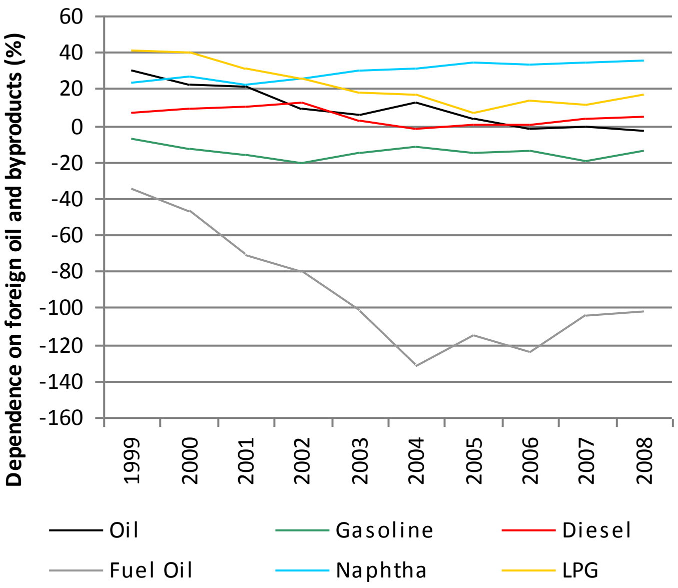
43 On June 28, 1990, and transformed into Conama Resolution nº 03/1990. See Part III, Section A.3.6, on the Motor Vehicle Air Pollution Control Program - Pronar.

4.5 External Dependence on Oil and Its Byproducts

In the 1970s, foreign energy dependency grew from 28% to nearly 46% of national demand. Data from 2007 show a reduction in this level to just over 8%. This reduction was even more significant, specifically in relation to oil: from being dependent on nearly 85% in 1979, the country became self-sufficient in 2005, and, in 2006, it reported a 1.7% surplus (calculated as the difference between domestic energy demands, including losses from transformation, distribution and storage and domestic production) (BRASIL, 2008).

Figure 4.5 shows the evolution of this dependency on foreign oil and its byproducts from 1999 to 2008. Negative figures represent those years in which Brazil had a surplus in this product.

Figure 4.5 Evolution of dependency on foreign oil* and its byproducts - 1999 to 2008



* Level of foreign dependency (%) = (1 - production / total consumption) * 100.

Source: BRASIL, 2009.

Large oil discoveries in Brazil have been recently made in the pre-salt layer[44], located between the states of Santa Catarina and Espírito Santo, where large volumes of light oil have been found. Thus, there is a tendency for Brazil to become a net exporter of oil byproducts in the mid-term.

44 The term pre-salt refers to a body of rocks located in the marine portions of a great part of the Brazilian coast with potential for the formation and accumulation of oil. It became pre-salt because it forms a wall of rocks that extends under an extensive layer of salt, which in certain areas of the coast can reach thicknesses of up to 2,000 m. The term pre- is used because over time these rocks were deposited before the layer of salt. Total depth of these rocks, which is the distance between the surface of the ocean and the oil reserves below the layer of salt, can reach more than 7 thousand meters (See: < http://www2.petrobras.com.br/presal/10-perguntas/>).

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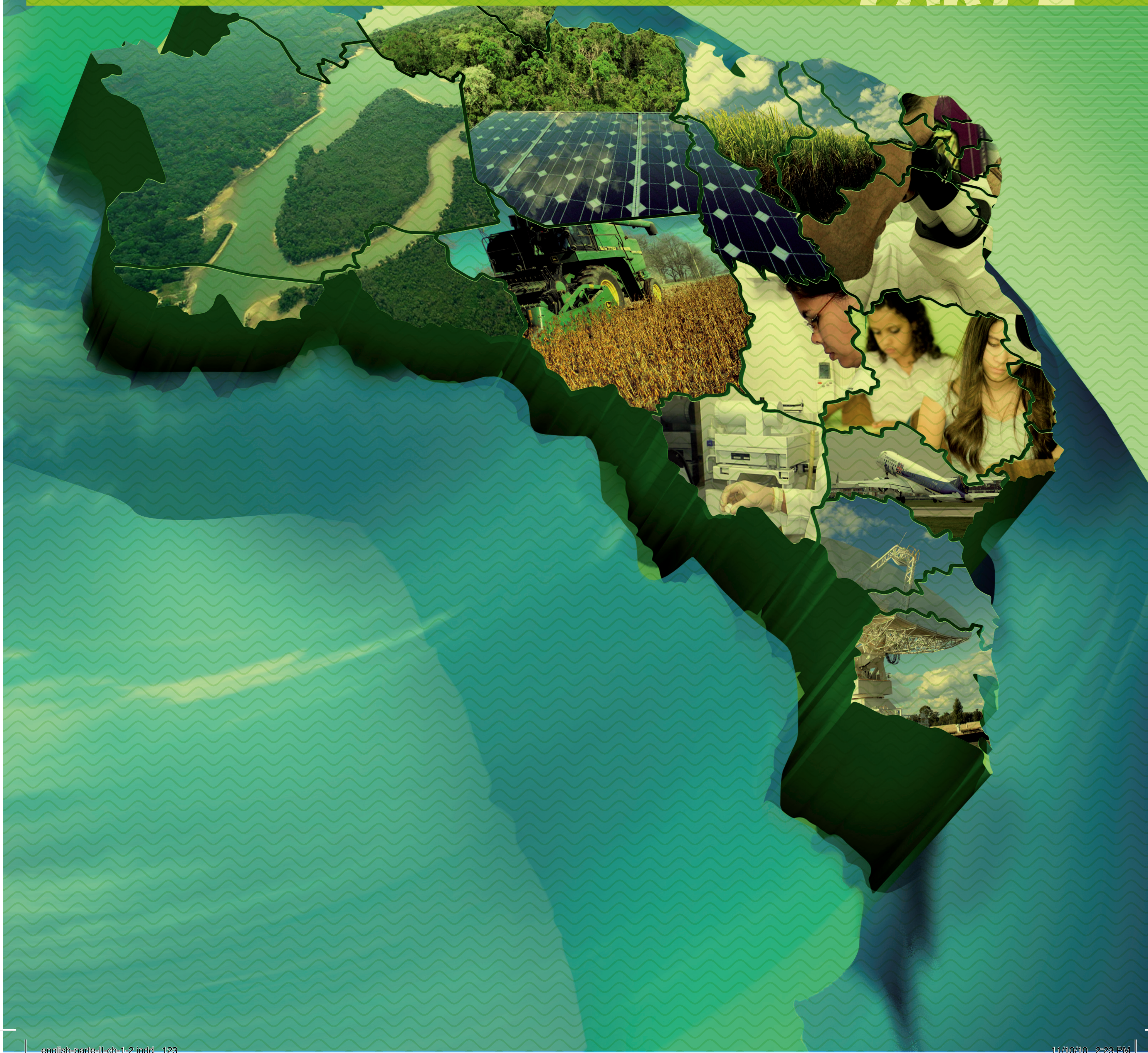
Brazilian Inventory of Anthropogenic Emissions by Sources and Removals by Sinks of Greenhouse Gases not Controlled by the Montreal Protocol

PART 2



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Pao de Acucar por Pedro Kirilos-Riotur

Chapter 1

Introduction

1 Introduction

As a Party to the United Nations Framework Convention on Climate Change, henceforth called the Convention, one of Brazil's main commitments is to develop and periodically update the National Inventory of Anthropogenic Emissions by Sources and Removals by Sinks of Greenhouse Gases not Controlled by the Montreal Protocol, henceforth called the Inventory.

Development of this Inventory follows the Guidelines for the Preparation of National Communications from Parties not Included in Annex I to the Convention, established by Decision 17/CP.8 of the Conference of the Parties to the Convention on its eighth session, held in Delhi, India in October/November of 2002.

In conformity with these Guidelines, this Inventory is presented for the year of 2000. In addition, the values that refer to the other years from 1990 to 2005 are also presented. In relation to the years from 1990 to 1994, this Inventory updates the information presented in the Initial Inventory of Anthropogenic Emissions and Removals by Sinks of Greenhouse Gases not Controlled by the Montreal Protocol (BRASIL, 2004) – Initial Inventory.

The following documents, elaborated by the Intergovernmental Panel on Climate Change (IPCC), "Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories" – 1996 Guidelines, published in 1997; "Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories" – Good Practice Guidance 2000, published in 2000; and "Good Practice Guidance for Land Use, Land-Use Change and Forestry" – Good Practice Guidance LULUCF, published in 2003, were used as basic technical guidelines. Some of the estimates already take into account information found in "2006 IPCC Guidelines for National Greenhouse Gas Inventories" – 2006 Guidelines, published in 2006.

1.1 Greenhouse Gases

The Earth's climate is regulated by the constant flow of solar energy that passes through the atmosphere in the form of visible light. Part of this energy is returned to the Earth in the form of infrared radiation. Greenhouse gases are gases found in the Earth's atmosphere that have the property of blocking part of this 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 maintaining life on the planet, since without them, the Earth would be, on average, about 30°C colder.

As a consequence of anthropogenic activities in the biosphere, the concentration level of some of these gases, like CO_2, CH_4 and N_2O, has been increasing in the atmosphere. Furthermore, emissions of other exclusively man made greenhouse gases began to occur, such as chlorofluorocarbons (CFCs), hydrofluorocarbons (HFCs), hydrofluorochlorocarbons (HCFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6).

As determined by the Convention, the Inventory should include only the anthropogenic emissions by sources and removals by sinks of greenhouse gases not controlled by the Montreal Protocol. Hence, CFC and HCFC gases that destroy the ozone layer and are already controlled by the Montreal Protocol should not be included.

Greenhouse gases whose anthropogenic emissions and removals were estimated in this Inventory include CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6. Some other gases, such as carbon monoxide (CO), nitrogen oxides (NO_x) and other non-methane volatile organic compounds (NMVOC) are not direct greenhouse gases, but have influence on chemical reactions that occur in the atmosphere. Information on the anthropogenic emissions of these gases is also included in this Inventory when available.

1.2 Sectors covered

Anthropogenic emissions of greenhouse gases occur in several activity sectors. This Inventory is organized in accordance with the structure suggested by the IPCC, covering the following sectors: Energy; Industrial Processes; Use of Solvents and Other Products; Agriculture; Land-Use Change and Forestry; and Waste.

Removals of greenhouse gases occur in the Land-Use Change and Forestry sector as a result of protected area management and reforestation activities, the abandonment of managed lands and increase of carbon stocks in soils.

1.2.1 Energy Sector

This sector estimates all anthropogenic emissions caused by energy production, transformation and consumption. It includes emissions resulting from fuel combustion as well as fugitive emissions from leaks in the production, transformation, distribution and consumption chain.

1.2.1.1 Fuel Combustion

The Energy sector includes CO_2 emissions from oxidation of carbon contained in fossil fuels during combustion, whether when generating other forms of energy, such as electricity, or in final consumption. Emissions of other greenhouse gases that occur during the combustion process (CH_4, N_2O, CO, NO_x and NMVOC) are also included.

In the case of biomass fuels (firewood, charcoal, biomass residues, black liquor, ethanol and bagasse), CO_2 emissions are informed, but not accounted for in total energy sector emissions. Renewable fuels do not generate net emissions and emissions associated with the non-renewable part are included in the Land-Use Change and Forestry sector.

CO_2 emissions from combustion of fuels supplied for international water-borne navigation and international aviation (the so-called bunker fuels) are informed in accordance with Decision 17/CP.8, but not accounted for in total energy sector emissions.

As a result of the basic information available, emissions are presented following the structure defined in the Brazilian Energy Balance – BEB, which is similar, but not identical to the structure suggested by the IPCC.

1.2.1.2 Fugitive Emissions

The Energy sector also includes greenhouse gas emissions from coal mining and handling, encompassing coal production, storing, processing and transportation phases, as well as those resulting from oil and natural gas production, transportation and processing.

Emissions associated with coal mining and handling include CH_4 emissions from surface and underground mines and CO_2 emissions from inadvertent burning in coal waste piles.

Emissions associated with oil and natural gas activities include fugitive emissions of CH_4 during oil and natural gas production (venting), during transportation and distribution in pipelines and ships and during processing at refineries. CO_2 emissions from non-productive combustion (flaring) at oil and natural gas production platforms and refining units are also considered. The use of oil and natural gas or fuel by-products to provide energy for internal use in energy production processing and transportation is considered as combustion, and therefore, handled in the section on fuel combustion. CO_2 emissions from flaring are included as fugitive emissions, even when formally they result from combustion, since they derive from process leaks and not from productive fuel consumption.

1.2.2 Industrial Processes Sector

This sector estimates the anthropogenic emissions resulting from production processes in industries that do not result from fuel combustion, since the latter are reported in the Energy sector.

The subsectors of mineral products, chemical industry, metal production, pulp and paper, food and beverage and production and consumption of HFCs, PFCs and SF_6 were considered.

1.2.2.1 Mineral products

This subsector includes emissions that result from the heating of limestone and dolomite at high temperatures (calcination), as well as emissions resulting from soda ash production and use.

There are CO_2 emissions from cement production stemming from limestone ($CaCO_3$) calcination during clinker production. In lime production, limestone and dolomite ($CaCO_3 \cdot MgCO_3$) are calcinated, also producing CO_2. CO_2 emissions also occur in the glass industry, steel industry and magnesium production due to limestone and dolomite calcination.

CO_2 emissions can occur due to the production of soda ash (Na_2CO_3), depending on the production process. This is not the case for the synthetic process used in Brazil. On the other hand, during soda ash consumption in other industries, such as glass industry, CO_2 emissions occur.

1.2.2.2 Chemical industry

Among the emissions reported in this subsector, the following deserve to be highlighed: CO_2 emissions resulting from ammonia production, N_2O and NO_x emissions from nitric acid production, and N_2O, CO and NO_x emissions resulting from adipic acid production.

During production of other chemical products greenhouse gas emissions can also occur, especially NMVOC emissions in the petrochemical industry.

1.2.2.3 Metal production

This subsector includes the iron and steel industry and ferroalloys industry, where CO_2 emissions occur in the iron ore reduction process, and the aluminum industry where PFCs, CO_2, CO and NO_x emissions occur.

In the iron and steel and ferroalloys industries, CO_2 emissions occur when the carbon contained in the reducing agent combines with the oxygen in metallic oxides. The same reducing agents, such as coke, are also used as fuel for generating energy. Emissions attributed to both processes are reported in this sector when refering to the sintering/pelleting and blast furnace/steel mill stages. Other emissions related to steel making are reported under the Energy sector (coke and electricity production), and the mineral production sector (lime manufacturing, and limestone and dolomite use). For the ferroalloy subsector, it was impossible to separate the fuels used for each purpose, with total emissions being reported in the Energy sector.

CO_2 emissions occur in the aluminum industry during the electrolysis process, when the oxygen from aluminum oxide reacts with anode carbon. During the same process, if the level of aluminum oxide in the production vat is too low, there can be a rapid increase in voltage (anode effect). In that case, the fluoride contained in the electrolytic solution reacts with the anode carbon producing perfluorcarbons (CF_4 and C_2F_6), which are greenhouse gases that remain in the atmosphere for a long period of time. Depending on the technology employed, CO and NO_x emissions can also occur.

1.2.2.4 HFC and SF_6 production and use

HFC gases were developed in the 1980s and 1990s as alternative substances to CFCs and HCFCs. The use of these latter gases is being eliminated because they are substances that destroy the ozone layer. HFCs are greenhouse gases that do not contain chlorine, and for that reason do not affect the ozone layer.

During HFC production and use, fugitive emissions may occur. Also, during HCFC-22 production process there can be a secondary production of HFC-23 and its consequent emission.

SF_6, another exclusively anthropogenic greenhouse gas, has excellent characteristics for the use in high capacity and performance electric equipment. Since Brazil is not a producer of this gas, reported emissions only refer to leaks in equipment installed in the country.

SF_6 is also used as a coverage gas during magnesium production to avoid its oxidation.

1.2.2.5 Other Industries

The pulp and paper subsector generates emissions during chemical treatment wood pulp receives during the manufacturing process. These emissions depend on the type of raw material used and the quality desired for the product.

In Brazil, eucalyptus is mainly used as a pulp source, with a predominance of the sulfate process, resulting in CO, NO_x and NMVOC emissions, which were estimated in this Inventory.

NMVOC emissions occur in the food and beverage subsector in many transformation processes from primary products, such as sugar, animal feed and beer production. Emissions were estimated based on national production data and default emission factors. Vegetable oil extraction processes are handled in the Solvent Use and Other Products sector.

1.2.3 Solvent and Other Product Use Sector

In general, the use of solvents favors their evaporation, which configures NMVOC emissions. This Inventory sought to identify the most relevant sectors in solvent application, despite the high degree of uncertainty surrounding these estimates.

The following activities were analyzed: application in paints, degreasing metals, dry cleaning, foam processing, printing industry, edible vegetable oil extraction, and household consumption of solvents.

1.2.4 Agriculture Sector

Agriculture and livestock are extremely important economic activities in Brazil. Due to the great extension of agricultural lands and pasture, the country is also highly ranked in the world with regard to this sector's production.

Several processes that result in greenhouse gas emissions are described below.

1.2.4.1 Enteric fermentation

Enteric fermentation is part of the ruminant herbivore animal digestion. It is one of the major sources of CH_4 emissions in the country. The intensity of this process depends on several factors, such as the animal type, diet, intensity of physical activity and the diverse raising practices. Among the various types of animals, it is necessary to underscore emissions resulting from non-dairy cattle herd, which is the second largest in the world.

1.2.4.2 Manure Management

Manure management systems can cause CH_4 and N_2O emissions. Anaerobic decomposition produces CH_4, especially when manure is stored in liquid form.

1.2.4.3 Rice Cultivation

Rice cultivation can be an important source of CH_4 emissions when grown in flooded fields or low grassland areas. This results from the anaerobic decomposition of organic matter located in the water. In Brazil, most of the rice is produced in non-flooded areas, reducing the subsector's significance in total CH_4 emissions.

1.2.4.4 Field Burning of Agricultural Residues

The imperfect burning of agriculture waste, which is done directly in the field, produces CH_4, N_2O, NO_x, CO and NMVOC emissions. CO_2 emitted is not considered as net emission, because the same quantity of CO_2 is necessarily absorbed during plant growth through photosynthesis.

In Brazil, the burning of agriculture residues occurs mainly in the sugarcane crop.

1.2.4.5 N_2O Emissions from Agricultural Soils

N_2O emissions in agricultural soils result from applying nitrogen fertilizer, both from synthetic and organic origin and from the deposition of animal manure in pasture. The latter process could not be considered as a fertilizer application since it is not done intentionally; however, it is the most important in Brazil due to the predominance of extensive livestock raising practice.

Crop residues left in the field are also sources of N_2O emissions.

This sector also includes the cultivation of organic soils, which increase organic matter mineralization and release N_2O.

1.2.5 Land-Use Change and Forestry Sector

This sector includes the estimates of emissions and removals of greenhouse gases associated with the increase or decrease of carbon in biomass above and below ground as land-use change occurs, for example, in the conversion of a forest area to agriculture or livestock activity, or when replacing cropland by reforestation.

As recommended by the Good Practice Guidance LULUCF, estimations are provided for emissions and removals from land that did not undergo any use change, reflecting increase or loss of carbon under the same type of use (e.g. carbon increase in secondary vegetation or even in primary vegetation in managed areas).

Estimates should consider all carbon compartments: living biomass above ground; below-ground living biomass (roots); thin branches and dead leaves (fine litter); dead thick branches (thick litter); and soil carbon.

The predominant gas in this sector is CO_2, but there are also emissions of other greenhouse gases such as CH_4 and N_2O from imperfect burning of wood left in the field, in case of forest conversion to other uses.

CH_4 emissions also occur in reservoirs (hydroelectric plants' reservoirs, dams, etc.), but they were not estimated in this inventory because there is no methodology agreed by the IPCC since it is difficult to identify the anthropogenic part of these emissions.

1.2.6 Waste Sector

1.2.6.1 Solid waste disposal

Solid waste disposal provides anaerobic conditions that generate CH_4. CH_4 emission potential increases the better the landfill control conditions are and the deeper the open dumps are. Waste incineration, as all combustion, generates emissions of several greenhouse gases, but this activity is not widespread in Brazil.

1.2.6.2 Wastewater handling

Effluents with a high degree of organic content have great CH_4 emission potential, especially household and commercial sewage, effluents from food and beverage industries and those from the pulp and paper industry. Other industries also contribute to these emissions, but at a lesser degree.

In the case of household sewage, as a result of nitrogen content in human food, N_2O emissions can also occur.

Chapter 2

Summary of Anthropogenic Emissions by Sources and Removal by Sinks of Greenhouse Gases by Gas

2 Summary of Anthropogenic Emissions by Sources and Removal by Sinks of Greenhouse Gases by Gas

In 2005, net anthropogenic emissions of greenhouse gases were estimated at 1,637,905 Gg CO_2; 18,107 Gg CH_4; 546 Gg N_2O; 0.124 Gg CF_4, 0.0104 Gg C_2F_6, 0.0252 Gg SF_6, 2.28 Gg HFC-134a, 0.125 Gg HFC-125, 0.093 Gg HFC-143a, and 0.175 Gg HFC-152a. Between 1990 and 2005, total emissions of CO_2, CH_4 and N_2O increased by 65%, 37% and 45%, respectively. Indirect greenhouse gas emissions were also reported. In 2005, these emissions were estimated as 3,399 Gg NO_x; 41,339 Gg CO; and 2,152 Gg NMVOC.

2.1 Carbon Dioxide Emissions

CO_2 emissions result from many activities. In developed countries, the main source of emissions is the fossil fuel combustion for energy generation. Other important sources of emissions in these countries are the industrial processes for producing cement, lime, soda ash, ammonia and aluminum, as well as waste incineration.

Unlike industrialized countries, in Brazil, the largest share of net CO_2 emissions comes from land-use change, especially the conversion of forests to cropland and pasture. As a result of the high share of renewable energy in the Brazilian energy matrix, including electricity generation in hydroelectric plants, the ethanol use in transportation and sugarcane bagasse and charcoal use in industry, the share of CO_2 emissions from fossil fuel use in Brazil is relatively small. Furthermore, Brazil's energy consumption is still modest, when compared to those from industrialized countries.

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

The Energy sector encompasses emissions from fossil fuel combustion and fugitive emissions. Fugitive emissions include the burning of gas in platform and refinery torches, and the inadvertent burning in coal waste piles. In 2005, CO_2 emissions from the Energy sector represented 19% of total CO_2 emissions, having increased 74% in comparison to 1990 emissions. The transport subsector alone was responsible for 43% of CO_2 emissions from the Energy sector, and for 8.1% of total CO_2 emissions.

Emissions from industrial processes represented 4% of total CO_2 emissions in 2005, with the iron and steel production making up the greatest share (58%). From 1990 to 2005, emissions from industrial processes increased by 45%.

The Land-Use Change and Forestry sector was responsible for the largest portion of CO_2 emissions and for all CO_2 removals, which include protected area management, regeneration of abandoned areas and the change in carbon stock in the soils, with net emissions for the sector with a share of 77% of total CO_2 net emissions in 2005. Conversion of forests to other uses, especially agriculture, accounted for virtually all CO_2 emissions for the sector and the small remaining share was due to addition of farming limestone to soils.

The Waste sector's share of CO_2 emissions was small due to the burning of waste containing non renewable carbon.

Table 2.1 CO_2 emissions and removals

Sector	1990	1994	2000	2005	Share in 2005	Variation 1990-2005
	(Gg)[1]				(%)	
Energy	**179,948**	**206,250**	**289,958**	**313,695**	**19.2**	**74.3**
Fossil Fuel Combustion	172,371	198,222	279,088	299,941	18.3	74.0
Energy Industries	22,668	25,443	43,595	48,601	3.0	114.4
Manufacturing Industries	36,835	42,217	71,115	75,620	4.6	105.3
Iron and Steel	3,862	5,401	13,089	16,467	1.0	326.4
Chemicals	8,681	9,230	14,649	15,446	0.9	77.9
Other Industries	24,292	27,586	43,377	43,707	2.7	79.9
Transport	79,914	91,820	120,130	133,431	8.1	67.0
Civil Aviation	3,503	3,763	5,278	5,374	0.3	53.4
Road Transportation	71,339	83,236	110,684	122,765	7.5	72.1
Other transportation	5,072	4,821	4,169	5,291	0.3	4.3
Residential Sector	13,818	15,220	17,044	15,484	0.9	12.1
Agricultural Sector	10,052	12,527	14,051	14,809	0.9	47.3
Other Sectors	9,083	10,995	13,154	11,996	0.7	32.1
Fugitive Emissions	7,578	8,028	10,870	13,754	0.8	81.5
Coal Mining and Handling	1,353	1,348	1,291	957	0.1	-29.3
Oil and Natural Gas Activities	6,225	6,680	9,579	12,797	0.8	105.6
Industrial Processes	45,265	48,703	63,220	65,474	4.0	44.6
Cement Production	11,062	10,086	16,047	14,349	0.9	29.7
Lime Production	3,688	4,098	5,008	5,356	0.3	45.2
Ammonia Production	1,683	1,689	1,663	1,922	0.1	14.2
Iron and Steel Production	24,756	28,428	35,437	38,283	2.3	54.6
Aluminum Production	1,574	1,955	2,116	2,472	0.2	57.1
Other	2,502	2,446	2,950	3,093	0.2	23.6
Land-Use Change and Forestry	766,493	830,910	1,258,345	1,258,626	76.8	64.2
Land-Use Change	761,390	821,919	1,249,627	1,251,152	76.4	64.3
Amazon Biome	460,525	521,054	814,106	842,967	51.5	83.0
Cerrado Biome	233,001	233,001	302,715	275,378	16.8	18.2
Other Biomes	67,863	67,863	132,806	132,806	8.1	95.7
Liming of Agricultural Soils	5,103	8,991	8,717	7,474	0.5	46.5
Waste	24	63	92	110	0.0	349.4
TOTAL	**991,731**	**1,085,925**	**1,611,615**	**1,637,905**	**100**	**65.2**

Gg = thousand tonnes

Figure 2.1 CO_2 Emissions by Sector - 1990

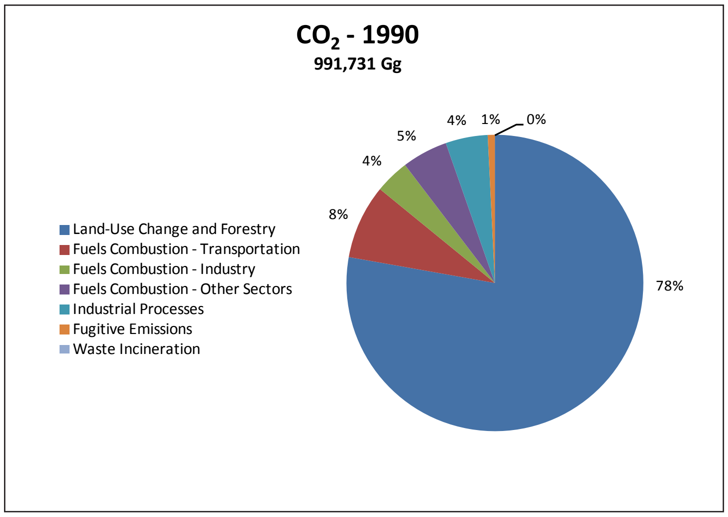


Figure 2.2 CO_2 Emissions by Sector - 2005

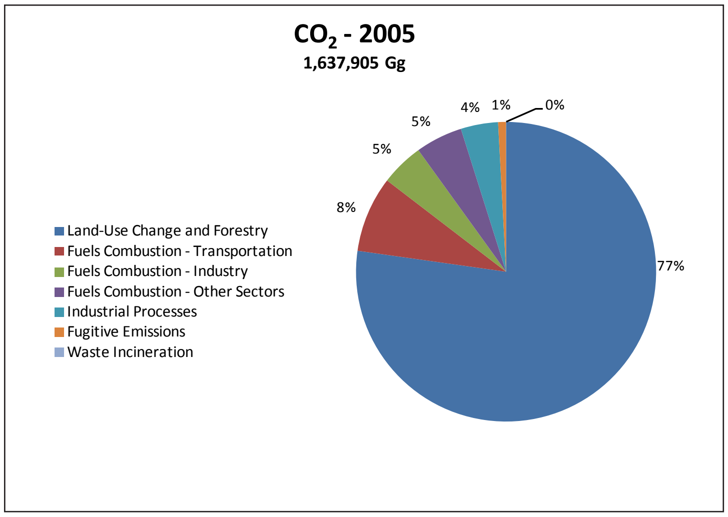
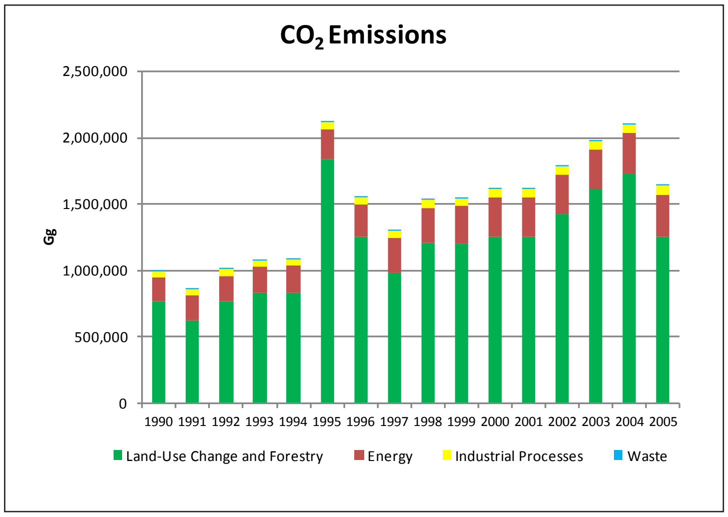


Figure 2.3 CO_2 Emissions Trend



2.2 Methane Emissions

CH_4 emissions result from diverse activities, including sanitary landfills, wastewater treatment, oil and natural gas production and processing systems, agriculture, coal mining and handling, fossil and biomass fuels combustion, conversion of forests to other uses and some industrial processes.

In Brazil, the Agriculture sector is the most responsible for CH_4 emissions (71% in 2005), with the main emission resulting from enteric fermentation (eructation) by the ruminant herd, almost all referring to non-dairy cattle, the second largest herd in the world. In 2005, CH_4 emissions associated with enteric fermentation were estimated at 11,487 Gg, 90% of total CH_4 emissions from the Agriculture sector. Manure management, irrigated rice crops and burning of agriculture residues were responsible for the remaining emissions. The increase in CH_4 emissions predominantly occurred due to the increase in non-dairy cattle herd size in recent years.

In the Energy sector, CH_4 emissions occurred due to imperfect fuel combustion and fugitive emissions during natural gas production and transportation and coal mining and handling processes. In 2005, CH_4 emissions from the Energy sector represented 3.0% of total CH_4 emissions, having increased 27% in comparison to 1990.

In the Industrial Processes sector, CH_4 emissions occurred during petrochemical production, but they have a minor share in Brazilian emissions.

Waste sector emissions represented 9.6% of total CH_4 emissions in 2005, with solid waste disposal responsible for 63% of that figure. From 1990 to 2005, CH_4 emissions from the Waste sector increased by 42%.

In the Land-Use Change and Forestry sector, CH_4 emissions occur from burning biomass in deforestation areas. These emissions represented 17% of total CH_4 emissions in 2005.

Table 2.2 CH_4 Emissions

Sector	1990	1994	2000	2005	Share in 2005	Variation 1990-2005
	(Gg)				(%)	
Energy	427	382	388	541	3.0	26.7
Fuel combustion	336	296	267	344	1.9	2.4
Energy Industries	169	148	125	165	0.9	-2.6
Manufacturing Industries	58	55	54	72	0.4	24.8
Iron and Steel	40	37	35	46	0.3	14.1
Other Industries	18	19	19	27	0.1	48.3
Transport	11	12	11	10	0.1	-2.9
Residential Sector	76	64	62	77	0.4	1.9
Other Sectors	22	17	15	19	0.1	-13.5
Fugitive Emissions	91	87	122	197	1.1	115.6
Coal Mining and Handling	50	42	43	49	0.3	-1.0
Oil and Natural Gas Activities	42	44	78	148	0.8	254.5
Industrial Processes (Chemical Industry)	5	7	9	9	0.1	79.2
Agriculture	9,539	10,237	10,772	12,768	70.5	33.9
Enteric fermentation	8,419	8,995	9,599	11,487	63.4	36.4
Cattle	8,004	8,579	9,256	11,129	61.5	39.0
Dairy Cattle	1,198	1,263	1,178	1,371	7.6	14.5
Non-Dairy Cattle	6,807	7,316	8,078	9,757	53.9	43.4
Other Animals	415	416	344	358	2.0	-13.7
Manure Management	635	675	678	723	4.0	13.8
Cattle	191	205	216	254	1.4	32.8
Dairy Cattle	36	38	34	40	0.2	10.6
Non-Dairy Cattle	155	167	182	214	1.2	38.0
Swine	373	387	365	358	2.0	-4.1
Poultry	48	61	78	92	0.5	89.0
Other Animals	22	23	19	20	0.1	-12.2
Rice Cultivation	363	436	393	426	2.4	17.2
Field Burning of Agriculture Residues	121	131	101	133	0.7	9.7
Land-Use Change and Forestry	1,996	2,238	3,026	3,045	16.8	52.5
Waste	1,227	1,369	1,658	1,743	9.6	42.0
Solid Waste Disposal on Land	792	897	1,060	1,104	6.1	39.5
Wastewater Handling	436	472	598	639	3.5	46.7
Industrial Wastewater	95	103	190	206	1.1	116.8
Domestic and Commercial Wastewater	341	369	408	433	2.4	27.2
TOTAL	**13,195**	**14,233**	**15,852**	**18,107**	**100**	**37.2**

Figure 2.4 CH_4 Emissions by Sector - 1990

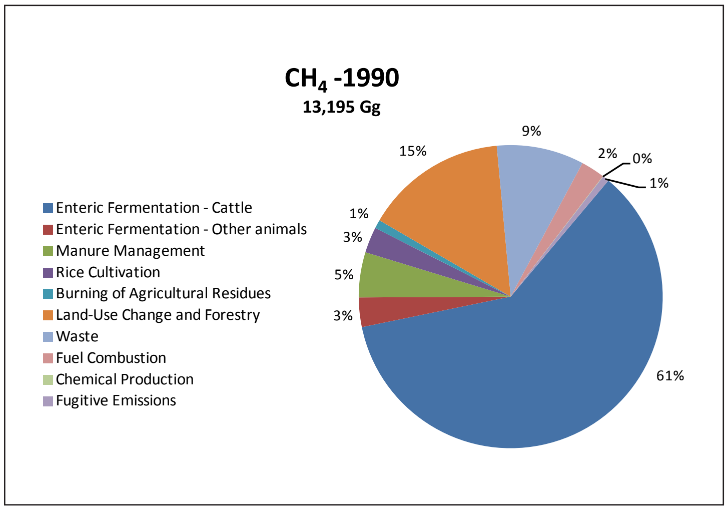


Figure 2.5 CH_4 Emissions by Sector - 2005

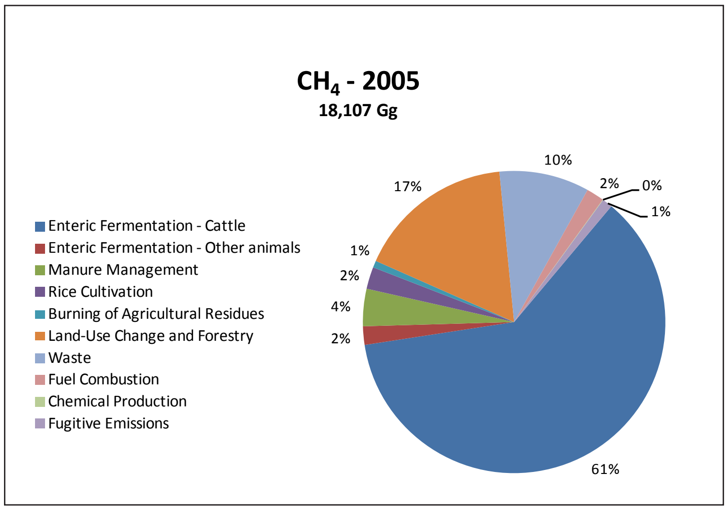
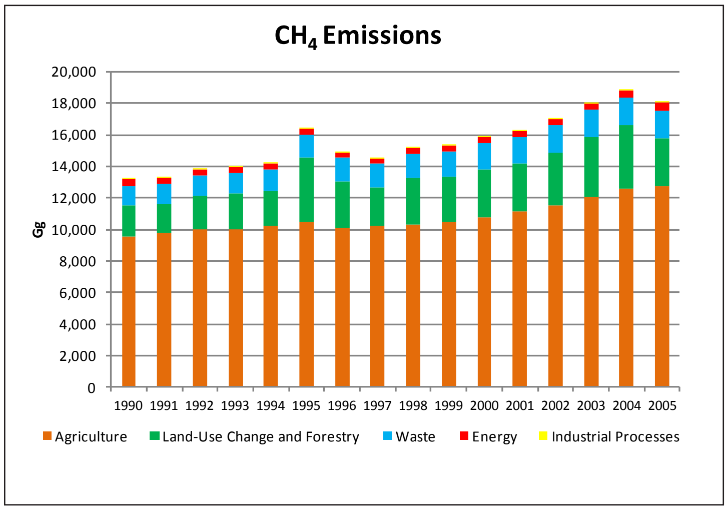


Figure 2.6 CH_4 Emissions Trend



2.3 Nitrous Oxide Emissions

N_2O emissions result from diverse activities, including agriculture, industrial processes, fossil and biomass fuels combustion, and conversion of forests to other uses.

In Brazil, N_2O emissions predominantly occur in the Agriculture sector (87% in 2005), whether from deposition of animal manure in pasture, or, in a smaller scale, from application of fertilizers in cropland. Sectoral N_2O emissions grew 43% between 1990 and 2005.

N_2O emissions in the Energy sector represented just 2.2% of total N_2O emissions in 2005, resulting basically from the imperfect burning of fuel.

In the Industrial Processes sector, N_2O emissions occur during production of nitric acid and adipic acid, and represented 4.2% of total N_2O emissions in 2005.

In the Waste sector, N_2O emissions occurred due to the nitrogen contained in proteins for human consumption that is eventually released in the soil or water bodies, and its contribution towards total N_2O emissions was 2.6% in 2005. An additional small share comes from waste incineration.

In the Land-Use Change and Forestry sector, N_2O emissions occur from burning biomass in deforestation areas. These emissions represented 3.8% of total N_2O emissions in 2005.

Table 2.3 N_2O Emissions

Sector	1990	1994	2000	2005	Share in 2005	Variation 1990-2005
	(Gg)				(%)	
Energy	8	9	10	12	2.2	42.9
Fuel Combustion	8	9	9	12	2.2	41.5
Manufacturing Industries	4	4	4	5	1.0	51.5
Transport	2	2	2	3	0.5	73.6
Other Sectors	3	3	3	4	0.6	13.0
Fugitive Emissions	0	0	0	0	0.0	217.6
Industrial Processes (Chemical Industry)	11	16	20	23	4.2	113.6
Nitric Acid Production	2	2	2	2	0.4	23.9
Adipic Acid Production	9	14	18	20	3.7	135.2
Other	0	0	0	0	0.1	18.1
Agriculture	334	369	393	476	87.2	42.7
Manure Management	10	11	11	13	2.3	27.8
Cattle	3	3	3	3	0.6	13.7
Swine	2	2	2	2	0.4	-10.8
Poultry	4	5	6	7	1.3	61.5
Other Animals	0	0	0	0	0.0	-18.0
Agriculture Soils	318	351	376	457	83.7	43.8
Direct Emissions	213	235	251	306	56.0	43.7
Grazing Animals	166	176	181	217	39.8	31.0
Synthetic Fertilizers	11	17	24	31	5.7	182.5
Animal Manure	13	14	14	16	2.9	18.3
Agriculture Residues	15	19	22	29	5.3	89.6
Organic Soils	8	9	11	13	2.4	70.3
Indirect Emissions	105	116	125	151	27.7	44.1
Field Burning of Agriculture Residues	6	6	5	7	1.2	8.2
Land-Use Change and Forestry	14	15	21	21	3.8	52.5
Waste (Domestic and Commercial Wastewater)	9	11	12	14	2.6	54.5
TOTAL	**376**	**421**	**455**	**546**	**100**	**45.3**

Figure 2.7 N_2O Emissions by Sector – 1990

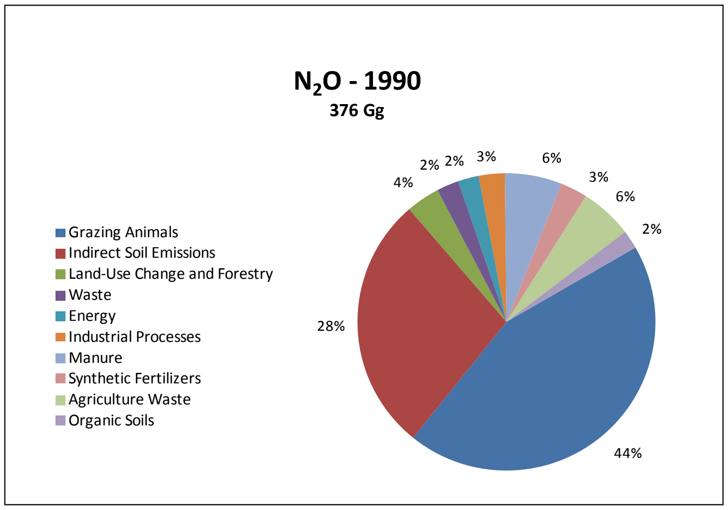


Figure 2.8 N_2O Emissions by Sector – 2005

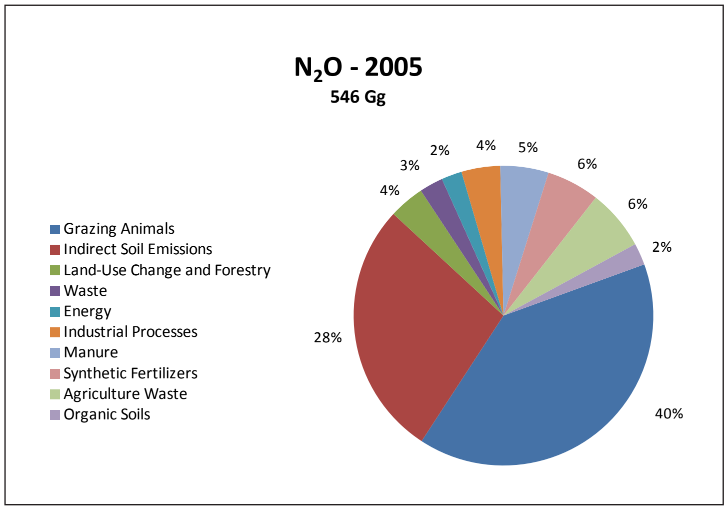
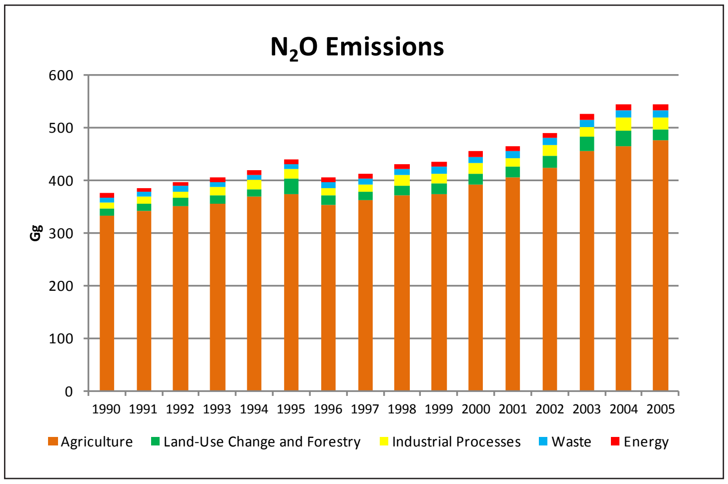


Figure 2.9 N_2O Emissions Trend



2.4 Emissions of Hydrofluorocarbons, Perfluorocarbons and Sulfur Hexafluoride

HFC, PFC and SF_6 gases do not exist in nature, resulting exclusively from human activities.

Brazil does not produce HFCs. Records show the import of 4.5 thousand tonnes of HFC-134a in 2005 for use in the refrigeration and air conditioning subsector. Emissions of HFC-134a were estimated according to the Tier 2b methodology, also called top-down method, which takes into account the sales of gas and its use in various products identified as being made in Brazil: household refrigeration; drinking fountains, commercial refrigeration; refrigerated transportation – refrigerated trucks; industrial air-conditioning and refrigeration; vehicle air-conditioning.

In 2005 imports of HFC-125, HFC-143a, and HFC-152a of 125 t, 93 t and 175 t, respectively, were identified, partly associated to use in special fire extinguishers. Use in other possible applications, such as the manufacturing of foam and solvents, was not observed. Additionally, HFC-23 is emitted as a by-product of HCFC-22 production, estimated at 97.2 t in 1999, year when production of HCFC-22 was ceased in Brazil, in accordance with the Review of the Brazilian Program for Eliminating Substances that Destroy the Ozone Layer - Prozon 1999.

PFC (CF_4 and C_2F_6) emissions occur during aluminum production and result from the anode effect that occurs when the quantity of aluminum oxide diminishes in the processing vats. PFC emissions were estimated at 124 t CF_4 and 10.4 t C_2F_6 in 2005, with a 60.7% reduction when compared to 1990.

SF_6 is used as insulation in large electrical equipment. Emissions of this gas occur due to leaks in equipment, especially during maintenance or disposal. In addition, this gas is used during magnesium production to avoid its oxidation in its liquid phase. SF_6 emissions were estimated at 25.2 t in 2005. Table 2.4 summarizes HFC, PFC and SF_6 emissions.

Table 2.4 HFCs, PFCs and SF_6 Emissions

Gas		1990	1994	2000	2005	Variation 1990-2005
		(Gg)				(%)
HFC-23	HCFC-22 Production	0.120	0.157	-	-	-100
HFC-125	Potential emissions by use	-	-	0.007	0.125	NA
HFC-134a	Real emissions by use	0.0004	0.068	0.471	2.282	527,498
HFC-143a	Potential emissions by use	-	-	0.007	0.093	NA
HFC-152a	Potential emissions by use	-	-	0.0001	0.175	NA
CF_4	Aluminum Production	0.302	0.323	0.147	0.124	-59
C_2F_6	Aluminum Production	0.026	0.028	0.012	0.010	-61
SF_6	Electrical Equipment	0.004	0.004	0.005	0.006	47
	Magnesium Production	0.006	0.010	0.010	0.019	231
	Total SF_6	**0.010**	**0.014**	**0.015**	**0.025**	**153**

2.5 Indirect Greenhouse Gases

Several gases influence chemical reactions that occur in the troposphere and thus play an indirect role in the increase of the radiactive effect. These gases include CO, NO_x and NMVOC. Emissions of these gases are mainly the result of human activities.

Most CO and NO_x emissions result from imperfect fuel combustion in the Energy sector, burning of residues in the Agriculture sector or biomass burning in deforestation areas in the Land-Use Change and Forestry sector. A small portion of CO emissions results from production processes, basically aluminum production. With regard to NO_x, the remaining emissions also occur in the Industrial Processes sector, as a result of nitric acid and aluminum production. CO emissions increased by 17% and NO_x emissions increased by 36% between 1990 and 2005.

Most NMVOC emissions also result from imperfect fuel combustion (45% in 2005), but a significant part is the result of solvent production and use (28% in 2005) or from the food and beverage industry (24% in 2005).

Table 2.5, Table 2.6 and Table 2.7 present CO, NO_x and NMVOC emissions, respectively.

Table 2.5 CO Emissions

Sector	1990	1994	2000	2005	Share in 2005	Variation 1990-2005
	(Gg)				(%)	
Energy	14,919	14,438	11,415	11,282	27.3	-24.4
Energy Industries	1,583	1,492	1,232	1,670	4.0	5.5
Manufacturing Industries	1,573	1,645	1,677	2,307	5.6	46.7
Iron and Steel	842	789	756	972	2.4	15.5
Food and Beverage	366	550	627	1,014	2.5	177.0
Other Industries	366	306	293	321	0.8	-12.2
Transport	7,886	8,069	5,402	3,407	8.2	-56.8
Road Transportation	7,783	7,967	5,303	3,302	8.0	-57.6
Other Transportation	103	102	100	105	0.3	1.7
Residential Sector	3,522	2,976	2,874	3,602	8.7	2.3
Other Sectors	355	257	229	295	0.7	-16.9
Industrial Processes	365	510	542	626	1.5	71.3
Aluminum Production	345	480	504	572	1.4	65.9
Other	20	29	37	53	0.1	161.5
Agriculture (Field Burning of Residues)	2,543	2,741	2,131	2,791	6.8	9.7
Cotton	88	11	-	-	-	-100.0
Sugar cane	2,455	2,730	2,131	2,791	6.8	13.7
Land-Use Change and Forestry	17,468	19,584	26,476	26,641	64.4	52.5
TOTAL	**35,296**	**37,273**	**40,563**	**41,339**	**100**	**17.1**

Table 2.6 NO_x Emissions

Sector	1990	1994	2000	2005	Share in 2005	Variation 1990-2005
	(Gg)				(%)	
Energy	1,781	1,996	2,334	2,388	70.2	34.1
Energy Industries	222	259	406	457	13.4	105.9
Manufacturing Industries	320	366	486	542	16.0	69.5
Iron and Steel	98	116	133	149	4.4	52.4
Other Industries	222	250	354	394	11.6	77.0
Transport	1,173	1,311	1,381	1,322	38.9	12.6
Road Transportation	1,066	1,206	1,283	1,203	35.4	12.9
Other Transportation	108	105	98	119	3.5	10.1
Residential Sector	53	48	48	55	1.6	3.4
Other Sectors	12	13	12	12	0.3	-3.1
Industrial Processes	8	11	14	18	0.5	127.5
Agriculture (Field Burning of Residues)	219	233	181	237	7.0	8.2
Cotton	10	1	-	-	-	-100.0
Sugarcane	208	232	181	237	7.0	13.7
Land-Use Change and Forestry	496	556	752	757	22.3	52.5
TOTAL	**2,504**	**2,797**	**3,280**	**3,399**	**100**	**35.8**

Table 2.7 NMVOC Emissions

Sector	1990	1994	2000	2005	Share in 2005	Variation 1990-2005
	(Gg)				(%)	
Energy	1,022	974	860	958	44.5	-6.2
Energy Industries	337	293	248	327	15.2	-3.0
Manufacturing Industries	51	55	57	75	3.5	45.9
Iron and Steel	24	23	22	27	1.3	16.7
Food and Beverage	14	19	22	33	1.5	135.6
Other Industries	14	13	13	15	0.7	5.3
Transport	371	403	342	288	13.4	-22.4
Road Transportation	354	387	326	270	12.5	-23.9
Other Transportation	16	16	15	18	0.9	11.5
Residential Sector	204	173	168	210	9.8	3.2
Other Sectors	59	50	45	58	2.7	-0.7
Industrial Processes	322	382	474	599	27.8	85.8
Chemical Industry	27	31	43	49	2.3	84.8
Pulp and Paper	13	19	25	35	1.6	161.5
Food Production	112	176	223	331	15.4	195.4
Beverage Production	170	157	183	184	8.5	7.8
Use of Solvents and Other Products	350	435	473	595	27.7	70.2
Paint Application	227	300	331	439	20.4	93.2
Other Uses	122	135	142	156	7.3	27.7
TOTAL	**1,693**	**1,791**	**1,807**	**2,152**	**100**	**27.1**

Box 1 – For information only

Greenhouse Gas Emissions in CO_2e

The option for aggregating reported emissions in carbon dioxide equivalent units using Global Warming Potential - GWP over a 100 year time horizon was not adopted in Brazil in its Initial Inventory. GWP is based on the relative importance of greenhouse gases, in relation to carbon dioxide, in producing a quantity of energy (by unit area) several years after an emission pulse. This variable does not appropriately represent the relative contribution of different greenhouse gases to climate change. Whether it is measured in terms of the increase in average temperature in the Earth surface, sea level rise or any meteorological statistics related to damage, climate change is not proportional to energy, except for very short time periods. The use of GWP would then provide inappropriate mitigation policies. Furthermore, its use would overemphasize and erroneously stress the importance of greenhouse gases that remain in the atmosphere for only a short period of time, particularly methane.

These facts were initially addressed in the "Brazilian Proposal for the Kyoto Protocol" in 1997. The scientific aspects are in constant evolution. However, they can be taken into account by conventionally considering the knowledge found in the IPCC's Fourth Assessment Report (AR4) based on the fact that such knowledge was properly reviewed by the scientific community and by governments. If necessary, estimates can be revised when a new IPCC assessment is made available. The AR4 already examines alternative metrics to the GWP, and the IPCC's Fifth Assessment Report (AR5) should provide a more in-depth analysis. The metrics provided in the AR4 include the Global Temperature Potential - GTP described by SHINE *et al.* (2005), ZHANG *et al.* (2010) and ZHANG *et al.* (submitted for publication). Despite higher uncertainty in its calculation due to the need to use climate system sensitivity, GTP is a more appropriate metric to measure the effects of different gases on climate change, and its use would be conducive to more appropriate mitigation policies.

In this Inventory, a decision was made to continue reporting the anthropogenic emissions by sources and removals by sinks of greenhouse gases not controlled by the Montreal Protocol simply in units of mass for each greenhouse gas. However, in order to make it clear that using the GWP leads to an overestimation of the share of methane, the results of the Inventory using different CO_2 equivalent conversion metrics are described just for information purposes. Therefore, the approach of using both GWP-100 years and GTP-100 years is used for two main reasons:

1. Although providing emissions for different gases in a mass unit is sufficient to ensure information transparency, providing a total, single number in CO_2e is usual, although misleading;

2. The submission of results using the two metrics explains the difference of the result, and shows how the use of GWP-100 years has been misleadingly driving mitigation priorities. Exaggerated importance has been assigned to methane emission reduction and to some industrial gases that remain in the atmosphere for a short period of time, thus shifting the focus away from the need to reduce CO_2 emissions from fossil fuels and to control some of the industrial gases that remain in the atmosphere for a long period of time.

Table 2.8 GTP-100 and GWP-100 Factors

Gas	GTP-100[1]	GWP-100[2]
CO_2	1	1
CH_4	5	21
N_2O	270	310
HFC-125	1,113	2,800
HFC-134a	55	1,300
HFC-143a	4,288	3,800
HFC-152a	0.1	140
CF_4	10,052	6,500
C_2F_6	22,468	9,200
SF_6	40,935	23,900

Sources:
[1] GTP-100 for CH_4 and N_2O – SHINE *et al.* (2005); for HFCs - ZHANG *et al.* (2010) and for PFCs and SF_6 –ZHANG *et al* (submitted for publication);
[2] GWP-100 – Pursuant to Decision 17/CP.8

Figure 2.10 Differences between two possible metrics for estimating Brazilian greenhouse gas emissions in CO_2e in 2005

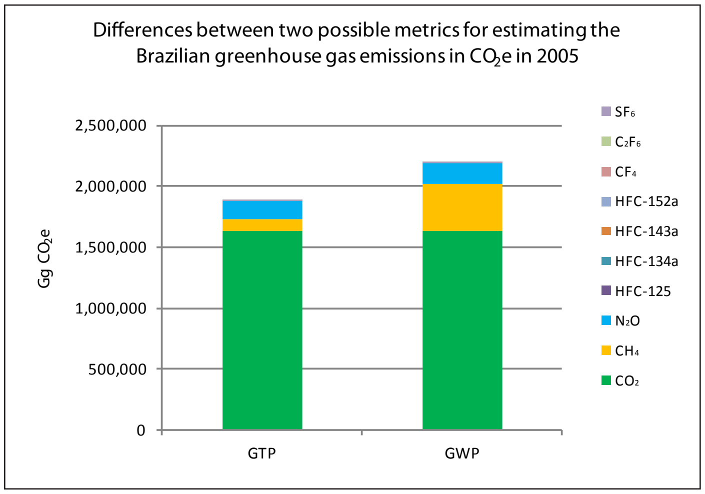


Table 2.9 Anthropogenic emissions by sources and removals by sinks of greenhouse gases in CO_2e, using GTP-100 and GWP-100 metrics in 2005, by sector

Sector	GTP		GWP	
	2005	Share in 2005	2005	Share in 2005
	Gg CO_2e	(%)	Gg CO_2e	(%)
Energy	319,667	17.0	328,808	15.0
Industrial Processes	74,854	4.0	77,939	3.6
Agriculture	192,411	10.2	415,754	19.0
Land-Use Change and Forestry	1,279,501	68.1	1,329,053	60.6
Waste	12,596	0.7	41,048	1.9
TOTAL	**1,879,029**	**100**	**2,192,601**	**100**

Figure 2.11 Emissions in CO_2e , converted using two different metrics, for 2005, by sector

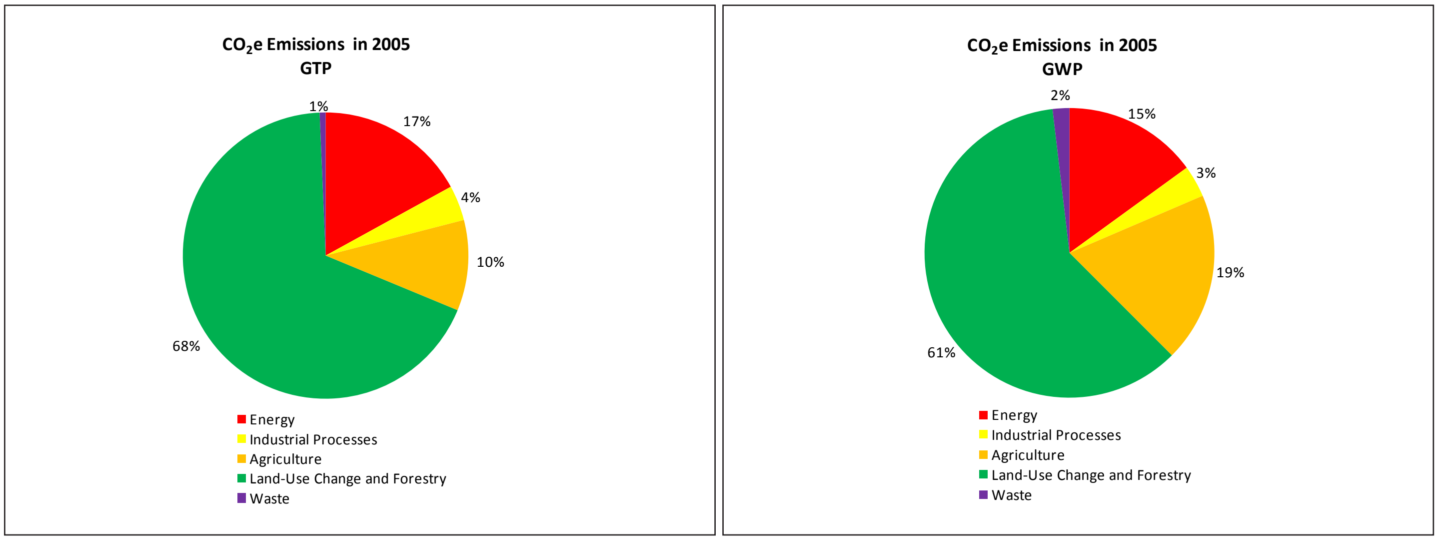
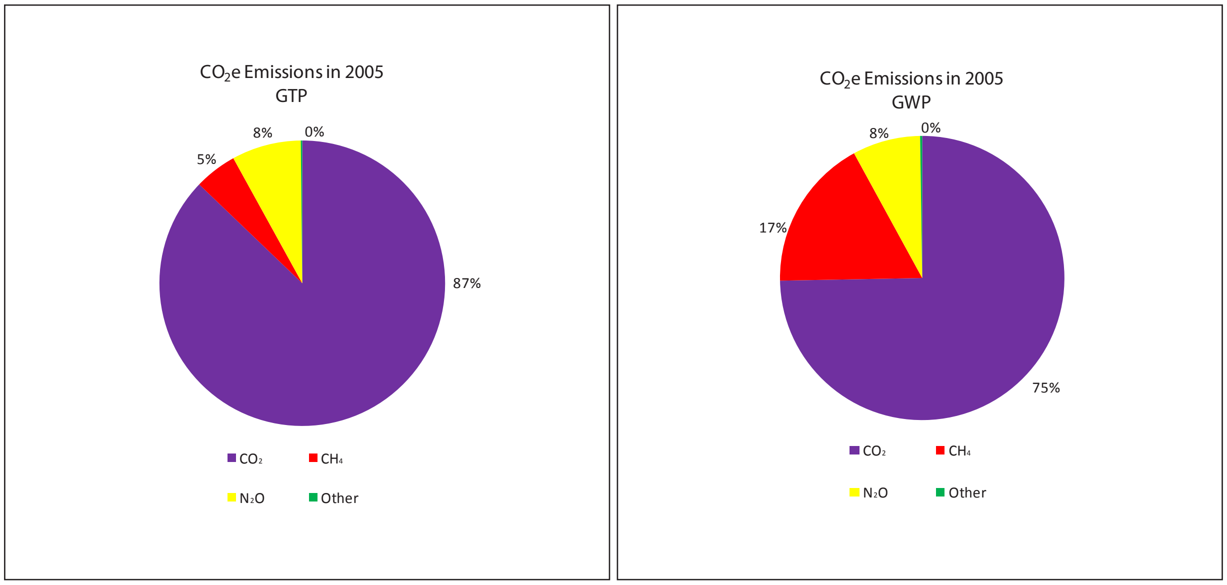


Table 2.10 Anthropogenic emissions by sources and removals by sinks of greenhouse gases in CO_2e, using GTP-100 and GWP-100 metrics in 2005, by gas

Gas	GTP		GWP	
	2005	Share in 2005	2005	Share in 2005
	Gg	%	Gg	%
CO_2	1,637,905	87.2	1,637,905	74.7
CH_4	90,534	4.8	380,241	17.3
N_2O	147,419	7.8	169,259	7.7
HFC-125	139	0.0	350	0.0
HFC-134a	126	0.0	2,966	0.1
HFC-143a	398	0.0	353	0.0
HFC-152a	0.0175	0.0	24	0.0
CF_4	1,245	0.1	805	0.0
C_2F_6	233	0.0	95	0.0
SF_6	1,031	0.1	602	0.0
Total	**1,879,029**	**100**	**2,192,601**	**100**

Figure 2.12 – Emissions in CO_2e , converted using two different metrics, for 2005, by gas



Chapter 3

Anthropogenic Emissions by Sources and Removals by Sinks of Greenhouse Gases by Sector

- Energy
- Industrial Processes
- Solvent and Other Product Use Sector
- Agriculture
- Land-Use Change and Forestry
- Waste

Caio Coronel - Itaipu Binacional

Energy

3 Anthropogenic Emissions by Sources and Removals by Sinks of Greenhouse Gases by Sector

3.1 Energy

3.1.1 Characteristics of the Brazilian Energy Matrix

The Brazilian energy matrix is characterized by a large share of renewable sources, partly due to the country's current state of development and the shortage of fossil energy resources until the 1970s. Strong dependence on imported crude oil made the country vulnerable to crude oil crises. This vulnerability, aligned with the availability of lands, led to commercial uses of biomass, especially ethanol in road transport and charcoal in the iron and steel production, placing Brazil as one of the most relevant countries in terms of the use of fossil fuel source alternatives.

In order to understand Brazilian policy regarding fossil energies, the behaviour of fuel demand and greenhouse gas emissions, one must consider crude oil price variations, in real terms and over the years. The first two oil crises occurred in 1973 and 1979. The latter resulted in serious impacts for Brazil's economy, which at the time was strongly dependent on commodity exports in general and oil imports. During the first half of the 2000s, a third crisis occurred, characterized by a structural change in prices. The 1979 crisis and the one from the beginning of 2000 reduced the demand for oil and increased the demand for biomass. In this third crisis, the demand for oil was further reduced due to the entry of Bolivia's natural gas in the market.

The second oil crisis marks the beginning of a recession period. The 1990s witnessed low economic growth rates and GDP per capita dropped during the first two years. Since 2004, GDP per capita growth has become higher than population growth. The GDP per capita increase between 1990 and 2005 was of 1.1% per year.

The lack of fossil energy reserves in Brazil is reflected in Table 3.1, which shows the gross domestic supply[45], used as an approximation to demand. Net imports[46] of fossil energy divided by demand is a measure of external energy dependence and shows that Brazil went from nearly 70% of dependence to less than 20% in three decades (1970 to 2005).

In 2005, the primary fossil fuel sources represented 55% of gross domestic supply of energy. Of these sources, crude oil and oil by-products were responsible for the greatest contribution, followed by natural gas, whose share increased from 3.1% in 1990 to 9.6% in 2005. Almost all metallurgical coal is imported and most of it is destined to the iron and steel subsector. Brazilian anthracite, other bituminous coal, sub-bituminous coal and lignite (steam coal) have low calorific value and high ash content, which for economical reasons limits their use to areas near extraction sites. It is predominantly used for thermoelectric generation.

45 Gross domestic supply is used as an approximation to demand and it equals the production of fossil fuels plus imports minus variations in stock, exports, non-utilized energy and reinjection. Gross domestic supply is used as an indicator to evaluate energy demand at the primary fuel level, since private stock is small in face of total demand.

46 Net imports equals imports minus exports of fossil fuels.

Table 3.1 Gross Domestic Energy Supply, by source

Source	1990	1994	2000	2005	Share in 2005	Variation 1990-2005
	(10³ toe[a])				(%)	
Energy – Fossil	71,640	83,123	110,556	117,476	55	64
Oil and Oil By-products	57,749	66,692	86,743	83,229	38.9	44.1
Natural Gas	4,337	5,128	10,256	20,526	9.6	373.3
Coal and Coal By-products	9,555	11,304	13,557	13,721	6.4	43.6
Energy – Non-Fossil	68,019	71,539	76,234	96,265	45	41.5
Uranium - U_3O_3	598	43	1,806	2,549	1.2	326.4
Hydro[b]	17,770	20,864	26,168	29,021	13.6	63.3
Firewood	28,537	24,858	23,058	28,420	13.3	-0.4
Sugar Cane Products	18,988	22,773	20,761	29,907	14	57.5
Charcoal	-	-3	2	49	0	-
Other Primary Sources	2,126	3,004	4,439	6,320	3	197.2
Gross Domestic Supply	**139,659**	**154,662**	**186,789**	**213,742**	**100**	**53**

[a] toe (1 tonne of oil equivalent) ≅ 41.868 x 10^3TJ (based on the lower average calorific value of the oil consumed in Brazil) [47].
[b] Hydropower and electricity energy conversion factor to toe: 1 MWh = 0.086 toe[48].

Source: BRASIL, 2008.

47 Brazilian Energy Balance (BEB) editions until 2001 considered gross calorific values (GCV). More recent editions use net calorific value (NCV) and they correct the entire historical series, avoiding the need for converting "old toe" (equal to 10,800 Mcal) to the "new toe" (10,000 Mcal). Calculations adopt the NCV for each fuel, in order to deal with electricity as the mechanical equivalent of toe in generating thermoelectricity with fuel oil, i.e., by the calorie content of the oil mass consumed to generate 1 unit of electric energy (MWh). The conversions of data from BEB from natural units to toe was made by applying conversion factors made available by the *Empresa de Pesquisa Energética* (EPE), which vary from 1990 to 2005 for some fuels, and therefore, generate a slight distortion between data used in this Inventory and those presented in the Brazilian Energy Balance.

48 For converting hydropower and electricity into tonnes of oil equivalent, BEB-2008 adopts the principle of "equivalence in consumption" based on the first law of thermodynamics (1 MWh = 0.086 toe), as done in most countries. In the Initial National Communication, the principle of "equivalence in production" was adopted. This establishes the quantity of oil needed to generate 1 MWh at a thermoelectric plant (1 MWh = 0.29 toe). Thus, the gross domestic supply of hydropower, electricity and nuclear energy was overestimated, as was the final consumption of electricity in relation to the criteria adopted internationally, generating distortions in comparisons with other countries.

From 1990 to 2005, hydropower was responsible for nearly 90% of the electricity generation in the country. Ethanol produced from sugarcane also had an important share, as a result of the National Alcohol Program - *Proalcool*, a government program designed to increase hydrated ethanol production for use in motor vehicles and the addition of anhydrous ethanol to gasoline. Another example of renewable source share in energy generation is the bagasse produced from sugarcane, mainly used in industrial sector boilers.

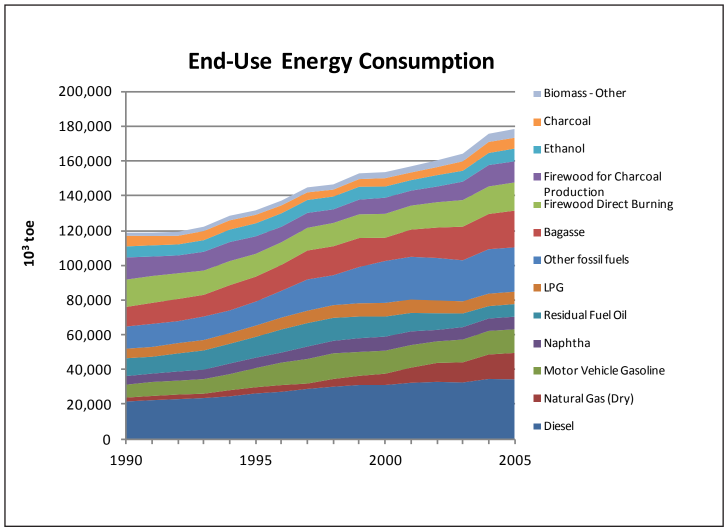
The evolution of end-use energy consumption for energy purposes is presented in Table 3.2. From 1990 to 2005 there is a retraction in steam coal, fuel oil, tar and aviation gasoline, the most relevant cases, accompanied by a more important increase in the use of petroleum coke, natural gas, solvent, gasoline and other primary fossil fuel sources and black liquor. Piped gas consumption ended in 2002, and other kerosene, whose consumption was already not representative in 1990, presents a reduction of 82%. In Figure 3.1 the behaviour of the end-use consumption of energy by fuel is presented for the period from 1990 to 2005.

Table 3.2 End-use energy consumption, by source

Source	1990	1994	2000	2005	Share in 2005	Variation 1990-2005
	(10^3 toe)				(%)	
Gasoline	7,436	9,235	13,261	13,595	7.6	82.8
Aviation Gasoline	49	52	58	43	0.0	-12.7
Jet Kerosene	1,133	1,218	1,722	1,771	1.0	56.3
Other Kerosene	272	154	118	48	0.0	-82.3
Diesel	21,515	24,470	31,009	34,277	19.2	59.3
Residual Fuel Oil	10,266	11,359	11,573	7,270	4.1	-29.2
LPG	5,525	6,124	7,844	7,121	4.0	28.9
Naphtha	4,958	6,140	8,102	7,277	4.1	46.8
Bitumen	1,234	1,278	1,727	1,461	0.8	18.4
Lubricants	697	639	822	856	0.5	22.7
Solvents	223	355	424	1,005	0.6	351.4
Other Non-Energy Oil Products	1,079	880	1,478	1,179	0.7	9.2
Petroleum Coke	391	542	3,317	3,821	2.1	877.3
Steam Coal	1,945	1,939	2,643	1,183	0.7	-39.2
Metallurgical Coal	0	258	2,482	3,169	1.8	-
Tar	252	294	242	210	0.1	-16.8
Coke Oven/Gas Coke	196	266	441	353	0.2	80.3
Natural Gas (Humid)	801	60	1,291	2,016	1.1	151.6
Natural Gas (Dry)	2,245	3,552	6,502	15,205	8.5	577.2
Refinery Gas	1,819	2,343	3,015	3,905	2.2	114.7
Other Energy Oil Products	960	1,194	2,196	2,149	1.2	123.9
Piped Gas	280	141	85	0	0	-100
Coke Oven Gas	1,078	1,133	1,127	1,122	0.6	4.1
Firewood Direct Burning	15,757	13,893	13,774	16,247	9.1	3.1
Firewood for Charcoal Production	12,780	10,965	9,284	12,173	6.8	-4.8
Charcoal	6,137	5,333	4,814	6,248	3.5	1.8
Bagasse	11,266	14,546	13,381	21,147	11.8	87.7
Biomass Residues	426	462	593	819	0.5	92
Other Primary Fossil Fuel Sources	347	321	955	1,249	0.7	260.3
Black Liquor	1,313	2,183	2,891	4,252	2.4	223.7
Ethanol	6,346	7,182	6,457	7,321	4.1	15.4
Total	**118,727**	**128,508**	**153,629**	**178,491**	**100**	**50.3**

Source: BRASIL, 2008.

Figure 3.1 End-use energy consumption, by source



A sectoral breakdown shows higher energy consumption than the average growth rate in thermoelectric plants and in the industrial and transport subsectors, the latter driven by road and aviation. Although an important change cannot be observed in the fuel consumption of the industrial subsector, some changes can be seen in the subsectors that comprise it. That is the case of the cement subsector, in which a 23% increase in total energy consumption can be observed from 1990 to 2005, marked by the strong reduction in residual fuel oil consumption (whose total share falls from 49% in 1990 to 0.9% in 2005), greatly compensated by the increase in petroleum coke consumption (0.2% share in total consumption in 1990 and 76% in 2005).

The industrial subsector increases its share in total energy consumption from 24% to 29% from 1990 to 2005. The transport subsector increases its share in total energy consumption from 27% to 29% in the period of the Inventory. The increase in natural gas consumption stands out in the road transport, although its share in total fuel consumption is still modest in 2005.

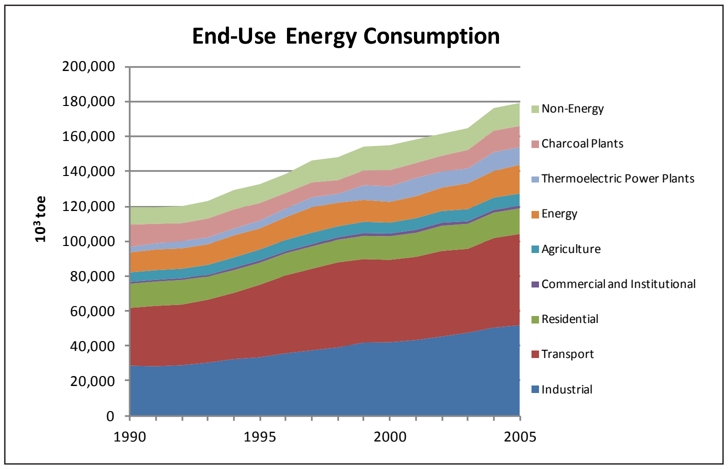
The highest growth consumption rate comes from thermopower plants, mostly relied on natural gas (35% total share in 2005) and diesel (19%). Nevertheless, the share of thermopower plants in total consumption in 2005 is only 5.7%. Throughout the period of the Inventory, renewable energy fuel sources maintain a share of nearly 40% of total consumption, but with a trend towards long-term reduction. Table 3.3 shows the end-use energy consumption for 1990, 1994, 2000 and 2005 by subsector.

Table 3.3 End-use energy consumption for 1990, 1994, 2000 and 2005, by sector

Subsector	1990	1994	2000	2005	Share in 2005	Variation 1990-2005
	(10^3 toe)				(%)	
Industrial	28,557	32,367	42,013	51,781	29.0	81.3
Transport	32,375	37,163	45,876	51,574	28.9	59.3
Residential	13,864	13,069	13,501	14,672	8.2	5.8
Commercial and Institucional	1,061	1,306	1,616	1,488	0.8	40.2
Agriculture	5,454	5,931	6,217	7,009	3.9	28.5
Energy	11,454	12,652	11,942	16,479	9.2	43.9
Thermo Power Plants	3,167	3,914	8,884	10,092	5.7	218.7
Charcoal Plants	12,780	10,965	9,284	12,173	6.8	-4.8
Non-energy	10,014	11,139	14,297	13,222	7.4	32.0
Total	**118,727**	**128,508**	**153,629**	**178,491**	**100**	**50.3**

End-use energy consumption behavior, by subsector, can be seen in Figure 3.2 for the period of 1990 to 2005.

Figure 3.2 End-use energy consumption, by sector



The next section presents greenhouse gas emissions estimates due to energy production, transformation, transport and consumption and is divided into two sub-sections: fuel combustion and fugitive emissions.

3.1.2 Fuel Combustion Emissions

The combustion process essentially generates CO_2 from oxidation of the carbon contained in fuels, releasing energy. However, the combustion process is imperfect, and as a consequence, also produces CH_4, CO, and NMVOC. N_2O and NO_x are also generated as a secondary effect.

3.1.2.1 CO_2 emissions from fuel combustion

Brazil's CO_2 emissions from fuel combustion were estimated with the reference or Top-down approach, in which CO_2 emissions are calculated from fuel supply; and the sectoral or Bottom-up approach, in which CO_2 emissions are calculated from each sector's final energy consumption (IPCC, 1997). Only CO_2 emissions arising from fossil fuel combustion are considered in this chapter and accounted for in the national total. Emissions resulting from biomass fuel combustion should not be included in national CO_2 emissions and are here presented for information purposes only, as can be seen in Table 3.4, since they are derived from a photosynthesis process. For CO_2 emissions, biomass consumption for fuel is assumed to equal its regrowth. Any departures from this assumption are accounted within the Land-Use Change and Forestry module.

Emission estimates are based on production and consumption data by energy source, obtained from the Brazilian Energy Balance (BRASIL, 2008), previously published by the Ministry of Mines and Energy (MME) and in recent years published by EPE, a company subordinate to MME.

The three editions of the Useful Energy Balance (BEU – *Balanço de Energia Útil*) available in Brazil were used specifically for the sectoral approach. They were published in 10 year intervals (1983, 1993 and 2003), aimed at breaking down fuel consumption into final destinations. BEU provides the destination of each energetic, in final energy, by type of use for the several sectors, as well as their respective efficiencies. Among the available destinations, process heat, direct heating and drive force are the most relevant for emissions, since they indicate employed technology (boiler or heater, oven or dryers and motor or turbine, respectively). A residual fuel application for illumination is also considered.

For non-CO_2 gas emission factors, a set of criteria was introduced to aggregate them by technology type (motors, boilers, dryers, ovens, etc.) with the objective of identifying more appropriate factors for each type of equipment and fuel, combining specific and default emission factors and considering similar characteristics (physical state, fossil or renewable, carbon content, etc.) for fuels and equipment. The main sources of data for the adopted emission factors are the 1996 Guidelines and the CORINAIR Guidebook. An attempt was made to establish the level of detail that can be reached by associating fuels with the equipment in which they are most frequently used in Brazil.

Top-down

The Top-down approach allows for the estimation of CO_2 emissions considering the energy supplied in the country, regardless of the details on energy consumption. Emissions are estimated from a balance involving the domestic production of primary fuels, net imports of primary and secondary fuels and domestic variation of these fuel stocks. The methodology establishes that, once introduced in the domestic economy, in a specific year, the carbon contained in a fuel is released into the atmosphere or it is somehow retained, through an increase in fuel stock, the incorporation into non-energy products or its partial retention in combustion residue. A small fraction of the fuels (around 1%) is considered to be unoxidised and ends up incorporated to ashes or other sub-products. For the non-energy use of fuels, also it is also considered that a fraction is retained over a long period of time (around one century). These considerations indicate that the advantage of the Top-down approach over other methods is that it does not depend on detailed information about fuel use by the final user, or about intermediate transformations of fuel for the calculation of CO_2.

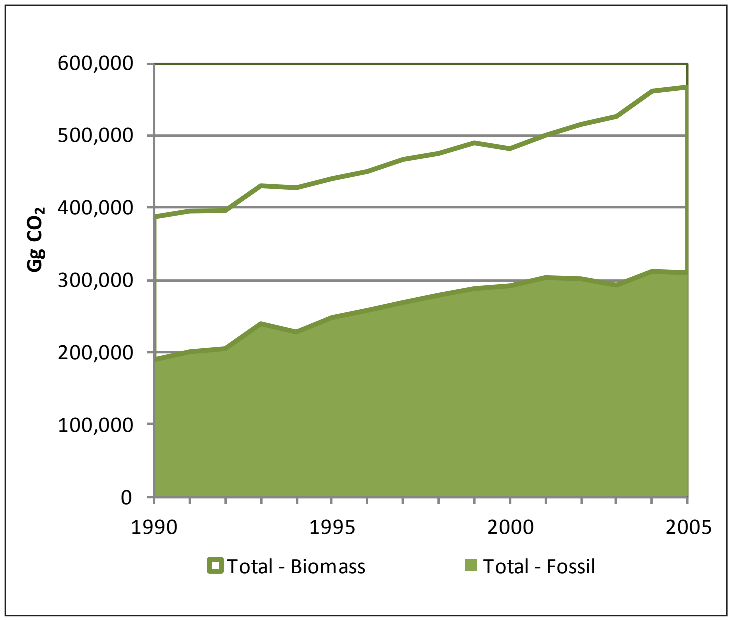
In the Top-down approach, energy sources are separated by physical state of the primary product, fundamentally corresponding to oil, oil by-products and liquids of natural gas (liquids), coal and coal by-products (solids) and dry natural gas (gaseous). Table 3.4 presents the result of CO_2 emissions estimated by the Top-down approach for 1990, 1994, 2000 and 2005.

Table 3.4 CO_2 Emissions (Top-down)

Source	1990	1994	2000	2005	Share in 2005	Variation 1990-2005
	(Gg)				(%)	
Oil and oil by-prod.	151,565	175,859	228,660	221,254	71.4	46.0
Coal and coal by-prod.	27,725	39,886	37,774	38,407	12.4	38.5
Natural Gas	9, 317	11,598	23,992	48,245	15.6	395.8
Other Primary Fossil Fuel Sources	614	570	1,426	2,071	0.7	237.4
Total - Fossil	**189,635**	**227,913**	**291,851**	**309,978**	**100.0**	**63.5**
Liquid Biomass	24,467	28,697	28,273	35,989	14.0	47.1
Solid Biomass	173,199	171,047	161,600	221,100	86.0	27.7
Gaseous Biomass	-	-	-	-	0.0	NA
Total Biomass**	**197,666**	**199,744**	**189,873**	**257,089**	**100**	**30.1**

*Includes primary sources with different physical states.
**CO_2 emissions from use of biomass as fuel are presented for information purposes only, and should not be accounted for in this Inventory.

Figure 3.3 CO_2 Emissions (Top-down)



Total CO_2 emissions from fossil fuels combustion grew from 189.6 Mt CO_2, in 1990, to 310.0 Mt CO_2, in 2005, representing a 63.5% growth, i.e., an average annual increase of 3.3%. The upward trend for CO_2 emissions is maintained in relation to the Initial Inventory.

Emissions from oil by-products stand out with 71.4% of total CO_2 emissions for the Energy sector in 2005. Oil consumption is still important in 2005, but in a lesser extent, making room for a greater consumption of other fuels. Second place is occupied by emissions from coal and coal by-products, with a 12.4% share in total emissions in 2005. The main source is imported metallurgical coal and domestic steam coal.

Emissions from natural gas stand out the most in terms of growth over the period, expanding their share of total emissions from 5.1% in 1990 to 15.6% in 2005 and, therefore, replacing the use of oil by-products.

Bottom-Up

The sectoral, or Bottom-up approach allows the identification of where and how emissions occur, favouring the establishment of mitigation measures. This approach also addresses emissions of other greenhouse gases whose behaviour is important.

The estimation of emissions based on the Bottom-up approach considers the various destinations of the fuel use. Besides CO_2, emissions from so-called non-CO_2 gases are also estimated, which are: CO, CH_4, N_2O, NO_x, and NMVOC.

CO_2 emissions depend on fuel carbon content and can be estimated at a high level of aggregation, with reasonable accuracy, as proposed in the Top-down approach. However, for non-CO_2 gases it is necessary to work with complementary information about final use, equipment technology, usage conditions, etc., and therefore it is necessary to use a more disaggregated approach. Nevertheless, under the IPCC methodology (IPCC, 1997) it is recommended that CO_2 emissions also be estimated using a more disaggregated level of information, which permits comparison between the two approaches, as will be addressed further ahead. In this sense, CO_2 emissions from fuel combustion were estimated for the various sectors of the economy.

The determination of end-use consumption of fuels by sector required an adjustment of the available database. The adjustment was needed regarding the fuels as well as the activity sectors. In relation to emissions, each country's peculiarities are reflected in the difference of carbon content of the fuels used and/or the characteristics of use and transformation equipment. Taking into account that in fuel combustion emission factors for non-CO_2 gases depend on the technology used, an attempt was made to develop appropriate emission factors for Brazil by identifying the equipment used by the diverse sectors.

Table 3.5 and Table 3.6 show, respectively, emissions by fuel and by subsector for 1990, 1994, 2000 and 2005. CO_2 emissions in 2005 were estimated at 300 Mt. Emissions grew 74% during the period of the Inventory, while the growth in energy consumption was of 50%. Therefore, it can be inferred that there was an increase in carbon intensity in the country's energy system.

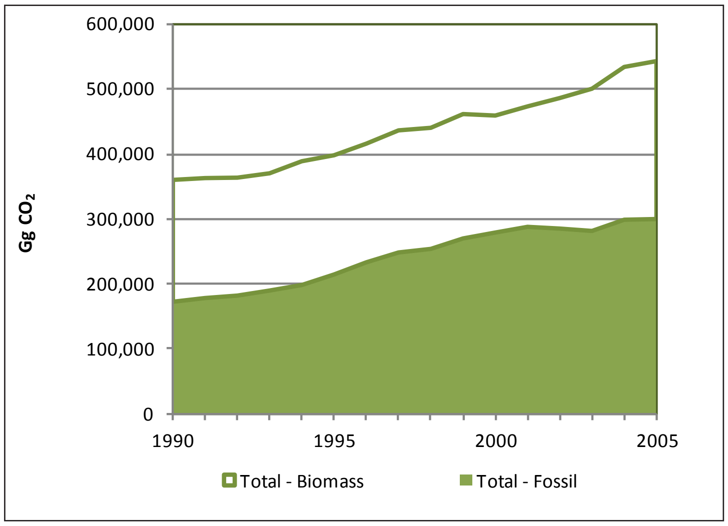
Table 3.5 CO_2 emissions, by fuel

Source	1990	1994	2000	2005	Share in 2005	Variation 1990-2005
	(Gg)				(%)	
Gasoline	21,361	26,526	38,092	39,052	13.0	82.8
Aviation Gasoline	145	154	173	127	0.0	-12.7
Aviation Kerosene	3,358	3,609	5,104	5,248	1.7	56.3
Other Kerosene	568	365	166	74	0.0	-87.0
Diesel	66,053	75,123	95,199	105,231	35.1	59.3
Residual Fuel Oil	32,921	36,425	37,113	23,315	7.8	-29.2
LPG	14,443	16,007	20,504	18,616	6.2	28.9
Naphtha	3,768	4,665	6,157	5,530	1.8	46.8
Lubricants	1,059	972	1,249	1,300	0.4	22.7
Petroleum coke	1,634	2,266	13,865	15,968	5.3	877.3
Steam Coal	7,549	7,526	10,261	4,592	1.5	-39.2
Metallurgical Coal	0	1,003	9,635	12,302	4.1	-
Tar	667	929	531	352	0.1	-47.3
Coke Oven/Gas Coke	869	1,182	1,959	1,567	0.5	80.3
Natural Gas (Humid)	1,825	139	3,018	4,711	1.6	158.2
Natural Gas (Dry)	5,176	8,479	16,448	39,299	13.1	659.2
Refinery Gas	4,350	5,879	7,862	10,371	3.5	138.4
Other Energy Oil Products	2,918	3,629	6,674	6,534	2.2	123.9
Piped Gas	749	363	199	0	0.0	-100.0
Coke Oven Gas	1,916	2,014	2,004	1,994	0.7	4.1
Other Primary Fossil Fuel Sources*	1,043	967	2,874	3,759	1.3	260.3
Total	**172,371**	**198,222**	**279,088**	**299,941**	**100**	**74.0**
Firewood Direct Burning	67,810	59,789	59,275	69,919	28.7	3.1
Firewood for Charcoal Production	25,728	22,074	18,691	24,506	10.1	-4.8
Charcoal	26,868	23,346	21,076	27,353	11.2	1.8
Bagasse	44,917	57,993	53,347	84,308	34.6	87.7
Biomass Residues	1,917	2,077	2,667	3,682	1.5	92.0
Black Liquor	3,992	6,636	8,786	12,924	5.3	223.7
Ethanol	16,729	18,982	16,630	20,915	8.6	25.0
Total Biomass**	**187,962**	**190,896**	**180,471**	**243,606**	**100**	**29.6**

*Includes primary sources with different physical states.

**CO_2 emissions from use of biomass as fuel are presented for information purposes only, and should not be accounted for in this Inventory.

Figure 3.4 CO_2 emissions (Bottom-up)



Diesel is responsible for most of the CO_2 emissions (35%) and consumption (19%) of fossil fuels in 2005. The second fuel that most contributes towards CO_2 emissions was natural gas (dry), which with its high growth rate expanded its share in emissions from 3.0% in 1990 to 13% in 2005, exceeding gasoline (13%) and residual fuel oil (7.8%). Residual fuel oil emissions, in turn, fell about 30% in the analyzed period, accompanying a reduction in consumption of 30%. For the remaining fuels, the decreasing order of share in 2005 is as follow: LPG (6.2%) and petroleum coke (5.3%). Some of these fuels presented a significant increase in the period, such as petroleum coke (877%) and natural gas (dry) (659%), for example. Table 3.6 shows CO_2 emissions by subsector for fossil fuels.

Table 3.6 CO_2 emissions of fossil fuels, by subsector

Subsector	1990	1994	2000	2005	Share in 2005	Variation 1990-2005
	(Gg)				(%)	
Energy Subsector	22,668	25,443	43,595	48,601	16.2	74.0
Public Electricity Plants	5,979	7,215	18,581	17,365	5.8	190.5
Autoproducer Electricity Plants	3,273	3,785	7,468	8,621	2.9	163.4
Energy Consumption	13,417	14,443	17,546	22,616	7.5	68.6
Residential	13,818	15,220	17,044	15,484	5.2	12.1
Commercial	2,075	1,579	2,218	1,954	0.7	-5.9
Institutional	509	1,972	2,104	1,739	0.6	241.6
Agriculture	10,052	12,527	14,051	14,809	4.9	47.3
Transport	79,914	91,820	120,130	133,431	44.5	67.0
Civil Aviation	3,503	3,763	5,278	5,374	1.8	53.4
Railways	1,625	1,262	1,238	1,730	0.6	6.5
Road Transportation	71,339	83,236	110,684	122,765	40.9	72.1
Navigation	3,448	3,560	2,931	3,561	1.2	3.3
Industrial	36,835	42,217	71,115	75,620	25.2	105.3
Cement	5,621	4,944	10,441	8,641	2.9	53.7
Pig Iron and Steel	3,685	5,116	12,515	15,322	5.1	315.8
Iron Alloys	177	285	574	1,146	0.4	548.5
Mining and Pelleting	2,425	3,244	5,655	7,255	2.4	199.1
Non-Ferrous Metals	3,149	3,939	6,488	8,224	2.7	161.2
Chemical	8,681	9,230	14,649	15,446	5.1	77.9
Food and Beverages	3,268	3,684	4,496	3,873	1.3	18.5
Textile	1,619	1,364	1,307	1,246	0.4	-23.0
Pulp and Paper	2,467	2,979	4,349	3,951	1.3	60.1
Ceramic	1,706	2,550	3,430	4,022	1.3	135.7
Others	4,037	4,884	7,212	6,495	2.2	60.9
Non-Energy Consumption	6,499	7,444	8,832	8,303	2.8	27.8
Total	**172,371**	**198,222**	**279,088**	**299,941**	**100**	**74.0**

The subsector that most contributed to emissions in 2005 was transport subsector, being responsible for 44% of CO_2 emissions. Road transport, with consumption growth of 72% from 1990 to 2005, was alone responsible for 41% of total emissions in 2005, and 92% of total transport emissions, slightly increasing its share in this subsector's between 1990 and 2005.

The industrial subsector contributed with 25% of emissions of the Energy sector, with pig iron and steel and chemicals standing out, each of those responsible for 5.1% of emissions. The increase in total energy consumption for this subsector reached 81% in the period analyzed. In the Initial Inventory, emissions from the steel industry were accounted for in the Energy sector due to lack of information that would allow proper allocation of the consumption of specific fuels in the Industrial Processes sector. In this Second Inventory, however, it was possible to adequately estimate emissions in the steel industry from the consumption of coal, coke oven/ gas coke, natural gas, and coke oven gas, accounting for them in the Industrial Processes sector, according to 1996 Guidelines. The recalculation was done for the entire period from 1990 to 2005 so as to maintain the time series consistency.

The industrial subsector of iron alloys presented the largest growth from 1990 to 2005 in terms of CO_2 emissions, although it only represents 1.5% of total emissions in 2005. Charcoal consumption predominates in this subsector in the period of Inventory, but its share in the total falls from 88% in 1990 to 60% in 2005 due to the entry of other fuels in the subsector consumption matrix, among which firewood for direct burning, petroleum coke and residual fuel oil stand out. In general, an increase in fuel consumption can be observed in industry, with some exceptions (other kerosene, residual fuel oil, steam coal, tar and refinery gas) and emissions grew 105%, accompanying the 81% growth rate for energy consumption in the period.

Among the subsectors with a minor share of total emissions, the institutional subsector presented the highest growth rate for emissions in the period, 242%. Total consumption for the sector increased about 268% with a predominance of LPG use in 2005. In relation to the commercial subsector, a 5.9% drop can be observed in emissions from 1990 to 2005 given the 4.2% retraction in energy consumption subsector.

Table 3.7 presents the comparison between CO_2 emission estimates obtained from the two methods. It is expected to find some difference between the two results, since they use different levels of aggregation and hypotheses that sometimes only apply to one of the approaches. The fact that the Bottom-up approach makes use of a broader scope of variables also contributes to this difference.

In accordance with IPCC (1997), the difference between Reference and Sectoral approaches can be considered reasonable if it is within a 2% range (negative or positive). If the result extrapolates this limit, it would be necessary to present justifications for it.

As can be seen in Table 3.7 the results from the Top-down approach are consistently higher than the ones obtained through the Bottom-up approach. Estimates using Bottom-up do not account for energy losses from transformation and distribution, resulting in a slightly lower estimate. Among the factors that contribute to divergences of results, the allocation of emissions from the steel industry in the Industrial Processes sector stands out, in accordance with 1996 Guidelines and unlike what was done for the Initial Inventory, where such emissions were accounted for in the Energy sector. Adjusting the Bottom-up approach is simpler, because this is done directly on fuel consumption, which is one of the input data according to the methodology. The adjustment is more complex under the Top-down approach, because the apparent consumption results from the consideration of production, imports, exports, and stock variation. Moreover, it is not possible to identify the consumption intended for use in the steel industry from the total consumption. Emissions based on the Top-down approach are, therefore, overestimated.

Table 3.7 Fossil fuel CO_2 emissions by Top-down and Bottom-up approaches

Approach	1990	1994	2000	2005
	(Gg)			
Top-down (A)	189,635	227,913	291,851	309,978
Bottom-up (B)	172,371	198,222	279,088	299,941
Difference (%) ((A-B)/B)	**10.0**	**15.0**	**4.6**	**3.3**

In accordance with Decision 17/CP.8 and recommendations presented in the Good Practice Guidance 2000, only emissions from domestic flights should be accounted for in the national inventory. Emissions due to international aviation fuel combustion (bunker fuels) must be reported separately. Moreover, only emissions related to fuel consumption in the country will be considered in the inventory.

BEB used to include information on bunker fuels for aviation (fuel supplied to air transport companies for international transportation) in the export account (fuel exported as a good), but it began to present the information in a separate format since 1998. In this case, it was adopted information provided by the National Civil Aviation Agency (*Agencia Nacional de Aviação Civil - ANAC*), since it separated bunker fuel data from exports since 1990. Furthermore, greater details in the distinction made between national and international transportation grants more accuracy to the data presented. Therefore, in the case of international aviation, more precise data on exports and bunker fuels were used, obtained from the National Agency of Petroleum, Natural Gas and Biofuels (*Agência Nacional de Petróleo, Gás e Biocombustúveis - ANP*) and ANAC, respectively.

Aviation gasoline consumption in international flights was considered negligible, because it is restricted to small airplanes, with piston engine and limited scope. Air taxi and special air services were also considered negligible.

Due to technical characteristics of aircraft usually used in air taxi service, specialized or private services, it was considered that activities not recorded in the Yearbook of Air Transport from ANAC correspond to a negligible portion of aviation kerosene consumption. Similarly, fuel stored by end users and eventual leaks, evaporation, etc., were considered negligible. Thus, it was assumed that all fuel distributed was consumed in aviation activities in the same year.

Fuel consumption directly informed by companies (ANAC, 1996-2008), in principle, includes the total amount relative to operations, irrespective of origin. On domestic flights, it is assumed that all fuel consumption is of national origin. On international flights, however, it is expected that part of the fuel is acquired abroad. Therefore, fuel consumption informed on international flights by airlines to ANAC is not taken directly, but adjusted to the distributions data provided by ANP.

For the emissions estimates it was assumed, for each year, the most detailed approach (Tier), depending on the available data on fuel consumption and/or aircrafts movements. For the years of 2005 to 2007 it was possible to use Tier 2 methodology. For the period between 1990 and 2004, Tier 1 methodology was applied, since for these years the information available is limited.

According to Good Practice Guidance 2000, in situations in which different tiers are applied for different years, results should be adjusted. Thus, results obtained with Tier 1 were adjusted in order to result in a consistent time series.

The next inventory should include a similar study on emissions from international marine transportation. As in the case of international aviation, BEB has only included information on bunker fuels of diesel and residual fuel oil since 1998. For previous years, it was assumed that these fuels were entirely intended for the exports. Table 3.8 shows CO_2 emissions for bunker fuels for 1990, 1994, 2000, and 2005.

Table 3.8 Bunker fuels CO_2 emissions

International Bunkers	1990	1994	2000	2005
	(Gg)			
Aviation				
Aviation Kerosene	5,231	4,339	5,708	5,805
Marine				
Diesel	-	-	1,922	1,821
Residual Fuel Oil	-	-	6,997	8,136

3.1.2.2 Non-CO_2 emissions from fuel combustion

Other greenhouse gases that have been estimated in this Inventory are: CH_4, N_2O, CO, NO_x and NMVOC. These gases are broadly treated as "non-CO_2" gases and their emissions were estimated for all fuels, including those derived from biomass.

Non-CO_2 gas emissions do not depend only on the type of fuel used, but also on combustion technology, operation conditions, equipment maintenance conditions and age, etc. Therefore, for applying the Bottom-up approach, the final uses of the energy sources, as well as the characteristics of the equipment used must be known. Thus, a more accurate estimation of non-CO_2 gases requires more disaggregated data and detailed methodology (Tier 2 and Tier 3). However, since this information is not always available, a simplified method was developed (Tier 1) to evaluate these emissions using only information on energy consumption by sector. Detailed Tier 2 method adopts emission factors for classes of equipment and fuels by sector (IPCC, 1997) and was applied to most of the final fuel uses. In those cases where appropriate factors were not available, Tier 2 emission factors were used from the previous version of the IPCC (IPCC, 1995) and also from CORINAIR's guidelines. Tier 1 was used in some cases where no data, technologies or equivalent fuels were available (IPCC, 1977). For gasoline, ethanol and natural gas consumed in road transport, specific emission factors were used for the country, calculated from data obtained at Cetesb (CETESB, 2006), as required by the Tier 3 method.

Table 3.9 presents emissions from other greenhouse gases from fuel combustion for 1990, 1994, 2000, and 2005.

Table 3.9 Emissions of Non-CO_2 gases from fuel combustion

Gas	1990	1994	2000	2005	Variation 1990-2005
	(Gg)				(%)
CO	14,919	14, 438	11,415	11,282	-24.4
CH_4	336	296	267	344	2.4
NO_x	1,781	1,996	2,334	2,388	34.1
N_2O	8.4	9.0	9.5	11.9	41.5
NMVOC	1,022	974	860	958	-6.2
Bunker Fuel emissions					
CO	NE	NE	NE	1	NA
CH_4	0.01	0.01	0.6	0.7	NA
NO_x	23	19	201	221	NA
N_2O	0.1	0.1	0.2	0.2	NA
NMVOC	NE	NE	NE	0.1	NA

In 2005, 11,282 Gg CO; 344 Gg CH_4; 2,388 Gg NO_x; 11.9 Gg N_2O; and 958 Gg NMVOC were emitted. Despite the increase in fuel consumption from 1990 to 2005, CO and NMVOC emissions fell due to a decline in emission factors.

A more detailed analysis is shown below. Emissions tables are presented for each gas by fuel and sector for 1990 to 2005. Each of these tables also shows the percent distribution in 2005 and the corresponding growth rate for the period.

Methane

In 2005, 344 Gg CH_4 were emitted from fuel combustion. Emissions increased 2.4% from 1990 to 2005.

Table 3.10 shows that biomass fuels are the main sources of CH_4 emissions (96% in 2005), in spite of a modest growth of 1.5% in the period. On the other hand, fossil fuel emissions, which were responsible for 4.5% of emissions in 2005, increased 26% during the period for which this Inventory was prepared. The main fuel in terms of CH_4 emissions was firewood (72% share in 2005 emissions), followed by charcoal (15%) and bagasse (7.8%). Among these fuels, only firewood presented a reduction in CH_4 emissions (-3.3%). In relation to fossil fuels combustion, oil by-products and natural gas are dominant in methane emissions.

Table 3.10 CH_4 emissions, by fuel

Emissions by fuel	1990	1994	2000	2005	Share in 2005	Variation 1990-2005
Fossil	**(Gg)**				**(%)**	
Gasoline	3.1	3.7	3.0	2.3	0.7	-24.1
Aviation Kerosene	0.07	0.07	0.10	0.10	0.03	44.0
Other Kerosene	0.056	0.035	0.0016	0.007	0.002	-86.9
Diesel	7.2	8.3	9.4	9.3	2.7	29.1
Residual Fuel Oil	0.86	0.93	0.95	0.69	0.2	-19.1
LPG	0.27	0.31	0.47	0.44	0.13	63.2
Petroleum coke	0.016	0.022	0.14	0.16	0.05	884.9
Steam Coal	0.081	0.080	0.086	0.046	0.01	-43.6
Metallurgical Coal	-	0.010	0.049	0.034	0.01	-
Tar	0.006	0.009	0.003	0.001	0.0004	-77.4
Coke Oven/Gas Coke	0.22	0.28	0.27	0.27	0.08	25.0
Natural Gas	0.12	0.16	0.50	1.58	0.5	1,261.4
Refinery Gas	0.038	0.084	0.090	0.082	0.02	121.8
Other Energy Oil Products	0.054	0.066	0.170	0.17	0.05	212.6
Piped Gas	0.022	0.012	0.007	0.000	0	-100.0
Coke Oven Gas	0.072	0.077	0.091	0.086	0.03	.19.3
Other Primary Fossil Fuel Sources	0.013	0.012	0.032	0.041	0.01	211.7
Total Fossil Sources	**12.17**	**14.19**	**15.66**	**15.35**	**4.5**	**26.1**
Biomass	**1990**	**1994**	**2000**	**2005**	**Share in 2005**	**Variation 1990-2005**
	(Gg)				**(%)**	
Firewood	255.7	216.0	192.2	247.4	71.9	-3.3
Charcoal	51.4	44.6	40.3	52.3	15.2	1.8
Bagasse	14.3	18.5	17.1	27.0	7.8	89.0
Bagasse Residues	0.54	0.58	0.70	0.88	0.3	64.5
Black liquor	0.15	0.24	0.31	0.45	0.13	213.1
Ethanol	1.61	1.45	0.79	0.65	0.2	-59.5
Total Biomass	**323.6**	**281.4**	**251.3**	**328.6**	**95.5**	**1.5**
Total	**335.8**	**295.6**	**267.0**	**344.0**	**100**	**2.4**

In terms of sectoral emissions in 2005 (Table 3.11), the energy subsector was dominant in terms of CH_4 emissions (48%) driven by charcoal plant (44% of total CH_4 emissions). This is followed by the residential (22%) and industrial (21%) subsectors. The subsectors that presented the highest growth rates in emissions for the period include public electricity plants and autoproducers (growth rates of 834% and 203%, respectively), in spite of being responsible for only 0.5% of 2005 emissions when totalled together; food and beverage industry (157%) and pulp and paper (76%). Comparison of emission results by fuel (Table 3.10) and by sector (Table 3.11) indicates a reduction in emissions from the residential sub-sector due to a drop in firewood use between 1996 and 2000, with a slight increase in recent years, due to the removal of subsidies for LPG. In the transformation sector, emissions are mainly tied to charcoal use (charcoal plants).

By crossing the three variables – equipment, fuel and sector – firewood for charcoal production is identified as the main emission source, with 44% of CH_4 emissions resulting from fuel combustion in 2005, followed by firewood in stoves in the residential sector (21%). Although the other biomass fuels show a high growth rate for CH_4 emissions in the period, a 3.3% decrease can be observed in the case of firewood and a slight increase of 1.8% for charcoal, which together are responsible for 87% of CH_4 emissions in 2005, explaining the modest growth in total CH_4 emissions between 1990 and 2005.

Table 3.11 CH_4 emissions by subsector

Emissions by Subsector		1990	1994	2000	2005	Share in 2005	Variation 1990-2005
		(Gg)				(%)	
Energy Subsector	Public Electricity Plants	0.1	0.1	0.4	1.0	0.3	833.9
	Autoproducers Electricity Plants	0.2	0.3	0.6	0.7	0.2	202.6
	Charcoal Plants	161	138	117	153	44.5	-4.8
	Energy Consumption Sector	8.6	9.7	7.2	10.5	3.0	21.4
Industry	Cement	3.0	2.3	2.1	2.2	0.6	-28.4
	Pig Iron and Steel	37	33	31	41	11.8	10.2
	Iron Alloys	3.0	3.7	3.7	4.9	1.4	61.8
	Mining and Pelleting	0.3	0.1	0.1	0.1	0.03	-64.9
	Non-Ferrous Metals	2.2	1.1	0.2	0.2	0.1	-90.0
	Chemical	0.8	0.7	0.4	0.5	0.1	-43.0
	Food and Beverages	7.3	10.4	11.9	18.6	5.4	157.1
	Textile	0.4	0.3	0.3	0.3	0.1	-28.6
	Pulp and Paper	1.0	1.2	1.5	1.8	0.5	76.3
	Ceramic	2.2	2.0	2.2	2.3	0.7	4.6
	Others	0.8	0.7	0.7	0.8	0.2	-4.1
	Subtotal	**58**	**55**	**54**	**72**	**21.0**	**24.8**
Transport	Aviation	0.07	0.08	0.11	0.10	0.03	41.4
	Road	10.2	11.4	11.1	9.8	2.9	-3.5
	Railways	0.11	0.09	0.08	0.12	0.03	6.4
	Marine	0.23	0.24	0.19	0.24	0.1	3.2
	Subtotal	**10.6**	**11.8**	**11.5**	**10.3**	**3.0**	**-2.9**
Other Sub-sectors	Commercial	1.5	1.5	1.3	1.3	0.4	-10.4
	Institutional	0.07	0.09	0.06	0.004	0.01	-39.2
	Residential	76	64	62	77	22	1.9
	Agriculture	21	15	14	18	5.2	-13.6
Total		**336**	**296**	**267**	**344**	**100**	**2.4**

Nitrous Oxide

In 2005, 11.9 Gg N_2O were emitted from fuel combustion. The emissions growth rate was 42% between 1990 and 2005.

Table 3.12 shows that biomass fuels are the mains sources of N_2O emissions (68% in 2005), with a 26% growth rate for emissions in the period, much below the growth rate achieved by fossil fuels (91%). N_2O emissions highlight the relevance of gasoline for fossil fuel emissions. N_2O emissions due to gasoline consumption represented 12% of total emissions in 2005, growing 118% between 1990 and 2005.

Table 3.12 N_2O emissions, by fuel

Emissions by Fuel	1990	1994	2000	2005	Share in 2005	Variation 1990-2005
Fossil	(Gg)				(%)	
Gasoline	0.67	0.91	1.36	1.47	12.4	117.7
Aviation Kerosene	0.11	0.12	0.17	0.17	1.5	58.3
Other Kerosene	0.005	0.003	0.001	0.001	0.01	-87.0
Diesel	0.54	0.61	0.78	0.86	7.2	59.5
Residual Fuel Oil	0.19	0.21	0.20	0.13	1.1	-32.1
LPG	0.03	0.03	0.05	0.05	0.4	71.5
Petroleum coke	0.02	0.03	0.2	0.2	1.9	899.8
Steam Coal	0.09	0.09	0.10	0.05	0.4	-46.1
Metallurgical Coal	0.00	0.01	0.06	0.03	0.3	-
Tar	0.003	0.005	0.002	0.001	0.01	-79.5
Coke Oven/Gas Coke	0.30	0.39	0.38	0.38	3.2	25.0
Natural Gas	0.01	0.021	0.084	0.394	3.3	3,805.5
Refinery Gas	0.007	0.009	0.012	0.016	0.1	138.4
Other Energy Oil Products	0.016	0.021	0.053	0.052	0.4	219.2
Piped Gas	0.001	0.001	0.000	0.000	-	-100.0
Coke Oven Gas	0.006	0.006	0.006	0.006	0.05	10.8
Other Primary Fossil Fuel Sources	0.005	0.004	0.012	0.01	0.1	207.5
Total Fossil Sources	**2.0**	**2.5**	**3.5**	**3.8**	**32.3**	**91.3**
Biomass	**1990**	**1994**	**2000**	**2005**	**Share in 2005**	**Variation 1990-2005**
	(Gg)				(%)	
Firewood	3.04	2.72	2.69	3.12	26.2	2.4
Charcoal	0.94	0.82	0.75	0.97	8.2	3.8
Bagasse	1.89	2.44	2.24	3.54	29.8	87.7
Bagasse Residues	0.07	0.08	0.09	0.12	1.0	64.5
Black Liquor	0.02	0.03	0.04	0.1	0.4	223.7
Ethanol	0.44	0.42	0.23	0.24	2.0	-44.6
Total Biomass	**6.39**	**6.49**	**6.04**	**8.04**	**67.7**	**25.9**
Total	**8.4**	**9.0**	**9.5**	**11.9**	**100**	**41.5**

The main fuel was sugar cane bagasse (30%), followed by firewood (26%), gasoline (12%), charcoal (8.2%), diesel (7.2%), and natural gas (3.3%). Among these, high growth rates are seen for bagasse (88%), gasoline (118%), diesel (60%), and natural gas (3,806%), though the share of natural gas is only 3.3% in 2005. In the case of firewood, growth is more modest (2.4%), which also goes for charcoal (3.8%).

Table 3.13 N_2O emissions, by subsector

Emissions by Subsector		1990	1994	2000	2005	Share in 2005	Variation 1990-2005
		(Gg)				(%)	
Energy Subsector	Public Electricity Plants	0.05	0.05	0.13	0.09	0.7	87.3
	Autoproducers Electricity Plants	0.04	0.05	0.08	0.08	0.7	91.6
	Charcoal Plants	-	-	-	-	-	-
	Energy Consumption Sector	1.18	1.31	0.97	1.40	11.8	19.0
Industry	Cement	0.12	0.09	0.17	0.16	1.3	27.7
	Pig Iron and Steel	1.04	1.07	1.05	1.20	10.1	15.5
	Iron Alloys	0.06	0.08	0.09	0.13	1.1	102.4
	Mining and Pelleting	0.02	0.03	0.04	0.06	0.5	159.0
	Non-Ferrous Metals	0.08	0.07	0.06	0.07	0.6	-16.6
	Chemical	0.12	0.11	0.11	0.10	0.8	-18.2
	Food and Beverages	1.32	1.69	1.84	2.69	22.7	104.6
	Textile	0.05	0.03	0.03	0.03	0.2	-43.2
	Pulp and Paper	0.31	0.37	0.43	0.5	4.2	59.9
	Ceramic	0.28	0.28	0.30	0.31	2.6	9.2
	Others	0.19	0.17	0.19	0.21	1.8	13.0
	Subtotal	**3.60**	**3.98**	**4.31**	**5.45**	**45.9**	**51.5**
Transport	Aviation	0.11	0.12	0.17	0.18	1.5	55.4
	Road	1.51	1.78	2.22	2.67	22.4	76.8
	Railways	0.01	0.01	0.01	0.01	0.1	7.9
	Marine	0.03	0.03	0.02	0.03	0.2	3.2
	Subtotal	**1.66**	**1.94**	**2.43**	**2.89**	**24.3**	**73.6**
Other Subsectors	Commercial	0.03	0.03	0.03	0.04	0.4	46.4
	Institutional	0.003	0.009	0.008	0.009	0.1	165.6
	Residential	1.38	1.18	1.15	1.43	12.0	3.0
	Agriculture	0.45	0.42	0.40	0.50	4.2	9.6
Total		**8.40**	**8.97**	**9.49**	**11.88**	**100**	**41.5**

In terms of subsectoral emissions (Table 3.13), the industrial subsector was the most responsible for N_2O emissions in 2005 (46%), driven by the food and beverage segment (23%) and pig iron and steel (10%). These are followed by transport (24%), energy (13%) and residential (12%) subsectors. Almost all of those subsectors that most contributed to emissions presented high growth rates from 1990 to 2005, except for the residential subsector, which saw growth of only 3.0% for the period.

N_2O emissions are not very concentrated in a single use, fuel or sector. Crossing the three variables – equipment, fuel and sector, the main sources of N_2O emissions are identified as the bagasse powered boilers in the food and beverages subsector (22%) and the energy subsector (12%) and the burning of firewood in stoves in the residential subsector (12%). Other important emissions result from road transport consumption – gasoline (13%), ethanol (2.1%) and diesel (5.6%) – and charcoal consumption in pig iron and steel industries (7.8%).

Carbon Monoxide

Carbon monoxide emissions occur due to imperfect combustion in equipment. These emissions also often reveal inefficiency in fuel use. It is a chemical compound that is harmful to human health and an environmental problem in large urban centers.

In 2005, 11,282 Gg CO were emitted from fuel combustion, presenting a decrease of 24% from 1990 to 2005. Table 3.14 shows that biomass fuels are the main sources of CO emissions (72% in 2005). Emissions from firewood consumption are dominant, with a share of 44% of total CO emissions in 2005. With regard to fossil fuels, oil by-products (gasoline and diesel) and natural gas (at a lower scale) are the most responsible fuels for CO emissions. Gasoline and diesel together are responsible for 26% of CO emissions from fossil fuels in 2005.

In terms of total emissions, firewood is the main driver, despite the low growth rate between 1990 and 2005. It is followed by bagasse (14%), gasoline (24%), charcoal (10%), and ethanol (3.9%). Emission reductions of gasoline (-58% from 1990 to 2005) rely on technological changes in the light vehicles fleet, entailing a progressive reduction in average emission factors.

Table 3.14 CO emissions, by fuel

Emissions by fuel	1990	1994	2000	2005	Share in 2005	Variation 1990-2005
Fossil	(Gg)				(%)	
Gasoline	6,460	6,798	4,589	2,698	23.9	-58.2
Aviation Kerosene	4.7	5.1	7.2	7.4	0.1	56.3
Other Kerosene	0.3	0.2	0.1	0.0	0.0003	-87.3
Diesel	188.0	201.4	243.2	242.9	2.2	29.2
Residual Fuel Oil	47.7	51.4	41.8	42.5	0.4	-10.9
LPG	2.8	3.4	5.4	4.4	0.04	57.9
Petroleum coke	1.3	1.7	10.6	12.2	0.1	841.6
Steam Coal	3.9	3.7	2.7	1.8	0.02	-54.4
Metallurgical Coal	0.0	0.8	4.6	3.9	0.03	-
Tar	0.4	0.6	0.2	0.1	0.001	-81.3
Coke Oven/Gas Coke	45.3	59.4	57.5	56.7	0.50	25.0
Natural Gas	6.2	7.9	18.4	45.3	0.4	630.4
Refinery Gas	3.1	4.9	4.7	5.1	0.04	62.8
Other Energy Oil Products	0.4	0.5	1.3	1.3	0.01	254.2
Piped Gas	0.4	0.1	0.1	0.0	-	-100.0
Cok Oven Gas	3.9	4.5	4.0	4.1	0.04	-4.8
Other Primary Fossil Fuel Sources	0.3	0.2	0.8	0.8	0.01	195.1
Total Fossil Sources	**6,769**	**7,143**	**4,991**	**3,126**	**27.7**	**-53.8**
Biomass	**1990**	**1994**	**2000**	**2005**	**Share 2005**	**Variation 1990-2005**
	(Gg)				(%)	
Firewood	4,967	4,189	3,978	4,999	44.3	0.7
Charcoal	1,120	967	866	1,121	9.9	0.1
Bagasse	812	1,055	973	1,538	13.6	89.4
Biomass Residues	38	39	45	54	0.5	41.4
Black Liquor	0.8	1.4	1.8	2.7	0.02	223.7
Ethanol	1,214	1,044	560	442	3.9	-63.6
Total Biomass	**8,150**	**7,295**	**6,423**	**8,156**	**72.3**	**0.1**
Total	**14,919**	**14,438**	**11,415**	**11,282**	**100**	**-24.4**

In terms of subsectoral emissions (Table 3.15) those from the residential subsector are dominant in 2005 (32%). Transport subsector accounted for 30% of emissions, driven by road transport which was responsible for 29% of total emissions. From 1990 to 2005, CO emissions from transport subsector decreased by 57%, while in the industrial sector emissions increased by 47% in the meantime.

Table 3.15 CO emissions, by subsector

Emissions by sector		1990	1994	2000	2005	Share in 2005	Variation 1990-2005
		(Gg)				%	
Energy Subsector	Public Electricity Plants	7	9	20	31	0.3	314.7
	Autoproducers Electricity Plants	13	14	24	24	0.2	87.3
	Charcoal Plants	1,070	918	777	1,019	9.0	-4.8
	Energy Consumption Sector	492	551	411	596	5.3	21.1
Industry	Cement	68	51	52	48	0.4	-28.5
	Pig Iron and Steel	781	715	679	867	7.7	11.1
	Iron Alloys	61	74	78	105	0.9	71.9
	Mining and Pelleting	10	3	4	6	0.1	-36.8
	Non-Ferrous Metals	47	25	6	9	0.1	-81.6
	Chemical	18	17	6	7	0.1	-61.1
	Food and Beverages	366	550	627	1,014	9.0	177.0
	Textile	6	5	4	4	0.04	-30.4
	Pulp and Paper	33	36	42	54	0.5	61.3
	Ceramic	144	136	146	154	1.4	6.9
	Others	40	32	33	39	0.3	-2.7
	Subtotal	**1,573**	**1,645**	**1,677**	**2,307**	**20.5**	**46.7**
Transport	Aviation	35	38	44	34	0.3	-3.5
	Road	7,783	7,967	5,303	3,302	29.3	-57.6
	Railways	22	17	17	24	0.2	7.1
	Marine	46	47	39	47	0.4	3.2
	Subtotal	**7,886**	**8,069**	**5,402**	**3,407**	**30.2**	**-56.8**
Other Subsectors	Commercial	33	33	32	32	0.3	-0.6
	Institutional	1	1	0,4	0,3	0.002	-79.1
	Residential	3,522	2,976	2,874	3,602	31.9	2.3
	Agriculture	321	223	198	263	2.3	-18.3
Total		**14,919**	**14,438**	**11,415**	**11,282**	**100**	**-24.4**

Crossing the information on subsectoral emissions and emissions by fuels, firewood burned in the residential subsector stoves proves to be responsible for most CO emissions (31%), followed by gasoline consumed in road transport, accounting for 24% of total emissions in 2005.

Nitrogen Oxides

NO_x emissions, which are indirect related greenhouse gases, are also an important pollution factor and may cause several negative effects on health, also contributing to acid rain.

In contrast of what has been previously analysed in terms of emission behaviour for other non-CO_2 gases, NO_x emissions are more directly related to fossil fuels since they involve high burning temperatures (90% share of total emissions in 2005). In this case, oil by-products are the main drivers of emissions: diesel (accounted for 49.3% of total emissions) and natural gas (14.7% share).

In 2005, 2,388 Gg NO_x were emitted from fuel combustion. The emissions growth rate was 34% between 1990 and 2005.

Table 3.16 NO_x emissions, by fuel

Emissions by Fuel	1990	1994	2000	2005	Share in 2005	Variation 1990-2005
Fossil	(Gg)				(%)	
Gasoline	167	211	202	152	6.4	-9.3
Aviation Kerosene	12	13	19	19	0.8	53.5
Other Kerosene	1	1	0.5	0.2	0.01	-87.5
Diesel	900	999	1,168	1,166	48.8	29.6
Residual Fuel Oil	172	187	164	124	5.2	-27.8
LPG	16	22	41	30	1.3	81.6
Petroleum coke	9	11	71	82	3.4	847.7
Steam Coal	54	55	88	36	1.5	-32.6
Metallurgical Coal	-	5	23	14	0.6	-
Tar	3	4	1	1	0.02	-80.1
Coke Oven/Gas Coke	7.5	9.9	10	9	0.39	25.0
Natural Gas	81	99	201	359	15.0	341.6
Refinery Gas	42	64	60	66	2.8	58.4
Other Energy Oil Products	6	8	20	20	0.8	232.7
Piped Gas	3	0.5	0.3	-	-	-100.0
Coke Oven Gas	51	59	51	52	2.2	3.0
Other Primary Fossil Fuel Sources	3	3	8	10	0.4	204.7
Total Fossil Sources	**1,528**	**1,752**	**2,129**	**2,140**	**89.6**	**40.0**
Biomass	**1990**	**1994**	**2000**	**2005**	**Share in 2005**	**Variation 1990-2005**
	(Gg)				(%)	
Firewood	87	76	75	88	3.7	1.1
Charcoal	26	22	20	26	1.1	1.8
Bagasse	32	42	38	61	2.5	88.1
Biomass Residues	1.3	1.4	1.7	2.0	0.1	55.2
Black Liquor	10	16	21	31	1.3	226.0
Ethanol	97	87	48	40	1.7	-59.0
Total Biomass	**253**	**245**	**205**	**248**	**10.4**	**-2.0**
Total	**1,781**	**1,996**	**2,334**	**2,388**	**100**	**34.1**

Table 3.16 shows that the main sources of NO_x emissions are fossil fuels, presenting a high growth rate from 1990 to 2005 (40%). The main fuel in terms of emissions is diesel (49%). It is followed by natural gas (15%), gasoline (6.4%), and residual fuel oil (5.2%). Petroleum coke grew rapidly in the period (848%), although it only represents 3.4% of emissions in 2005; natural gas grew 342%, increasing its share in total emissions from 4.3% in 1990 to 14.7% in 2005; other oil energy products grew 233% and black liquor, 226%.

Table 3.17 NO_x emission, by subsector

Emissions by Subsector		1990	1994	2000	2005	Share in 2005	Variation 1990-2005
		(Gg)				(%)	
Energy Subsector	Public Electricity Plants	61	72	161	147	6.2	141.3
	Autoproducers Electricity Plants	17	21	44	45	1.9	157.8
	Charcoal Plants	3	2	2	3	0.1	-4.8
	Energy Consumption Sector	141	165	199	262	11.0	86.2
Industry	Cement	38	33	55	44	1.8	15.5
	Pig Iron and Steel	95	113	128	142	5.9	49.1
	Iron Alloys	3	3	5	7	0.3	168.6
	Mining and Pelleting	9	11	24	29	1.2	210.6
	Non-Ferrous Metals	17	20	35	54	2.3	219.9
	Chemical	41	45	52	34	1.4	-16.7
	Food and Beverages	42	49	56	72	3.0	72.0
	Textile	5	4	4	5	0.2	-1.8
	Pulp and Paper	21	28	37	46	1.9	116.7
	Ceramic	20	27	42	59	2.5	200.8
	Others	29	33	48	50	2.1	72.3
	Subtotal	**320**	**366**	**486**	**542**	**22.7**	**69.5**
Transport	Aviation	13	14	20	20	0.8	50.7
	Road	1,066	1,206	1,283	1,203	50.4	12.9
	Railways	26	21	20	28	1.2	7.8
	Marine	68	71	58	71	3.0	3.2
	Subtotal	**1,173**	**1,311**	**1,381**	**1,322**	**55.4**	**12.6**
Other Subsectors	Commercial	4	3	4	3	0.1	-24.7
	Institutional	1	3	3	2	0.1	150.9
	Residential	53	48	48	55	2.3	3.4
	Agriculture	8	6	6	8	0.3	-5.9
Total		**1,781**	**1,996**	**2,334**	**2,388**	**100**	**34.1**

In terms of subsectoral emissions in 2005 (Table 3.17), transport subsector was the main driver for NO_x emissions (55%), of which 50% was due to road transport. It is followed by the industrial (23%) and energy (19%) subsectors. All of these subsectors grew significantly from 1990 to 2005: transport (13%), industrial (70%) and energy (106%).

The three variables analyzed – equipment, fuel and subsector – indicate that emissions are concentrated in road transport: diesel (42%), gasoline (6.4%) and ethanol (1.7%).

Non-Methane Volatile Organic Compounds

Non-methane volatile organic compounds (NMVOC) are presented in Table 3.18. From 1990 to 2005 total emissions have decreased by 6.2%. In 2005, 958 Gg NMVOC were emitted due to fuel combustion.

Table 3.18 NMVOC emission by fuel

Emissions by Fuel	1990	1994	2000	2005	Share in 2005	Variation 1990-2005
Fossil	(Gg)				(%)	
Gasoline	183	222	194	140	14.6	-23.9
Aviation Kerosene	2.4	2.5	3.6	3.7	0.4	56.3
Other Kerosene	0.04	0.03	0.01	0.01	0.001	-87.1
Diesel	59	65	82	91	9.5	54.6
Residual Fuel Oil	8.4	9.1	7.7	8.1	0.8	-3.6
LPG	1.2	1.3	1.6	1.5	0.2	28.9
Petroleum coke	0.1	0.1	0.7	0.8	0.1	877.3
Steam Coal	1.0	0.9	0.8	0.5	0.05	-55.0
Metallurgical Coal	0.0	0.2	1.0	0.7	0.1	-
Tar	0.030	0.04	0.02	0.007	0.001	-76.9
Coke Oven Gas/Gas Coke	3.4	4.5	4.4	4.3	0.45	25.0
Natural Gas	0.5	0.6	1.4	3.2	0.3	580.7
Refinery Gas	0.3	0.4	0.6	0.8	0.1	138.4
Other Energy Oil Products	0.1	0.2	0.5	0.4	0.05	224.8
Piped Gas	0.1	0.0	0.0	-	-	-100.0
Coke Oven Gas	0.3	0.3	0.3	0.3	0.03	10.8
Other Primary Fossil Fuel Sources	0.1	0.1	0.2	0.2	0.02	212.3
Total Fossil Sources	**260**	**307**	**298**	**255**	**26.7**	**-1.9**
Biomass	**1990**	**1994**	**2000**	**2005**	**Share in 2005**	**Variation 1990-2005**
	(Gg)				(%)	
Firewood	590	504	453	582	60.7	-1.4
Charcoal	26	22	20	26	2.7	1.8
Bagasse	24	31	29	45	4.7	89.2
Biomass Residues	1	1	1	1	0.2	64.5
Black Liquor	0,3	0,5	1	1	0.1	223.7
Ethanol	121	108	58	48	5.0	-60.5
Total Biomass	**761**	**667**	**562**	**703**	**73.3**	**-7.7**
Total	**1,022**	**974**	**860**	**958**	**100**	**-6.2**

Table 3.18 shows that biomass sources play an important role in terms of emissions (73%), despite the reduction of 7.7% from 1990 to 2005. The main driver of biomass fuels to NMVOC emissions is firewood, accounting for 61% of total emissions in 2005. Fossil fuel emissions decreased by 1.9% in the period. In 2005, diesel emissions were dominant, accounting for 9.5% of total emissions; gasoline accounted for 15% of emissions. From 1990 to 2005, NMVOC emissions from gasoline consumption decreased from 183 to 140 Gg, while, in the meantime, diesel emissions increased from 59 to 91 Gg.

Table 3.19 NMVOC emissions, by subsector

Emissions by Subsector		1990	1994	2000	2005	Share in 2005	Variation 1990-2005
		(Gg)				(%)	
Energy Subsector	Public Electricity Plants	0.4	0.4	1.1	1.2	0.1	246.2
	Autoproducers Electricity Plants	0.6	0.7	1.2	1.4	0.1	122.8
	Charcoal Plants	321	275	233	306	31.9	-4.8
	Energy Consumption Sector	15	17	13	19	1.9	24.0
Industry	Cement	2.2	1.7	1.6	1.5	0.2	-33.3
	Pig Iron and Steel	22	21	21	25	2.6	12.7
	Iron Alloys	1.5	1.9	2.0	2.7	0.3	74.6
	Mining and Pelleting	0.3	0.3	0.6	0.9	0.1	148.2
	Non-Ferrous Metals	1.3	0.9	0.6	0.7	0.1	-49.7
	Chemical	1.4	1.3	1.0	0.9	0.1	-34.6
	Food and Beverages	14	19	22	33	3.4	135.6
	Textile	0.8	0.7	0.6	0.6	0.1	-23.4
	Pulp and Paper	2.5	2.9	3.5	4.2	0.4	68.3
	Ceramic	3.6	3.5	3.8	4.0	0.4	11.7
	Others	1.7	1.5	1.7	1.9	0.2	11.3
	Subtotal	**51**	**55**	**57**	**75**	**7.8**	**45.9**
Transport	Aviation	3.0	3.2	4.3	4.2	0.4	42.1
	Road	354	387	326	270	28.1	-23.9
	Railways	4.4	3.4	3.4	4.7	0.5	7.9
	Marine	9.1	9.4	7.8	9.4	1.0	3.2
	Subtotal	**371**	**403**	**342**	**288**	**30.0**	**-22.4**
Other Subsectors	Commercial	3.3	2.7	2.3	2.3	0.2	-30.4
	Institutional	0.1	0.2	0.2	0.1	0.01	20.2
	Residential	204	173	168	210	21.9	3.2
	Agriculture	55	47	42	56	5.8	1.0
Total		**1,022**	**974**	**860**	**958**	**100**	**-6.2**

The energy subsector emitted 34% of NMVOC emissions in 2005 (Table 3.19), driven by charcoal plants (32%). In this sense, it is also noted the importance of transport subsector, due to road traffic (28%), and residential (22%) subsectors. A small increase in emissions for the residential subsector (3.2%) and a reduction in transport subsector (22%) were observed. Meanwhile, energy subsector emissions dropped 3% from 1990 to 2005.

Crossing the three variables – equipment, fuel and subsector – gasoline (15%), firewood consumed in charcoal plants (32%), ethanol for road traffic (5.0%), wood-burning stoves in the residential sector (22%) and diesel (8.6%) are identified as the main sources of NMVOC emissions.

3.1.3 Fugitive Emissions

3.1.3.1 Fugitive emissions from coal mining and handling

This section presents the estimates for greenhouse gas emissions from the coal mining and handling, from 1990 to 2005. Fugitive emissions of CH_4 from surface and underground mines and from post-mining activities (from both underground and surface mines) were estimated. CO_2 emissions from the inadvertent combustion of coal deposits and waste piles are also estimated. Brazil did not report any cases between 1990 and 2005 involving the recovery of gases and thermal conversion in coal mining companies. Therefore, this category was disregarded.

Coal formation is a complex physio-chemical process, usually called coalification. External factors, such as pressure, temperature and exposure time determine the coal's characteristics, including the degree of carbonification of these fuels.

Coal production in Brazil takes place in all of the three states located in the south region of the country, *Rio Grande do Sul, Santa Catarina* and *Paraná*, where the main coal reserves are located. *Rio Grande do Sul* is the state with the largest geological reserves, followed by *Santa Catarina* and *Paraná*. Brazilian coal quality varies from south to north, reducing ash content and increasing calorific value and sulfur content, demanding environmental control due to SO_x emissions (sulfur oxides – SO_2 and SO_3).

CH_4 production is inherent to the coal formation process, being released into the atmosphere during mining and handling. The amount of CH_4 released is initially linked to coal classification, the depth at which it is found, its gas content and the mining method. CO_2 emissions can occur as a consequence of burning coal in deposits and waste piles.

Brazil produces two types of coal: energetic coal, also called steam coal, for industrial application in steam and energy production; and metallurgical coal, for industrial application in steel mills. A significant increase can be observed in steam coal production from 1990 to 2005. Metallurgical coal, on the other hand, is mostly imported.

Brazil's dependence on imported coking coal rose from 77.8% in 1990 to 80.1% in 2005. In the beginning of the 1980s, national coking coal started being replaced by imported coal. In 1990, deregulation of imports caused the largest national producer of metallurgical coal to close. Its production was based on coal from mines in *Santa Catarina*.

Emissions are shown by producer states (*Rio Grande do Sul, Santa Catarina and Paraná*) and in total for the country. Studies are currently being conducted in Brazil on coal's methane content, aimed at developing cleaner technologies for obtaining energy from coal. The main interest is on the quantity of methane that can be extracted from the coal layer (on-site) without going through the physical removal of the coal layer, favouring removals of CO_2 in the bed.

The total production of Run-of-mine (ROM) coal in Brazil is shown in Table 3.20. In 2005, 60.1% of total ROM production was due to coal production from underground mines and 39.9% from surface mines. Data used for developing this study and applying the IPCC methodology were obtained from official sources from national government entities, specifically the National Department of Mineral Production – DNPM, tied to the Ministry of Mines and Energy - MME. These publications ceased in 2000, motivating a review of the database and the consultation of the Annual Mining Report (RAL) informed by the sector to the DNPM.

ROM coal production data were obtained from Annual Carbon Industry Information / DNPM, with mine detail characteristics. However, there is no detailed data by mine for 1997 for the states of *Rio Grande do Sul* and *Paraná* and for 2000 there is no data for any state. DNPM's Brazilian Mineral Yearbook provides ROM coal production by state for 1996 to 2000 and for the processed products from 1996 to 2005. Since ROM data from the Yearbook for 1999 and 2000 increased greatly in relation to previous years and since there is no continuity after that, it was decided not to use ROM production values from this Yearbook.

The share of coal and its by-products in the primary energy supply in Brazil dropped from 6.8% in 1990 to 6.4% in 2005. Coal's share in the supply of primary energy exceeds national production due to imports by diverse sectors.

Table 3.20 Coal run-of-mine production

Run-of-Mine Coal (ROM)	1990	1994	2000	2005	Variation 1990-2005
	Production (t)				(%)
Surface mines					
Rio Grande do Sul	3,577,545	3,643,478	5,950,038	4,250,367	18.8
Santa Catarina	21,970	397,972	383,873	131,720	499.5
Paraná	0	0	0	0	NA
Total surface mines	**3,599,515**	**4,041,450**	**6,333,911**	**4,382,087**	**21.7**
Underground mines					
Rio Grande do Sul	213,527	111,134	53,058	0	-100.0
Santa Catarina	6,231,261	5,255,499	5,571,109	6,300,417	1.1
Paraná	239,313	304,657	108,225	287,573	20.2
Total underground mines	**6,684,101**	**5,671,290**	**5,732,392**	**6,587,990**	**-1.4**
Total Brazil	**10,283,616**	**9,712,740**	**12,066,303**	**10,970,077**	**6.7**

Methane Emissions

Methane content in coal is related to factors like rank (difference in the stages of coal formation), depth of the layer and physical-chemical properties, among others. However, there are relevant geological factors that affect the dynamic equilibrium of methane found in the coal layer.

There was an initial effort in this Inventory to develop emission factors that best reflected Brazil's coal mining and handling activities. The emission factors suggested by IPCC were compared to the measurements made in some coal layers in *Rio Grande do Sul* and *Santa Catarina*. A correlation was made between the geological characteristics of sampled mines/layers and the characteristics that refer to quantity and quality of ROM coal and energetic coal produced in the country.

Results obtained from the experimental part conducted indicated that Brazilian coal has a lower methane emission factor than the minimum factors indicated by IPCC. However, the need for defining effectively representative values for Brazil's mines is still being considered, specifically focused on fugitive emissions resulting from coal extraction.

From what was observed, the expected correlation between coal with a higher rank and emissions was not detected. Since results turned out to be considerably inferior to emission factor intervals for Tier 1 approach from 1996 Guidelines and due to the that fact these were the first studies on national emissions factors for coal, the minimum emission factors for Tier 1 approach were adopted, not only for post-mining, but, coherently, for the mining as well. The adopted approach aimed at safeguarding the calculated values, considering that the experimental part pointed to divergences between the behavior conceptually foreseen for methane emissions and the results achieved in the sampled mines. For surface mines, the minimum null value for post-mining was discarded and an arbitrated value was used so measured emissions would not be disregarded. An attempt was made to adopt emission factors that more closely resembled national context, but further studies are needed. The factors adopted in this Inventory are shown in the Table 3.21.

Table 3.21 Emission factors for CH_4 fugitive emissions

Emission factors for CH_4 fugitive emissions from coal	LOW EMISSIONS LEVEL	
	Mining	Post-mining
	(m^3 CH_4/t coal)	
Underground mines	10	0.9
Surface mines	0.3	0.05

Total CH_4 emissions are shown in Table 3.22. Underground mines accounted for 89.8% of total CH_4 emissions, open-air mines accounted for 1.8% and emissions from post-mining activities represented 8.4% of the total.

Table 3.22 Coal mining and post-mining emissions

Coal mining and post-mining emissions	1990	1994	2000	2005	Share in 2005	Variation 1990-2005
	(Gg)				%	
Surface mining						
Rio Grande do Sul	0.72	0.73	1.2	0.85	1.7	18.8
Santa Catarina	0.004	0.080	0.077	0.026	0.1	499.5
Paraná	-	-	-	-	0.0	NA
Total	**0.72**	**0.81**	**1.27**	**0.88**	**1.8**	**21.7**
Underground mining						
Rio Grande do Sul	1.43	0.74	0.36	0,00	0.0	-100.0
Santa Catarina	41.75	35.21	37.33	42.21	85.9	1.1
Paraná	1.60	2.04	0.73	1.93	3.9	20.2
Total	**44.78**	**38.00**	**38.41**	**44.14**	**89.8**	**-1.4**
Post-mining						
Rio Grande do Sul	0.25	0.19	0.23	0.14	0.3	-42.7
Santa Catarina	3.76	3.18	3.37	3.80	7.7	1.2
Paraná	0.14	0.18	0.07	0.17	0.4	20.2
Total	**4.15**	**3.56**	**3.67**	**4.12**	**8.4**	**-0.8**
Total Brazil	**49.66**	**42.37**	**43.35**	**49.14**	**100**	**-1.0**

Carbon Dioxide Emissions

Carbon present in coal can be converted into CO_2 emissions from inadvertent combustion in storage and in waste, as well as in final consumption. This Inventory considers all extracted ROM coal processed, resulting in washed coal and waste. In order to assess CO_2 emissions resulting from inadvertent combustion in waste piles, the quantity of waste was estimated using company records, mass balances and average carbon content in ROM coal and in processed products. In this evaluation, ROM coal was considered a product that does not remain as extracted from the mine, being immediately processed or sold.

A limiting factor for estimating CO_2 emissions is the absence of knowledge of run-of-mine and washed coal storage time, nor of the waste piles. For this study, only those mines that produce made to order coal or that have a guaranteed consumer market were considered. Therefore, they do not administer stocks. It was also considered that all carbon present in ROM coal was transferred to processed products and to waste, with the process losses being accounted for in the waste. Since in *Santa Catarina*, waste was reprocessed, carbon percentages were estimated and the carbon thus calculated was added to the carbon in the run-of-mine coal for mass balance. For calculating CO_2 emissions, a 50% oxidation factor was used for waste.

Estimates of CO_2 emissions from coal deposits and waste piles can be observed in Table 3.23 separately, and by producer states.

Table 3.23 CO_2 emissions from coal mines

Calculating CO_2 emissions from waste piles	1990	1994	2000	2005	Variation 1990-2005
Carbon in Run-of-Mine coal (t)					**(%)**
Rio Grande do Sul	890,966	915,713	1,437,521	903,529	1.4
Santa Catarina	1,438,429	1,386,489	1,390,053	1,396,938	-2.9
Paraná	58,870	69,271	24,892	66,142	12.4
Brazil	**2,388,265**	**2,371,473**	**2,852,467**	**2,366,608**	**-0.9**
Carbon in products (t)					**(%)**
Rio Grande do Sul	785,152	808,804	1,110,518	935,743	19.2
Santa Catarina	812,407	768,842	1,013,524	910,669	12.1
Paraná	52,684	58,549	24,167	30,429	-42.2
Brazil	**1,650,244**	**1,636,195**	**2,148,209**	**1,876,842**	**13.7**
Carbon in waste piles (t)					**(%)**
Rio Grande do Sul	105,814	106,909	327,004	0	-100
Santa Catarina	626,022	617,647	376,529	486,268	-22.3
Paraná	6,186	10,722	725	35,712	477.3
Brazil	**738,022**	**735,278**	**704,258**	**521,981**	**-29.3**
Emissions (Gg CO_2)	**1,353.0**	**1,348.0**	**1,291.1**	**957.0**	**-29.3**

3.1.3.2 Fugitive emissions from oil and natural gas activities

This category includes emissions from production, processing, transportation and use of oil and natural gas and from combustion not related to production. Therefore, anthropogenic emissions of CO_2, CH_4 and N_2O are estimated due to oil and natural gas activities. Fugitive emission sources are considered for: Exploration and Production (E&P), Refining and Transportation.

Emissions associated with oil and natural gas include fugitive emissions of CH_4 during oil and natural gas production (venting), during transportation and distribution in pipelines and ships and during processing at refineries. CO2 emissions from non-useful combustion (flaring) at oil and natural gas production platforms and refining units is also considered. The following processes and equipment were considered:

- E&P: Gas ventilation, methane flash tanks, glycol dehydration process, CO_2 removal process from gas (MEA/DEA), running pigs in lines, fugitives from line components (flanges, connectors, valves, pump and compressor seals, drains and others) and flare;

- Refining: FCC Regenerator, Hydrogen Generation Units (HGU), fugitives from line components (flanges, connectors, valves, pump and compressor seals, drains and others) and flare; and

- Transport: line decompression, fugitives from line components (flanges, connectors, valves, pump and compressor seals, drains and others), pipeline and flare.

The use of oil and natural gas, or their by-products, for domestic use in the production of energy and transportation is considered a fuel, and therefore, discussed in another Energy sector section.

Data from condensed oil and liquid natural gas (NGL) production were used to calculate fugitive emissions in the Exploration and Production (E&P) area and processed load volume data from refineries were used to estimate Refining emissions. Data were obtained from SIGEA for 2003 to 2005. Prior to 2003, SIGEA was not yet implemented. Thus, an extrapolation of emissions was made based on oil and gas production data for the E&P area and processed oil load for Refining. Oil and gas production data were obtained from Petrobras website for the complete period of the Inventory and they are shown in Table 3.24 for 1990, 1994, 2000 and 2005.

Table 3.24 Production of Condensed Oil and Liquid Natural Gas

Production	1990	1994	2000	2005	Share in 2005	Variation 1990-2005
	(Mbpd[1])				(%)	
Condensed Oil	631,256	668,024	1,234,454	1,604,413	95.3	154.2
NGL	22,372	24,809	36,270	79,642	4.7	256.0
Total	**653,628**	**692,832**	**1,270,725**	**1,684,054**	**100**	**157.6**

[1] bpd - Barrels per day.

The processed load in refineries was obtained from Petrobras website for the period between 1998 and 2008. For 1990 to 1997, the processed load volume was obtained from BEB. Data for 1990, 1994, 2000 and 2005 can be seen in Table 3.25.

Table 3.25 Volume of oil processed in Petrobras refineries

1990	1994	2000	2005	Variation 1990-2005
(Mbpd)				(%)
1,174	1,266	1,626	1,829	55.8

Table 3.26 shows the estimated emissions in accordance with Tier 2 methodology (IPCC, 1997). CH_4 emissions include those released during oil and natural gas production (venting), transportation, refining and storing. In terms of CH_4 emissions, the E&P area is the subsector that contributes the most to total emissions subsector, raising its share from 84% in 1990 to 90% in 2005. CO_2 emissions are those related to flaring activities. As a consequence of the increase in production from 1990 to 2005, a 110% increase in total CO_2 emissions can be observed. In terms of N_2O fugitive emissions, E&P also has a greater share. During the Inventory period, E&P's share increased, achieving nearly 90% in 2005.

Table 3.26 Oil and natural gas fugitive emissions

Gas	1990	1994	2000	2005	Variation 1990-2005
	(t)				(%)
CO_2	6,224.7	6,680.2	9,578. 6	12,797.5	105.6
CH_4	41.7	44.4	78.2	147.9	254.5
N_2O	0.069	0.073	0.126	0.218	217.6

Condensed oil production reveals a growth of 154% from 1990 to 2005, whereas NGL grows 256%, reflecting an increase in fugitive emissions from E&P. With regard to E&P activities, fugitive emissions of CO_2, CH_4 and N_2O increased 243%, 278% and 256%, respectively, in 1990-2005.

Refining activities emissions also grew from 1990 to 2005. In terms of production, a 56% increase in processed load volume can be observed in Petrobras refineries, from 68,136 $10^3 m^3$/year in 1990 to 106,138 $10^3 m^3$/year in 2005. As a consequence, fugitive emissions from refining process increased by 53.5% for CO_2, 62.8% for CH_4 and 64.1% for N_2O.

Marcos Teixeira

Industrial Processes

3.2 Industrial Processes

The Industrial Processes sector is responsible for part of CO_2 emissions from fossil fuels combustion. Apart from these emissions, which are included in item 3.1.2 in the Energy sector, some industries generate greenhouse gases as a by-product of their production processes.

The main industrial processes that generate CO_2 emissions in Brazil are iron and steel production, cement production, lime production, aluminum production and ammonia production. N_2O emissions occur mainly in the adipic acid production process. During aluminum production, PFCs emissions (CF_4 and C_2F_6) can also occur. HFC emissions occur during their use in the refrigeration sector and during production of HCFC-22. CO emissions can also occur during aluminum production. Pulp and paper production is the main NO_x generator. The food and beverage subsector is responsible for most NMVOC emissions by industrial processes.

3.2.1 Mineral products

3.2.1.1 Cement production

In 2007, Brazil was ranked 10th in cement production in the world, being responsable for 1.7% of global production, and it was the largest cement producer in Latin America, accounting for 30% of this region's production. Cement is produced in several Brazilian states, with *Minas Gerais* as the main producer, responsible for 24.3% of total production in the country in 2008. *São Paulo* was second, with 15.7%, followed by *Paraná*, with 10.2%, and *Rio de Janeiro*, with 6.0%. The remaining states produced 43.7%.

Portland cement is basically a mixture of clinker and gypsum. The clinker is obtained from the calcination of limestone ($CaCO_3$), a process that emits CO_2. In 2005, cement production was 39 million tonnes and clinker, 26 million tonnes. In Table 3.27 production data for cement and clinker are presented for 1990, 1994, 2000 and 2005.

Table 3.27 Clinker and cement production

Product	1990	1994	2000	2005	Variation 1990-2005
	(10^3 t)				(%)
Cement	25,848	25,230	39,901	38,706	49.7
Clinker	20,161	18,412	29,227	26,307	30.5

Source: National Cement Industries Union – SNIC, 2009

Globally, approximately 90% of CO_2 emissions from cement manufacturing occur during clinker production, both for the calcination/decarbonation of raw material, or for the fuel combustion in furnaces. The remaining emissions derive from the transportation of raw materials and for the electricity consumption at the factory. The emissions reported in the Industrial Processes sector are only for calcination/decarbonation of raw materials.

The national cement industry has a tradition of using cement with additions, making use of by-products from other activities (such as slag and thermoelectric ash) and alternative raw materials. These additions have been ongoing for more than 50 years in the country, a practice that only recently has been adopted in the world and which, in addition to diversifying the applications and specific characteristics of the cement, leads to less CO_2 emissions, both by decreasing the production of clinker and by reducing the use of fossil fuels.

More than 90% of Brazilian cement is mixed with other compounds. Average clinker content in cement has fallen from 78% in 1990 to 68% in 2005, indicating a replacement that exceeds the global average. The IPCC default value for clinker content in cement is 98%.

For this reason, CO_2 emissions in the cement industry were estimated from clinker production and not from cement production. A more detailed methodology was used in this Inventory, based on studies conducted since 2001 using the sectorial methodology adopted by the Cement Sustainability Initiative - CSI and compatible with the Tier 3 approach from 2006 Guidelines. Results are summarized in Table 3.28.

Table 3.28 CO_2 emissions from decarbonation process of limestone for clinker production in cement industry

CO_2 source	1990	1994	2000	2005	Variation 1990-2005
	(Gg)				(%)
Clinker production	11,062	10,086	16,047	14,349	29.7

3.2.1.2 Lime production

In 2005, Brazil was responsible for 5.1% of the global lime production, and was the sixth largest producer, after China, United States, Japan, Russia and Germany, in this order. That year, lime production in Brazil was mainly located in the states of *São Paulo*, *Minas Gerais*, *Rio de Janeiro* and *Espírito Santo*.

The term lime is used in Brazilian literature and in Brazilian Association of Technical Standards - ABNT to designate the product made of calcium oxide (CaO) and calcium and magnesium oxide (CaO.MgO), resulting from the calcination of limestone, magnesium and dolomite limestones. Lime is classified in accordance with the total percentage of calcium oxide.

Thus, when referring to a type of lime, reference is actually made to a range of products with different amounts of CaO and CaO.MgO.

Lime is formed by heating limestone for decomposition of carbonates, a process called calcination or decarbonation. It is carried out at high temperatures in a rotary oven, followed by CO_2 emissions. Hydrated lime is obtained from quicklime by adding water. Dolomite ($CaCO_3.MgCO_3$) can also be processed at high temperatures to obtain dolomite lime (and CO_2 emissions).

Lime is a product with several applications, among which we can underscore metallurgy, civil construction, pulp and paper industry, water and effluent treatment, pH control and soil stabilization.

In Table 3.29 the production of quicklime and hydrated lime ($Ca(OH)_2$ or $Ca(OH)_2{\cdot}Mg(OH)_2$) is presented for some years during the period 1990-2005.

Table 3.29 Lime production in Brazil

Product	1990	1994	2000	2005	Variation 1990-2005
	(10^3 t)				(%)
Quicklime – associated with ABPC	1,335	1,498	1,595	2,189	64.0
Quicklime – captive production	1,048	1,378	1,546	1,392	32.8
Quicklime – non-associated with ABPC	646	599	1,491	1,521	135.3
Total quicklime	3,029	3,475	4,632	5,102	68.4
Hydrated lime – associated with ABPC	978	1,122	1,244	1,165	19.1
Hydrated lime – non-associated with ABPC	893	828	682	720	-19.3
Total hydrated lime	1,871	1,950	1,926	1,885	0.8
Total	**4,900**	**5,425**	**6,558**	**6,987**	**42.6**

Source: ABPC

Similar to the cement and lime production processes, there are others where limestone and dolomite are submitted to high temperatures and where CO_2 is released, at the same time in which the produced lime undergoes several other reactions. This item encompasses the processes that involve limestone and dolomite calcination, besides those related to cement and lime production, specifically iron and steel, glass and magnesium production. CO_2 emissions from lime production and those tied to other uses of limestone and dolomite are shown in Table 3.30.

Table 3.30 CO_2 emissions from lime production and other uses for limestone and dolomite

CO_2 sources	1990	1994	2000	2005	Variation 1990-2005
	(Gg)				(%)
Lime production	3,688	4,098	5,008	5,356	45.2
Other uses of limestone and dolomite	1,630	1,480	1,756	1,812	11.2

3.2.1.3 Production and consumption of soda ash

Soda ash (neutral sodium carbonate, Na_2CO_3) is used as feedstock in many industries, including glass, soap and detergent manufacturing, pulp and paper production and water treatment.

Four different processes can be commercially used to produce soda ash. Three are referred to as natural processes and use trona as a basic input. The fourth, the Solvay process, is classified as a synthetic process. The natural processes are the only ones that produce CO_2 emissions. Brazilian production, discontinued in 2002, used the synthetic process, and thus no net emissions were produced.

CO_2 emissions occur when soda ash is consumed in industry. Data on production, imports and exports of soda ash in Brazil are shown in Table 3.31.

Table 3.31 Production, imports, exports and consumption of soda ash

Product	1990	1994	2000	2005	Variation 1990-2005
	(t)				(%)
Production	195,893	219,471	190,616	0	-100.0
Imports	242,788	231,827	393,845	597,888	146.3
Exports	0	255	4	2	NA
Consumption	438,681	451,043	584,457	597,886	36.3

Source: ABIQUIM

Estimated CO_2 emissions were based on the IPCC default value and are shown in Table 3.32.

Table 3.32 CO_2 emissions from soda ash consumption

CO_2 source	1990	1994	2000	2005	Variation 1990-2005
	(Gg)				(%)
Soda ash use	182	187	243	248	36.3

3.2.2 Chemical Industry

Several production processes in the national chemical industry cause greenhouse gas emissions – CO_2, CH_4 and N_2O – as well as indirect greenhouse gas emissions – CO, NO_x, and NMVOC.

With the advance in biofuel production technologies, the national chemistry industry has begun to replace fossil fuels, used as raw materials in its production processes, with these renewable fuels. This action aims at reducing greenhouse gas emissions in the process. Additionally, new N_2O control technologies have been adopted, mainly for adipic acid and nitric acid production, which were responsible for most of this sort of greenhouse gas emissions.

Direct greenhouse gases were estimated based on 2006 Guidelines and indirect greenhouse gases based on 1996 Guidelines.

3.2.2.1 Ammonia production

Ammonia is one of the basic chemical products, produced in large quantities, used as a source of nitrogen. It is a raw material for manufacturing urea, the main nitrogenated fertilizer, and for producing nitric acid, an intermediate element in the production of ammonium nitrate fertilizer or explosive.

Ammonia production requires a source of hydrogen and another of nitrogen. The atmosphere is the nitrogen source. Hydrogen can be obtained from different raw materials, such as: asphalt residue, residual refining gas, natural gas, petrochemical naphtha and even ethanol.

CO_2 is generated as a by-product of ammonia production, and is released into the atmosphere. When there is integration with an urea or methanol plant, part of this CO_2 is used as a raw material to produce those products. Alternatively, CO_2 can also be recovered for use as a refrigerant fluid, in liquid carbonation and as an inert gas. In all such cases, however, CO_2 is short-lived and thus not deducted from ammonia production emissions.

Emissions related to ammonia production were estimated based on measurement of fuels used as raw materials in the process.

Considering the raw materials used in Brazil and their respective emissions factors (asphalt residue: 2.0 t of CO_2/t ammonia; refining gas: 1.3 t of CO_2/t ammonia; and natural gas: 1.2 t CO_2/t ammonia) the average value for the national emission factor was 1.46 t CO_2/t ammonia. This factor was employed for all years in the period 1990-2005.

Ammonia production is shown in Table 3.33 and the corresponding CO_2 emissions in Table 3.34.

3.2.2.2 Nitric acid production

Nitric acid (HNO_3) is an inorganic compound mainly used for manufacturing synthetic fertilizers. It is the most important compound not only as a feedstock in adipic acid production, but also as an intermediate element in concentrated nitric acid production, as a nitration agent in organic compounds or as an input for the production of explosives.

The traditional and commercially available production process for nitric acid involves the catalytic oxidation of ammonia with air and the subsequent reactions of oxidation with water, through the Ostwald process, generating N_2O as a by-product. Furthermore, NO_x emissions other than those from combustion may occur.

In production units in Brazil, which comprise low pressure and medium pressure and vacuum plants, there are abatement technologies for NO and NO_2 emissions (nitric oxide, nitrogen dioxide, generically called NO_x), in accordance with the standards established by environmental control entities. The following technologies are used in the country to control these emissions: extended absorption; non-selective catalytic destruction; and selective catalytic destruction.

From late 2006, CDM project activities began to be developed in Brazil, involving the installation of secondary catalyzers for N_2O destruction.

N_2O emissions were estimated using different methods, depending on the plant.

For those plants that conducted CDM project activities, it was possible to apply the most accurate method, with direct measurements of emissions, which result in specific emission factors for each plant. For the others, the simplified method was used, applying default emission factors from 2006 Guidelines.

For NO_x emissions, the country's specific emission factor was applied, 1.75 kg NO_x /t nitric acid, in accordance with ABIQUIM, as a result of the emission controls for these gases in the country.

Nitric acid production is shown in Table 3.33 and the corresponding N_2O and NO_x emissions in Table 3.34.

3.2.2.3 Adipic acid production

Adipic acid is a white crystalline solid used as an intermediate in the manufacturing of synthetic fibers, plastics, polyurethanes, elastomers and synthetic lubricants. Commercially, it is the most important aliphatic dicarboxylic acid used in the manufacturing of polyester and nylon 6.6.

The only adipic acid plant in Brazil uses the two-stage production technology. The first involves cyclohexane oxidation for the cyclohexanone/cyclohexanol mixture. The second stage involves the cyclohexanol oxidation process using nitric acid. In this latter stage, N_2O is released. Adipic acid production also emits CO and NO_x.

An N_2O abatement project at this factory was registered at the CDM Executive Board in the end of 2005. A dedicated installation was constructed for high temperature conversion of nitrous oxide into nitrogen, as part of the N_2O thermal decomposition process.

The measured N_2O emission factor was of 0.270 t N_2O/t adipic acid, applied from 1990 to 2006. After implementation of the CDM project in 2007, there was a significant emission reduction, with the new emission factor, being measured as 0.00625 t N_2O/t adipic acid.

Indirect greenhouse gases were estimated with national emission factors as a result of the control of emissions of these gases in the country. CO emissions were estimated with a factor of 16 kg CO /t adipic acid. For NO_x emissions, the emission factor of 5 kg NO_x /t adipic acid was applied.

Adipic acid production is shown in Table 3.33 and the corresponding N_2O, CO and NO_x emissions in Table 3.34.

3.2.2.4 Caprolactam production

The primary industrial use of caprolactam is as a monomer in the production of nylon-6. This chemical is also used for manufacturing plastics, bristles, films, covers, carpets, synthetic leather, plastifiers, and automotive paints. It is biodegradable and allows for a removal rate of 94% for the chemical demand for oxygen in activated sludge systems.

Brazilian production of caprolactam stems from the hydrogenation of benzene to cyclohexane, oxidation of cyclohexanol and cyclohexanone with nitric acid, a step in which N_2O is generated, followed by the dehydrogenation of the cyclohexanol produced and subsequent reaction with sulfate.

N_2O emissions were based on plant measurements and the average value that resulted of 6 kg N_2O / t caprolactam was adopted.

Caprolactam production is shown in Table 3.33 and the corresponding N_2O emissions in Table 3.34.

3.2.2.5 Calcium carbide production and use

Calcium carbide (CaC_2) is produced from the calcination of limestone and the subsequent reduction of lime with petroleum coke or charcoal. These two types of reducing agents are used in Brazil. Emissions related to lime production are reported in the specific lime item. From the reaction of calcium carbide production, only those emissions related to the use of petroleum coke, a fossil fuel, are considered.

Around 67% of the carbon contained in petroleum coke is retained in the final product (CaC_2). Later use of calcium carbide in the steel industry and in the production of acetylene leads to more CO_2 emissions.

CO_2 emissions associated with the production of calcium carbide (CaC_2) were based on petroleum coke consumption data, using the default emission factor of 1.7 t CO_2 / t consumed coke. The emission factor 1.10 t CO_2 / t CaC_2 consumed was used for consumption, disregarding the emissions that occur after product exportation, which accounts for about 15% of national production.

The calcium carbide production data are confidential. However, the corresponding emissions are shown in Table 3.34.

3.2.2.6 *Titanium dioxide production*

Titanium dioxide, also known as titanium oxide (IV) or titania, is found in nature. When used as pigment, it is called white titanium or white pigment. This compound is used in a great variety of applications, in paints, sunblock or even as a food coloring.

There are two technological routes for producing titanium dioxide: using sulfuric acid and using chlorine. Only the second route generates greenhouse gases. Since the industry installed in the country uses the first route, which is the oldest and uses ilmenite and slag as raw materials, emissions from this source were not accounted for.

Table 3.33 Ammonia, nitric acid, adipic acid, and caprolactam production

Chemical Product	1990	1994	2000	2005	Variation 1990-2005
	(t)				(%)
Ammonia	1,152,563	1,156,830	1,139,109	1,316,154	14.2
Nitric Acid	295,824	326,489	336,025	363,422	22.9
Adipic Acid	31,951	51,825	64,862	75,147	135.2
Caprolactam	42,059	50,838	56,005	49,655	18.1

Source: ABIQUIM

Table 3.34 Greenhouse gas emissions from ammonia, calcium carbide, nitric acid, adipic acid, and caprolactam production

Gas	Chemical Product	1990	1994	2000	2005	Variation 1990-2005
		(t)				(%)
CO_2	Ammonia	1,682,742	1,688,972	1,663,099	1,921,585	14.2
	Calcium Carbide	0	0	50,613	34,938	NA
N_2O	Nitric Acid	1,805	2,004	2,089	2,236	23.9
	Adipic Acid	8,627	13,993	17,513	20,290	135.2
	Caprolactam	252	305	336	298	18.1
CO	Adipic Acid	511	829	1,038	1,202	135.2
NO_x	Nitric Acid	518	571	588	636	22.9
	Adipic Acid	160	259	324	376	135.2

3.2.2.7 *Petrochemical and carbon black production*

The petrochemical industry uses fossil fuels such as natural gas or refinery products such as naphtha as raw materials. The same occurs in the carbon black production process, although it is not considered a petrochemical product.

Methanol

The main use of methanol is in the production of formaldehyde applied in the production of resins for the furniture and plywood industry. It is also used to produce biodiesel, although in this application, methanol is recyclable.

Methanol production technologies need hydrogen, CO and CO_2. In Brazil, the process used consists of low and high pressure synthesis and the raw materials are CH_4 and CO_2.

Natural gas fed in the synthesis reactor uses primary reformation as the process for hydrogen and CO generation. CO_2 as a raw material is obtained by partially recycling the gas produced in the CO conversion phase. Alternatively, CO_2 can be obtained as a by-product from another production process, as in ammonia production, for example.

The main greenhouse gases emitted are: CO_2 and CH_4, with estimated emissions with default factors of 0.267 t CO_2 / t methanol, and 2.3 kg CH_4 / t methanol.

Ethylene

Ethylene is the most produced primary hydrocarbon in the country and one of the most important products in the petrochemical industry value chain. It is used in the plastic production process including high and low density polyethylenes and polyvinyl chloride, and is also used as a raw material in the manufacturing of vinyl chloride, ethylene oxide, ethylbenzene and dichloroethylene.

Ethylene is universally produced through the cracking of petrochemical raw materials. Ethylene production also generates propylene, butadiene and aromatic compounds as secondary substances. The traditional naphtha cracking process is the technological route used in Brazil. However, in 2004, natural gas was introduced for the first time as a raw material in the pyrolysis process.

The main gases emitted are CO_2 and CH_4, in addition to NMVOC. CO_2 emissions were estimated with the default emission factor of 1.73 t CO_2 / t ethylene, corrected with a factor of 1.1 to consider the production mix from the steam cracking process line, which includes ethylene, propylene, butadiene, aromatics and other chemicals. Default factors of 3 kg CH_4 / t ethylene and 1.4 kg NMVOC / t ethylene were also used for the other gases.

Dichloroethane and vinyl chloride (MVC)

Dichloroethane (1.2 dichloroethane) was one of the first chlorinated hydrocarbons, synthesized in 1795, as a light-colored oily, with a sweet chloroform odor. It is used as an intermediate in the production of vinyl chloride – MVC, solvents, polychlorinated hydrocarbons, ethylene glycol and others. It is also used as a solvent for greases, oils and fats, industrial cleaning, additive for fuels and in solvent formulations. It is also much used in the extraction of natural products like steroids, vitamin A, caffeine and nicotine.

MVC is applied as an intermediate in the production of polyvinyl chloride, broadly used in electrical materials and wires manufacturing, civil construction materials, tubes, connections and packaging.

The production of MVC and dichloroethane in Brazil uses direct chlorination and ethylene oxichlorination technological route, using hydrogen chloride generated in dichloroethane cracking. MVC and dichloroethane production plant can operate as a "balanced process" between the two products. Since the process does not reach 100% conversion of ethylene, a small percentage of raw material is not converted. Thus, exhaust gases are treated to eliminate the chlorinated compounds formed in secondary reactions. Non-reacted ethylene is converted into CO_2 and the chlorinated compounds undergo a catalytic reduction process. So, clean gases are sent into the atmosphere in compliance with environmental control entity demands.

The main greenhouse gases are CO_2 and CH_4, as well as NMVOC, with estimated emissions with default factors of 0.294 t CO_2 / t vinyl chloride, 0.0226 kg CH_4 / t vinyl chloride and 8.5 kg NMVOC / t vinyl chloride. The calculations are valid for the integrated production of two chemicals.

Ethylene oxide

The main use of ethylene oxide, or ethylene, in the world is in the production of ethylene glycol, commonly known for its use as automotive refrigerant and anti-freeze. This chemical product is also used in the production of polyester polymers, as an intermediate in the production of ethers, higher alcohols and amines. In Brazil, it is mainly used to produce glycols. Additionally, ethylene oxide is broadly used in the sterilization of medical supplies such as bandages, sutures and surgical instruments.

It can be produced through two technological routes. The first begins with the reaction of chlorine on ethylene in the presence of water, followed by the dehydrochlorination of the ethylene chlorihydrin that forms. The second one uses the direct oxidation of ethylene from the air. The latter is the process adopted in ethylene oxide production in Brazil.

The main gases emitted are CO_2 and CH_4. CO_2 emissions were estimated by the total carbon mass balance of raw materials used, resulting in the factor of 0.52 t CO_2 / t ethylene oxide; for methane, the default factor used was 1.79 kg CH_4 / t ethylene oxide.

Acrylonitrile

Acrylonitrile is used to manufacture acrylic fibers, organic syntheses, fumigants, surfactants and dyes. The most known compounds that use it are NBR rubber, ABS resin and the ABS/PA mixture. The main gases emitted in its production in Brazil are CO_2 and CH_4, as well as NMVOC. CO_2 emissions were estimated from the total carbon mass balance from raw materials used, resulting in the factor of 0.2325 t CO_2 / t acrylonitrile; for the others, the default factors used were 0.18 kg CH_4 / t acrylonitrile and 1 kg NMVOC / t acrylonitrile.

Carbon black

The main use of carbon black is as an additive in rubber for tires manufacturing. Another important use is as a pigment in paints manufacturing. In Brazil, carbon black's principal raw material is aromatic residue associated with heavy fuel oil (naphthenic), and natural gas or fuel oil as a secondary raw material.

CO_2 and CH_4 are the major gases emitted. CO_2 emissions were estimated by the total carbon mass balance of raw materials used, resulting in the factor of 0.52 t CO_2 / t ethylene oxide; for methane, the default factor used was 1.79 kg CH_4 / t ethylene oxide.

Production data for petrochemicals and carbon black are shown in Table 3.35 and the corresponding emissions are provided in Table 3.37.

Table 3.35 Petrochemical and carbon black production

Chemical Product	1990	1994	2000	2005	Variation 1990-2005
	(t)				(%)
Methanol	168,557	222,310	211,584	240,360	42.6
Ethylene	1,499,714	1,895,754	2,633,818	2,699,831	80.0
Vinyl Chloride	480,415	409,757	424,732	609,207	26.8
Ethylene oxide	127,221	163,473	256,035	297,183	133.6
Acrylonitrile	78,000	76,522	87,361	76,780	-1.6
Carbon black	178,395	204,301	229,860	280,140	57.0

3.2.2.8 Phosphoric Acid

Phosphoric acid is mainly used to produce phosphate fertilizers, the most representative being monoammonium phosphate, diammonium phosphate, simple superphosphate and triple superphosphate.

The raw materials used in the production of phosphoric acid include sulfuric acid and phosphate rock. The latter contains inorganic carbon to a lesser or greater degree in the form of calcium carbonate ($CaCO_3$), which is an integral part of the mineral. The carbonate contained in the rock reacts with the sulfuric acid and produces agricultural gypsum and CO_2 as by-products.

CO_2 emissions were based on the quantity of carbon in the phosphate concentrate, estimated at 0.6%. The use of phosphate concentrate is shown in Table 3.36 and the corresponding CO_2 emissions in Table 3.37.

Table 3.36 Phosphate rock consumption in primary phosphoric acid production

Raw Material	1990	1994	2000	2005	Variation 1990-2005
	(t)				(%)
Phosphate concentrate	2,817,000	3,937,000	4,725,106	5,631,000	99.9

Table 3.37 Greenhouse gas emissions from petrochemical, carbon black and phosphoric acid production

Gas	Chemical Product	1990	1994	2000	2005	Variation 1990-2005
		(t)				(%)
CO_2	Methanol	45,005	59,357	56,493	64,176	42.6
	Ethylene	2,849	3,602	5,004	5,130	80.1
	Vinyl chloride	141,242	120,469	124,871	179,107	26.8
	Ethylene oxide	66,155	85,006	133,138	154,535	133.6
	Acrylonitrile	18,135	17,791	20,311	17,677	-2.5
	Carbon black	354,827	406,355	457,191	453,266	27.7
	Phosphoric acid	61,974	86,614	103,952	123,882	99.9
CH_4	Methanol	388	511	487	553	42.5
	Ethylene	4,499	5,687	7,901	8,099	80.0
	Vinyl chloride	10.9	9.3	9.6	13.8	26.6
	Ethylene oxide	228	293	458	532	133.3
	Acrylonitrile	14.0	13.8	15.7	13.8	-1.4
	Carbon black	10.7	12.2	13.8	16.8	57.0
NO_x	Carbon black	25	29	32	39	57.0
NMVOC	Ethylene	2,100	2,654	3,687	3,780	80.0
	Vinyl chloride	4,084	3,483	3,610	5,178	26.8
	Acrylonitrile	78	77	87	77	-1.3

3.2.2.9 Production of other chemicals

For the chemical products in this section, with production presented in Table 3.38, indirect greenhouse gas emissions were calculated using the default emission factors shown in Table 3.39. For styrene butadiene rubber (SBR), the emission factor was estimated by ABIQUIM as 5.8 kg NMVOC / t SBR. The corresponding NMVOC emissions are shown in Table 3.40.

Table 3.38 Activity data for other chemical products

Chemical Product	1990	1994	2000	2005	Variation 1990-2005
	(t)				(%)
ABS	27,000	32,100	33,000	33,000	22.2
Phthalic Anhydride	65,645	91,390	87,595	84,579	28.8
Styrene butadiene rubber (SBR)	184,692	209,409	236,627	212,205	14.9
Monomer Vinyl Chloride (MVC)	480,415	409,757	424,732	456,364	-5.0
Dichloroethane	538,183	499,934	541,335	581,366	8.0
Styrene	306,217	261,613	406,225	405,205	32.3
Ethylene	1,499,714	1,895,754	2,633,818	2,699,831	80.0
Ethylbenzene	441,007	345,514	436,577	395,024	-10.4
Formaldehyde	177,391	261,775	357,262	508,680	186.8
PVC – Polyvinyl Chloride	504,330	593,413	648,199	640,319	27.0
Polystyrene	134,332	153,641	175,575	317,434	136.3
HDPE Polyethylene	322,219	478,549	891,050	812,160	152.1
LDPE Polyethylene	626,028	609,248	646,832	681,686	8.9
LLDPE Polyethylene	0	133,433	333,756	442,274	NA
Polypropylene	303,841	521,540	847,639	1,212,200	299.0
Propylene	793,544	1,086,330	1,409,375	1,731,428	118.2

* The production of LLDPE polyethylene began in Brazil in 1993.

Table 3.39 NMVOC emission factors for other chemical products

Chemical Product	(kg NMVOC / t chemical product)
ABS	27.2
Phthalic Anhydride	1.3
Styrene butadiene rubber (SBR)	5.8
Monomer Vinyl Chloride (MVC)	8.5
Dichloroethane	2.2
Styrene	18
Ethylene	1.4
Ethylbenzene	2
Formaldehyde	5
PVC – Polyvinyl Chloride	1.5
Polystyrene	3.3
HDPE Polyethylene	6.4
LDPE Polyethylene	3
LLDPE Polyethylene	2
Polypropylene	12
Propylene	1.4

*ABIQUIM

Table 3.40 NMVOC emissions from the production of other chemical products

Chemical Product	1990	1994	2000	2005	Variation 1990-2005
	(t)				(%)
ABS	734	873	898	898	22.2
Phthalic Anhydride	85	119	114	110	28.8
Styrene butadiene rubber (SBR)	1,071	1,215	1,372	1,231	14.9
Monomer Vinyl Chloride (MVC)	4,084	3,483	3,610	3,879	-5.0
Dichloroethane	1,184	1,100	1,191	1,279	8.0
Styrene	5,512	4,709	7,312	7,294	32.3
Ethylene	2,100	2,654	3,687	3,780	80.0
Ethylbenzene	882	691	873	790	-10.4
Formaldehyde	887	1,309	1,786	2,543	186.8
PVC – Polyvinyl Chloride	756	890	972	960	27.0
Polystyrene	443	507	579	1,048	136.3
HDPE Polyethylene	2,062	3,063	5,703	5,198	152.1
LDPE Polyethylene	1,878	1,828	1,940	2,045	8.9
LLDPE Polyethylene	0	267	668	885	NA
Polypropylene	3,646	6,258	10,172	14,546	299.0
Propylene	1,111	1,521	1,973	2,424	118.2

* The production of LLDPE polyethylene began in Brazil in 1993.

3.2.3 Metallurgical industry

3.2.3.1 Iron and steel production

In 2006, Brazil was ranked 10th in the global steel industry with a production of 30.9 million tonnes, which represented approximately 2.5% of global steel production, as per Table 3.41.

Table 3.41 Crude steel production

Crude steel production	1970	1980	1990	2000	2005	2006
	(10^6 t)					
Global - (A)	595.4	715.6	770.5	848.9	1,144.3	1,246.9
Latin America - (B)	13.2	28.9	38.2	56.1	62.9	62.7
Brazil - (C)	5.4	15.3	20.8	28.7	31.6	30.9
C/A (%)	0.9	2.1	2.7	3.4	2.8	2.5
C/B (%)	40.9	52.9	54.5	51.1	50.2	49.3
Brazil's relative position in the world	18th	10th	9th	8th	9th	10th

Source: WSA/ILAFA/IABr

Brazil is the largest steel producer in Latin America (59.3% of total crude steel production in the region), followed by Mexico and Argentina, with 26% and 8.9%, respectively.

Brazil's park includes 11 integrated plants and 14 semi-integrated plants. In 2006, 78.6% of Brazil's production of crude steel came from integrated plants. Production at these plants is summarized in Table 3.42.

Table 3.42 Steel production of the integrated and semi-integrated plants

Production	1990	1994	2000	2005	Variation 1990-2005
	(10^3 t)				(%)
Crude Steel	20,340	24,764	28,148	31,025	52.5
Special Steels	474	572	510	625	32.0
Total	**20,814**	**25,336**	**28,658**	**31,650**	**52.1**

The steel industry uses carbon to generate energy and as a reducing agent for iron ore (the latter used in integrated plants). A fraction of this carbon is incorporated to products and the other part is released as CO_2 either directly in steel industry gases or after their burning.

Up to 75% of the CO_2 emissions from steel manufacturing occur during production of pig iron in the blast furnace, during the iron ore reduction process. The remaining percentage results from the transportation of raw materials and the generation of electric energy and heat.

CO_2 emissions from coke and lime production plants are computed in the Energy sector and the mineral production subsector, respectively. Emissions resulting from the use of fuels for energy production (thermoelectric plants) are included in the Energy sector. Emissions related to the use of dolomite and limestone are encompassed in the mineral production subsector. This item accounts for the emissions from sintering/pelleting and blast furnace/steel mill.

The semi-integrated plants do not have the reduction phase, and as a consequence, they consume carbon basically for metallurgical and energetic adjustment purposes. The total weight of charcoal in the pig iron production phase in integrated plants was 34.4% in 2006. Besides the 25 plants mentioned, there are countless independent producers of pig iron that use charcoal for reducing the ore. CO_2 emissions from charcoal are not considered here.

Energetic consumption at Brazilian steel plants is around 21 GJ/t steel. This number is similar to the world average and places Brazilian steel plants at the same level as steel plants in Europe and Japan.

CO_2 emissions were estimated based on the carbon balance of each phase considered, that is, the carbon that enters the process that leaves less carbon in the products and/or energetic gases, according to a study at each plant. The results are summarized in Table 3.43.

Table 3.43 CO_2 emissions from sintering/pelleting and blast furnace/steel mill

CO_2 Emissions	1990	1994	2000	2005	Variation 1990-2005
	(Gg)				(%)
Sintering	3,888	4,143	4,066	4,610	18.6
Blast Furnace and Steel Mill	20,868	24,285	31,371	33,673	61.4
Total Steel Industry	**24,756**	**28,428**	**35,437**	**38,283**	**54.6**

Note: Excluding emissions from coking, energy generation, lime production and limestone and dolomite use.
Source: Brazilian Steel Institute – IABr

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, chrome, molybdenum, vanadium and tungsten. These alloys are used to deoxidize and alter the physical properties of steel. Ferroalloy factories produce concentrated compounds that are sent to steel plants to be incorporated to diverse steel alloys. Ferroalloy production involves the metallurgical reduction process, which results in CO_2 emissions.

In the production of ferroalloys, the ore is melted with the coke and slag under high temperatures. During ferroalloy fusion, the reduction reaction occurs at high temperatures. Carbon captures the oxygen from metallic oxides to form CO_2, while the minerals are reduced to basic melted metals. Consequently, those metals present combine with each other in the solution.

The most appropriate methodology is to estimate emissions from the quantity of reducing agent used. Emissions can also be estimated from production volume. The IPCC suggests default values, admitting the use of only fossil carbon.

In Brazil, the production of ferroalloys predominantly uses charcoal, reaching 98% of its needs according to ABRAFE. National production data are shown in Table 3.44.

Table 3.44 Brazilian ferroalloy production

Production	1990	1994	2000	2005	Variation 1990-2005
	(t)				(%)
Ferroalloys (does not include metallic Si)	807,663	846,336	736,622	1,171,583	30.2

Source: Brazilian Association of Ferroalloy and Silicon Metal Producers – ABRAFE

From this information, it would be possible to estimate the portion of ferroalloy production that uses coal and coke, and which therefore releases CO_2, to be accounted for. In this Inventory, given the impossibility of separating combustion emissions from ore reduction emissions, they were all estimated together in the Energy sector (section 3.1).

3.2.3.3 Aluminum production

Brazil has the third largest reserve of bauxite in the world. This factor, along with great hydraulic potential, favorable geographic conditions and Brazil's industrial tradition in metallurgy, ranked Brazil sixth among the world's major producers of primary aluminum in 2008.

Primary aluminum is produced through an electrolytic reduction process. The reduction occurs in a carbon container that acts like a cathode and which contains the electrolytic solution. The carbon anode is partially submerged in the solution and consumed during the process.

The electrolysis of aluminum oxide produces melted aluminum, which deposits on the cathode, and oxygen, which deposits on the anode and reacts with the carbon, producing CO_2 emissions. Some quantity of CO_2 is also produced when the anode reacts with other sources of oxygen (like air). The primary aluminum production process can use two main types of technology, Soderberg and Prebaked Anode. The distinction between these technologies is related to the type of anode used. Brazilian aluminum production by type of technology is shown in Table 3.45.

Table 3.45 Aluminum production by type of technology

Technology	Type	Factory	Location	1990	1994	2000	2005	Variation 1990-2005
				(t)				(%)
Soderberg	VSS+HSS	Novelis	*Aratu - BA*	56,382	29,890	56,631	57,033	1.2
	HSS	Novelis	*Ouro Preto - MG*	50,896	42,580	50,302	50,593	-0.6
	VSS	Alcoa	*Poços Caldas - MG*	88,512	90,401	91,733	95,267	7.6
	VSS	CBA	*Alumínio - SP*	174,013	221,804	240,078	370,368	112.8
	Total Soderberg			369,803	384,675	438,744	573,261	55.0
Prebaked Anode	CWPB	Albras	*Barcarena - PA*	193,997	347,419	369,209	449,520	131.7
	CWPB	Alumar	*São Luís - MA*	264,324	362,630	369,059	380,967	44.1
	CWPB	Valesul	*Santa Cruz - RJ*	92,749	90,696	92,572	94,007	1.4
	Total Prebaked Anode			551,070	800,745	830,840	924,494	67.8
Total				**920,873**	**1,185,420**	**1,269,584**	**1,497,755**	**62.6**

Source: producing companies

In the aluminum industry, the main emissions are PFC gases, which are produced as long as when it is not possible to properly control the relation between substances in the electrolytic cell, during primary aluminum production. These occurrences are also not desirable from the industry perspective, because they entail lower productivity.

In primary aluminum production, alumina (Al_2O_3) is dissolved in melted fluoride, which mainly consists of cryolite (Na_3AlF_6). When an electrolytic cell of aluminum is operating normally, measurements demonstrate no PFCs are produced. However, if the aluminum oxide contained in the solution dilutes too much, below 1.5%, there is a rapid increase in voltage (anode effect) and the solution begins to react with carbon, producing PFC gases as in the following reactions:

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

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

Therefore, PFC emissions during the anode effects depend on the frequency and duration of these effects.

Companies made a great effort to report emissions in the most precise manner possible, revealing an evolution since the Initial Inventory. The IPCC methodology offers three levels of approach: a basic one, Tier 1, with default factors; a detailed one, Tier 2, with the carbon balance taking into account all process components; and a more precise one, Tier 3, with specific measurements for these components. In Table 3.46 the level of approach for estimating emissions from the aluminum production is presented for each plant.

Table 3.46 Level of approach for estimating CO_2 and PFC emissions by plant, for the period 1990-2005

Technological Route		Plant	CO_2	PFCs
Type	Sub-division			
Soderberg	VSS and HSS	*Novelis (BA)*	Tier 2	Tier 2
	HSS	*Novelis (MG)*	Tier 2	Tier 2
	VSS	*Alcoa (MG)*	Tier 2	Tier 3
	VSS	*CBA (SP)*	Tier 3	Tier 3
Prebaked Anode	CWPB	*Albras (PA)*	Tier 1	Tier 1 (1990-1996) Tier 3 (1997-2007)
	CWPB	*Alumar (MA)*	Tier 3	Tier 2
	CWPB	*Valesul (RJ)*	Tier 2	Tier 1

Indirect greenhouse gas emissions also occur in aluminum production, such as CO and NO_x. These can be estimated from emission factors from the IPCC guidelines.

Emissions that refer to anode baking are present only in the Prebaked Anode process, where the anodes are prepared previously.

In Table 3.47 there is a summary of the estimates for CO_2, CF_4 and C_2F_6 emissions for the aluminum industry in Brazil, as well as the indirect gases.

Table 3.47 Direct and indirect greenhouse gas emissions from aluminum industry

Gas	Technology	1990	1994	2000	2005	Variation 1990-2005
		(Gg)				(%)
CO_2	Soderberg	672	692	791	1,002	49.1
	Prebaked Anode	902	1,264	1,325	1,471	63.0
	Total	**1,574**	**1,955**	**2,116**	**2,472**	**57.1**
CF_4	Soderberg	0.1407	0.1316	0.0743	0.0636	-54.8
	Prebaked Anode	0.1615	0.1916	0.0722	0.0603	-62.7
	Total	**0.3022**	**0.3231**	**0.1465**	**0.1239**	**-59.0**
C_2F_6	Soderberg	0.0092	0.0084	0.0051	0.0042	-54.0
	Prebaked Anode	0.0171	0.0195	0.0066	0.0061	-64.3
	Total	**0.0263**	**0.0279**	**0.0117**	**0.0104**	**-60.7**
CO	Soderberg	50	52	59	77	55.0
	Prebaked Anode	295	428	444	495	67.8
	Total	**345**	**480**	**504**	**572**	**65.9**
NO_x	Soderberg	0.80	0.83	0.94	1.23	55.0
	Prebaked Anode	1.18	1.72	1.79	1.99	67.8
	Total	**1.98**	**2.55**	**2.73**	**3.22**	**62.6**

3.2.3.4 Magnesium production

SF_6 is used as a coverage gas to avoid oxidation of melted magnesium during production and casting of metal magnesium products, and it normally leaks into the atmosphere. SF_6 is considered a non-reactive gas and ideally adapts to this type of protection, as "coverage" for molten magnesium (thus the term "coverage gas"). So, gas consumption is used to estimate emissions. In Table 3.48 SF_6 emissions in this subsector are presented.

Table 3.48 SF_6 emissions from magnesium industry

Source	1990	1994	2000	2005	Variation 1990-2005
	(t)				(%)
Use of SF_6 in the magnesium industry	5.75	9.87	10.30	19.05	231.0

3.2.4 Pulp and Paper Industry

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

This industry has 1.4 million hectares of company-owned forests, mainly of *Eucalyptus* (62%) and *Pinus* (35%). Pulp production is exclusively made from wood from planted forests.

Preparation of pulp paste for papers and other purposes consists of separating the fibers from the other wood components, especially lignin, which gives firmness to the wood firm.

Some types of wood, such as pine have long fibers (3 to 5 mm), whereas eucalyptus has shorter and thinner fibers (0.8 to 1.2 mm). Those from the first group are called conifers or softwood, whereas those from the second group are called leafy or hardwood.

There are many and varied preparation processes for pulp paste, from the purely mechanical to the chemical, in which wood is treated with chemical products, pressure and heat (temperatures greater than 150°C) to dissolve the lignin. The use of chemical products in the process generates greenhouse gas emissions.

Pulp and paper paste production have three main phases: pulping, bleaching and paper production. The type of pulping and the quantity 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 process.

In Brazil, the most used process is a variation of Kraft, called Sulfate. It uses the same chemical products, although employing higher doses of sodium sulfate and caustic soda, and it is cooked longer and at higher temperatures. It is considered the most appropriate for obtaining chemical pastes from eucalyptus. There are CO, NO_x and NMVOC emissions during the process.

In Table 3.49 a summary of Brazilian production of pulp paste is shown, highlighting the sulfate process, which generates indirect greenhouse gases.

Table 3.49 Brazilian pulp paste production

Type of Pulp / Chemical Process	1990	1994	2000	2005	Variation 1990-2005
	(t)				(%)
Chemical and Semi-Chemical Pulp	3,914,688	5,376,271	6,961,470	9,852,462	151.7
Sulfate	3,593,547	5,127,981	6,639,971	9,397,450	161.5
Other Processes	321,141	248,290	321,499	455,012	41.7
High Performance Pastes	436,455	452,599	501,796	499,651	14.5
TOTAL	**4,351,143**	**5,828,870**	**7,463,266**	**10,352,113**	**137.9**

Source: Brazilian Pulp and Paper Association – BRACELPA.
For the sulfate process, the same share as in 1994 was considered for the subsequent years

In this Inventory, emission factors from IPCC guidelines for the Kraft process were used for the Sulfate process, responsible for most of the production, since information about emissions for the other processes was not available. Sectoral greenhouse gas emissions are shown in Table 3.50.

Table 3.50 Emissions from pulp production in Brazil

Gas	1990	1994	2000	2005	Variation 1990-2005
	(Gg)				(%)
CO	20.1	28.7	37.2	52.6	161.5
NO_x	5.4	7.7	10.0	14.1	161.5
NMVOC	13.3	19.0	24.6	34.8	161.5

3.2.5 Food and Beverage

NMVOC emissions can occur in the industrial processing of foods and production of beverages. The IPCC presents emissions factors for some subsectors. Without additional information, these factors were adopted in this Inventory. In Table 3.51 Brazilian production of foods for which emissions have been associated is shown for 1990, 1994, 2000 and 2005. Vegetable oil extraction processes are handled in the Solvent Use and Other Products Use sector (item 3.3).

Table 3.51 Brazilian production of foods

Product	1990	1994	2000	2005	Variation 1990-2005
	(10^3 t)				(%)
Meat, fish and poultry	5,837	7,510	11,241	17,484	199.5
Sugar	7,365	12,618	16,256	25,906	251.7
Margarines and solid cooking fats	453	466	602	759	67.5
Cakes, biscuits and breakfast cereals	460	632	729	829	80.2
Breads	2,896	3,977	4,585	5,218	80.2
Animal feed	8,258	9,832	12,935	16,225	96.5
Coffee roasting	584	651	890	1,134	94.3

Sources: ABIA; UNICA; SINDIPAN; ABIP; IBGE; ABIC

In the production of alcoholic beverages, there are NMVOC emissions during cereal and fruit fermentation. IPCC default emission factors were also used to estimate these emissions. In Table 3.52 Brazilian beverage production is presented for the years of 1990, 1994, 2000 and 2005. The corresponding NMVOC emissions are shown in Table 3.53.

Table 3.52 Brazilian production of beverages

Product	1990	1994	2000	2005	Variation 1990-2005
	(10^3 L)				(%)
Wine	308,954	245,158	319,161	378,272	22.4
Beer	3,749,150	4,276,950	9,023,303	9,214,807	145.8
Spirits (*cachaça*)	1,125,000	1,035,000	1,200,000	1,200,000	6.7

Sources: UVIBRA; ABIA; ABRABE, with estimates for production capacity starting in 1994.

Table 3.53 NMVOC emissions from food and beverage production

Sector	1990	1994	2000	2005	Variation 1990-2005
	(Gg)				(%)
Food industry	112.1	175.7	222.8	331.3	195.4
Beverage industry	170.3	156.9	183.4	183.5	7.8
Total	282.4	332.7	406.2	514.8	82.3

3.2.6 Emissions Related to Hydrofluorocarbon Production

There was no production of HFCs in Brazil from 1990 to 2005, only emissions of HFC-23, generated as a by-product from the production of HCFC-22, which ceased in 1999. Emissions were estimated using the IPCC's default emission factors, as per Table 3.54.

Table 3.54 Potential HFC-23 emissions due to HCFC-22 production

Description	1990	1994	2000	2005	Variation 1990-2005
	(t)				(%)
HCFC-22 production	3,006	3,915	-	-	-100
HFC-23 emissions	120.24	156.60	-	-	-100

3.2.7 Emissions Related to Hydrofluorocarbon Consumption

In this sector in Brazil, only HFC emissions for the refrigeration and air conditioning; fire extinguisher and explosion protection; and aerosol subsectors were identified, but not for solvents and foams.

In refrigeration and air conditioning, HFC gases are used as the main alternatives to CFCs, as refrigeration fluids. There has been a complete replacement in new products from 1996 to 2000. An estimate of real emissions was made for this subsector based on the IPCC's Tier 2b methodology, using the following formula:

Emissions = (Annual Sales of New Chemical Substances) – (Total Charge in New Equipment) + (Total Original Charge of Scrap Equipment)

Productions of the following were analyzed in refrigeration and air conditioning:

- Household and commercial refrigeration (household refrigerators, vertical freezers and horizontal refrigerators and freezers)
- Automobiles
- Buses
- Chillers
- Refrigerated trucks
- Water fountains

Significant use of HFCs in Brazil only began after 1994 for the refrigeration and air conditioning subsector. There is no record of gas production or destruction from 1990 to 2005.

The average refrigerant charges in new products considered in this Inventory are shown in Table 3.55.

Table 3.55 Average refrigerant charges in new products

Equipment	Average refrigerant charge	
	(kg)	per
Household refrigerators	0.15	unit
Vertical freezers	0.4	unit
Horizontal freezers	0.25	unit
Centrifugal and screw chillers	0.34	kW of chilling
New vehicles	0.96	unit
Bus	5	unit
Refrigerated trucks	6	unit
Water fountains	0.05	unit
Aerosols	0.006	tube

An average number of one thousand garages was estimated for vehicle maintenance installing two units per months from 1996 to 2005. For aerosols, emissions occur for half of the production from the previous year and half of the production from the present year.

In Table 3.56 the national products manufactured with HFC-134a refrigerant are shown.

In Table 3.57 the estimates for HFC emissions due to consumption in refrigeration, air conditioning and aerosols are shown.

Table 3.56 National products manufactured with HFC-134a refrigerant

Year	Refrigerator Production	Vertical freezer production	Horizontal freezer and refrigerator production	Screw compressor	Centrifugal compressor	New vehicles with air conditioning	New buses with air conditioning	Refrigerated trucks	Water Fountains	Aerosols
	(unit)			(kW-refrigeration)		(unit)				(tube)
1990	-	-	-	-	-	-	-	-	-	-
1991	-	-	-	-	-	-	-	-	-	-
1992	-	-	-	-	-	-	-	-	-	-
1993	-	-	-	-	-	-	-	-	-	-
1994	-	-	-	-	-	-	-	-	-	-
1995	-	-	-	17,500	24,500	-	-	-	-	-
1996	-	-	-	17,500	27,300	370,593	1,884	953	-	842,693
1997	1,159,947	161,475	219,504	17,500	29,750	494,240	2,513	570	161,057	758,457
1998	1,469,024	165,396	225,805	17,500	35,875	423,112	2,151	592	194,776	586,943
1999	1,210,518	126,610	144,121	23,975	43,750	423,346	2,153	621	154,809	451,450
2000	3,230,689	302,880	332,458	37,800	58,975	580,093	2,949	648	404,043	319,279
2001	3,649,331	184,830	252,198	40,250	69,125	705,272	3,586	675	427,078	1,072,764
2002	3,488,098	179,762	277,310	35,000	78,750	777,748	3,954	702	356,391	1,369,169
2003	4,321,992	222,737	343,606	33,250	78,750	828,809	4,214	726	266,734	1,340,746
2004	4,791,913	246,955	380,966	36,750	86,625	1,091,338	5,549	755	247,003	2,073,784
2005	4,683,262	241,356	372,328	39,375	95,550	1,239,648	6,303	780	340,474	1,585,596

Table 3.57 HFC-134a emissions due to consumption in refrigeration, air conditioning and aerosols

		1990	1994	2000	2005	Variation 1990-2005
		(t)				(%)
Importation of HFC-134a		0.87	136.91	1,814.41	4,491.01	519,092
Sales	Aerosols	-	-	1.92	9.51	NA
	Refrigeration and air conditioning	0.87	136.91	1,812.49	4,481.50	517,992
Charges (refrigeration and air conditioning)		-	-	1,343.49	2,210.61	NA
Real emissions	Aerosols	-	-	2.31	10.98	NA
	Refrigeration and air conditioning	0.43	68.45	469.01	2,270.88	524,960
	Total	**0.43**	**68.45**	**471.32**	**2,281.86**	**527,498**

Another form of presenting emissions from these subsectors is by potential emissions, using the following formula:

Emissions Potent = Production + Imports - Exports – Destruction

Besides HFC-134a, imports of HFC-125, HFC-143a and HFC-152a were identified, which include use in fire extinguishers. In relation to exports, exported refrigerators with HFC-134a coolant were considered. In Table 3.58 potential emissions of HFCs are shown.

Table 3.58 Potential HFC emissions

HFC		1990	1994	2000	2005	Variation 1990-2005
		(t)				(%)
HFC-134a	Imports	0.87	136.91	1,814.41	4,491.01	519,092
	Exports	-	-	62.05	166.33	NA
	Potential emissions	0.87	136.91	1,752.36	4,324.68	499,863
HFC-125	Imports	-	-	7.07	124.90	NA
	Potential emissions	-	-	7.07	124.90	NA
HFC-143a	Imports	-	-	7.48	92.87	NA
	Potential emissions	-	-	7.48	92.87	NA
HFC-152a	Imports	-	-	0.14	174.76	NA
	Potential emissions	-	-	0.14	174.76	NA

3.2.8 Emissions Related to Consumption of Sulfur Hexafluoride

Due to its excellent properties as an inert, non-toxic, high dielectric rigidity insulation and non-flammable, thermically stable and self-regenerating refrigerant, SF_6 permitted the development of high capacity and performance electrical equipment, which are also compact, light and safe. Among the electrical equipment developed as a result of SF_6, circuit breakers and shielded substations stand out using 10% of the physical space of the equivalent conventional substations.

In Brazil, there is no production of SF_6, but emissions occur due to gas leaks at SF_6 insulated and shielded substations.

Starting in 2009 a study coordinated by ANEEL and MCT was conducted involving power generators and electricity distributors that use SF_6 with information received on-line on MCT's website, with the objective of improving the database for estimating emissions. A total of 521 companies were invited. The response rate was 74%, referring to 387 companies, allowing a preliminary estimate for the installed equipments containing SF_6.

In Table 3.59 below a summary of the installed capacity in terms of SF_6 in equipment and an estimate of annual leaks based on a default factor of 2% per year, in accordance with the Good Practice Guidance 2000, are shown.

Table 3.59 Installed capacity in terms of SF_6 in equipments and estimates of annual leaks

Description	1990	1994	2000	2005	Variation 1990-2005
	(t)				(%)
Installed capacity	208.85	204.16	248.31	306.32	46.7
SF_6 emissions	4.18	4.08	4.97	6.13	46.7

Solvent and Other Product Use Sector

3.3 Solvent and Other Product Use Sector

This item presents the series of NMVOC emissions from the use of solvents in Brazil from 1990 to 2005. In some sectors, emissions may possibly include CH_4 emissions, which are then represented as volatile organic compounds – VOC.

As per the CORINAIR (1996) methodology, the following activities are highlighted: application in paints, degreasing metals, dry cleaning, polystyrene and polyurethane foam processing, printing industry, edible vegetable oil extraction, household use, asphalt aeration and wood preservation.

First, two obstacles for estimations must be underscored: the precariousness of statistical data, especially at the levels of required broken down information and the non-existence of appropriate emission factors for NMVOC gases and those activities encompassed in this sector.

Therefore, when addressing a specific activity that may have some relevance for the Brazilian case, even without the statistical information, this Inventory considers, as a first approach, per capita emission factors observed in a set of countries, applied to the economically active population of Brazil.

Data related to domestic sales and imports of chemical products were taken from the ABIQUIM Yearbook (ABIQUIM, 1995 and 1997, 2005, 2007 and 2008). In Table 3.60 NMVOC and VOC emissions in those activities for the years of 1990, 1994, 2000 and 2005 are shown.

Table 3.60 Summary of NMVOC and VOC emissions by activity

Application		1990	1994	2000	2005	Share in 2005	Variation 1990-2005
		(Gg)				(%)	
NMVOC	Paints applications	227.2	299.9	330.9	438.9	73.8	93.2
	Metal degreasing	15.1	15.6	8.6	0.9	0.1	-94.3
	Printing Industry	48.2	52.7	59.0	67.1	11.3	39.3
	Production of polystyrene foams	0.6	0.9	1.0	1.2	0.2	120.4
	Dry cleaning	0.7	0.7	1.8	0.2	0.0	-71.8
VOC	Edible vegetable oil extraction	13.7	16.6	18.0	25.4	4.3	85.7
	Household solvents	44.1	48.2	53.9	61.4	10.3	39.3
Total (VOC + NMVOC)		**349.6**	**434.6**	**473.2**	**595.1**	**100**	**70.2**

3.3.1 Application in Paints

This activity is broken down into four subactivities: motor vehicle production; construction and buildings; household use; and other industrial applications.

3.3.1.1 Motor vehicle production

The Brazilian motor vehicle industry is large and an intensive consumer of paints. The activity encompasses both coating and corrosion protection. The statistics for Brazilian motor vehicle production used for estimating emissions are presented in Table 3.61. In Table 3.62 emission factors used in this Inventory for vehicle painting are presented.

Table 3.61 Brazilian motor vehicle production

Vehicle type	1990	1994	2000	2005	Variation 1990-2005
	(10^3 units)				(%)
Automobiles	663.1	1,248.8	1,361.7	2,011.8	203.4
Light commercial	184.8	251.0	235.1	365.6	97.8
Heavy commercial	66.6	81.5	94.3	153.4	130.3
Trucks	51.6	64.1	71.7	118.0	128.7
Buses	15.0	17.4	22.6	35.4	136.0

Source: ANFAVEA, 1997.

Table 3.62 Emission factors related to the painted area

Motor vehicle type	Painted surface (m^2)	NMVOC emission factor (g / m^2)
Small car	65	203
Van	120	120
Truck	171.5	120
Bus	271.5	500

Source: CORINAIR (1996)

In order to harmonize Table 3.61 with Table 3.62, automobiles were all considered as small cars and all light commercial as vans. In Table 3.64 NMVOC emissions for this subactivity are shown.

3.3.1.2 Construction and buildings

This refers to paint use in architectural applications by construction companies and professional painters. In order to estimate NMVOC emissions, an average per capita emission factor of 1.2 kg/capita/year was used, associated with the evolution of the economically active population – EAP in Brazil from 1990 to 2005. In Table 3.64 NMVOC emissions for this subactivity are shown.

3.3.1.3 Household use

This subactivity considers the use of paints in household applications.

In a manner analogous to the previous subactivity, an average emission factor of 0.73 kg/capita/year was used, in association with EAP evolution. In Table 3.64 NMVOC emissions for this subactivity are shown.

3.3.1.4 Other industrial applications

This subactivity includes the use of paint in shipbuilding, manufacturing of metal articles, wood products and production of plastic articles.

The ratio between the share of this subactivity in total NMVOC emissions and the motor vehicle production subactivity in 28 countries was used to estimate emissions for this subactivity. This ratio is shown in Table 3.63.

Table 3.63 Relationship between the average share in total NMVOC emissions from "Other Industrial Applications" and from "Motor Vehicle Production" in 28 countries

Subactivity	Contribution towards total NMVOC emissions
A – Motor vehicle production	0.6%
B – Other industrial applications	3.3%
Ratio (B / A)	5.5

In Table 3.64 total NMVOC emissions in solvent use in paints for the years of 1990, 1994, 2000 and 2005 are shown.

Table 3.64 NMVOC emissions – paint application

Description	Unit	1990	1994	2000	2005	Share in 2005	Variation 1990-2005
						%	
EAP	(10^6 inhab.)	68.9	75.3	84.2	95.9	NA	39.3
Motor vehicle production	(Gg)	14.5	23.8	25.9	39.0	8.9	169.1
Building construction		82.6	90.4	101.1	115.1	26.2	39.3
Household use		50.3	55.0	61.5	70.0	16.0	39.3
Industrial applications		79.8	130.8	142.4	214.7	48.9	169.1
Total		**227.2**	**299.9**	**330.9**	**438.9**	**100**	**93.2**

3.3.2 Metal degreasing

This activity is the process of removing dirt from agents like grease, fats, oils, waxes and carbon deposits from metals, plastics, fiber glass, circuit boards and other surfaces, mainly employing chlorinated solvents.

Tetrachloroethylene (also called perchloroethylene - PER); methylene chloride; trichloroethylene; 1.1.1-trichloroethane and trichlorotrifluorethane, are indicated as the most used chlorinated solvents in this activity. Only PER consumption was identified from 1990 to 2005.

Two of the above mentioned products were identified as being of local production (ABIQUIM, 1995 and 1997):

- 1.1.1-trichloroethane, produced until 1991; its production was ceased 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 the country, with 93% of its sales involved in the Metal Degreasing application.

In face of the above, estimated NMVOC emissions for this activity were based on the Brazilian consumption of perchloroethylene, which is shown in Table 3.65. Metal degreasing was considered to represent 93% of PER sales (ABIQUIM, 1997) from the period from 1990 to 1996. As per ABIQUIM (2010) and the Research and Development Center (CEPED) (2006), it is possible to continue assuming this predominance of PER in metal degreasing, where, starting 2000, annual percentages of quantities available in the market and applied to this activity began to be measured and are those shown in Table 3.65, below. For the period from 1997 to 1999, the average percentage from 1996 and 2000, that is, 78%, was adopted. Brazil is currently ceasing production of PER. Emissions were estimated based on the apparent consumption of PER, that is, the sum of domestic production plus imports, minus exports, and adopting the default emission factor of 1.0 kg NMVOC/1.0 kg of solvent used (CORINAIR, 1996), as per Table 3.60.

Table 3.65 Perchloroethylene consumption for metal degreasing

Perchloroethylene	1990	1994	2000	2005	Variation 1990-2005
	(t)				(%)
Production	30,853	33,855	36,239	24,040	-22.1
Imports	0	5,319	2,269	1,671	NA
Exports	14,583	22,453	24,912	24,486	67.9
Apparent consumption	16,270	16,721	13,596	1,224	-92.5
Use in degreasing	15,131	15,551	8,565	857	-94.3
Use of PER in degreasing	93%	93%	63%	70%	-

Source: ABIQUIM, 1995, 1997, 2005 and 2008.

3.3.3 Dry Cleaning

This activity refers to the process for cleaning diverse materials like furs, leathers, textiles and fibers using chlorinated solvents. The main solvent employed is dry cleaning is perchloroethylene. In order to estimate use of this solvent in Brazil, the same market share percentage as verified in Europe will be considered, where PER represents 90% of total solvent consumption for dry cleaning (CORINAIR, 1996), since this input is locally produced in the country. It was also considered that 4% of PER consumption was for laundries (ABIQUIM, 1997) and it assumed an emission factor of 100% of solvent used. In Table 3.66 solvent consumption in dry cleaning is presented for 1990, 1994, 2000 and 2005, resulting in the NMVOC emissions shown in Table 3.60.

Table 3.66 Solvent consumption – dry cleaning

Description	1990	1994	2000	2005	Variation 1990-2005
	(t)				(%)
Total PER consumption	16,270	16,721	13,596	1,224	-92.5
Use of PER in laundries	651	669	1,632	184	-71.8
Total solvent use	723	743	1,813	204	-71.8

Source: ABIQUIM, 1995, 1997, 2005 and 2008.

3.3.4 Processing Polystyrene Foams

Foams are produced through action by an expansion agent. In the case of polystyrene foams – PSF, mainly used in insulation and packaging, this agent is pentane. For flexible foams, water is used as the expansion agent.

In accordance with CORINAIR (1996), the expansion agent is incorporated to foams at a 6% proportion, prior to expansion. Thus, for estimating NMVOC emissions in this activity, PSF production as shown in Table 3.67 was used. NMVOC emissions are presented in Table 3.60.

Table 3.67 Polystyrene foams production (PSF)

Description	1990	1994	2000	2005	Variation 1990-2005
	(t)				(%)
Production PSF foams	9,393	14,588	17,073	20,706	120.4

Source: ABIQUIM, 1995 and 1997; estimated by linear growth starting in 1997.

3.3.5 Printing Industry

The methodology for estimating NMVOC emissions in this activity requires knowledge of the historical series of ink consumption verified in the printing, publication/publishing, packaging and other sectors. As in other sectors, average for per capita emission factors observed in other countries, associated with the EAP, were used.

An average emission factor of 0.7 kg/capita/year was used. NMVOC emissions for this activity are presented in Table 3.60.

3.3.6 Edible Vegetable Oil Extraction

This activity involves the extraction, through the use of solvents, of edible oils from oleaginous seeds/grains. Although in other countries the solvents may be used in drying residue from the crushing of grains/seeds, this process is not used in Brazil.

In accordance with the methodology (CORINAIR, 1996), the VOC emission factor is located within a range of 0.85 and 19 kg VOC/t of crushed seed/grain. It is reasonable to suppose that these factors depend on variables such as technology, efficiency in emission control and type of processed seed/grain. Since Brazil has a modern exporting soy bean processing industry with cutting edge technology, the lower limit of the range (0.85 kg VOC/t of crushed seed/grain) was used.

Table 3.68 shows the edible oil industry data involving oleaginous seeds/grains for 1990 to 2005. Soy bean's share in total crushed seeds/grains was considered as 96%. The corresponding VOC emissions are shown in Table 3.60.

Table 3.68 Edible oil industry data

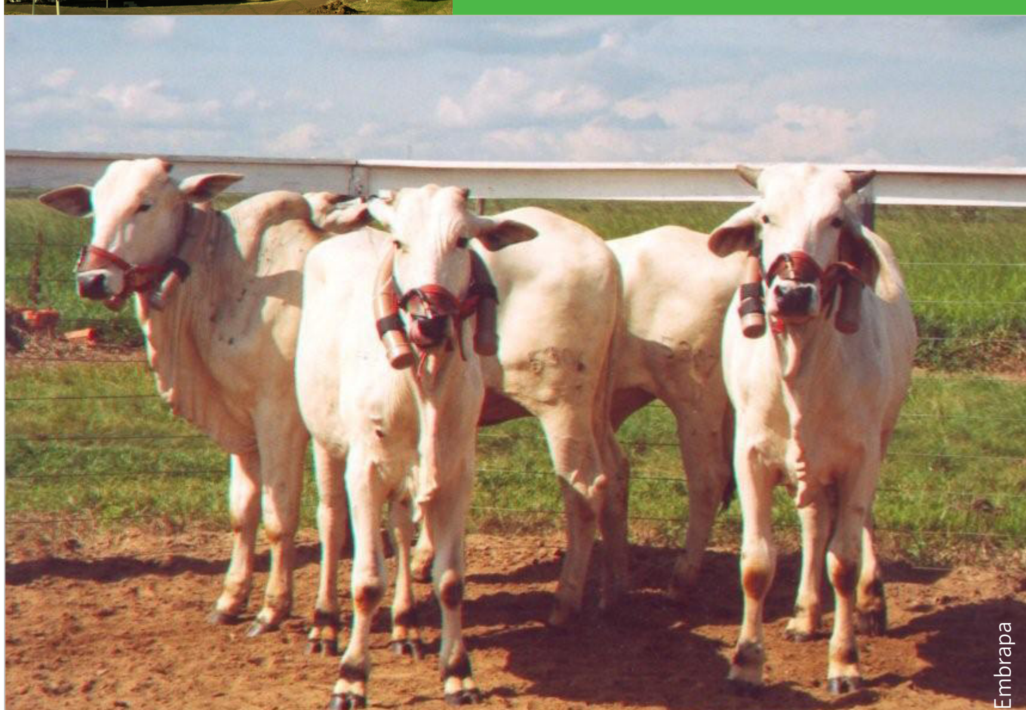
Description	1990	1994	2000	2005	Variation 1990-2005
	(t)				(%)
Crushed soy bean	15,435	18,736	21,180	29,862	93.5
Total crushed grains	16,078	19,517	22,063	31,106	93.5

Source: Brazilian Association of Vegetable Oil Industries - ABIOVE.

3.3.7 Household Use

This activity encompasses the following categories of products: cosmetics and personal hygiene (aerosols of every type, perfumes, after-shave lotions, deodorants, nail-polish removers), household products (aerosols of all types, cleaners, disinfectants, waxes and polishers), construction (adhesives for carpets and tiles, solvents, paint removers, adhesives for construction) and automobiles (aerosols of all types, brake fluids, waxes and polishes).

In the methodology for estimating emissions resulting from this activity, an average annual emission factor of 2,556 g VOC/capita is indicated. This factor results from the average emission factors from selected countries. The direct use of this average factor (from highly developed countries) entails an overestimation of emissions, even if only EAP is used. Brazilian specialists, taking into account GDP per capita suggested an annual value of 640 g VOC/capita. Estimated VOC values are shown in Table 3.60.



Embrapa

Agriculture

3.4 Agriculture

Agriculture, which includes livestock, is an economic activity of great importance in Brazil. Due to its large extension of agricultural and grazing lands, the country is one of the largest producers of this sector in the world.

Agriculture and livestock activities generate greenhouse gas emissions that occur through several processes. Enteric fermentation in ruminants is one of the most important sources of CH_4 emissions in the country (63.2%) in 2005. Manure management systems cause CH_4 and N_2O emissions.

Flooded rice crops, which are one of the main sources of CH_4 in the world, are not a very expressive emissions source in Brazil, because a major portion of the rice is produced in non-flooded areas.

The imperfect field burning of agricultural residues produces CH_4 and N_2O emissions, besides NO_x, CO and NMVOC. In Brazil, waste burning is applied in the sugarcane and cotton crops.

N_2O emissions in agricultural soils occur mainly from the animal waste deposition in pasture land and also from soil fertilization practices, which include the use of synthetic nitrogen fertilizers and animal waste management. The use of organic soils for farming also generates N_2O emissions.

3.4.1 Livestock

There are several processes in the cattle activity that cause greenhouse gas emissions. The production of CH_4 is part of the normal digestive process in ruminant herbivores (enteric fermentation); animal waste management produces CH_4 and N_2O emissions; the use of animal manure as a fertilizer and deposition of grazing animal wastes also produce N_2O in the soil.

Livestock, in particular ruminant herbivores, constitute an important source of methane emissions. The categories of animals considered by the 1996 Guidelines include: ruminant animals (dairy cattle, non-dairy cattle, buffalo, sheep and goats) and non-ruminant animals (horses, mules, donkeys and swine). Poultry category is only included in the estimate of emissions from animal waste management.

In 2005, there was an estimated 276 million heads of national cattle herd, not including poultry, which accounted for another one billion. The country also has significant herds of swine and ovine animals, as per Table 3.69.

Table 3.69 Population of the different herds

Categories of animals	1990	1994	2000	2005	Variation 1990-2005
	(10^3 head)				(%)
Non-dairy cattle	128,306	138,175	151,991	186,531	45
Dairy cattle	19,167	20,068	17,885	20,626	8
Swine	33,687	35,142	31,562	34,064	1
Sheep	20,049	18,466	14,785	15,588	-22
Goats	11,901	10,879	9,347	10,307	-13
Horses	6,161	6,382	5,832	5,787	-6
Asses	1,343	1,313	1,242	1,192	-11
Mules	2,034	1,987	1,348	1,389	-32
Buffalo	1,398	1,571	1,103	1,174	-16
Hens	174,714	207,539	183,495	186,573	7
Roosters, chicks and broilers	372,066	473,549	659,246	812,468	118
Quails	2,464	2,424	5,775	6,838	178

Source: IBGE

In 2005, 94% of total methane emissions from Brazilian livestock were attributed to enteric fermentation, as per Table 3.70. Still considering 2005, the categories of cattle contributed with 97% of methane emissions from enteric fermentation and 91% of total methane emissions from livestock.

Table 3.70 Methane emissions from livestock

Source	1990	1994	2000	2005	Variation 1990-2005
	(Gg)				(%)
Enteric fermentation	8,419	8,995	9,599	11,487	36.4
Manure management	635	675	678	723	13.8
Total emissions	**9,054**	**9,670**	**10,277**	**12,210**	**34.8**

Detailed estimates of emissions from enteric fermentation and animal waste management are presented below. N_2O emissions from manure addition to the soil, whether intentional or by grazing livestock, are treated with other types of fertilizers in item 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. It occurs in much smaller quantities in other herbivores. The contribution of non-ruminant animals to global methane emissions is considered insignificant, representing only about 5% of total methane emissions from domestic and wild animals.

Emission intensity depends on the type of animal, the type and amount of food, the degree of digestibility and the intensity of the animal's physical activity, as a result of the diverse raising practices.

The estimate of emission factors is based on recognition of these parameters, which will allow for the evaluation of emissions. In Brazil, due to its large territorial extension and wide dispersion of activity with a diversity of practices and food types provided to the animals, there is a great variation in these parameters.

Unfortunately, studies in this area are insufficient in the country. However, with the contribution of Brazilian specialists, emission factors that could be straight forwardly applied to raising characteristics and regional differences were obtained for cattle. The values obtained proved to be consistently higher than the 1996 Guidelines default values.

In accordance with diet characteristics, methane gas emissions were estimated to vary between 4% and 12% of gross ingested food energy. Average CH_4 gas emissions. was considered to be 8%. As the production of methane varies with the quantity and quality of food ingested, different types and conditions for livestock production systems result in different percentages of methane emissions. Food consumption is related to animal size, environmental conditions, growth rate and production (milk, meat, wool and gestation). Generally, the greater this consumption, the greater the CH_4 emission and the better quality of the diet, the lower this emission will be per unit of ingested food.

Furthermore, it is necessary to consider that ruminants experience seasonal differences in food supply, considering climatic conditions that alter pasture quality, which also differs in accordance with soil type. Thus, it is possible to observe a seasonal pattern of weight gain in the wet season (hot) and weight loss in the dry season (cold), which occurs in individuals over 3.5 years of age.

For dairy farming, production systems are observed with different degrees of specialization, from subsistence properties – without techniques and daily production of less than 10 liters, to highly specialized producers - with daily production above 50 thousand liters. It is estimated that only 2.3% of dairy properties are specialized and that these are responsible for approximately 44% of total milk production in the country. On the other hand, 90% of the producers considered small are responsible for only 20% of total production. There is also an intermediate group in terms of property specialization that corresponds to 7.7% of producers and that are responsible for 36% of production.

Zootechnical features were set for 1990-1995, 1996-2001 and 2002-2006, according to the peculiarities of the country's herds. Among these periods, there was a variation in digestibility and pregnancy data for the Southeast, South and Central-West regions. Based on these parameters, methane emission factors were estimated for enteric fermentation in livestock. For females in non-dairy cattle and for dairy cattle, estimations also take into account the production of milk, which is assumed to be the same in both cases and is available by state and year, resulting in different emission factors for all years in each state.

For other animals, IPCC default emission factors were used due to the non-existence of consistent national data, increasing the degree of uncertainty of the estimates.

In Table 3.71 estimates are provided for methane emissions, resulting from enteric fermentation, in accordance with animal category. Among the types of animals, non-dairy cattle were the major contributor for these emissions.

Table 3.71 CH_4 emissions from enteric fermentation

Type of animal	1990	1994	2000	2005	Share in 2005	Variation 1990-2005
	(Gg)				(%)	
Cattle	8,004	8,579	9,256	11,129	96.9	39.0
Dairy Cattle	1,198	1,263	1,178	1,371	11.9	14.5
Non-dairy Cattle	6,807	7,316	8,078	9,757	84.9	43.4
Other Animals	415	416	344	358	3.1	-13.7
Total	**8,419**	**8,995**	**9,599**	**11,487**	**100**	**25**

3.4.1.2 Manure management

The main source of methane emissions is related to animal wastes treated under anaerobic conditions. This occurs due to methanogenic bacteria activity in anaerobic conditions producing important quantities of CH_4. This process is favored when dejects are stored in liquid form.

Due to the characteristics of extensive livestock raising in Brazil, anaerobic treatment lagoons constitute a small fraction of the management systems. Even for confined cattle, a restricted number of deject treatment installations can be observed. Animal wastes deposited in pasture dries and decomposes in the field, so that minimum quantities of CH_4 emissions are expected from this source. The use of manure as fertilizer is not expressive in the country. It is estimated as no more than 20% in the cases of non-dairy and dairy cattle and swine, and approximately 80% in the case of poultry.

CH_4 emissions were estimated using IPCC methodologies. Detailed methodology that takes into account national feeding parameters, digestibility and management systems, obtained with the collaboration of Brazilian specialists was used for cattle and swine.

The waste composition is determined by the animal's diet so that the greater the energy content and digestibility of the food, the greater the capacity for CH_4 production. Cattle fed a high quality diet produces a highly biodegradable manure with greater potential for methane generation, whereas cattle fed a more fibrous diet will produce a les biodegradable deject, containing more complex organic material, such as cellulose, hemicellulose and lignin. The latter would be more closely associated with cattle raised on pastures in tropical conditions. The higher emissions of methane from animal waste are associated with animals raised under intensive management.

In accordance with researchers, the existing swine deject treatment and storage systems in the South of the country consist of manure storage systems. The objective is to apply them to the soil and valorize them as agricultural fertilizer for corn and other crops. At present, the two swine manure storage systems most used are known as bio manure piles and conventional manure piles. There were few biodigesters installed in the country until 1996, but due to new technologies that emerged within the scope of the CDM, there was an increase in the adoption of this equipment from 2004 on.

In accordance with national studies, the waste treatment systems were divided into six periods: 1990-1999; 2000-2001; 2002-2003; 2004; 2005; and 2006. The differences in the first three systems were identified only in *Santa Catarina*. Composting data were inserted in the "other systems" category. Data on digesters for the period of 1996 to 2003 were also inserted in the "other systems" category. For the years of 2004 and 2005, smaller fractions of digesters, compared to 2006, were considered. Information on herd size (small and mid-sized properties, with less than 300 animals, and large properties, with more than 300 animals) was also used as a basis for estimates.

Animal manure management, depending on the system employed, can also produce N_2O emissions during processing, which are described under the agricultural soils subsection. N_2O emissions were estimated based in the IPCC methodology, considering the participation of various systems used for each type of animal. Due to lack of information about specific emission factors for Brazil, IPCC default values were used.

The highest methane emissions from animal waste are associated with animals raised under intensive management. The potential of animal wastes to produce CH_4 can be expressed in terms of CH_4 generated per kg of volatile solids (VS) of residual material. Estimates for CH_4 emissions from animal manure management can be observed in Table 3.72.

Table 3.72 CH_4 emissions from animal manure management

Type of animal	1990	1994	2000	2005	Share in 2005	Variation 1990-2005
	(Gg)				(%)	
Cattle	191	205	216	254	35.1	32.8
Dairy cattle	36	38	34	40	5.5	10.6
Non-dairy cattle	155	167	182	214	29.6	38.0
Swine	373	387	365	358	49.5	-4.1
Poultry	48	61	78	92	12.7	89.0
Other animals	22	23	19	20	2.7	-12.2
Total	635	675	678	723	100	105

3.4.2 Rice Cultivation

The anaerobic decomposition of organic matter in irrigated or flooded rice fields is an important source of CH_4 emissions. However, this process does not occur when rice is cultivated on uplands (dryland rice).

Contrary to what happens globally, where upland rice is responsible for only 15% of harvested areas, in Brazil it is responsible for most of the harvested area (63% in 2005), which was of 3,916 thousand hectares in 2005. Upland rice is the most used form of growing practice in the Northeast and Central-West regions of the country.

The flooded rice crop is present in Brazilian regions, and as such, is subject to different climatic influences, availability of water for irrigation and field size. It is grown on a wide variety of soils and topographies, with different varieties and forms of management. Despite occupying less area for cultivation (1.4 million hectares in 2005), irrigated rice is responsible for the greater part of total production of 13.2 million tonnes in Brazil, which is concentrated in *Rio Grande do Sul* (70.1% of the irrigated rice area and 46.3% of total production in 2005). Rice is also grown in a wet grassland system, at a lower scale, especially in the state of *Minas Gerais*.

Between 1990 and 2005, annual domestic production of rice growth was of 77.8%. The average annual growth rate was of 3.9% per year.

Total harvested area of rice using irrigation or lowland systems can be observed in Table 3.73.

Table 3.73 Harvested area of rice

Harvested Area		1990	1994	2000	2005	Variation 1990-2005
		(10^3 ha)				(%)
Continuous flooded		1,077	1,333	1,262	1,382	28.3
Intermittent flooded	Single aeration	-	0	-	-	-
	Multiple aerations	19	14	-	-	-100
Rainfed	Floodprone	162	148	59	46	-72
Irrigated Rice Total		1,258	1,495	1,321	1,428	13.5
Upland Rice		2,689	2,920	2,344	2,488	-7.5
Total		**3,947**	**4,415**	**3,665**	**3,916**	**-0.8**

Source: Embrapa.

Studies conducted in different countries have shown the influence of several factors on CH_4 emissions in flooded rice fields. These factors include temperature, solar radiation, types of fertilizer, types of cultivars, and types of soil. Brazil still does not have experimental data that allow defining specific emission factors under different regional and climatic conditions. For this reason, IPCC default factors have been used.

Estimates for CH_4 emissions from rice crop can be seen in Table 3.74. Emission reductions observed between 1994 and 2005 were due to a reduction in harvest area during the period. In 2005, emissions from rice cultivation in continuous flooded fields represented 97.4%, and in lowlands, they accounted for 2.6% of total emissions. In Table 3.75 the contribution of each region of the country to methane emissions from rice cultivation is shown.

Table 3.74 Methane emissions in accordance with rice cultivation regime

Planting regime		1990	1994	2000	2005	Variation 1990-2005
		(Gg)				(%)
Continuous regime		323.1	399.9	378.6	414.7	28.4
Intermittent regime	Single Aeration	-	0.0	-	-	NA
	Multiple Aeration	1.2	0.9	-	-	-100
Grassland regime	Wet Grassland	38.8	35.5	14.2	11.0	-71,6
Total		**363.1**	**436.3**	**392.9**	**425.7**	**17.2**

Table 3.75 Methane emissions by rice cultivation and by region

Region	1990	1994	2000	2005	Variation 1990-2005
	(Gg)				(%)
North	8.8	19.4	16.8	23.3	164.1
Northeast	16.3	18.0	15.4	16.2	-0.2
Southeast	67.2	56.2	26.6	20.0	-70.2
South	249.8	328.2	321.7	349.8	40.0
Central-West	21.0	14.6	12.4	16.3	-22.4
Brazil	**363.1**	**436.3**	**392.9**	**425.7**	**17.2**

3.4.3 Burning of Agriculture Residues

In Brazil, the burning of agricultural wastes still occurs, mainly in the sugarcane crop, despite the progressive increase in mechanized harvesting in recent years. However, for the cotton crop, the burning practice ceased being common in the beginning of the 1990s, according to information from specialists.

Although the burning of waste releases a large quantity of CO_2, these emissions are not considered in the Inventory, since, through photosynthesis, the same amount of CO_2 is necessarily absorbed during plant growth. However, during the combustion process, other gases besides CO_2 are produced. Emission rates for these gases depend on the type of biomass and burning conditions. In the combustion with flame phase, N_2O and NO_x gases are generated; and CO and CH_4 gases are formed under burning conditions with a predominance of smoke.

3.4.3.1 Sugarcane

Sugarcane presents high photosynthetic efficiency, with optimal growth within the 20 to 35°C temperature range. Therefore, its growing expanded to very diversified types of soil in the national territory. It is also highly tolerant to acidity and alkalinity. Sugarcane has great importance in the national economy, mainly due to sugar production.

The sugarcane burning practice during pre-harvest was broadly used in the country by 2005 with the objective of improving manual cutting performance, avoiding problems with poisonous animals, common in plantations, and facilitating land preparation for new planting. After 2006, a significant increase in the share of harvesting without burning was observed, reaching 34% of the total harvest area in 2007.

More than 55% of the sugarcane crop area in the state of *São Paulo* is currently being harvested without burning (AGUIAR *et al*., 2010), and the state is responsible for more than 60% of Brazilian production (Unica, 2008[49]).

Preliminary data on sugarcane production area for 2007 harvest, from a survey conducted by CONAB with 355 plants in the country, indicate that mechanical harvesting was used in only 4% of the state of *Pernambuco*, the second largest sugarcane producer, and only 3% in the state of *Alagoas*. For years prior to 2006, due to the lack of reliable data and indications as to the gradual proportions of mechanization, it was assumed that the entire sugarcane producing area in these states was subject to burning.

In 2005, the Southeast region contributed the most to emissions, accounting for 62.8% of total average emis-

49 Production Expansion Perspectives. Elaboration: UNICA, Copersucar and Cogen. Not Published.

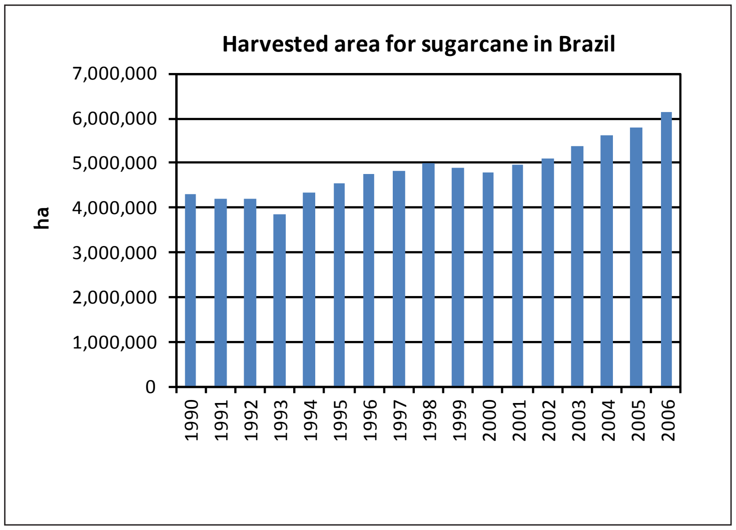
sions in the period, followed by the Northeast, which contributed with 17.3%. The North contributed with only 0.3%. The increase in CH_4 emissions from 2000 to 2005 can be explained by the increase in harvested sugarcane area and the increase in average crop yield, reflecting greater biomass subject to burning. During this period, there was a 28.6% increase in burnt area in the state of *São Paulo* alone, which contributed with 53.1% of the country's harvested area in 2005.

The average annual harvest area for sugarcane, its production and average yield can be observed in Table 3.76 and Figure 3.5.

Table 3.76 Harvested area, production and average yield for sugarcane crop

Year	Harvested Area (ha)	Production (t)	Average Yield (t/ha)
1990	4,287,625	262,674,150	61
1991	4,210,954	260,887,893	62
1992	4,202,604	271,474,875	65
1993	3,863,702	244,531,308	63
1994	4,345,260	292,101,835	67
1995	4,559,062	303,699,497	67
1996	4,750,296	317,016,081	67
1997	4,814,084	331,612,687	69
1998	4,985,624	345,254,972	69
1999	4,898,844	333,847,720	68
2000	4,804,511	326,121,011	68
2001	4,957,897	344,292,922	69
2002	5,100,405	364,389,416	71
2003	5,371,020	396,012,158	74
2004	5,631,741	415,205,835	74
2005	5,805,518	422,956,646	73
2006	6,144,286	457,245,516	74

Figure 3.5 Evolution of harvested area for sugarcane in Brazil from 1990 to 2006



In Table 3.77 estimated values for gas emissions from burning sugarcane are shown. A 13.7% increase in gas emissions from burning sugarcane waste in the country was observed from 1990 to 2005, although the sugarcane harvest area had grown 35.4%.

Table 3.77 Estimated emissions from sugarcane burning

Gas	1990	1994	2000	2005	Variation 1990-2005
	(Gg)				%
CH_4	116.9	130	101.5	132.9	13.7
N_2O	5.8	6.4	5.1	6.6	13.7
CO	2,454.7	2,729.7	2,130.6	2,790.5	13.7
NO_x	208.4	231.8	180.9	236.9	13.7

3.4.3.2 Herbaceous cotton

Cotton crops are broken down into two categories, which are the herbaceous cotton and the arboreal cotton, the latter characterized by being a perennial crop where waste is not burned.

The total harvested area for cotton had a significant reduction from 1992 to 1997 (Table 3.78 and Figure 3.6), and its production was later recovered with an increased in the harvested area in Brazil's central region until 2006. In Figure 3.7 the evolution of the harvested area for herbaceous cotton across Brazil's regions is shown for specific years from 1990 to 2005, where the reduction in harvested areas in the Northeast, South and Southeast regions and the increase in the Central-West region become apparent.

Table 3.78 Harvested area, production and average yield for herbaceous cotton crop

Year	Harvested Area	Production	Average Yield
	(ha)	(t)	(t/ha)
1990	1,391,884	1,783,175	1.28
1991	1,485,963	2,041,123	1.37
1992	1,594,036	1,863,077	1.17
1993	922,593	1,127,364	1.22
1994	1,060,564	1,350,814	1.27
1995	1,103,536	1,441,526	1.31
1996	744,898	952,013	1.28
1997	620,417	821,271	1.32
1998	825,029	1,172,017	1.42
1999	669,313	1,477,030	2.21
2000	801,618	1,759,129	2.19
2001	875,107	2,643,524	3.02
2002	760,431	2,166,014	2.85
2003	712,556	2,199,268	3.09
2004	1,150,040	3,798,480	3.30
2005	1,258,308	3,666,160	2.91
2006	898,008	2,898,721	3.23

Figure 3.6 Evolution of harvested area for herbaceous cotton in Brazil from 1990 to 2006

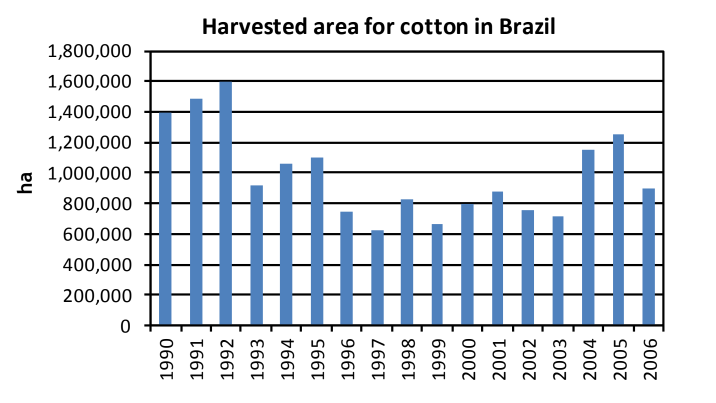
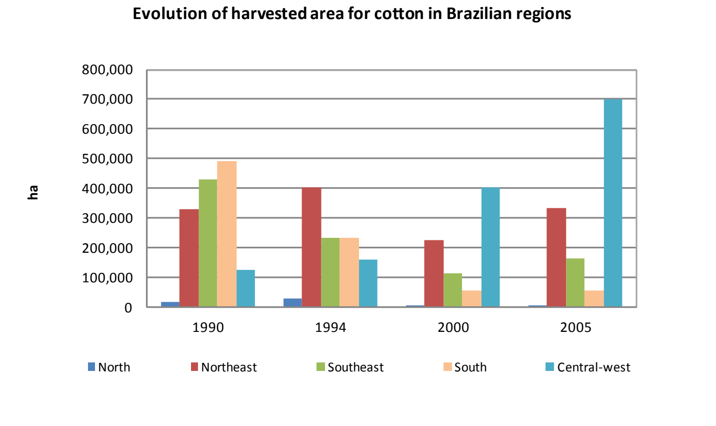


Figure 3.7 Evolution of harvested area for cotton by region from 1990 to 2005



For this Inventory, based on information obtained after consulting cotton production chain agents and current legislation, the practice of burning was re-evaluated as a method for eradicating and eliminating crop residues for the period after 1990. According to specialists, the common practice has been to grub and harrow crop residues, incorporating the waste to the soil, in consonance with the non-obligatory burning in current legislation. Chemical treatment is most used in cases of resprouting. It was thus assumed that there was a transition period between the obligatory and non-obligatory burning of cotton wastes in the beginning of the 1990s, as well as the eradication mechanisms of crop residues in the field. A gradual drop from 50% to 0% was considered from 1990 to 1995, as a fraction of the areas still practicing burning. After this period, it was assumed that cotton waste burning no longer existed in the country.

In Table 3.79 estimated emissions from cotton crop waste burning are shown. It was considered that there was a linear reduction in the burning practice between 1990 and the extinction of the practice in 1995, when specialists claim that the practice of burning waste was replaced by mechanical and chemical methods for eradicating cotton waste after harvest.

Table 3.79 Estimated emissions from cotton crop waste burning

Gas	1990	1994	2000	2005	Variation 1990-2005
	(Gg)				%
CH_4	4.2	0.5	-	-	-100
N_2O	0.3	0	-	-	-100
CO	87.9	11.5	-	-	-100
NO_x	10.5	1.4	-	-	-100

3.4.4 N_2O Emissions from Agricultural Soils

Use of nitrogen fertilizers is pointed out as the main reason for the global increase in N_2O emissions by agricultural soils. However, in Brazil, the main source of emissions is manure from grazing animals. N_2O emissions also occur from applying animal manure as fertilizer, from the nitrogen found in agricultural waste and from the atmospheric deposition of NO_x and NH_3.

N_2O emissions from agricultural lands were subdivided into three categories, as per 1996 Guidelines:

- N_2O emissions from grazing animal manure;
- other direct sources of N_2O emissions, including the use of synthetic fertilizers, manure used as fertilizer, the biological nitrogen fixation and crop residues; and
- indirect sources of N_2O emissions from the nitrogen used in agriculture, which include the volatilization and subsequent atmospheric deposition of NO_x and NH_3 from fertilizer applications, and leaching and runoff of nitrogen from fertilizers.

Estimates of N_2O emissions from agricultural soils in Brazil are shown in Table 3.80. In 2005, total emissions were estimated at 456.8 Gg N_2O, the greatest share coming from direct emissions, in which grazing animal waste is the main cause.

From 1990 to 2005, the different source of N_2O emissions maintained the same order of importance as to their contribution towards total N_2O emissions from agricultural soils. The deposition of animal excrement in pastures remained as the most important source. Indirect emissions represented 27.7% of the total in 2005.

It is important to underscore that recent results from studies on N_2O emissions from national agriculture do not confirm that biological nitrogen fixation is an important process for N_2O emissions, an understanding in line with the 2006 Guidelines, in which this source of emissions is absent. Therefore, biological fixation of nitrogen was not considered as a source of emissions in this Inventory.

Table 3.80 N_2O emissions from agricultural soils

Source	1990	1994	2000	2005	Share in 2005	Variation 1990-2005
	(Gg)				(%)	
Direct emissions	212.8	235.0	251.2	305.7	66.9	43.7
Synthetic fertilizers	11.0	16.6	23.6	31.1	6.8	182.5
Application of fertilizer	13.2	14.3	14.0	15.6	3.4	18.3
Cattle	4.7	5.0	4.9	5.5	1.2	15.2
Others	8.5	9.3	9.2	10.2	2.2	20.0
Crop residues	15.3	19.0	21.6	29.1	6.4	89.6
Soy bean	4.8	6.1	8.0	12.5	2.7	157.2
Sugarcane	1.0	1.2	1.8	2.3	0.5	123.5
Beans	0.8	1.2	1.1	1.0	0.2	35.2
Rice	0.9	1.2	1.3	1.5	0.3	77.8
Corn	3.5	5.3	5.3	5.7	1.3	64.5
Cassava	2.7	2.7	2.5	2.8	0.6	6.4
Others	1.7	1.4	1.7	3.2	0.7	88.0
Organic soils	7.5	9.0	11.1	12.8	2.8	70.3
Grazing animals	165.7	176.2	180.8	217.1	47.5	31.0
Cattle	144.0	154.7	162.7	198.4	43.4	37.8
Others	21.7	21.5	18.1	18.6	4.1	-14.4
Indirect emissions	104.8	116.4	124.8	151.1	33.1	44.1
Atmospheric deposition	21.1	23.0	24.2	29.1	6.4	37.8
Synthetic fertilizers	1.2	1.8	2.6	3.5	0.8	182.5
Animal fertilizer	19.9	21.2	21.6	25.6	5.6	28.9
Cattle	15.6	16.7	17.5	21.2	4.6	36.1
Others	4.3	4.5	4.1	4.4	1.0	2.6
Leaching	83.7	93.3	100.6	122.0	26.7	45.7
Synthetic Fertilizers	9.2	13.9	19.7	25.9	5.7	182.5
Animal Fertilizer	74.5	79.5	81.0	96.1	21.0	28.9
Cattle	58.4	62.7	65.6	79.5	17.4	36.1
Others	16.1	16.8	15.4	16.5	3.6	2.6
Total	**317.7**	**351.4**	**376.0**	**456.8**	**100**	**43.8**

3.4.4.1 N_2O emissions due to grazing animals

Waste deposited on soils by animals during grazing are the most important source of N_2O emissions by agricultural soils in Brazil due to the large herd and the fact that extensive raising is the predominant cattle practice in the country. The production systems are also characterized by large territorial extension, with pasture management conducted continuously.

Between 1990 and 2005, total nitrogen directly excreted in pastures increased considerably (31.0%), and it is possible to observe this evolution from data in Table 3.82. N_2O emissions from grazing animals represented 47.5% of emissions of this gas from agricultural soils, in 2005, with cattle as the main contributor of these emissions.

N_2O emissions were estimated using IPCC default emission factors for the nitrogen content in animal wastes and for the N_2O emission factor for the quantity of nitrogen deposited. Among the Brazilian regions, in 2000, the Central-West had the largest number of heads of non-dairy cattle, corresponding to 37.3% of the Brazilian herd. In Table 3.82 it can be seen that the Central-West region offers the highest contribution in quantity of nitrogen from animal dejects directly applied to pasture.

Non-dairy cattle production in the beginning of the 2000s was characterized by a migration from the Southeast to the Central-West and North regions. This explains the increase in the quantity of nitrogen applied directly to the soil in the North and Central-West regions.

3.4.4.2 N_2O emissions from other direct sources

Use of synthetic fertilizer

The most important nitrogen fertilizers used in Brazil are urea, ammonia, anhydrous ammonium nitrate and ammonium sulfate. Total consumption of synthetic nitrogen fertilizers in Brazil in 2005 was 2.2 million tonnes of nitrogen content, 182% more than consumption in 1990. Part of this nitrogen is incorporated to plants and soil, part is volatized as NO_x and NH_3 and part is released as N_2O. Due to the absence of specific studies on emission factors for Brazil's management and climate conditions, IPCC default emission factors have been used.

Nitrogen consumption in the form of fertilizers in the country has been increasing linearly at a rate of 97.2 thousand tonnes of nitrogen per year. The Southeast's share in total consumption of nitrogen fertilizers in the country fell between 1990 and 2005, but it was still responsible for the largest share in 2005, with 44.4% of the total as per Table 3.81. Direct N_2O emissions from the use of synthetic fertilizers represented 6.8% of N_2O emissions for agricultural soil in 2005, as per Table 3.80.

Table 3.81 Synthetic fertilizers applied in agricultural soils by region

Region	1990	1994	2000	2005	Share in 2005	Variation 1990-2005
	(t N)				(%)	
North	1,273	2,781	13,731	22,692	1.0	1,683
Northeast	80,013	117,103	147,286	197,012	8.9	146
Southeast	402,060	541,614	721,382	977,190	44.4	143
South	231,403	386,882	499,749	631,653	28.7	173
Central-West	64,566	128,560	286,047	372,857	16.9	477
Brazil	**779,315**	**1,176,940**	**1,668,195**	**2,201,404**	**100**	**182**

Animal manure management

The estimated nitrous oxide (N_2O) emissions in this section are related to the N_2O produced during storage and treatment of animal waste, before being applied to the soil as fertilizer. Manure or dung is used in this inventory collectively for solid and liquid wastes produced by livestock. N_2O emissions from manure during storage and treatment depend on its nitrogen and carbon contents, the period of storage and the type of treatment. The term "management system" is used for all types of manure storage and treatment.

The quantity of nitrogen excreted by animals but not directly on pasture is assumed as being applied to the soil as fertilizer.

In accordance with the practices used in each region, it was considered that managed manure, using the anaerobic lagoon, solid storage, dry lot, pasture, manure pile and biodigester systems are applied to the field as fertilizer. IPCC default values were adopted as N_2O emission factors. Direct N_2O emissions from the use of animal manure represented 3.4% of N_2O emissions for agricultural land in 2005, as per Table 3.80.

Except for the swine and poultry categories, most excrement is deposited directly in the pastures, as it can be seen in Table 3.82. In the case of animals whose manure is "not managed", that is, in pasture range and paddock system, dejects are not stored or treated, but rather deposited directly on the field.

Table 3.82 Nitrogen amount in animal manure

System	Region	1990	1994	2000	2005	Share in 2005	Variation 1990-2005
		(t Nex[1])				(%)	
Grazing animals	North	514,405	654,575	826,639	1,358,545	19.7	164.1
	Northeast	1,157,440	1,029,980	1,004,210	1,162,718	16.8	0.5
	Southeast	1,262,937	1,309,611	1,227,253	1,281,403	18.6	1.5
	South	872,450	905,474	843,641	877,841	12.7	0.6
	Central-West	1,465,912	1,705,973	1,851,101	2,226,094	32.2	51.9
	Total	**5,273,143**	**5,605,614**	**5,752,843**	**6,906,602**	**100**	**31.0**
Other management systems	North	71,207	83,657	61,546	64,687	5.2	-9.2
	Northeast	207,200	195,023	171,135	181,051	14.6	-12.6
	Southeast	299,922	316,080	313,788	336,297	27.0	12.1
	South	349,212	404,250	432,639	485,119	39.0	38.9
	Central-West	123,310	136,990	138,503	176,124	14.2	42.8
	Total	**1,050,851**	**1,135,999**	**1,117,611**	**1,243,278**	**100**	**18.3**

[1] Excreted nitrogen

The amounts of nitrogen in manure used for fertilization that generate direct emissions of N_2O are estimated as 80% of the total, while the remaining 20% corresponding to losses by volatilization of NH_3 and NO_x, which will generate indirect emissions of N_2O.

In Table 3.83 N_2O emissions from manure management systems in Brazil are presented, not including those deposited directly in pastures, where it can be seen the predominance of the South region in 2005.

Table 3.83 Summary of N_2O emissions from manure management in Brazil

Region	1990	1994	2000	2005	Share in 2005	Variation 1990-2005
	(t)				(%)	
North	0.73	0.87	0.66	0.67	5.2	-8.0
Northeast	2.36	2.33	2.13	2.27	17.7	-4.1
Southeast	2.95	3.22	3.47	3.79	29.6	28.4
South	2.98	3.64	3.94	4.45	34.7	49.2
Central-West	1.01	1.16	1.29	1.65	12.8	63.0
Total	**10.03**	**11.21**	**11.49**	**12.82**	**100**	**27.8**

Biological nitrogen fixation

The reduction process of atmospheric N_2 to combined forms of ammonium-N using living organisms is called biological nitrogen fixation. In Brazil, the practice of inoculation with specific bacteria for N_2 fixation is routinely used only in the soy bean crop, and there is no other available information about its application in other crops.

In relation to N_2O emissions resulting from the biological nitrogen fixation (BNF) process using legumes, as shown in 1996 Guidelines, Rochette and Janzen (2005) demonstrated that there are no data in literature to confirm the existence of any relation between the two processes, thus BNF is no longer considered a source of N_2O in 2006 Guidelines. The confirmation that the soy bean crop does not imply N_2O emissions due to BNF associated with the culture was achieved by Cardoso *et al*. (2008) by failing to find any difference between N_2O emissions measured in soil planted with a nodulating variety and another non-nodulating variety (unable to benefit from BNF). In the South of Brazil, Jantalia *et al.* (2008) did not record N_2O emissions either during soy bean crop growth that could suggest BNF as a relevant source of this gas.

Thus, for this Inventory, BNF was removed as a source of N_2O, as described in the 2006 Guidelines methodology, corroborated by national studies.

Crop residues

Nitrogen contained in crop residues and incorporated into the soil is also a source of N_2O emissions. In order to estimate these emissions, annual productions and the amount of dry matter per crop were used. The main crops considered were sugarcane, corn, soy bean, rice, beans, and cassava.

The area occupied by temporary crops represents about 90% of the total and it remained practically the same from 1990 to 2003, with minor fluctuation. After 2003, there was an increase in planted area with annual crops, from 52 to 56 million hectares between 2003 and 2006. Despite the large variety of agriculture species planted in the country, only five crops were responsible for 78% of planted area in 2006. Soy bean occupied the largest area (33.0%), followed by corn (22.5%), sugarcane (11.4%), beans (6.4%) and rice (4.7%).

Considering the quantity of nitrogen contained in the waste of each main crop, as well as other annual crops, there has been a 92.5% increase in the amount of nitrogen between 1990 and 2005 that returns to the agricultural soil (Table 3.84), with soy bean standing out as the main contributor.

Table 3.84 Nitrogen amount in residue left on agricultural soils by crop

Crop	1990	1994	2000	2005	Share in 2005	Variation 1990-2005
	(t)				(%)	
Soy bean	308,484	386,528	508,834	793,496	42.1	157.2
Corn	221,385	336,910	335,182	364,139	19.3	64.5
Beans	49,241	74,258	67,352	66,588	3.5	35.2
Rice	54,232	77,032	81,372	96,413	5.1	77.8
Sugarcane	65,863	73,242	115,486	148,001	7.8	124.7
Cassava	169,233	170,223	160,341	180,017	9.5	6.4
Others	111,493	91,150	112,428	237,614	12.6	113.1
Total	**979,931**	**1,209,342**	**1,380,995**	**1,886,270**	**100**	**92.5**

Due to lack of reliable data related to residues from permanent crops (coffee, coconut, oranges, among others), the quantity of nitrogen that returns as waste from these crops was not calculated. The parameters used for permanent waste (fraction of dry matter from the harvested product) would not serve as reference for perennial crop waste, since residues from these cultures do not return to agricultural soils.

For annual crops, a bibliographical study was conducted to estimate dry matter fraction of the product and the nitrogen fraction of the aerial part of the plant. Due to the lack of better information, IPCC default emission factors were used for nitrogen content in residues and for the portion of waste that remains in the field. Direct N_2O emissions from the use of harvest waste represented 6.4% of N_2O emissions from agricultural soil in 2005, as per Table 3.80, and the six main crops accounted for 89% of emissions for all crops.

High organic content soils

Brazil does not have available information on soils, at the appropriate scales, for actually estimating cultivated organic soil area each year.

Due to the reduced area organosoils represent in Brazil, along with the great uncertainty in their distribution and agricultural use, for estimating N_2O emission, a one million hectare area was assumed, 40% of which would be in use in 1990, and reaching 70% of the total being planted in 2006.

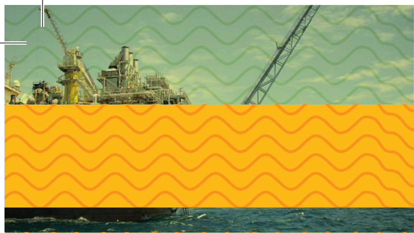
3.4.4.3 N_2O emissions from indirect sources

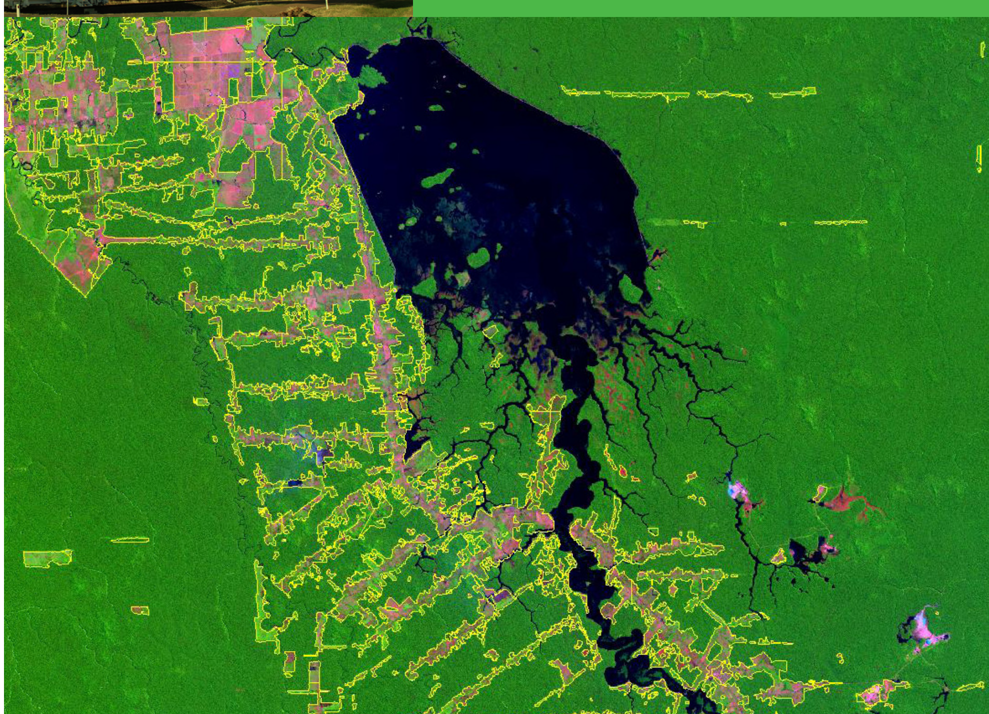
Atmospheric deposition of NO_x and NH_3

Part of the nitrogen contained in synthetic fertilizers and in animal manure, used as fertilizers, volatilizes as NO_x and NH_3. This part is discounted from the estimates of emissions from direct sources. However, part of these gases is deposited again on the Earth's surface, and if this deposition occurs on agricultural soils, it can result in additional N_2O emissions. It is impossible to determine where this deposition will occur, and it may even occur in the oceans. Likewise, NO_x and NH_3 stemming from other sources, such as combustion, may deposit on agricultural soils. Therefore, the uncertainty related to this portion of emissions is very large. It was decided to consider total deposition corresponding to the volatilized gases from agricultural soils. IPCC default emission factors were used. N_2O emissions from atmospheric deposition of NO_x and NH_3, in 2005, represented 6.4% of N_2O emissions from agricultural soils, growing 38% compared to the value estimated in 1990, as per Table 3.80.

Nitrogen leaching and surface runoff

Part of the nitrogen applied to agricultural soils as synthetic fertilizers or animal manure is subject to leaching and runoff, flowing through rivers into the ocean. These environments also have N_2O emissions, classified as indirect emissions from fertilizer applications. Uncertainty regarding N_2O emission factors by runoff of this nitrogen is very large, and there is no assessment concerning the most appropriate values for Brazil's wide-ranging conditions. IPCC default emission factors were used. In 2005, N_2O emissions due to leaching and runoff nitrogen applied as fertilizer accounted for 26.7% of N_2O emissions from agricultural soils, a growth of 45.7% compared to the estimated value for 1990, as per Table 3.80.



Land-Use Change and Forestry


3.5 Land-Use Change and Forestry

As noted in section 1.2.5, the land-use change and forestry sector has been expanded in the present Inventory to include anthropogenic greenhouse gas emissions and removals in areas where no land-use change have occurred.

The methodologies adopted for this part of the Inventory are consistent with those in the Good Practice Guidance LULUCF, whose use is mandatory for Annex I Parties while only recommended for non-Annex I Parties. However, due to the importance of the net anthropogenic emissions associated with Land-Use Change and Forestry (LUCF), as identified and reported in the Initial Inventory, it was decided to implement in the present report the more comprehensive, yet complex and detailed approach described in the Good Practice Guidance LULUCF, that is based on land-use categories and complete territorial coverage instead of the more activity oriented approach in the 1996 Guidelines applied in the Initial Inventory.

The net anthropogenic emission estimates are based on correct representation of areas and their association with land-use categories, and follow the general IPCC reporting principles for adequate, accurate, consistent, complete, and transparent estimates, whenever possible.

One of the greatest difficulties associated with the estimation of emissions and removals from the Land-Use Change and Forestry sector relates to the identification of the anthropogenic component in the total net emissions. In order to overcome this difficulty and allow greater comparability of national inventories, the Good Practice Guidance LULUCF elaborated further the concept of *Managed Land* already introduced in the 1996 Guidelines, as a proxy for estimating anthropogenic emissions and removals. The Good Practice Guidance LULUCF defines managed land as the land subjected to the process of planning and implementing practices for land use and management in order to fulfill relevant ecological, economic and social functions. In accordance with this concept, all emissions by sources and removals by sinks in *managed* land are considered to be anthropogenic in nature, whereas emissions and removals in unmanaged land are considered non-anthropogenic, except when the unmanaged land is converted to other land uses, according to 1996 Guidelines.

For the purposes of this inventory, *Managed Land* comprises all forest land and native non-forest vegetation (Grassland) contained in Indigenous Lands and in the National System of Protected Areas (Law 9985/2000), except the Private Reserves of Natural Heritage - RPPN, for which little adequate information is available. All remaining native vegetation is classified as *Unmanaged Land.*

The net anthropogenic CO_2 emissions by sources and removals by sinks associated with land-use change and forestry have been estimated considering changes in carbon stock during the inventory period for all the carbon pools (above and, below-ground biomass, dead organic matter (litter and dead wood), and soil organic carbon), as described in the Good Practice Guidance LULUCF.

The mean annual net emissions presented in this inventory for the period 1994-2002, as well some of the associated methodological information, were extracted from the more comprehensive Background Report entitled "Greenhouse Gas Emissions in the Land-Use Change and Forestry Sector" (MCT, 2010).

Based on these results, the average net annual emissions for the period 1990 to 2005 were estimated, as described in section 3.5.3.8.

3.5.1 Methodology

3.5.1.1 Land representation

For the purposes of this report, approach 3 (IPCC, 2003) for land representation, which requires spatially explicit information on land use and land-use change was used. The entire national territory was subdivided into spatial units (polygons) that resulted from the integration of the following data sources (layers):

- Biome
- Municipal borders
- Vegetation map (plant physiognomies)
- Soil type
- Land use in 1994
- Land use in 2002.

All these data sources were used to estimate anthropogenic CO_2 emissions and reductions for the period from 1994 to 2002. Each information plan (layer) is described in more detail below.

Brazilian Biomes

The national territory comprises six large biomes, according to IBGE (IBGE, 2004): Amazon, *Cerrado*, *Pantanal*, Atlantic Forest, *Caatinga* and *Pampa* (refer to Figure 3.8).

The names of the biomes are generally associated with the predominant vegetation or relief, as in the case of the *Pantanal* biome, which is the largest inland wetland surface in the world. The Amazon biome is defined by its unique climate, forest physiognomies and geographic location. The Atlantic Forest biome, which stretches along the entire eastern Atlantic continental strip, is defined by its predominant vegetation and diversified relief. The *Pampa*, confined to the state of Rio Grande do Sul, is defined by a set of different grassland vegetation and plain topography. The *Cerrado*, the second largest biome in Brazil that extends from the coast of Maranhão to the Midwest part of Brazil, gets its name from the predominant vegetation (Savannas). Finally, the *Caatinga* biome is typical of the semi-arid Northeast part of Brazil.

Figure 3.8 Brazilian biomes

Source: IBGE, 2004.

In Table 3.85 the approximate area of each biome and the corresponding fraction to the total national area are presented.

Table 3.85 Area of Brazilian biomes

Brazilian biomes	Approximate area (km²)	Share (%)
Amazon	4,196,943	49.29
Cerrado	2,036,448	23.92
Atlantic Forest	1,110,182	13.04
Caatinga	844,453	9.92
Pampa	176,496	2.07
Pantanal	150,355	1.76
Brazil	**8,514,877**	**100**

Source: IBGE, 2004.

Municipal Borders

The inclusion of the political boundaries (states and municipalities) as an information layer aimed at facilitating the use of secondary statistical information as auxiliary data in the process of image interpretation as well as establishing differentiate parameters for each state or municipality in cases where detailed information could not be drawn from the images (e.g., types of crops, reforestation species etc.).

The IBGE's 2005 Digital Municipal Grid was used in this study. This version portrays the current situation of Brazil's Political-Administrative Division, as per year 2005. The 2005 Digital Municipal Grid consists of 5,564 municipalities.

Plant Physiognomy[50]

The IBGE's (2004) Vegetation Map of Brazil seeks to recover the vegetation cover in the Brazilian territory at the time of its discovery. It defines two major elements: a forest that covers more than 60% of the national territory, and a non-forest formation, with meadow influence. The forest formation includes humid forests (typical of regions that rainfalls are abundant all year long) and seasonal forests (marked by alternation between rainy and dry seasons) located in Amazon; it also includes areas outside Amazon such as the Atlantic Forest. Dense and open humid forests predominate in the Amazon biome, with mid-sized and large trees, vines, bromeliad species and orchids.

Non-forest/grassland formations are composed of open vegetation typologies, such as: a) **savanna**, corresponding to the *Cerrado*, predominant in the central Brazil but also occurring in small areas in other regions of the country, including Amazon; b) **steppe savanna**, which includes the northeastern *Caatinga*, the grasslands of Roraima, Mato Grosso's *Pantanal* and a small part of the extreme west of Rio Grande do Sul; c) **steppe**, that includes the grasslands, plateau and prairies in the far south area of Brazil; and d) **campinarana**, a type of (scrubby) vegetation that results from a lack of mineral nutrients in the soil and can be found in Amazon, in the Rio Negro Basin.

The map also indicates the areas of pioneer formations that are home to sandbank vegetation, mangroves and marshes, as well as areas of ecological tension, where there is contact among types of vegetation, and the so-called vegetation refuges, where vegetation is in general comprised of relic mounds.

Digital data of the mosaic from the IBGE's 2004 Vegetation Map were obtained directly from the IBGE web site (http://www.ibge.gov.br).

In Table 3.86 the aggregate plant physiognomies[51] considered in this report and the associated abbreviations to be referred to in the remaining report text are presented.

50 There may be inconsistencies between the terminology used in this Inventory and the terminology used elsewhere in this NC since this Inventory adopts the terminology used in Brazil's Forest Resource Assessment to FAO.

51 IBGE's (2004) original vegetation map shows transition classes between diverse types of vegetation. In order to associate each plant physiognomy to a single value of carbon (C), the original vegetation map was reclassified, considering only the predominant phyto-physiognomies, without transition classes, mainly based on more detailed information contained in SIVAM, RADAM and PROBIO vegetation maps available for Brazil or some of its regions.

Table 3.86 Phyto-physiognomies

Physiognomy	Denomination	Abbreviation
Forest	Alluvial Open Humid Forest	Aa
	Lowland Open Humid Forests	Ab
	Open Montane Humid Forest	Am
	Open Submontane Humid Forest	As
	Alluvial Deciduous Seasonal Forest	Ca
	Lowland Deciduous Seasonal Forest	Cb
	Montane Deciduous Seasonal Forest	Cm
	Submontane Deciduous Seasonal Forest	CS
	Alluvial Dense Humid Forest	Da
	Lowland Dense Humid Forests	Db
	Montane Dense Humid Forest	Dm
	High montane Dense Humid Forest	Dl
	Submontane Dense Humid Forest	Ds
	Wooded Steppe	Ea
	Alluvial Semi deciduous Seasonal Forest	Fa
	Lowland Semi deciduous Seasonal Forest	Fb
	Montane Semi deciduous Seasonal Forest	Fm
	Submontane Semi deciduous Seasonal Forest	Fs
	Wooded Campinarana	La
	Forested Campinarana	Ld
	Alluvial Mixed Humid Forest	Ma
	Montane Mixed High Humid Forest	Ml
	Montane Mixed Humid Forest	Mm
	Submontane Mixed High Humid Forest	Ms
	Fluvial and/or lacustre influenced Vegetation	Pa
	Pioneer formation Fluviomarine influenced (mangroves)	Pf
	Pioneer formation marine influenced (sand banks)	Pm
	Wooded Savanna	Sa
	Forested Savanna	Sd
	Wooded Steppe Savanna	Ta
	Forested Steppe Savanna	Td
Grassland	Woody Grass Steppe	Eg
	Park Steppe	Ep
	Wooded Campinarana	Lb
	Woody-grass Campinarana	Lg
	High Montane Vegetational Refuge	Rl
	Montane Refuge	Rm
	Submontane Refuge	Rs
	Woody-grass Savanna	Sg
	Park Savanna	Sp
	Woody Grass Steppe Savanna	Tg
	Park Steppe Savanna	Tp

Soil Type

The changes in soil carbon stock were estimated following the methodology used in the Initial Inventory, consisting of the following steps:

1) Adaptation of the EMBRAPA/IBGE (2004) soil map, at scale 1:5,000,000;

2) Adaptation of the IBGE vegetation map (IBGE, 2004).

3) Creation of the soil and vegetation association map. IBGE (2004) soil and vegetation maps were used, at scale 1:5,000,000;

The 69 classes categorized into the 18 soil orders of the Brazilian system of soil classification were reclassified into six large soil groups, as per the IPCC (1996; 2003): Soils with high clay activity (S1), Oxisols with low clay activity (S2), Non-Oxisols with low clay activity (S3), Sandy soils (S4); Organic soils (S5) and Other soils (S6). This regrouping is adequate to estimate carbon stock changes in soils.

Vegetation classes were grouped in categories in accordance with the criteria used in the Initial Inventory, based on the IBGE vegetation map (2004). Fifteen categories were thus obtained. The contact areas were included in this grouping and were associated with each one of the 15 categories, according with the dominat vegetation and location. For this classification key, the categories were distributed as follows: Open Amazon Forest (V1), Dense Amazon Forest (V2), Atlantic Forest (V3), Deciduous Seasonal Forest (V4), Semi deciduous Seasonal Forest (V5), Mixed Humid Forest (V6), Southern Savanna (V7), Amazon Savanna (V8), *Cerrado* (V9), Southern Steppe (V10), Northeastern Steppe (*Caatinga*) (V11), Western Steppe (*Pantanal*) (V12), Southern Steppe (V10), Amazon Savanna (V8), High Montane Vegetational Refuge (V13), Pioneer Formation Areas (V14) and Woody Oligotrophic Vegetation of Swamps and Sandy Areas (V15).

Land Use

The IPCC (2003) defines six broad land-use categories: Forest land, Grassland, Cropland, Wetlands, Settlements and Other land. Based on these broad categories of the Good Practice Guidance LULUCF, the definitions adopted in this report were as follows:

- Forest land

Comprises areas with the following characteristics:

a) minimum tree crown coverage: 10 percent; b) minimum area: 0.5 hectare, and c) minimum tree height: 5 meters.

The following sub-categories of Forest land were created:

I) Primary Forest

Forests in which human action did not cause significant alterations in its original structure and species. Also referred to as Climax Forest.

II) Primary Forest with Selective Wood Extraction (Selective logging)

Selective logging is normally associated with areas where predatory exploration of wood from native forests occurs, basically in Amazon, and where the opening of trails and yards for the extraction and storage of wood can be detected by remote sensors due to alterations in the spectral response of targets (forests). After the first exploration, these areas can be further explored, leading to forest degradation or deforestation, or abandoned for natural regrowth. Estimates of net emissions from this sub-category were assessed only for the Amazon biome, and areas of selective logging were not identified for year 1994.

III) Secondary Forest

Consists of vegetation areas in advanced, medium or initial stages of regeneration and that have conditions to reach the forest thresholds defined for forest land.

IV) Reforestation

Includes planted areas or areas being prepared for the planting of forest essentials (black green-wattle acacia, eucalyptus, pine etc.) and the areas occupied by forest essential sapling nurseries. Commercial reforestation is basically oriented towards the sale of forest products such as pulp, wood and firewood, as well as other services to meet market demands.

- Grassland

a) Primary Grassland Vegetation

Grassland where human actions did not cause significant alterations in its original structure and species.

b) Secondary Grassland Vegetation

Includes grassland vegetation in advanced, medium or initial stages of regeneration that is not expected to exceed the thresholds set for forests.

c) Pasture

Encompass areas set aside for grazing and that have been established by planting.

- Cropland

Encompasses all areas cultivated with annual and perennial crops.

- Wetlands

Extension of natural or artificial, permanent or temporary, stagnant or running, fresh, brackish or salted salt marshes, swamps, peat bogs or waters, including extensions of sea waters, whose depths at low tide do not exceed 6 (six) meters. It includes lakes and rivers, and reservoirs.

- Settlements

Internal area of an urban perimeter of a city or village, defined by municipal law and characterized by continuous construction and the existence of social equipment for basic functions such as housing, work, recreation and circulation.

- Other Areas

Rock formations, mining activities, dunes etc.

- Not Observed

Areas not assessed by remote sensing due to continuous cloud cover.

In Table 3.87 land-use categories considered in this report along with their associated abbreviations and related broad land category are summarized.

Table 3.87 Land-Use Categories considered in the LUCF Inventory

Abbreviation	Category	IPCC Category
FNM	Unmanaged Forest	Forest
FM	Managed Forest	
FSec	Secondary Forest	
CS	Forest with Selective Wood Extraction	
Ref	Reforestation	
GNM	Unmanaged Grassland	Grassland
GM	Managed Grassland	
GSec	Grassland with secondary vegetation	
Ap	Planted pasture	
Ac	Cropland area	Cropland
S	Urban Area	Settlements
A	Rivers and lake (unmaged wetlands)	Wetlands
Res	Reservoirs (managed wetland)	
O	Other uses	Other land
NO	Not observed	

Construction of transition matrices between categories and sub-categories for land use from 1994 to 2002

Net anthropogenic emissions are estimated for each polygon in accordance with their characteristics and land-use information for years 1994 and 2002.

The estimation is performed for each of the possible land-use transitions between 1994 and 2002 as indicated in Table 3.88. The cells shaded indicate transitions that cannot occur.

The diagonal of the matrix identifies the land areas that remain under a same land-use category between 1994 and 2002. It should be noted that because this report uses satellite images from 1994 and 2002 only, it is not possible to understand the land-use dynamics that might have occurred between these two years. For instance, land classified as forest in 1994 and as cropland in 2002 could have undergone an intermediate step, for example, from forest in 1994 to grassland in 1999, and then from grassland to cropland in 2002. This issue will be resolved as national inventories advance to be produced at shorter periods of time, allowing a more precise estimation of the annual net anthropogenic emissions.

Table 3.88 Possible land-use transitions matrix

1994	2002														
	FNM	FM	FSec	Ref	CS	GNM	GM	GSec	Ap	Ac	S	A	Res	O	NO
FNM						X	X	X				X			
FM	X					X	X	X				X			
FSec	X	X			X	X	X	X				X			
Ref	X	X			X	X	X					X			
CS	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
GNM	X	X	X		X							X			
GM	X	X	X		X	X						X			
GSec	X	X	X		X	X	X					X			
Ap	X	X			X	X	X					X			
Ac	X	X			X	X	X					X			
S	X	X	X	X	X	X	X	X	X	X		X	X	X	
A	X	X	X	X	X	X	X	X	X	X	X				
Res	X	X	X	X	X	X	X	X	X	X	X	X		X	
O	X	X			X	X	X								
NO															

3.5.1.2 Estimation of emissions by sources and removals by sinks for assessed transitions

In accordance with the 1996 Guidelines, the fundamental basis of the methodological approach for national inventories is founded on two related assumptions:

I) the flow of CO_2 from or to the atmosphere is assumed to be equal to the changes in carbon stocks in existing biomass and in the soils; and

II) changes in carbon stock can be estimated by first assessing the rates of land-use change and the practices associated with land-use change (for instance, biomass burning, deforestation, selective logging etc.). The impact of these practices on carbon stocks and the biological response to a specific land-use category can then be assessed.

The Good Practice Guidance LULUCF methodology indicates that CO_2 emissions during a certain period of time can be estimated as the difference in carbon stocks at the beginning and the end of the period considered, for each one of the transitions defined in Table 3.88 above. Two approaches are applied for this estimation: (a) direct calculation of carbon stocks at the beginning and end of the time period; and (2) calculation of carbon gains and losses that occurred during the period. Carbons stocks or gains and losses are calculated for each carbon pool (above and below-ground biomass, dead organic matter (litter and dead wood) and soil organic carbon). This report uses the two approaches, depending on the reported land-use change.

The balance of carbon losses and gains for all pools in the period 1994-2002 was obtained as follows:

- Estimating emissions and removals associated with changes in live biomass stock (above and below-ground biomass) and dead organic matter (litter and dead wood)
- Estimating emissions and removals from changes in the soil organic carbon stock.

The estimations are based on Equations 3.1.1 and 3.1.2 from the Good Practice Guidance LULUCF, reproduced below.

Equation 3.1.1

$$\Delta C = \sum_{ijk} \left[A_{ijk} \bullet (C_I - C_L)_{ijk} \right]$$

where:

ΔC : is the change in carbon stock (tC/year)

A: is the land area (ha)

ijk : Indexes that correspond to type of climate *i*, type of vegetation *j* and management practice *k*, etc.

C_I : annual increment in carbon stock (tC/ha/year)

C_L : annual decrease in carbon stock due to carbon loss (tC/ha/year)

Equation 3.1.2

$$\Delta C = \sum_{ijk} \left(C_{t_2} - C_{t_1} \right) / (t_2 - t_1)_{ijk}$$

where:

C_{t1} : carbon stock at time t_1 (tC)

C_{t2} : carbon stock at time t_2 (tC)

The equations used for estimating anthropogenic emissions and removals associated with carbon stock change in living biomass and dead organic matter for each of the transitions indicated in Table 3.88 are detailed in the Reference Report "Greenhouse Gas Emissions in the Land-Use Change and Forestry Sector" (MCT, 2010).

The methodology for estimating changes in soil carbon stocks uses the average carbon stock in the soil under primary (native) vegetation as a reference for each of the soil-vegetation association, as described in Table 3.94. In accordance with the Good Practice Guidance LULUCF, changes in carbon stock in soils due to land-use conversions are assumed to occur over a 20 years period.

The general equation for estimating changes in soil carbon is described below and is consistent with Equation 3.3.3 of the Good Practice Guidance LULUCF:

$$ES_i = A_i \times Csoil \times (fc(t_0) - fc(t_f)) \times (T/2)/20$$

where:

ES_i: Net emission of polygon i in period T due to the variation in soil carbon (tC)

A_i : area of polygon i (ha)
C_{soil} : soil carbon stock as per the polygon's soil-vegetation association (tC/ha)
$fc(t)$: soil carbon change factor at moment t (adimensional)
The carbon change factor is defined by the equation:

$$fc(t) = f_{LU} \times f_{MG} \times f_I$$

where:
f_{LU} : carbon change factor for land use;
f_{MG} : carbon change factor for management regime;
f_I : carbon change factor from additions of organic matter.

3.5.2 Data

3.5.2.1 Land-use map

The information on land use for each year is obtained through analysis of satellite imagery that associates all land in the national territory to the land-use categories and subcategories defined in the Section 3.5.1.1. Hence, land-use maps were generated for the first (1994) and final (2002) years of the studied period.

A database was constructed after the selection and acquisition of LANDSAT imagery for 1994. Each scene covering the national territory was selected from the website http://www.dgi.inpe.br/CDSR, seeking for images acquired at nearby dates, thus minimizing spatial variations (especially those related to land use and occupation) when merging scenes acquired at different dates. Other criteria for the selection were applied, such as the degree of cloud cover and the presence of unrecoverable noise. The images used to map land use in 2002 were the same as those used by the Ministry of the Environment for the PROBIO project (Map of Biome Vegetation Cover).

All data from the image interpretations were grouped to generate a coherent map of Land Use and Land Cover for all biomes, as shown in Figure 3.9 and Figure 3.10 for 1994 and 2002, respectively.

Figure 3.9 Land use and land cover map from interpretation of images acquired in year 1994, for all biomes

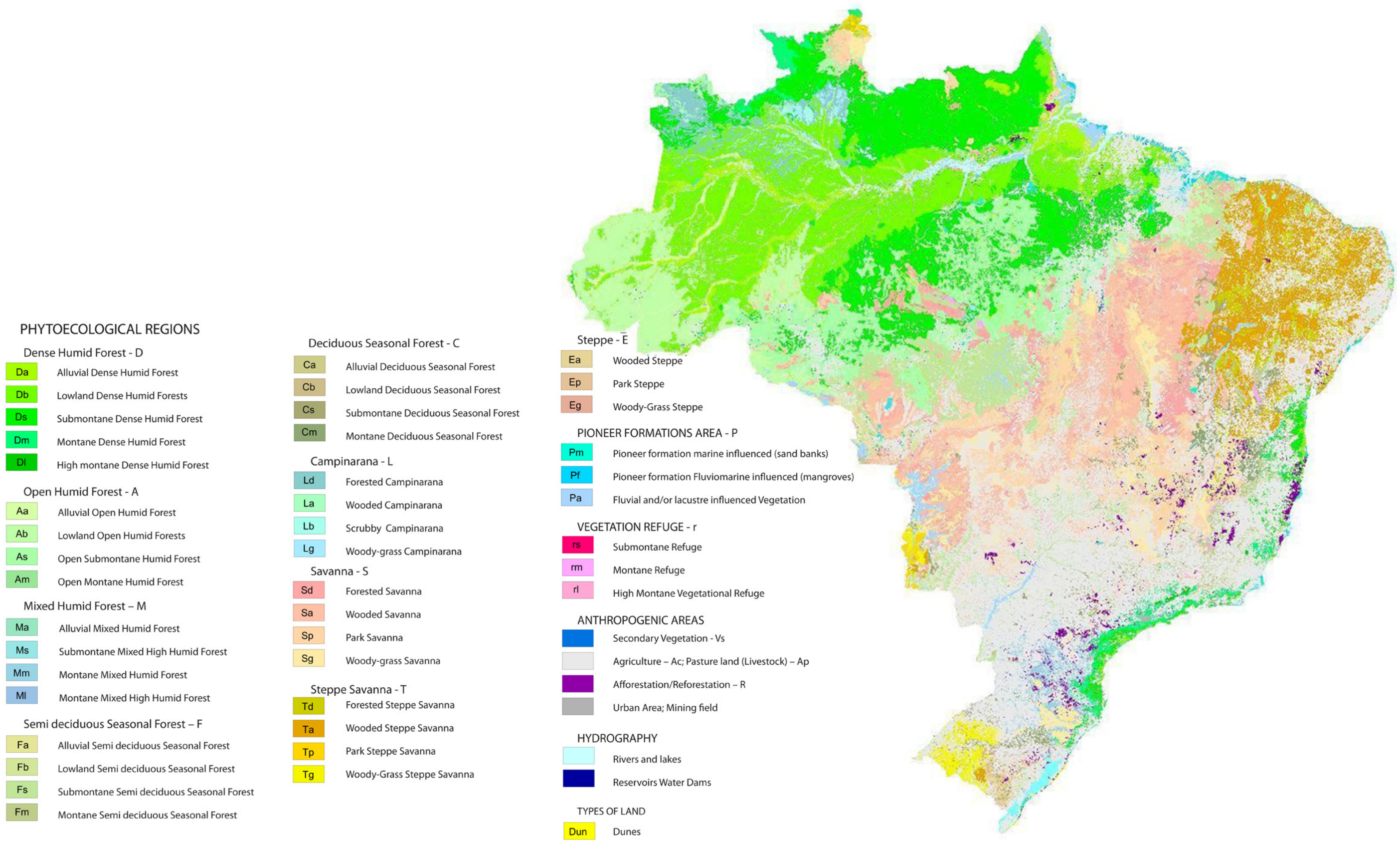
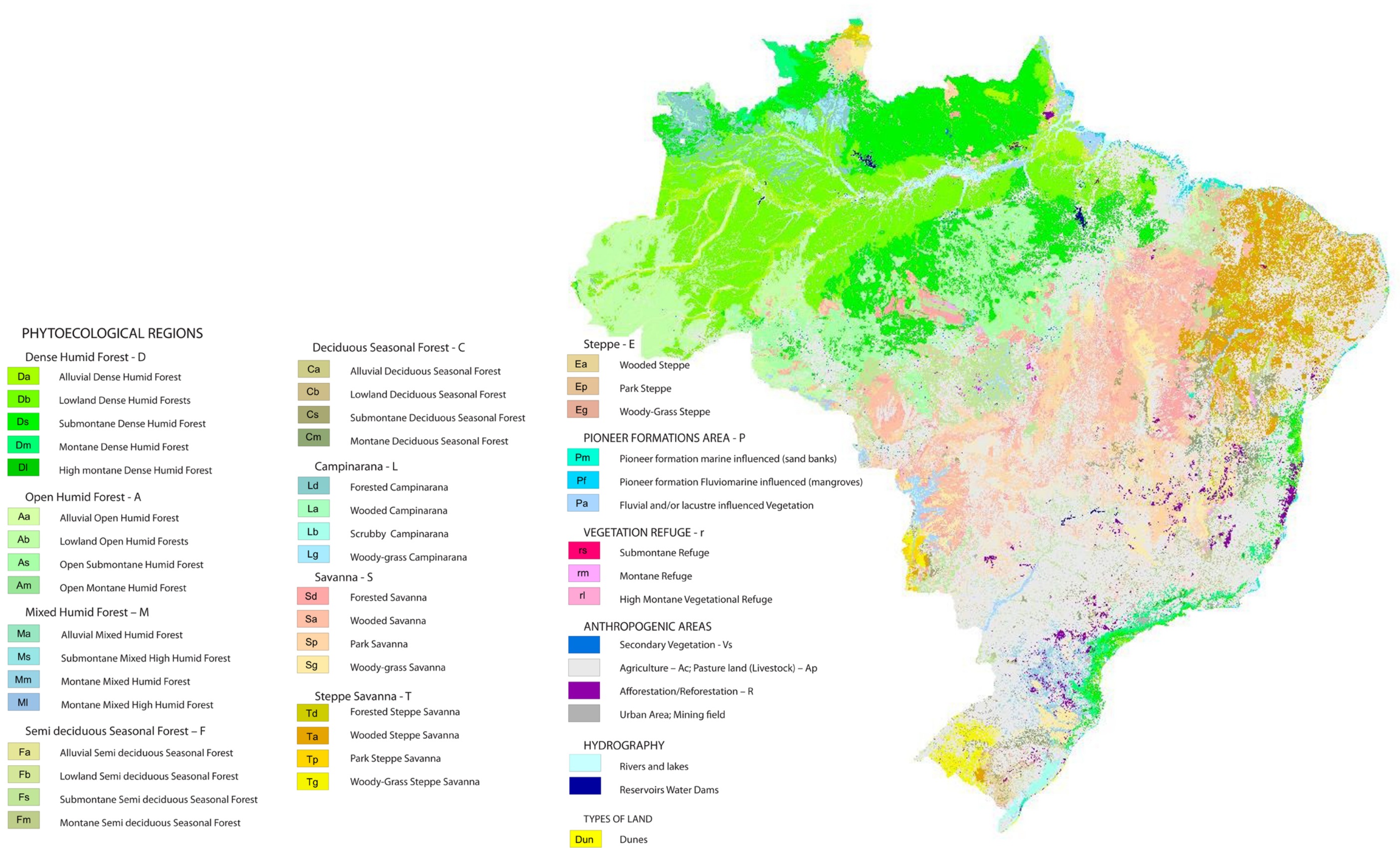


Figure 3.10 Land use and land cover map from interpretation of images acquired in year 2002, for all biomes



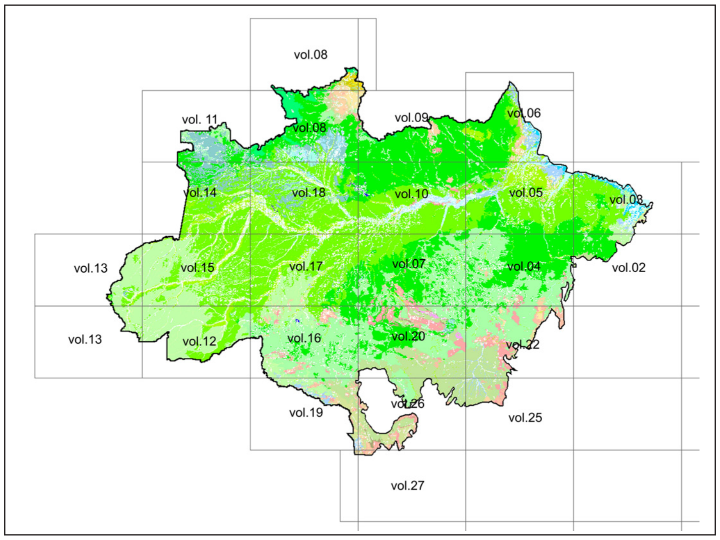
3.5.2.2 Carbon stock changes in living biomass and dead organic matter

Amazon Biome

The data for aboveground biomass for the Amazon Biome were based on the forest inventory and phyto-physiognomic maps from the RADAMBRASIL Project. This project was conducted from 1973 to 1987 and was the first major national survey of physical and environmental aspects of the country. In this survey, the natural resources comprising the physical environment of Brazil were systematically investigated, and summarized in 38 volumes that contain maps at the scale 1:1,000,000. Using radar imagery and other information available, the project became the main reference in some regions, like Amazon, where the collection and systematization of cartographic information are more difficult to obtain.

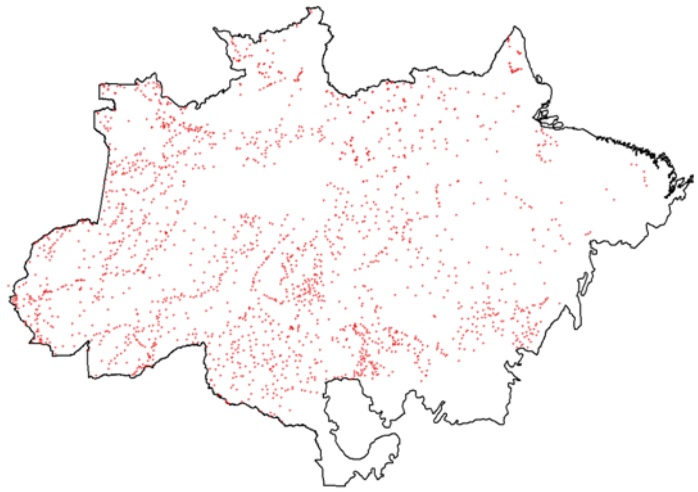
The vector data from RADAMBRASIL's Vegetation Map at 1:1,000,000 were used as support for the Amazon biome. In Figure 3.11 the distribution of these Vegetation Maps is presented, according to the RADAMBRASIL Volumes (38 volumes).

Figure 3.11 Vegetation maps for Brazilian Amazon, showing RADAMBRASIL volumes



The RADAM Project collected data for trees with circumference at breast height (CBH) greater than 100 centimeters, grouped by sampling unit, geodesic coordinates of the sampling units and their indications in the maps at a scale of 1:250,000 to which they belong, as shown in Figure 3.12.

Figure 3.12 Geographical distribution of collected data from RADAMBRASIL.



In the case of forests, the measurements were taken for all trees with CBH values greater than or equal to 100 cm. This corresponds to a diameter at breast height (DBH) greater than or equal to 31.83 cm. The DBH value was used to estimate the biomass and carbon present in each tree of the sampling units employing the model proposed by Higuchi *et al.* (1998) (BRASIL, 2006).

$$\ln P = -1.754 + 2.665 \ln D \quad \text{for } 5 \text{ cm} \leq D < 20 \text{ cm}$$

$$\ln P = -0.151 + 2.170 \ln D \text{ for } D \geq 20 \text{ cm}$$

and

$$C = 0.2859\, P$$

where:

P is the aerial biomass of the tree (kg);

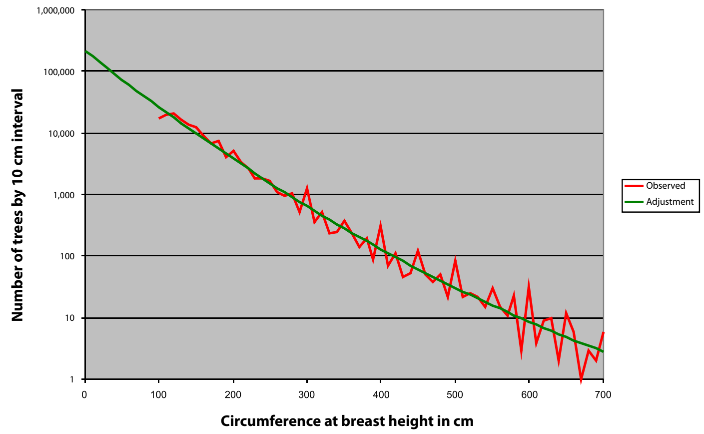
D is the diameter at breast height (DBH) of the tree (cm);

C is the carbon contained in the aerial part of the tree (kg)

For each sampling unit, the carbon for all trees was added and divided by the unit area, resulting in the estimate for the sample's average carbon density.

A correction was applied to carbon content for each sampling unit, in order to include trees with CBH less than 100 cm, based on an extrapolation of the trees' circumference histogram in the Amazon forest from the RADAMBRASIL Project (BRASIL, 2004), as shown in the Figure 3.13.

Figure 3.13 Circumference at breast height histogram in the Amazon forest



$$C_{Total} = 1.315698\ C_{(CAP > 100\ cm)}$$

According to Silva (2007), palm trees and vines contribute 2.31% and 1.77% to the total aboveground biomass per unit area. These values were thus considered in the correction of the C value, leading to the final equation for the total aboveground carbon for each sample, as follows:

$$C_{above\ the\ soil} = 1.3717\ C_{(CAP > 100\ cm)}$$

Silva (2007) also estimated that roots contributed 27.1% to the total living biomass in forest physiognomy, or 37.2% of the carbon in aboveground biomass. Litter corresponded to 3% of the total living biomass.

After these corrections are applied, the sample's total carbon value is given by:

$$C_{Total} = 1.9384\ C_{(CAP > 100\ cm)}$$

A total of 1,710 samples were considered to estimate the carbon stock in Amazon forest physiognomies. From the grouped classes of forest vegetation described in Table 3.89, samples have been identified in RADAMBRASIL for the following physiognomies: Aa, Ab, As, Da, Db, Dm, Ds and La.

After the grouping, the average carbon stock for the aboveground biomass and dead organic matter were estimated for each vegetation type on each RADAMBRASIL Volume, at the scale 1:1,000,000, in accordance with the rules described below. Note that these rules have been modified since the Initial Inventory:

1) If there were samples of the grouped vegetation class in the RADAMBRASIL Volume, then the average carbon stock in the samples from the grouped class in the RADAMBRASIL Volume was used;

2) If samples were not available for the grouped vegetation class in the RADAMBRASIL Volume, then the weighted average (by the number of samples per neighboring volume) of the carbon stock for the same class grouped in the neighboring RADAMBRASIL Volumes (at least one and at most eight maps) was used;

3) If samples were not available for the grouped vegetation class in the neighboring volumes, then the weighted average (by the number of samples per volume) of the carbon stock for the same class grouped in all RADAMBRASIL Volumes was used.

In Table 3.89 consolidated carbon stock values used for the forest physiognomies and for each RADAMBRASIL Volume and the rule applied are shown.

For other vegetation physiognomies not included in the table above, carbon stock values from the literature were used, except for the Ld physiognomy (Forest Campinarana), for which the same values as the La physiognomy (Wooded Campinarana) were used.

- *Cerrado* Biome

The carbon stocks for the *Cerrado* vegetation typologies were obtained from available scientific literature. Eleven different sources were consulted for the Forest Savanna (*Cerradão*), whereas for the Open Wooded Savanna (*Cerrado* Sensu Stricto), 34 sources were consulted; for the Woody Grassland Savanna (*Cerrado* Grassland and Clean Grassland) and the Park Savanna (*Cerrado* Grassland), thirteen and four sources were consulted, respectively. In order to obtain the total biomass values (above and below-ground), a root-to-shoot ratio expansion factor – R/S was applied, following Table 3.4.3 of the Good Practice Guidance LULUCF.

For other vegetation physiognomies of the *Cerrado* biome, emission factors (carbon stock) from neighboring forest physiognomies were used, such as the Atlantic Forest, *Pantanal*, Amazon and *Caatinga*.

The average carbon stock values from RADAMBRASIL Volumes neighboring the *Cerrado* biome were adopted, particularly for the Aa, Ab, As, Da, Dm and Ds forest physiognomies.

In Table 3.90 carbon stock values used for the *Cerrado* biome are presented.

Table 3.89 Carbon stock values used for the forest physiognomies of the Amazon biome

RADAMBRASIL Volume	Vegetation Physiognomy							
	Aa	Ab	As	Da	Db	Dm	Ds	La
	tC/ha							
2	98.24	154.55	110.06	182.98	176.10	139.03	169.35	183.00
3	98.24	154.55	129.28	137.85	161.01	139.03	275.37	183.00
4	94.88	154.55	129.28	119.67	154.59	139.03	148.30	183.00
5	108.33	154.55	146.82	213.85	185.15	109.69	230.13	183.00
6	123.75	154.55	133.99	131.82	222.39	109.69	213.55	183.00
7	159.51	160.29	180.66	142.58	153.42	139.03	175.71	262.99
8	146.97	197.91	73.64	270.89	163.92	149.50	138.56	183.00
9	127.61	213.37	112.13	262.68	157.38	109.69	184.64	262.99
10	141.81	169.49	146.45	174.03	149.54	147.77	171.21	262.99
11	154.71	197.91	158.20	166.72	168.13	83.74	144.81	114.31
12	144.32	150.69	116.14	164.35	157.42	139.03	161.84	183.00
13	144.76	144.62	139.24	168.64	153.25	104.05	121.02	160.43
14	154.71	177.28	173.89	157.86	174.17	104.05	142.46	160.43
15	172.81	164.36	156.03	171.77	154.38	104.05	155.40	228.80
16	165.70	136.14	156.76	175.73	188.14	139.03	175.02	183.00
17	136.09	159.17	157.15	175.64	165.53	104.05	159.63	228.80
18	162.92	213.37	150.61	174.79	158.01	139.03	140.48	262.99
19	150.22	147.92	135.72	170.56	159.40	139.03	154.78	183.00
20	150.61	151.80	117.97	169.39	163.05	139.03	123.29	183.00
22	148.74	154.55	97.40	137.67	153.42	139.03	145.55	183.00
25	155.84	154.55	113.12	172.77	162.51	139.03	127.87	183.00
26	165.70	136.14	130.49	175.73	188.14	139.03	153.93	183.00

	Rule 1
	Rule 2
	Rule 3

Table 3.90 Carbon stock values for the phyto-physiognomies of the Cerrado biome

Plant Physiognomy	Forest/Grassland	Cerrado (tC/ha)
Sa	Forest	47.1
Sd	Forest	77.8
Sg	Grassland	16.3
SP	Grassland	24.1

- *Caatinga Biome*

The carbon stocks in the biomass of steppe savanna typologies (Ta, Td, Tg, Tp) in the *Caatinga* biome were obtained from available scientific literature, using expansion factors to consider roots and dead organic matter.

For the other physiognomies in the *Caatinga* biome, emission factors from neighbouring forest physiognomies were obtained such as the Atlantic Forest and *Cerrado*.

In Table 3.91, the carbon stock values used for the *Caatinga* biome are presented.

Table 3.91 Carbon stock values for the phyto-physiognomies of the Caatinga biome

Vegetation Plant Physiognomy	Forest/Grassland	Caatinga (tC/ha)
Ta	Forest	14.9
Td	Forest	38
Tg	Grassland	14.9
Tp	Grassland	14.9

- *Atlantic Forest Biome*

The carbon stocks in biomass for the vegetation typologies in the Atlantic Forest biome were obtained from available scientific literature.

For the other physiognomies in the Atlantic Forest biome, emission factors from neighbouring forest physiognomies were used, such as the *Cerrado*, *Caatinga* and *Pampa*.

In Table 3.92 carbon stock values used for the Atlantic Forest biome are presented.

Table 3.92 Carbon stock values for the forest physiognomies of the Atlantic biome

Vegetation Plant Physiognomy	Forest/Grassland	Atlantic Forest (tC/ha)
Aa	Forest	166.93
Ab	Forest	166.93
Am	Forest	166.93
As	Forest	166.93
Ca	Forest	116.27
Cb	Forest	116.27
Cm	Forest	104.95
Cs	Forest	116.27
Da	Forest	166.93
Db	Forest	135.76
Dm	Forest	122.92
Dl	Forest	122.92
Ds	Forest	122.92
Fa	Forest	140.09
Fb	Forest	140.09
Fm	Forest	140.09
Fs	Forest	140.09
Ma	Forest	104.23
Ml	Forest	118.81
Mm	Forest	118.81
Ms	Forest	118.81
Pa	Forest	105.64
Pf	Forest	98.16
Pm	Forest	94.48
Rl	Grassland	6.55
Rm	Grassland	6.55
Rs	Grassland	6.55

- *Pampa Biome*

The carbon stocks in biomass for steppe typologies in the *Pampa* biome were obtained from available scientific literature, using expansion factors to consider roots and dead organic matter.

For the other physiognomies that comprise the *Pampa* biome, emission factors from neighbouring forest physiognomies were used, such as Amazon, *Cerrado* and Atlantic Forest.

In Table 3.93 carbon stock values used for the *Pampa* biome are presented.

Table 3.93 Carbon stock values for the phyto-physiognomies of the Pampa biome

Vegetation Physiognomy	Forest/Grassland	Pampa (tC/ha)
Ea	Forest	4.3
Eg	Grassland	4.3

- *Pantanal Biome*

Carbon stocks in biomass for the vegetation physiognomies of the *Pantanal* biome were obtained from forest physiognomies in neighbouring biomes such as Amazon, *Cerrado* and Atlantic Forest.

Soil Carbon

For each of the soil-vegetation associations described in this section, the same soil carbon stocks under natural vegetation adopted in the Initial Inventory were used. For the purposes of this report, median values were used (refer to Table 3.94).

Table 3.94 Soil carbon stocks

Categories of Vegetation	Soil (kg C/m²)					
	S1	S2	S3	S4	S5	S6
V1	5.09	4.75	4.89	4.11	4.36	7.87
V2	3.22	5.19	4.69	5.06	5.27	4.81
V3	5.83	5.23	4.29	6.33	3.58	41.78
V4	4.67	3.08	4	2.59	3.27	3.18
V5	4.09	4.43	3.74	2.7	5.36	3.16
V6	9.88	10.25	5.68		8.54	
V7	6.42	9.09	5.16		7.42	3.28
V8	4.8	1.98	3.81	4.37	3.46	2.9
V9	2.44	4.31	3.6	1.92	6.65	3.29
V10	6.6	4.66	6.12		3.38	4.99
V11	2.42	2.58	2.62	1.51	2.51	2.09
V12	3.38		3.52	3.54	10.52	2.17
V13	3.41	5.04[1]	3.99			
V14	7.3	4.13[1]	3.31	5.02	5.92	3.72
V15	5.09	4.68	4.81	6.17	9.05	12.09

[1] Unique value reported

3.5.2.3 Definition of emission factors and other parameters needed to estimate CO_2 emissions and removals

This section presents the specific values adopted for other parameters in the equations used to estimate changes in carbon stock from 1994-2002. Whenever possible, country specific values were used instead of the default values (Tier 1) from the Good Practice Guidance LULUCF.

- *Annual removal of carbon in managed areas*

The value of 0.62 tC/ha/year (PHILLIPS *et al.*, 1998) was used as an estimate of the annual carbon removal in native vegetation with forest physiognomy in managed land. For native vegetation with non-forest physiognomy in managed land, no removal was assumed, since there is no information about carbon removals for these physiognomies.

- *Average annual carbon gains in secondary vegetation areas*

The same values as those applied in the Initial Inventory were adopted for the carbon gains in aboveground biomass in Amazon forest physiognomies (Rebf). Hence, the value of 4.5 tC/ha/year (HOUGHTON *et al.*, 2000) for forest physiognomies with carbon densities in aboveground biomass greater than 93 tC/ha was used, whereas the value 3.7 tC/ha/year (ALVES *et al.*, 1997) was applied for forest physiognomies with carbon densities in aboveground biomass less than 93 tC/ha. These values have been revised to include carbon in belowground biomass, thus resulting in an annual gain value of 6.2 tC/ha/year for forest physiognomies greater than 127 tC/ha of total biomass, and 5.1 tC/ha/year for forest physiognomies with total biomass equal or under 127 tC/ha. For non-forest physiognomies, an annual gain (Rebg) of 1.5 tC/ha/year (DURIGAN, 2004 and AMORIM *et al*, 2005) was used.

- *Average carbon stock in secondary vegetation areas*

In order to estimate the average carbon stock in secondary vegetation, it was assumed that the carbon stock in areas of secondary vegetation (AvFsec and AvGsec) range from 5% to 65% of the total carbon content in primary vegetation. Thus, for the purposes of this report, the estimate of the carbon stock in secondary vegetation was assumed to be equal to 35% of the carbon density for primary vegetation.

- *Carbon loss in forest area submitted to selective wood removal (selective logging)*

The average carbon loss in forest land subject to selective logging was assumed to be 33% (ASNER *et al.*, 2005) of the total carbon stock in biomass of the forest physiognomy.

- *Carbon stock in reforestation areas*

An average annual net gain in volume for industrial processing of 41 m^3/ha/year was assumed for reforestation with *Eucalyptus* (Bracelpa, 2010). This corresponds to a carbon gain of 14.11 tC/ha/year, considering the same parameters (i.e., wood density, crown/trunk ratio, root/trunk ratio) used in the Initial Inventory to estimate the carbon contained in the trunk, crown and roots, and applying Equation 3.2.5 of the Good Practice Guidance LULUCF. A seven-years cycle was assumed between harvestings when estimating the average carbon of the reforested area, leading to an estimated average carbon stock value of 49.385 tC/ha.

An average annual net gain in volume for industrial processing of 36 m^3/ha/year was used for reforestations with *Pinus* (Bracelpa, 2010). This corresponds to a carbon gain of 11.69 tC/ha/year, considering the same parameters (i.e., wood density, crown/trunk ratio, root/trunk ratio) used in the Initial Inventory to estimate the carbon contained in the trunk, crown and roots, and applying Equation 3.2.5 of the Good Practice Guidance LULUCF. A 15 years cycle was assumed between harvesting when estimating the average carbon of the reforested area, leading to an estimated average carbon stock value of 87.675 tC/ha.

- *Average carbon stock in planted pasture areas*

The default value of 8.05 tC/ha in the Good Practice Guidance LULUCF (Table 3.4.9) was used for the average carbon stock in established planted pasture.

- *Carbon stock in agricultural areas*

It was necessary to differentiate between perennial and annual crops to estimate the average carbon stock in cropland, as well as the average annual carbon gains in perennial crops still in development.

The default carbon stock in the Good Practice Guidance LULUCF (Table 3.3.8) of 5 tC/ha was adopted for annual crops.For perennial crops, the value 21 tC/ha was used for the average carbon stock and the annual increment in biomass in perennial crops in development was assumed to be equal to 2.6 tC/ha/year. These values are the default values in the Good Practice Guidance LULUCF (Tables 3.3.2 and 3.3.9).

Carbon stock in biomass in reservoirs, settlements and other use areas

A carbon value of zero is assumed for biomass in reservoir areas (Res), settlements (S) and other land (O).

- *Soil carbon alteration factor*

The carbon change factors due to land use (f_{LU}), management regime (f_{MG}) and additions (f_I), defined in section 3.5.1.2, were chosen from the default values in the Good Practice Guidance LULUCF, and are shown in Table 3.95.

Table 3.95 Carbon soil change factors due to land-use change

Land Use	f_{LU}	f_{MG}	f_I	f_c
FNM	1	-	-	1
FM	1	-	-	1
FSec	1	-	-	1
Ref [1]	0.58	1.16	1	0.673
CS	1	-	-	1
GNM	1	-	-	1
GM	1	-	-	1
GSec	1	-	-	1
Ap[2]	1	0.97	1	0.97
Ac[1]	0.58	1.16	0.91	0.612
S	0	-	-	0
A	0	-	-	0
Res	0	-	-	0
O	0	-	-	0

[1] Good Practice Guidance LULUCF, Table 3.3.4.

[2] Good Practice Guidance LULUCF, Table 3.4.5.

3.5.3 Results

Estimates of the anthropogenic net CO_2 emissions of for each of the six Brazilian biomes are shown below. The tables present the areas under each land-use category and the conversions that occurred between 1994 and 2002, and the net emissions for each land-use conversion.

3.5.3.1 Amazon Biome

In Table 3.97 the estimated area for each of the land-use conversions between 1994 and 2002 for the Amazon biome is presented. In Table 3.98 the net CO_2 emissions associated with these conversions are presented. Of the 419,736,073 ha of mapped Amazon biome, land-use change was observed in 80,582,791 ha (19.2%). Net anthropogenic emissions totalled 6,886,989 Gg CO_2.

3.5.3.2 Cerrado Biome

In Table 3.99 the estimated area for each of the land-use conversions between 1994 and 2002 for the *Cerrado* biome is shown. In Table 3.100 the net CO_2 emissions associated with these conversions are presented. Of the total mapped area of 203,953,377 ha, land-use change was observed in 26,259,329 ha (12.9%). Net anthropogenic emissions totalled 2,421,720 Gg CO_2.

3.5.3.3 Caatinga Biome

In Table 3.101 the estimated area for each of the land-use conversions between 1994 and 2002 for the *Caatinga* biome is shown. In Table 3.102 the net CO_2 emissions associated with these conversions are presented. Of the total mapped area of 82,788,461 ha, land-use change was observed in 8,042,907 ha (9.7%). Net anthropogenic emissions totalled 301,027 Gg CO_2.

3.5.3.4 Atlantic Forest Biome

In Table 3.103 the estimated area for each of the land-use conversions between 1994 and 2002 for the Atlantic Forest biome is shown. In Table 3.104 the net CO_2 emissions associated with these conversions are provided. Of the total mapped area of 111,789,930 ha, land-use change was observed in 4,568,803 ha (4.1%). Net anthropogenic emissions totalled 632,868 Gg CO_2.

3.5.3.5 Pampa Biome

In Table 3.105 the estimated area for each of the land-use conversions between 1994 and 2002 for the *Pampa* biome is shown. In Table 3.106 the net CO_2 emissions associated with these conversions are presented. Of the total mapped area of 16,571,297 ha, land-use change was observed in only 30,325 ha (1.8%). Net anthropogenic emissions totalled -818 Gg CO_2 (net removal).

3.5.3.6 Pantanal Biome

In Table 3.107 land-use transition areas identified in the pantanal biome from 1994 to 2002 (hectares) is shown. In Table

3.108 the net CO_2 emissions associated with these conversions are presented. Of the total mapped area of 15,131,022 ha, land-use change was observed in 1,052,791 ha (7.0%). Net anthropogenic emissions totalled 129,373 Gg CO_2.

3.5.3.7 Consolidated results

In Table 3.109 the estimated area for each of the land-use conversions between 1994 and 2002 for Brazil is shown. In Table 3.110 the net CO_2 emissions associated with these conversions are presented. Of the total mapped area of 849,970,160 ha, land-use change was observed in 120,536,946 ha (14.2%). Net anthropogenic emissions totaled 10,371,159 Gg CO_2. In Table 3.96 the net emissions by biome are presented.

Table 3.96 Net anthropogenic CO_2 emissions by biome

Biome	Net Emissions	
	Total	Annual Average
	(Gg)	
Amazon	6,886,989	860,874
Cerrado	2,421,720	302,715
Caatinga	301,027	37,628
Atlantic Forest	632,868	79,109
Pampa	-818	-102
Pantanal	129,373	16,172
Brazil	**10,371,159**	**1,296,395**

Table 3.97 Land-use transition areas identified in the Amazon biome from 1994 to 2002 (hectares)

Land use in 1994	Land use in 2002															
	FNM	FM	FSec	Ref	CS	GNM	GM	GSec	Ap	Ac	S	A	Res	O	NO	Total 1994
FNM	234,180,714	57,011,452	119,957	26,629	255,844				13,992,549	1,771,583	17,997		9,876	8,174	747	307,395,523
FM		54,020,923	12,967		3,268				617,699	74,637	1,901		229	5,069	0	54,736,694
FSec			54,845	635					684,240	169,910	1,138		1	715		911,484
Ref			56	295,252					187	7,184	1			0		302,680
CS																0
GNM				8,771		7,701,764	1,242,178	185	338,234	23,807	5,743			6	6	9,320,694
GM							1,557,228	25	7,766	0	51					1,565,071
GSec				104				1,070	10,457	717	48					12,397
Ap			772,591	12,296				3,080	25,791,281	987,198	61,286		183	1,292	1,527	27,630,735
Ac			73,057	753				115	1,332,935	3,083,190	5,504		2		5	4,495,560
S											190,556					190,556
A												11,658,525	66,005			11,724,530
Res													553,912			553,912
O			10						10,787	12	5	417	0	48,942		60,174
NO			308	290	321				771,164	43,413	3,596		97	1,796	15,079	836,064
Total 2002	234,180,714	111,032,375	1,033,790	344,731	259,433	7,701,764	2,799,406	4,476	43,557,300	6,161,650	287,828	11,658,942	630,304	65,994	17,365	419,736,073

Table 3.98 Net CO_2 emissions in the Amazon biome from 1994 to 2002 (in Gg)

Land use in 1994	Land use in 2002															
	FNM	FM	Fsec	Ref	CS	GNM	GM	GSec	Ap	Ac	S	A	Res	O	NO	Total 1994
FNM		-518,424.14	56,600.46	11,106.78	40,770.15				6,882,784.77	904,422.86	11,047.80		5,610.69	4,605.17		7,398,524.5
FM		-982,460.52	6,251.30		720.93				322,777.25	39,564.07	1,101.07		145.09	2,943.49		-608,957.3
FSec			-9,406.33	15.34					98,194.82	30,527.83	264.49		0.12	144.67		119,740.9
Ref			6.22						29.38	1,162.54	0.20		0.01			1,198.4
CS																0.0
GNM				-890.16				7.43	18,462.40	1,842.43	602.81		0.64			20,025.5
GM								0.31	459.04	0.00	5.22					464.6
GSec				-16.27				-47.09	15.25	15.08	2.17					-30.9
Ap			-35,761.00	-2,042.30				20.36		18,900.64	3,702.93		11.03	81.97		-15,086.4
Ac			-4,372.16	-143.11				0.11	-24,004.90		297.88		0.07			-28,222.1
S																0.0
A																0.0
Res																0.0
O			-0.77						-666.83	-0.57						-668.2
NO																0.0
Total 2002	0.0	-1,500,884.7	13,317.7	8,030.3	41,491.1	0.0	0.0	-18.9	7,298,051.2	996,434.9	17,024.6	0.0	5,767.7	7,775.3	0.0	6,886,989.1

Table 3.99 Land-use transition areas identified in the *Cerrado* biome from 1994 to 2002 (hectares)

Land use in 1994	Land use in 2002														Total 1994
	FNM	FM	FSec	Ref	CS	GNM	GM	GSec	Ap	Ac	S	A	Res	O	NO	
FNM	68,710,165	5,405,969		58,003					4,567,523	3,770,666	74,151		37	462	295	82,587,270
FM		5,903,558		5,685					49,033	9,091	6,742					5,974,109
FSec			11	6					1,236	7						1,261
Ref				2,085,353					74,864	53,947	149					2,214,313
CS																0
GNM				15,567		30,797,802	4,702,496		1,751,558	2,031,959	30,497		0	346		39,330,225
GM				95			2,601,324		10,586	58,937	134					2,671,075
GSec								62	2,468							2,530
Ap			71	33,220				1	18,127,826	1,628,748	71,139			150	71	19,861,226
Ac			308	67,408				0	1,559,291	47,960,236	98,645		0	3		49,685,890
S											517,778					517,778
A												670,327				670,327
Res													312,331			312,331
O											571	3		7,274		7,848
NO			1	2,573					7,969	105,394	1,256					117,193
Total 2002	68,710,165	11,309,527	391	2,267,910	0	30,797,802	7,303,820	64	26,152,353	55,618,985	801,062	670,330	312,369	8,234	365	203,953,377

Table 3.100 Net CO_2 emissions in the *Cerrado* biome from 1994 to 2002 (in Gg)

Land use in 1994	Land use in 2002														Total 1994
	FNM	FM	FSec	Ref	CS	GNM	GM	GSec	Ap	Ac	S	A	Res	O	NO	
FNM		-49,158.28		13,166.00	6.93				1,200,920.16	1,052,361.61	26,450.64		13.19	172.14		2,243,932.4
FM		-107,366.04		1,651.05					17,308.52	2,147.64	2,454.08					-83,804.7
FSec			-1.79	-0.08					45.98	1.07						45.2
Ref									11,970.73	9,554.05	35.53					21,560.3
CS																0.0
GNM				-1,807.06					95,944.49	139,042.14	3,436.65		0.02	37.42		236,653.7
GM				-12.01			0.00		615.82	3,690.42	13.25					4,307.5
GSec								-2.74	4.65							1.9
Ap			-3.30	-5,494.50				0.01		33,115.24	4,089.44			11.36		31,718.3
Ac			-20.80	-11,494.25				0.00	-25,429.56		4,249.88		0.01	0.11		-32,694.6
S																0.0
A																0.0
Res																0.0
O																0.0
NO																0.0
Total 2002	0.0	-156,524.3	-25.9	-3,990.9	6.9	0.0	0.0	-2.7	1,301,380.8	1,239,912.2	40,729.5	0.0	13.2	221.0	0.0	2,421,719.8

Table 3.101 Land-use transition areas identified in the *Caatinga* biome from 1994 to 2002 (hectares)

Land use in 1994	Land use in 2002														
	FNM	FM	FSec	Ref	CS	GNM	GM	GSec	Ap	Ac	S	A	Res	O	NO	Total 1994
FNM	42,851,867	3,018,045		1,214					2,988,130	1,564,918	5,564		6	3,067		50,432,809
FM		379,108							11,821	240						391,169
FSec																0
Ref				96,367												96,367
CS																0
GNM				8		906,149	35,188		111,954	30,373	133		0	35		1,083,839
GM							118,938		5,910							124,848
GSec																0
Ap			158,754	1,323					16,927,716	46,851	8,723		1	1,504		17,144,872
Ac				2,302					38,720	12,478,417	7,080			737		12,527,256
S											229,355					229,355
A												277,947	258	44		278,249
Res													366,470			366,470
O									5	0	0	0		113,220		113,225
NO																0
Total 2002	42,851,867	3,397,152	158,754	101,213	0	906,149	154,126	0	20,084,256	14,120,799	250,855	277,948	366,735	118,606	0	82,788,461

Table 3.102 Net CO_2 emissions in the *Caatinga* biome from 1994 to 2002 (in Gg)

Land use in 1994	Land use in 2002														
	FNM	FM	FSec	Ref	CS	GNM	GM	GSec	Ap	Ac	S	A	Res	O	NO	Total 1994
FNM		-27,444.09		-170.29					183,831.36	151,079.04	796.54		1.19	481.30		308,575.0
FM		-6,894.71							1,286.57	68.70						-5,539.4
FSec																0.0
Ref																0.0
CS																0.0
GNM				-0.81					2,880.63	1,870.44	9.56		0.04	2.58		4,762.4
GM									-20.00							-20.0
GSec																0.0
Ap			-7,262.94	-223.18						710.68	418.90		0.03	87.33		-6,269.2
Ac				-394.72					-383.04		269.49			26.41		-481.9
S																0.0
A																0.0
Res																0.0
O									-0.38	0.00						-0.4
NO																0.0
Total 2002	0.0	-34,338.8	-7,262.9	-789.0	0.0	0.0	0.0	0.0	187,595.1	153,728.9	1,494.5	0.0	1.3	597.6	0.0	301,026.6

Table 3.103 Land-use transition areas identified in the Atlantic Forest biome from 1994 to 2002 (hectares)

Land use in 1994	Land use in 2002															
	FNM	FM	Fsec	Ref	CS	GNM	GM	GSec	Ap	Ac	S	A	Res	O	NO	Total 1994
FNM	22,148,527	1,648,003		12,098					1,562,565	101,748	103,214		129,965	235		25,706,356
FM		3,698,170		762					48,656	1,175	14,353		199			3,763,316
FSec			887	0					4	10						900
Ref				2,906,756					21,370	2,933	1,240		36			2,932,335
CS																0
GNM				8,731		3,399,016	77,423		94,873	5,123	3,068		6,318			3,594,553
GM							145,906				374					146,280
GSec				112		0		1,562	212							1,886
Ap			57,511	41,428				5,071	42,021,625	188,554	115,738		1,604	0		42,431,530
Ac			1,961	13,950				60	182,664	30,817,351	112,970		772			31,129,727
S											1,297,779					1,297,779
A												518,146	145	20		518,311
Res													255,209			255,209
O									146	512	844	52		10,193		11,747
NO																0
Total 2002	22,148,527	5,346,174	60,359	2,983,836	0	3,399,016	223,329	6,692	43,932,115	31,117,406	1,649,581	518,198	394,248	10,449	0	111,789,930

Table 3.104 Net CO_2 emissions in the Atlantic Forest biome from 1994 to 2002 (in Gg)

Land use in 1994	Land use in 2002															
	FNM	FM	FSec	Ref	CS	GNM	GM	GSec	Ap	Ac	S	A	Res	O	NO	Total 1994
FNM		-14,985.84		2,448.91					550,774.03	26,926.49	41,568.02		58,974.94	68.71		665,775.2
FM		-67,257.39		123.98					15,380.62	458.68	4,471.34		75.60			-46,747.2
FSec			-132.66	0.00					0.27	1.03						-131.4
Ref									3,412.26	526.52	309.06		8.15			4,256.0
CS																0.0
GNM				-910.83					4,801.24	395.21	273.95		747.70			5,307.3
GM											34.13					34.1
GSec				-18.00				-68.73	0.48							-86.2
Ap			-3,337.78	-6,800.01				33.87		3,497.63	7,117.17		85.08	0.00		595.9
Ac			-100.32	-2,376.61				0.10	997.15		5,347.39		26.22			3,893.9
S																0.0
A																0.0
Res																0.0
O									-8.08	-21.45						-29.5
NO																0.0
Total 2002	0.0	-82,243.2	-3,570.8	-7,532.6	0.0	0.0	0.0	-34.8	575,358.0	31,784.1	59,121.1	0.0	59,917.7	68.7	0.0	632,868.2

Table 3.105 Land-use transition areas identified in the *Pampa* biome from 1994 to 2002 (hectares)

Land use in 1994	Land use in 2002															
	FNM	FM	FSec	Ref	CS	GNM	GM	GSec	Ap	Ac	S	A	Res	O	NO	Total 1994
FNM	3,538,241	20,001		9					77	224	792					3,559,343
FM		74,259														74,259
FSec																0
Ref				222,347							13					222,360
CS																0
GNM				0		3,982,207	1,152		18	9	508					3,983,894
GM							274,256									274,256
GSec																0
Ap				34					4,389,949	452	5,549					4,395,984
Ac				1					439	3,173,375	706					3,174,521
S											116,877					116,877
A												638,996				638,996
Res													797			797
O				21					316		5			129,669		130,010
NO																0
Total 2002	3,538,241	94,260	0	222,413	0	3,982,207	275,408	0	4,390,799	3,174,060	124,449	638,996	797	129,669	0	16,571,297

Table 3.106 Net CO_2 emissions in the *Pampa* biome from 1994 to 2002 (in Gg)

Land use in 1994	Land use in 2002															
	FNM	FM	FSec	Ref	CS	GNM	GM	GSec	Ap	Ac	S	A	Res	O	NO	Total 1994
FNM		-181.88		1.48					24.29	3.89	307.37					155.1
FM		-1,350.52														-1,350.5
FSec																0.0
Ref											3.74					3.7
CS																0.0
GNM				-0.02					-0.25	0.09	28.87					28.7
GM																0.0
GSec																0.0
Ap				-5.04						10.32	347.03					352.3
Ac				-0.24					-10.34		29.97					19.4
S																0.0
A																0.0
Res																0.0
O				-3.93					-22.79							-26.7
NO																0.0
Total 2002	0.0	-1,532.4	0.0	-7.7	0.0	0.0	0.0	0.0	-9.1	14.3	717.0	0.0	0.0	0.0	0.0	-817.9

Table 3.107 Land-use transition areas identified in the *Pantanal* biome from 1994 to 2002 (hectares)

Land use in 1994	Land use in 2002															
	FNM	FM	FSec	Ref	CS	GNM	GM	GSec	Ap	Ac	S	A	Res	O	NO	Total 1994
FNM	8,905,227	108,265							593,438	60,422	2,639		32	539		9,670,561
FM		206,520							80	0						206,600
FSec																0
Ref																0
CS																0
GNM						3,452,179	48,651		107,745	4,153	10					3,612,738
GM							88,293									88,293
GSec																0
Ap			5,900					276	849,394	45,027	568					901,166
Ac			3						74,669	43,150						117,821
S											6,781					6,781
A												525,075	37	3		525,116
Res													580			580
O									192	10				1,032		1,234
NO									132							132
Total 2002	8,905,227	314,785	5,903	0	0	3,452,179	136,944	276	1,625,650	152,762	9,998	525,075	649	1,574	0	15,131,022

Table 3.108 Net CO_2 emissions in the Brazilian *Pantanal* from 1994 to 2002 (in Gg)

Land use in 1994	Land use in 2002															
	FNM	FM	FSec	Ref	CS	GNM	GM	GSec	Ap	Ac	S	A	Res	O	NO	Total 1994
FNM		-984.49							115,722.02	14,055.53	924.14		9.66	174.26		129,901.1
FM		-3,755.91							18.56	0.05						-3,737.3
FSec																0.0
Ref																0.0
CS																0.0
GNM									3,865.38	328.48	0.77					4,194.6
GM																0.0
GSec																0.0
Ap			-273.38					1.88		1,022.03	36.95					787.5
Ac			-0.21						-1,757.62							-1,757.8
S																0.0
A																0.0
Res																0.0
O									-14.76	-0.50						-15.3
NO																0.0
Total 2002	0.0	-4,740.4	-273.6	0.0	0.0	0.0	0.0	1.9	117,833.6	15,405.6	961.9	0.0	9.7	174.3	0.0	129,372.9

Table 3.109 Land-use transition areas identified in all Brazilian biomes from 1994 to 2002 (hectares)

Land use in 1994	Land use in 2002														
	FNM	FM	FSec	Ref	CS	GNM	GM	GSec	Ap	Ac	S	A	Res	O	NO	Total 1994
FNM	380,334,740	67,211,736	119,957	97,953	255,844				23,704,282	7,269,559	204,357		139,916	12,477	1,042	479,351,863
FM		64,282,538	12,967	6,447	3,268				727,289	85,143	22,997		429	5,069		65,146,147
FSec			55,743	641					685,481	169,927	1,138		1	715		913,646
Ref			56	5,606,076					96,422	64,064	1,402		36			5,768,056
CS																0
GNM				33,076		50,239,117	6,107,088	185	2,404,383	2,095,423	39,959		6,319	387	6	60,925,944
GM				95			4,785,945	25	24,262	58,937	559					4,869,823
GSec				216				2,694	13,137	717	48					16,813
Ap			994,827	88,301				8,429	108,107,791	2,896,830	263,004		1,787	2,946	1,598	112,365,513
Ac			75,328	84,414				175	3,188,716	97,555,719	224,906		774	740	5	101,130,776
S											2,359,127					2,359,127
A												14,289,017	66,445	67		14,355,529
Res													1,489,299			1,489,299
O			10	21					11,446	534	1,425	472		310,330		324,238
NO			309	2,863	321				779,265	148,807	4,851		97	1,796	15,079	953,388
Total 2002	380,334,740	131,494,273	1,259,197	5,920,103	259,433	50,239,117	10,893,033	11,508	139,742,473	110,345,662	3,123,773	14,289,489	1,705,101	334,527	17,730	849,970,160

Table 3.110 Net CO_2 emissions in all Brazilian biomes from 1994 to 2002 (in Gg)

Land use in 1994	Land use in 2002														
	FNM	FM	Fsec	Ref	CS	GNM	GM	GSec	Ap	Ac	S	A	Res	O	NO	Total 1994
FNM		-611,178.7	56,600.5	26,552.9	40,777.1				8,934,056.6	2,148,849.4	81,094.5		64,609.7	5,501.6		10,746,863.5
FM		-1,169,085.1	6,251.3	1,775.0	720.9				356,771.5	42,239.1	8,026.5		220.7	2,943.5		-750,136.5
FSec			-9,540.8	15.3					98,241.1	30,529.9	264.5		0.1	144.7		119,654.8
Ref			6.2						15,412.4	11,243.1	348.5		8.2			27,018.4
CS																0.0
GNM				-3,608.9				7.4	125,953.9	143,478.8	4,352.6		748.4	40.0		270,972.2
GM				-12.0				0.3	1,054.9	3,690.4	52.6					4,786.2
GSec				-34.3				-118.6	20.4	15.1	2.2					-115.2
Ap			-46,638.4	-14,565.0				56.1		57,256.5	15,712.4		96.1	180.7		12,098.4
Ac			-4,493.5	-14,408.9				0.2	-50,588.3		10,194.6		26.3	26.5		-59,243.1
S																0.0
A																0.0
Res																0.0
O			-0.8	-3.9					-712.8	-22.5						-740.1
NO																0.0
Total 2002	0.0	-1,780,263.8	2,184.5	-4,289.9	41,498.0	0.0	0.0	-54.5	9,480,209.6	2,437,279.9	120,048.4	0.0	65,709.5	8,836.9	0.0	10,371,158.7

3.5.3.8 *Annual net anthropogenic CO_2 emissions for the period 1990-2005*

The net average anthropogenic CO_2 emissions for the period 1994-2002 are presented in section 3.5.3.7.

Based on these results, the net annual anthropogenic CO_2 emissions for the period 1990-1994 and 2003-2005 were also estimated.

Annual net anthropogenic emissions for the period 1990-1994

Due to improvements in this Inventory, regarding the estimates for carbon stocks in the Land-Use Change and Forestry sector for the period 1994-2002, the average values for carbon stocks per hectare provided in the Initial Inventory have been corrected for the new ones for all biomes. Removals by sinks in managed areas have also been included for the period 1990-1994.

The correction of the average carbon stocks was done by incorporating carbon estimates for all forest pools, with the additional inclusion of below-ground living biomass and thick and thin litter, which had not been included in the Initial Inventory.

The average CO_2 emissions was considered to be constant for the period 1990-1994 for all biomes, except for the Amazon biome, for which the total emissions for the period 1990 to 1994 was weighted and adjusted annually according to the values observed annually for gross deforestation in Amazon (PRODES, 1990-1994), published by INPE.

Regarding CO_2 removal by sinks from managed areas for the period 1990-1994, the same annual removal by sinks of 0.62 tC/ha was applied to the managed areas under forest physiognomy identified in 1994 (assumed to be the same as in 1990) for all years of this Inventory.

Annual net anthropogenic emissions for the period 1995-2002

The average values obtained for CO_2 emissions for the 1995-2002 period were considered to be constant for the entire period and for all biomes, except for the Amazon biome. In this case, the total value for the emissions corresponding to the transitions (land-use changes) from natural physiognomy to other uses was distributed proportionally to the annual values for the gross deforestation by Prodes. The total net emissions corresponding to the other transitions were considered constant for all the period.

Annual net anthropogenic CO_2 emissions for the period 2003-2005

Based on the average carbon stock calculated for the forest physiognomies of the Amazon and the *Cerrado* biomes in this Inventory for the period 1994-2002, on annual deforestation data for the Brazilian Amazon (PRODES, 2002-2005) and on deforestation data for the *Cerrado* (PPCerrado, 2002-2008), annual gross CO_2 emissions for these biomes were estimated for the period 2003-2005. For the other biomes, the net anthropogenic CO_2 emissions for the period 2003-2005 were assumed to be constant and equal to the average value for 1994-2002.

In Table 3.111 below net anthropogenic CO_2 emissions are presented for the years 1990, 1994, 2000 and 2005 for each of the Brazilian biomes.

Table 3.111 Summary of annual net anthropogenic CO_2 emissions for the period 1990 to 2005 by biome

Biome	1990	1994	2000	2005	Share in 2005	Variation 1990-2005
	(Tg)				(%)	
Amazon	460.53	521.05	814.11	842.97	67.4	83.0
Cerrado	233.00	233.00	302.71	275.38	22.0	18.2
Atlantic Forest	22.17	22.17	79.11	79.11	6.3	256.9
Caatinga	27.97	27.97	37.63	37.63	3.0	34.6
Pantanal	17.83	17.83	16.17	16.17	1.3	-9.3
Pampa	(0.10)	(0.10)	(0.10)	(0.10)	0.0	0.0
Total	**761.39**	**821.92**	**1,249.63**	**1,251.15**	**100**	**64.3**

3.5.3.9 *Other greenhouse gas emissions*

When the forest is converted to agricultural or livestock use, it is known that part of the original biomass is removed as commercial timber or as firewood for charcoal or other fuel uses. The remaining wood debris left on the field are usually burned in a non efficient manner. As result, greenhouse gases such as CH_4, N_2O, CO, and NO_x, are emitted under this imperfect combustion.

In the absence of available statistics about the wood fraction that is removed before combustion, IBGE's statistics may be alternatively used as a proxy. These statistics refer to timber, charcoal and firewood annual consumption which are derived from extractive activities in native forest and assumed here as being extracted from deforested areas.

As these data are available annually in the form of timber and firewood volume (m^3) and amount of charcoal (t) they are converted to carbon stock (tC), summed and discounted from the total biomass.

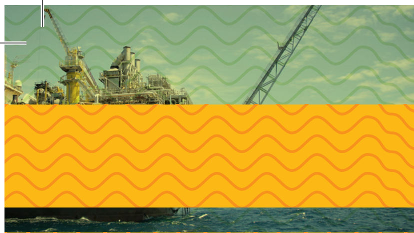
For the period 1990 to 2005 the fraction of carbon removed as commercial timber, decreased from 9% to 3% of total carbon released as CO_2. On the other hand, the fraction removed as charcoal and firewood, decreased from 10% to 3% of total carbon emitted in the same period. The fraction of total biomass removed decreased from 18% to 4% between 1990 and 2005, which means that the biomass effectively burned increased from 82% to 96% of the total biomass over that period of deforestation.

Estimates of CH_4, N_2O, CO and NO_x emissions were based on the 1996 Guidelines. For the fraction of biomass really burnt it was adopted a value of 0.5 for burning efficiency (Carvalho *et al.*, 2001).

In Table 3.112 a summary of non-CO_2 emissions from biomass burning after forest conversion to agricultural uses is provided.

Table 3.112 Summary of non-CO_2 emissions from biomass burning after forest conversion to agricultural uses

Gas	1990	1994	2000	2005	Variation 1990-2005
	(Gg CO_2)				(%)
CH_4	1,996	2,238	3,026	3,045	52.5
CO	17,468	19,584	26,476	26,641	52.5
N_2O	13.73	15.39	20.80	20.93	52.5
NO_x	496	556	752	757	52.5



Waste

3.6 Waste

Solid waste disposal to land and domestic and industrial wastewater handling can produce greenhouse gas emissions.

Methane emissions can occur as a result from both solid waste disposal to land and anaerobic wastewater handling.

N_2O emissions can also occur in domestic wastewater treatment due to the nitrogen content in human sewage. Waste incineration, like all combustion, generates greenhouse gas emissions, according to the waste composition, but this activity is not widespread in Brazil.

Solid waste can be disposed of in landfills or dumps, recycled or incinerated. Handling systems for liquid waste vary in the environment that is provided for CH_4 generation. Systems that provide anaerobic environments will generally produce CH_4, whereas systems that provide aerobic environments will normally produce little or no methane.

CH_4 is the most important gas produced in the Waste sector. Significant quantities of emissions of CH_4 produced are released as a by-product of the waste anaerobic decomposition. The two major sources of methane are waste disposal in landfills and anaerobic wastewater treatments.

This inventory estimates CH_4 emissions from solid waste disposal to land and from domestic and industrial wastewater handling. CO_2 and N_2O emissions from incineration and N_2O emissions from human sewage treatment are also considered.

In order to estimate greenhouse gas emissions from the Waste sector, the following data were necessary: urban population, urban solid waste generation rates at municipal level and organic matter generation rates for wastewater treatment. These data were gathered for the period of 1990 to 2005.

However, part of the data needed for the estimations are not available for the entire country. In addition, some data, such as waste disposal conditions, volume of generated waste, landfill or dump installations, as well as wastewater treatment systems and the organic matter content present large uncertainty.

3.6.1 Solid waste disposal to land

Waste disposal in landfills and dumps generates CH_4 under certain conditions. The extent of CH_4 production varies according to several factors, including: the amount of waste, the deposit's age, the presence of an anaerobic environment, acidity and handling conditions and facilities. The better the landfill control conditions and the deeper the dump, which improve sanitary conditions, the greater CH_4 emission potential.

The methodology for estimating CH_4 emissions from solid waste disposal to land was the first order decay method (Tier 2), as described in the 1996 Guidelines, and in the Good Practice Guidance 2000. According to this method, CH_4 emissions persist over a long period of time, after waste disposal. The following data were necessary for the Tier 2 method application: urban population, climate data (annual temperature and rainfall averages), quantity of waste disposed, waste composition, quality of landfill operation and quantities of recovered and oxidized CH_4, since 1970.

Data related to urban population of all municipalities in Brazil used in these estimates correspond to those available in IBGE censuses for 1970, 1980, 1991 and 2000, and the 2007 Population Count (IBGE, 2009). The urban population of 2005 was estimated based on the urban population growth rate of the last decade in each municipality[52].

Waste generation types and rates vary due to the country's large territorial extension and to regional, economic and social differences. In accordance with studies conducted by the Environmental Enterprise of the State of São Paulo - Cetesb, in a large number of municipalities in the state of *São Paulo* the waste generation per capita rate in Brazil varies between 0.4 and 0.7 kg/capita/day and average daily rate was estimated at 0.5 kg/capita. This value was adopted in this Inventory, as in the previous one.

In accordance with the National Basic Sanitation Survey - PNSB (2000), solid waste disposal and treatment were distributed as follows: 76% was deposited in open-air dumps, 22% in managed landfills and 2% had other destinations, as to composting plants or incineration.

In Brazil, there is little information on the total amount of waste generated and the fraction of wasted placed in landfills. There are also no detailed studies on the conditions of solid waste disposal sites, or on the average composition of such waste. In the absence of available data in national literature, IPCC default values were adopted.

The amount of waste disposed in landfills was estimated by the product of the waste generation rate per capita and the urban population. The solid waste generation per capita rate was estimated based on data from Cetesb and from the

52 For the case of new municipalities, the information on population is not available, and therefore the state population growth rate for the relevant state was adopted.

Brazilian Association of Public Cleaning and Special Waste Companies - Abrelpe. Cetesb data were used to estimate quantities placed in landfills in 1970 and Abrelpe data were used to estimate these quantities in 2005. Data for the intermediate years were linearly interpolated.

Data on waste composition were classified as recommended in the Good Practice Guidance 2000 in the following types of waste: paper and textiles; garden and other non-food putrescibles; food waste and wood and straw. Linear regressions were used in estimates for each region of the country based on the waste composition data available for some states and municipalities.

The following recommended classification was used for the methane correction factor: managed landfills (1.0), unmanaged sites with a depth equal to or greater than five meters (0.8), unmanaged sites with a depth less than five meters (0.4), uncategorized (0.6). Furthermore, default values were adopted for the fraction of degradable organic carbon that truly degrades (0.5) and for the fraction of methane in landfill gas (0.5).

To estimate CH_4 emissions, the amount of methane recovered should be discounted. For the 1990-2002 period, these amounts were deemed to be zero. From 2003 onwards, CH_4 emissions reduction reported in CDM monitoring reports for Brazilian landfill projects were considered, for which Certified Emission Reductions (CERs)[53] were issued by the CDM Executive Board.

The CH_4 recovery amounts are discounted from the emissions of cities where CDM project activities take place. Since a landfill can receive waste from several municipalities, the amount of methane recovered can happen to be greater than the emission of a given municipality, which is estimated as a result of its urban population and other parameters described throughout this document. The total methane recovered amounts considered were: 1 Gg CH_4 in 2003, 45 Gg CH_4 in 2004 and 62.5 Gg CH_4 in 2005.

For cities with over 1,000,000 inhabitants, the existence of managed landfills was assumed . For these cases, the oxidation factor (OX) of 0.1 was adopted, according to the Good Practice Guidance 2000, in order to emphasize the fact that oxidation often occurs in the upper layers of the waste mass. For cities with fewer inhabitants, this factor was assumed to be zero.

Based on these assumptions, CH_4 emissions from solid waste disposal to land were estimated and are shown in Table 3.113.

53 1 CER is equal to a tonne of CO_2e.

Table 3.113 CH_4 emissions from solid waste disposal

Source	1990	1994	2000	2005	Variation 1990-2005
	(Gg)				(%)
Solid waste disposal	792	897	1,060	1,104	39.5

An increase in CH_4 emissions was identified for the period due to demographic growth, changes in habits, life quality improvement and industrial development, which caused an increase in the amount of waste generated.

3.6.2 Waste Incineration

Given the difficulty in disposing of solid waste in Brazil's metropolitan regions, alternative ways have been considered and waste incineration stands out among the possible alternatives identified.

Incineration of urban waste has been more often considered as an alternative in large cities due to the increasing cost of waste transportation to landfills, since these are getting farther away from metropolitan regions. This practice is applied to a small fraction of total treated waste, and is most used for hazardous waste from industry and clinical waste, which, in general, cannot be disposed of in common landfills and require special treatment.

The Good Practice Guidance 2000 and the 2006 Guidelines were used for estimating CO_2 and N_2O emissions from waste incineration. In accordance with Good Practice Guidance 2000, CO_2 emissions estimates rely on the type of waste incinerated, the carbon content in each type of waste, its fraction of fossil carbon and the incinerators efficiency. Analogously, N_2O emissions are estimated according to the type and amount of waste incinerated, considering the emission factor for each type of waste.

In order to estimate the fossil carbon fraction in municipal solid waste, the analysis undertaken for solid waste disposal to land was considered. The recent growth trend in fossil carbon quantity in municipal solid waste was also considered, therefore, a linear correlation was sought that could better estimate this fraction for the five regions of the country.

It was not possible to determine the fossil carbon share in other types of waste, such as hazardous waste, clinical waste and sewage sludge. Therefore, Good Practice Guidance 2000 default values were used for this calculation.

Regarding the incinerators burning efficiency, no national data were identified. Thus, Good Practice Guidance 2000 default values were adopted. 2006 Guidelines default values were applied for the N_2O emission factor, since this information was not available in the 1996 Guidelines or in the Good Practice Guidance 2000.

Data for hazardous waste incineration were obtained from the Brazilian Association of Waste Treatment Companies – ABETRE (2006). Data for clinical waste were obtained from the National Sanitation Information System – SNIS. For municipal solid incinerated waste, data were obtained directly from incinerator operators and manufacturers. Based on these assumptions, CO_2 and N_2O emissions from waste incineration were estimated and are shown in Table 3.114.

Table 3.114 CO_2 and N_2O emissions from solid waste incineration

Gas	1990	1994	2000	2005	Variation 1990-2005
	(Gg)				(%)
CO_2	24	63	92	110	349
N_2O	0.0015	0.0039	0.0059	0.0068	341

3.6.3 Wastewater Handling

Wastewater with high organic matter content have great CH_4 emission potential, such as domestic and commercial wastewater, effluents from food and beverage industries and those from the pulp and paper industry. In the case of domestic wastewater, N_2O emissions can occur due to the nitrogen content in human sewage.

3.6.3.1 Domestic and commercial wastewater

Several systems are used for treating effluents in Brazil. Nevertheless, a large amount of sewage is discharged directly into rivers and ocean, without treatment. In accordance with PNSB (2000), most of the districts (84.6%) discharge wastewater into rivers. The same survey shows that of the 5,507 municipalities in Brazil, 52.2% have some sort of sanitary sewage service.

Advances have not been very significant if compared to the results of the previous PNSB survey (IBGE, 1989) in which the percentage of municipalities in Brazil provided with some sort of sanitary sewage service was of 47.3%. During this period, the number of municipalities increased by 24% and sanitary sewage services increased by 10%. Of the censused households, including occupied, vacant, closed and occasional use households, only 33.5% are provided with municipal sewer lines.

Among the various collective options for biological treatment, the ones that are most used in Brazil are the stabilization ponds and the variants of the activated sludge process, especially those that use the prolonged aeration concept and biological filters.

CH_4 emissions were estimated based on the amount of degradable organic material present in wastewater, expressed in terms of Biochemical Oxygen Demand (BOD), which represents the amount of oxygen that would be required to completely consume the organic matter contained in the wastewater.

The volume of the generated sewage per capita depends on the quantity of water consumed and normally corresponds to 80% of this consumption. The organic matter per capita varies from one country to another, in a range between 0.02 and 0.08 g BOD per person, per day.

The Brazilian average BOD per capita is of 0.054 kg BOD/(capita/day). For maximum methane production capacity, the Good Practice Guidance 2000 default value of 0.60 kg CH_4/kg BOD was used.

The organic matter of domestic wastewater can be increased by launching industrial effluents into the urban sewage systems or reduced by rainfall infiltrations in the sewage system. However, these data were considered to be null, since there is no information on it.

Population data used in the estimates, differently from data applied in the waste disposal emission estimates, refer to the total population, because the methodology takes into account uncollected household sewage, which includes those generated and degraded in rural areas.

The anaerobic treatments in wastewater plants include anaerobic digester for sludge, anaerobic processes in reactors and ponds, latrines and septic systems. Organic matter discharges into the sea, rivers and lakes, in which CH_4 emissions occur through anaerobic reactions, were also considered.

Methane recovered in anaerobic reactors and in anaerobic digesters of activated sludge systems was considered to be completely destroyed in a burner, since that is the common practice in Brazil. Burner's efficiency was considered to be of approximately 50%. Methane oxidation was considered null for emissions at septic systems and anaerobic lagoon systems and for discharges of untreated wastewater into water bodies .

Besides CH_4, N_2O emissions from human sewage were also estimated based on population and on annual average consumption per capita of protein, by state or region.

Data for protein consumption per capita were taken from FAO's publication, according to the 1996 Guidelines. For those years for which no data was found, an interpolation has been applied. The study identified values ranging between 68 and 84.5 g/day/capita, depending on the region. Population data were the same as those used for CH_4 estimates.

CH_4 and N_2O emissions from domestic and commercial wastewater treatment are shown in Table 3.115 for 1990, 1994, 2000, and 2005.

Table 3.115 CH_4 and N_2O emissions from domestic and commercial wastewater treatment

Gas	1990	1994	2000	2005	Variation 1990-2005
	(Gg)				(%)
CH_4	341	369	408	433	27.2
N_2O	9.0	10.8	12.4	14.0	54.4

3.6.3.2 Industrial Wastewater

Industrial wastewater has been traditionally treated through the use of pond or activated sludge processes and biological filters. However, in recent years, an increasing trend for the use of anaerobic reactors has been identified due to the reduced space required for the implementation of this technology, besides the fact that it does not consume energy through aeration.

Only industrial activities with higher methane emissions potential were included in this Inventory, in accordance with the Good Practice Guidance 2000. Activities were chosen based on the Initial Inventory, data in the Annual Industrial Survey (PIA - Product) (IBGE, 2005), IBGE Statistical Yearbook - 2005 (IBGE, 2006) and representative entities of industrial sectors, such as the cotton industry (ABRAPA), food industry (ABIA), pulp and paper (BRACELPA) and sugar and ethanol industry (UNICA).

Industrial production data and emission factors for each of the considered sectors were used for estimating CH_4 emissions.

Data related to industrial production in these sectors are shown in Table 3.116. Priority was given to data obtained from sector entities, since they proved to be more complete than those obtained from the IBGE database.

Table 3.116 Production data in selected sectors

Sectors	Unit	Industrial Production			
		1990	1994	2000	2005
Ethanol [a]	t/year	9,090,060	10,011,465	8,362,142	12,588,557
Sugar [a]	t/year	7,365,344	12,618,165	16,256,105	25,905,723
Beer [b,d]	m^3/year	3,749,150	4,276,950	9,023,303	9,214,807
Raw milk [b,d]	t/year	13,039,250	13,808,250	22,674,628	24,915,456
Cotton [c]	t/year	716,800	537,100	938,800	1,037,856
Paper [e]	t/year	4,914,113	5,653,597	7,187,831	8,597,307
Swine [f]	t/year	729,545	976,874	1,348,522	2,156,518
Pasteurized milk [g]	t/year	4,003,625	4,466,925	4,842,801	5,189,665
Poultry [f]	t/year	1,604,696	2,459,307	5,081,965	7,865,780
Cattle [f]	t/year	2,835,762	3,333,479	3,899,806	6,345,811

Sources: (a) UNICA, 2009; (b) ABIA, 2008; (c) ABRAPA, 2009; (d) Vieira; Alves, 2006 – For the period from 1990 to 1994; (e) IBGE - PIA - Product, 2005; (f) IBGE – Statistical yearbook, 1993 to 2005; (g) ABIA, 2008.

Despite the great potential of methane emissions due to the high organic wastewater load, sugar and ethanol industry effluents do not represent a source of CH_4 emissions, since their effluents are discharged directly into the soil as fertilizer without anaerobic treatment. Emissions from this sector were considered null, as in the Initial Inventory.

Table 3.117 below presents the emission factors used in the estimates.

Table 3.117 CH_4 emission factors for each selected sector

Industrial Sector	Emission Factors (kg CH_4/kg BOD)
Sugar and Alcohol	0
Beer	0.395
Raw milk	0.3
Cotton	0.3
Paper	0.3
Swine	0.3
Pasteurized milk	0.3
Poultry	0.3
Cattle	0.3

The estimated emissions from industrial wastewater treatment are shown in Table 3.118.

Table 3.118 CH_4 emissions from industrial wastewater treatment

Source	1990	1994	2000	2005	Variation 1990-2005
	(Gg)				(%)
Industrial-Wastewater Treatment	95	103	190	206	116.8

Chapter 4

Estimate Uncertainties

4 Estimate Uncertainties

Estimates of anthropogenic emissions and removals of greenhouse gases presented in this inventory are subject to uncertainty due to several causes, from the lack of precision of basic data to incomplete knowledge of the processes that cause emissions or removals of greenhouse gases.

The Good Practice Guidance 2000 recognizes that the uncertainty of estimates cannot be completely eliminated and that the main objective should be to produce accurate estimates, i.e., estimates that are neither underestimated nor overestimated, while at the same time, whenever possible seeking to improve estimate precision.

In accordance with the recommendations, in the generation of estimates presented in this Inventory, attempt was made to ensure they were not biased. For some activities, that objective cannot be fully achieved, whether due to the impossibility of estimating values for some subsectors, or the inappropriate default parameters used in the absence of appropriate values for national conditions. These cases were highlighted in the previous sections.

Estimate precision varied depending on each sector's characteristics, available data and resources that could be invested for determining more fitting emission factors for Brazilian circumstances. In that sense, emphasis was given to the most important sectors in terms of greenhouse gas emissions.

The overall Inventory uncertainty is the result of the uncertainty associated with all activity and emission factor data and other parameters used in the estimates. Quantifying uncertainty for individual data items is as or more difficult to evaluate than the actual information being sought.

For many sectors, it was not possible to conduct a detailed uncertainty analysis, since that would demand a considerable effort in analyzing the accuracy and precision of basic information used. Nevertheless, a general evaluation of Inventory precision was conducted based on judgment/knowledge of specialists in specific areas and use of the default values described by the IPCC. The objective was only to identify those sectors of the Inventory where most resources should be used in the future.

The precision associated with activity data and emission factors, as well as emission or removal estimates, is expressed as ± x %, meaning the 95% confidence interval limits for a value shown.

4.1 Uncertainty of CO_2 Emission and Removal Estimates

Table 4.1 shows the results of the analysis of uncertainty for CO_2 emission and removal estimates.

Table 4.1 Uncertainty of emissions and removals of CO_2

Sector	Uncertainty (%)
Energy	3
Fossil Fuel Combustion	3
Fugitive Emissions	26
Coal Mining and Handling	32
Oil and Natural Gas Activities	28
Industrial Processes	3
Cement Production	4
Lime Production	10
Ammonia Production	11
Aluminum Production	5
Other Industries	12
Land-Use Change and Forestry	33
TOTAL	**32**

4.2 Uncertainty of CH_4 Emission Estimates

Table 4.2 shows the results of the analysis of uncertainty for CH_4 emission estimates.

Table 4.2 Uncertainty of CH_4 emissions

Sector	Uncertainty (%)
Energy	26
Fuel Combustion	31
Fugitive Emissions	44
Coal Mining and Handling	73
Oil and Natural Gas Activities	54
Industrial Processes (Chemical Industry)	14
Agriculture	31
Enteric Fermentation	34
Manure Management	38
Rice Cultivation	45
Field Burning of Agriculture Residues	32
Waste	37
Solid Waste Disposal to Land	56
Wastewater Handling	36
Industrial Wastewater	56
Domestic and Commercial Wastewater	47
TOTAL	**25**

4.3 Uncertainty of N_2O Emission Estimates

Table 4.3 shows the results of the analysis of uncertainty for N_2O emission estimates.

Table 4.3 Uncertainty of N_2O Emissions

Sector	Uncertainty (%)
Energy (Fuel Combustion)	26
Industrial Processes (Chemical Industry)	6
Agriculture	52
Manure Management	43
Agriculture Soils	52
Grazing Animals	81
Other Direct Sources	52
Indirect Emissions	100
Field Burning of Agriculture Residues	51
Waste (Domestic and Commercial Wastewater)	56
TOTAL	**45**

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Annex

Estimates For Greenhouse Gas Emissions By Gas And Sector, 1990-2005

Estimates For Greenhouse Gas Emissions By Gas And Sector, 1990-2005

CO_2

Sector	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	(Gg)															
Energy	179,948	185,488	189,323	197,258	206,250	221,986	241,058	257,029	263,345	280,302	289,958	299,635	296,482	292,757	309,516	313,695
Fossil Fuel Combustion	172,371	178,101	181,854	189,654	198,222	214,438	233,194	248,379	253,888	270,006	279,088	287,908	285,234	281,605	298,890	299,941
Energy Subsector	22,668	22,355	24,466	24,592	25,443	26,663	29,404	33,069	30,925	41,088	43,595	48,761	44,164	43,406	50,257	48,601
Industrial Subsector	36,835	38,363	38,786	41,409	42,217	46,638	54,557	57,657	59,681	65,305	71,115	70,837	71,468	70,838	73,100	75,620
Metallurgy of Iron	3,862	4,008	4,066	5,521	5,401	5,860	8,111	8,768	9,909	11,193	13,089	13,675	13,701	15,135	16,623	16,467
Chemical Industry	8,681	8,863	9,173	8,677	9,230	10,173	11,626	13,590	12,572	14,137	14,649	14,645	14,939	14,318	15,162	15,446
Other Industries	24,292	25,492	25,547	27,211	27,586	30,605	34,819	35,299	37,199	39,975	43,377	42,517	42,828	41,385	41,314	43,707
Transportation Subsector	79,914	83,850	84,187	87,393	91,820	101,003	108,487	115,095	120,944	119,200	120,130	122,781	125,385	124,938	132,716	133,431
Civil Aviation	3,503	3,947	3,214	3,510	3,763	3,940	3,679	4,379	4,809	5,037	5,278	5,591	5,737	5,026	5,297	5,374
Road Transportation	71,339	74,987	75,854	78,271	83,236	92,210	99,177	106,538	111,669	109,623	110,684	112,546	114,973	115,195	122,236	122,765
Other Means of Transportation	5,072	4,916	5,119	5,612	4,821	4,853	5,631	4,178	4,466	4,540	4,169	4,644	4,675	4,718	5,183	5,291
Residential Subsector	13,818	14,196	14,692	15,235	15,220	15,928	16,588	16,611	16,667	16,996	17,044	17,089	16,527	15,421	15,751	15,484
Agricultural Subsector	10,052	10,436	10,737	11,862	12,527	13,430	14,021	14,569	13,905	14,491	14,051	15,423	15,056	15,132	14,918	14,809
Other Subsectors	9,083	8,900	8,986	9,163	10,995	10,776	10,137	11,379	11,766	12,925	13,154	13,017	12,634	11,871	12,148	11,996
Fugitive Emissions	7,578	7,388	7,469	7,604	8,028	7,549	7,864	8,651	9,457	10,296	10,870	11,727	11,248	11,152	10,625	13,754
Coal Mining and Handling	1,353	1,316	1,200	1,247	1,348	920	654	902	1,004	1,150	1,291	1,656	867	945	1,044	957
Oil and Natural Gas Activities	6,225	6,072	6,269	6,356	6,680	6,628	7,210	7,749	8,453	9,146	9,579	10,071	10,381	10,206	9,582	12,797
Industrial Processes	45,265	48,504	47,577	48,266	48,703	52,806	53,993	57,874	59,846	57,820	63,220	60,368	64,172	64,771	65,952	65,474
Cement Production	11,062	11,776	9,770	10,164	10,086	11,528	13,884	15,267	16,175	16,439	16,047	15,227	14,390	13,096	13,273	14,349
Lime Production	3,688	3,755	3,948	4,241	4,098	4,104	4,248	4,338	4,141	4,325	5,008	4,811	4,956	5,064	5,505	5,356
Ammonia Production	1,683	1,478	1,516	1,684	1,689	1,785	1,754	1,829	1,718	1,943	1,663	1,396	1,567	1,690	1,934	1,922
Iron and Steel Production	24,756	26,974	27,896	27,816	28,428	30,686	29,414	31,366	32,767	30,084	35,437	34,283	38,216	39,562	39,545	38,283
Aluminum Production	1,574	1,901	2,011	1,946	1,955	1,965	1,981	1,975	2,007	2,079	2,116	1,879	2,176	2,198	2,408	2,472
Other Industries	2,502	2,621	2,435	2,415	2,446	2,739	2,712	3,100	3,038	2,950	2,950	2,773	2,868	3,162	3,287	3,093
Land-Use Change and Forestry	766,493	625,947	771,076	830,569	830,910	1,841,615	1,252,979	986,444	1,211,080	1,203,999	1,258,345	1,254,278	1,422,502	1,616,007	1,729,494	1,258,626
Land-Use Change and Forestry	761,390	621,228	764,297	821,919	821,919	1,836,220	1,246,108	978,938	1,203,980	1,197,265	1,249,627	1,246,324	1,412,696	1,604,364	1,717,913	1,251,152
Amazon Biome	460,525	320,364	463,432	521,054	521,054	1,400,699	810,586	543,417	768,459	761,744	814,106	810,803	977,175	1,196,179	1,309,729	842,967
Cerrado Biome	233,001	233,001	233,001	233,001	233,001	302,715	302,715	302,715	302,715	302,715	302,715	302,715	302,715	275,378	275,378	275,378
Other Biomes	67,863	67,863	67,863	67,863	67,863	132,806	132,806	132,806	132,806	132,806	132,806	132,806	132,806	132,806	132,806	132,806
Liming Agricultural Soils	5,103	4,719	6,780	8,650	8,991	5,395	6,871	7,506	7,100	6,734	8,717	7,954	9,806	11,644	11,581	7,474
Waste	24	38	70	59	63	79	63	63	70	84	92	76	80	111	111	110
TOTAL	991,731	859,978	1,008,046	1,076,151	1,085,925	2,116,486	1,548,093	1,301,411	1,534,341	1,542,206	1,611,615	1,614,357	1,783,237	1,973,647	2,105,072	1,637,905
For information purposes only																
Bunker fuels	5,231	3,913	4,365	4,405	4,339	5,455	6,539	7,038	13,529	14,962	14,627	16,651	16,794	14,972	15,298	15,759
Aviation	5,231	3,913	4,365	4,405	4,339	5,455	6,539	7,038	7,872	6,551	5,708	6,600	5,471	5,018	5,344	5,805
Marine	0	0	0	0	0	0	0	0	5,657	8,411	8,919	10,051	11,323	9,954	9,954	9,954
CO_2 Emissions from Biomass	187,962	185,012	181,912	180,851	190,896	183,878	183,035	188,329	186,746	191,865	180,471	185,741	201,339	219,347	235,655	243,606

CH_4

Sector	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	(Gg)															
Energy	427	405	379	382	382	363	336	345	341	362	388	403	412	416	473	541
Fossil Fuel Combustion	336	310	293	292	296	277	260	257	245	258	267	261	278	311	344	344
Energy Subsector	169	151	139	145	148	136	123	120	109	116	125	117	123	144	166	165
Industrial Subsector	58	52	50	53	55	53	51	50	49	53	54	53	56	64	73	72
Metallurgy of Iron	40	35	33	36	37	33	31	31	28	32	35	31	33	39	46	46
Other Industries	18	17	17	17	19	19	19	19	21	21	19	21	23	25	26	27
Transportation Subsector	11	11	11	11	12	13	13	13	13	12	11	11	11	10	11	10
Residential Subsector	76	75	75	66	64	58	56	57	58	60	62	64	72	75	76	77
Other Subsector	22	21	18	17	17	17	17	17	16	16	15	15	16	18	19	19
Fugitive Emissions	91	95	86	90	87	87	77	88	96	105	122	142	134	105	129	197
Coal Mining and Handling	50	54	44	47	42	41	26	33	33	34	43	60	44	41	48	49
Oil and Natural Gas Activities	42	41	42	43	44	46	51	55	63	71	78	82	90	64	81	148
Industrial Processes (Chemical Industry)	5	5	5	6	7	6	6	7	8	8	9	8	8	9	9	9
Agriculture	9,539	9,829	10,004	10,043	10,237	10,447	10,131	10,253	10,345	10,484	10,772	11,159	11,503	12,066	12,605	12,768
Enteric fermentation	8,419	8,671	8,802	8,834	8,995	9,175	8,980	9,133	9,222	9,297	9,599	9,966	10,297	10,832	11,322	11,487
Cattle	8,004	8,250	8,380	8,427	8,579	8,752	8,654	8,806	8,893	8,961	9,256	9,620	9,956	10,486	10,971	11,129
Dairy Cattle	1,198	1,245	1,279	1,258	1,263	1,297	1,081	1,124	1,137	1,143	1,178	1,207	1,237	1,269	1,321	1,371
Non - Dairy Cattle	6,807	7,005	7,101	7,169	7,316	7,455	7,573	7,682	7,756	7,818	8,078	8,414	8,719	9,217	9,651	9,757
Other Animals	415	421	422	407	416	423	325	326	329	335	344	345	341	347	351	358
Animal Manure Management	635	653	663	659	675	695	628	641	647	660	678	701	693	713	718	723
Cattle	191	198	200	201	205	209	200	205	207	209	216	224	224	236	248	254
Dairy Cattle	36	37	38	38	38	39	31	33	33	33	34	35	36	36	39	40
Non - Dairy Cattle	155	160	162	163	167	170	169	172	174	176	182	190	188	199	210	214
Swine	373	379	382	376	387	397	343	348	350	358	365	375	369	374	363	358
Poultry	48	53	58	59	61	66	66	70	71	75	78	82	81	84	87	92
Other Animals	22	23	23	22	23	23	18	19	19	19	19	19	19	19	19	20
Rice Crop	363	385	416	440	436	442	391	368	361	417	393	384	398	393	434	426
Agriculture Waste Burning	121	120	123	110	131	135	133	112	115	110	101	108	115	127	132	133
Land-Use Change and Forestry	1,996	1,811	2,119	2,229	2,238	4,157	2,928	2,402	2,910	2,905	3,026	3,024	3,383	3,807	4,058	3,045
Waste	1,227	1,266	1,297	1,333	1,369	1,455	1,486	1,525	1,567	1,606	1,658	1,688	1,708	1,734	1,729	1,743
Solid Waste Disposal	792	820	846	871	897	921	946	974	1,000	1,028	1,060	1,084	1,110	1,127	1,101	1,104
Wastewater Treatment	436	446	451	461	472	534	540	551	567	578	598	604	598	608	628	639
Industrial	95	97	95	99	103	159	158	163	172	177	190	191	180	184	199	206
Domestic	341	350	356	363	369	376	382	388	395	401	408	413	418	423	428	433
TOTAL	**13,195**	**13,317**	**13,803**	**13,992**	**14,233**	**16,429**	**14,889**	**14,532**	**15,170**	**15,365**	**15,852**	**16,283**	**17,015**	**18,032**	**18,874**	**18,107**
For information purposes only																
Bunker fuels	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.39	0.56	0.60	0.67	0.75	0.66	0.66	0.66
Aviation	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Marine	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.37	0.55	0.59	0.66	0.75	0.66	0.66	0.66

N_2O

Sector	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	(Gg)															
Energy	8.5	8.6	8.5	8.5	9.0	9.1	9.3	9.7	9.9	10.1	9.6	10.0	10.5	11.1	11.7	12.1
Fossil Fuel Combustion	8.4	8.6	8.4	8.4	9.0	9.0	9.2	9.7	9.8	9.9	9.5	9.8	10.4	11.0	11.6	11.9
Industrial Subsector	3.6	3.5	3.5	3.7	4.0	3.9	3.9	4.0	4.2	4.5	4.3	4.5	4.7	5.0	5.4	5.5
Transportation Subsector	1.7	1.8	1.7	1.8	1.9	2.2	2.3	2.5	2.6	2.5	2.4	2.4	2.5	2.6	2.8	2.9
Other Subsectors	3.1	3.3	3.2	3.0	3.0	2.9	3.0	3.2	3.0	2.9	2.8	2.9	3.1	3.3	3.4	3.5
Fugitive Emissions	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
Industrial Processes (Chemical Industry)	10.7	13.5	12.5	16.1	16.3	17.4	13.6	12.1	19.1	19.0	19.9	16.2	20.3	18.6	26.0	22.8
Nitric Acid Production	1.8	1.9	1.9	2.0	2.0	2.0	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.2	2.2
Adipic Acid Production	8.6	11.3	10.4	13.8	14.0	15.1	11.2	9.7	16.8	16.6	17.5	13.9	17.8	16.2	23.5	20.3
Other Productions	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Agriculture	333.7	343.1	352.5	356.3	369.0	375.4	352.7	363.0	371.4	374.7	392.5	405.7	423.6	456.5	466.1	476.2
Animal Manure Management	10.0	10.6	10.9	10.9	11.2	11.5	10.6	10.9	10.9	11.2	11.5	11.9	11.8	12.2	11.3	12.8
Cattle	2.9	3.0	3.0	3.0	3.0	3.1	2.8	2.9	2.9	2.9	3.0	3.0	3.1	3.2	2.1	3.3
Swine	2.4	2.5	2.5	2.4	2.5	2.5	1.9	2.0	2.0	2.0	2.1	2.1	2.0	2.0	2.1	2.2
Poultry	4.4	4.8	5.1	5.2	5.4	5.6	5.6	5.8	5.7	6.0	6.2	6.5	6.4	6.7	6.8	7.1
Other Animals	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Agricultural Soils	317.7	326.5	335.4	340.0	351.4	357.3	335.5	346.5	354.8	358.1	376.0	388.5	406.2	438.1	448.3	456.8
Direct Emissions	212.8	218.6	224.9	227.4	235.0	239.4	224.5	232.0	237.1	240.0	251.2	260.6	272.0	293.4	301.0	305.7
Grazing Animals	165.7	171.0	173.5	173.4	176.2	179.7	167.6	171.5	173.4	175.2	180.8	186.8	195.1	204.9	213.7	217.1
Synthetic Fertilizers	11.0	11.1	12.2	14.4	16.6	16.0	16.9	18.4	20.6	19.7	23.6	23.2	25.7	31.4	31.7	31.1
Animal Manure	13.2	13.7	14.0	14.0	14.3	14.6	13.0	13.3	13.4	13.7	14.0	14.5	14.5	14.9	13.4	15.6
Agricultural Waste	15.3	15.0	16.9	17.1	19.0	19.8	17.2	18.8	19.3	20.7	21.6	24.7	24.9	30.1	29.7	29.1
Organic Soils	7.5	7.9	8.3	8.6	9.0	9.3	9.7	10.0	10.4	10.7	11.1	11.4	11.8	12.1	12.5	12.8
Indirect Emissions	104.8	107.9	110.6	112.5	116.4	117.8	111.0	114.6	117.7	118.1	124.8	127.8	134.1	144.6	147.4	151.1
Agriculture Waste Burning	6.1	6.0	6.1	5.4	6.5	6.7	6.5	5.5	5.7	5.4	5.0	5.3	5.7	6.3	6.5	6.6
Land-Use Change and Forestry	13.7	12.5	14.6	15.3	15.4	28.6	20.1	16.5	20.0	20.0	20.8	20.8	23.3	26.2	27.9	20.9
Waste	9.0	9.2	9.7	10.2	10.8	10.9	11.1	11.4	11.8	12.1	12.4	12.5	13.1	13.6	13.8	14.0
TOTAL	**375.6**	**386.8**	**397.8**	**406.5**	**420.6**	**441.5**	**406.8**	**412.8**	**432.1**	**435.8**	**455.2**	**465.2**	**490.8**	**526.0**	**545.5**	**546.0**
For information purposes only																
Bunker fuels	0.15	0.11	0.12	0.12	0.12	0.15	0.18	0.20	0.27	0.25	0.23	0.27	0.24	0.22	0.23	0.24
Aviation	0.15	0.11	0.12	0.12	0.12	0.15	0.18	0.20	0.22	0.18	0.16	0.19	0.15	0.14	0.15	0.16
Marine	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.07	0.07	0.08	0.09	0.08	0.08	0.08

HFC-23

Sector	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	(Gg)															
HCFC-22 Production	0.120	0.138	0.164	0.172	0.157	0.153	0.089	0.095	0.013	0.097	-	-	-	-	-	-
TOTAL	**0.120**	**0.138**	**0.164**	**0.172**	**0.157**	**0.153**	**0.089**	**0.095**	**0.013**	**0.097**	**-**	**-**	**-**	**-**	**-**	**-**

HFC-125

Sector	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	(Gg)															
Potential Emissions by Use	-	-	-	-	-	-	-	-	-	-	0.007	0.039	0.051	0.055	0.121	0.125
TOTAL	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**0.007**	**0.039**	**0.051**	**0.055**	**0.121**	**0.125**

HFC-134a

Sector	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	(Gg)															
Actual Emissions by Use	0.0004	0.001	0.004	0.008	0.068	0.273	0.830	0.251	0.798	1.191	0.471	1.257	1.244	1.545	1.141	2.282
TOTAL	**0.0004**	**0.001**	**0.004**	**0.008**	**0.068**	**0.273**	**0.830**	**0.251**	**0.798**	**1.191**	**0.471**	**1.257**	**1.244**	**1.545**	**1.141**	**2.282**

HFC-143a

Sector	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	(Gg)															
Potential Emissions by Use	-	-	-	-	-	-	-	-	-	-	0.007	0.027	0.040	0.050	0.104	0.093
TOTAL	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**0.007**	**0.027**	**0.040**	**0.050**	**0.104**	**0.093**

HFC-152a

Sector	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	(Gg)															
Potential Emissions by Use	-	-	-	-	-	-	-	-	-	-	0.0001	0.030	0.008	0.024	0.054	0.175
TOTAL	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**0.0001**	**0.030**	**0.008**	**0.024**	**0.054**	**0.175**

CF_4

Sector	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	(Gg)															
Aluminum Production	0.302	0.337	0.356	0.335	0.323	0.306	0.298	0.203	0.228	0.201	0.147	0.115	0.135	0.136	0.124	0.124
TOTAL	**0.302**	**0.337**	**0.356**	**0.335**	**0.323**	**0.306**	**0.298**	**0.203**	**0.228**	**0.201**	**0.147**	**0.115**	**0.135**	**0.136**	**0.124**	**0.124**

C_2F_6

Sector	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	(Gg)															
Aluminum Production	0.026	0.029	0.031	0.029	0.028	0.026	0.026	0.016	0.017	0.015	0.012	0.009	0.012	0.011	0.010	0.010
TOTAL	**0.026**	**0.029**	**0.031**	**0.029**	**0.028**	**0.026**	**0.026**	**0.016**	**0.017**	**0.015**	**0.012**	**0.009**	**0.012**	**0.011**	**0.010**	**0.010**

SF_6

Sector	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	(Gg)															
Electrical Equipment	0.0042	0.0040	0.0040	0.0040	0.0041	0.0041	0.0041	0.0042	0.0047	0.0049	0.0050	0.0051	0.0053	0.0056	0.0060	0.0061
Magnesium Production	0.0058	0.0058	0.0070	0.0101	0.0099	0.0101	0.0097	0.0127	0.0101	0.0098	0.0103	0.0095	0.0122	0.0147	0.0170	0.0191
TOTAL	**0.0099**	**0.0098**	**0.0110**	**0.0141**	**0.0140**	**0.0142**	**0.0139**	**0.0169**	**0.0148**	**0.0147**	**0.0153**	**0.0146**	**0.0175**	**0.0204**	**0.0230**	**0.0252**

CO

Sector	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	(Gg)															
Energy	14,919	14,674	14,621	14,214	14,438	14,320	14,318	13,961	13,196	12,419	11,415	10,873	10,969	11,185	11,453	11,282
Energy Subsector	1,583	1,510	1,410	1,436	1,492	1,396	1,334	1,382	1,241	1,254	1,232	1,203	1,273	1,474	1,636	1,670
Industrial Subsector	1,573	1,458	1,455	1,520	1,645	1,598	1,568	1,599	1,622	1,752	1,677	1,746	1,867	2,073	2,297	2,307
Metallurgy of Iron	842	757	704	778	789	727	683	678	621	692	756	688	725	842	990	972
Food and Beverage	366	367	447	446	550	564	579	635	722	778	627	773	867	930	994	1,014
Other Industries	366	333	304	297	306	307	305	285	279	281	293	284	276	301	313	321
Transportation Subsector	7,886	7,878	7,979	7,931	8,069	8,380	8,531	8,067	7,370	6,371	5,402	4,699	4,240	3,885	3,702	3,407
Road Transportation	7,783	7,778	7,882	7,824	7,967	8,279	8,419	7,969	7,264	6,267	5,303	4,596	4,139	3,786	3,595	3,302
Other Means of Transportation	103	99	97	107	102	101	112	98	105	104	100	104	101	98	106	105
Residential Subsector	3,522	3,501	3,493	3,065	2,976	2,687	2,625	2,657	2,716	2,802	2,874	2,996	3,344	3,482	3,531	3,602
Other Subsectors	355	328	285	262	257	261	260	257	247	241	229	228	245	272	289	295
Industrial Processes	365	469	502	501	510	510	511	506	514	533	542	487	571	575	612	626
Aluminum Production	345	446	476	474	480	480	480	474	480	496	504	449	529	528	562	572
Other Productions	20	23	25	26	29	29	31	32	33	36	37	37	40	46	49	53
Agriculture (Waste Burning)	2,543	2,517	2,592	2,307	2,741	2,838	2,784	2,358	2,423	2,301	2,131	2,275	2,419	2,672	2,763	2,791
Cotton	88	79	55	22	11	0	0	0	0	0	0	0	0	0	0	0
Sugarcane	2,455	2,438	2,537	2,285	2,730	2,838	2,784	2,358	2,423	2,301	2,131	2,275	2,419	2,672	2,763	2,791
Land-Use Change and Forestry	17,468	15,850	18,538	19,500	19,584	36,370	25,622	21,016	25,464	25,415	26,476	26,463	29,603	33,310	35,507	26,641
TOTAL	**35,296**	**33,510**	**36,253**	**36,522**	**37,273**	**54,039**	**43,234**	**37,841**	**41,597**	**40,668**	**40,563**	**40,098**	**43,562**	**47,742**	**50,335**	**41,339**
For information purposes only																
Bunker fuels	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	74.73	110.72	117.56	132.37	149.03	131.02	131.02	131.84
Aviation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.82
Marine	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	74.73	110.72	117.56	132.37	149.03	131.02	131.02	131.02

NO_x

Sector	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	(Gg)															
Energy	1,781	1,845	1,881	1,936	1,996	2,094	2,198	2,265	2,268	2,337	2,334	2,342	2,327	2,284	2,407	2,388
Energy Subsector	222	232	256	258	259	269	289	329	308	399	406	433	391	417	465	457
Industrial Subsector	320	327	330	348	366	385	413	435	442	460	486	481	496	498	515	542
Metallurgy of Iron	98	99	100	109	116	121	127	130	126	123	133	126	128	135	139	149
Other Industries	222	227	230	239	250	264	286	305	316	337	354	355	368	363	376	394
Transportation Subsector	1,173	1,221	1,231	1,270	1,311	1,382	1,440	1,445	1,460	1,420	1,381	1,366	1,374	1,304	1,360	1,322
Road Transportation	1,066	1,115	1,123	1,152	1,206	1,276	1,319	1,349	1,358	1,314	1,283	1,258	1,264	1,197	1,244	1,203
Other Means of Transportation	108	106	108	118	105	106	121	95	103	105	98	108	109	106	116	119
Residential Subsector	53	53	53	49	48	45	44	45	45	47	48	49	53	54	54	55
Other Subsectors	12	11	11	11	13	13	12	12	12	13	12	12	13	11	12	12
Industrial Processes	8	9	10	10	11	11	12	12	12	13	14	13	15	16	17	18
Agriculture (Waste Burning)	219	216	222	197	233	241	236	200	206	195	181	193	205	227	235	237
Cotton	10	9	7	3	1	0	0	0	0	0	0	0	0	0	0	0
Sugarcane	208	207	215	194	232	241	236	200	206	195	181	193	205	227	235	237
Land-Use Change and Forestry	496	450	526	554	556	1,033	728	597	723	722	752	752	841	946	1,008	757
TOTAL	2,504	2,521	2,640	2,696	2,797	3,379	3,173	3,074	3,209	3,268	3,280	3,300	3,388	3,473	3,667	3,399
For information purposes only																
Bunker fuels	22.53	16.85	18.80	18.97	18.69	23.50	28.17	30.32	146.01	194.30	200.93	226.99	247.11	218.14	219.55	221.38
Aviation	22.53	16.85	18.80	18.97	18.69	23.50	28.17	30.32	33.91	28.22	24.59	28.43	23.57	21.61	23.02	24.85
Marine	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	112.10	166.08	176.35	198.56	223.54	196.53	196.53	196.53

NMVOC

Sector	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	(Gg)															
Energy	1,022	999	962	958	974	962	953	934	897	885	860	826	855	899	963	958
Energy Subsector	337	299	276	289	293	271	243	237	215	231	248	233	244	286	329	327
Industrial Subsector	51	49	49	51	55	54	53	54	56	59	57	59	63	68	74	75
Metallurgy of Iron	24	22	21	23	23	22	21	21	19	21	22	21	22	24	28	27
Food and Beverage	14	14	16	16	19	19	20	22	24	26	22	26	28	30	32	33
Other Industries	14	13	12	12	13	13	13	12	12	13	13	13	13	14	14	15
Transportation Subsector	371	391	383	390	403	430	452	437	419	384	342	314	304	288	296	288
Road Transportation	354	375	367	372	387	414	434	422	403	367	326	297	287	271	278	270
Other Means of Transportation	16	16	16	18	16	16	18	15	16	16	15	17	17	17	18	18
Residential Subsector	204	203	203	178	173	157	153	155	159	164	168	175	196	203	206	210
Other Subsectors	59	57	52	51	50	51	51	50	48	47	45	45	48	54	57	58
Industrial Processes	322	331	342	356	382	423	437	441	476	498	474	503	542	574	599	599
Chemical Industry	27	25	25	28	31	31	31	34	35	37	43	41	42	45	49	49
Pulp and Paper	13	15	17	17	19	19	20	21	22	24	25	25	27	30	32	35
Food Production	112	128	144	148	176	189	202	203	236	254	223	254	290	316	335	331
Beverage Production	170	164	157	164	157	183	183	183	183	183	183	183	183	183	183	184
Solvent and Other Product Use	350	365	379	407	435	450	455	492	450	431	473	490	497	512	565	595
Paint Application	227	240	254	280	300	311	320	352	314	293	331	344	347	358	408	439
Other Uses	122	125	125	127	135	139	135	140	136	138	142	146	150	154	157	156
TOTAL	1,693	1,695	1,683	1,722	1,791	1,835	1,845	1,867	1,823	1,814	1,807	1,820	1,894	1,985	2,127	2,152
For information purposes only																
Bunker fuels	0	0	0	0	0	0	0	0	15	22	24	26	30	26	26	26
Aviation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Marine	0	0	0	0	0	0	0	0	15	22	24	26	30	26	26	26