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 5°16′ North to latitude 33°44′ 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		
	(km²)	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.

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).

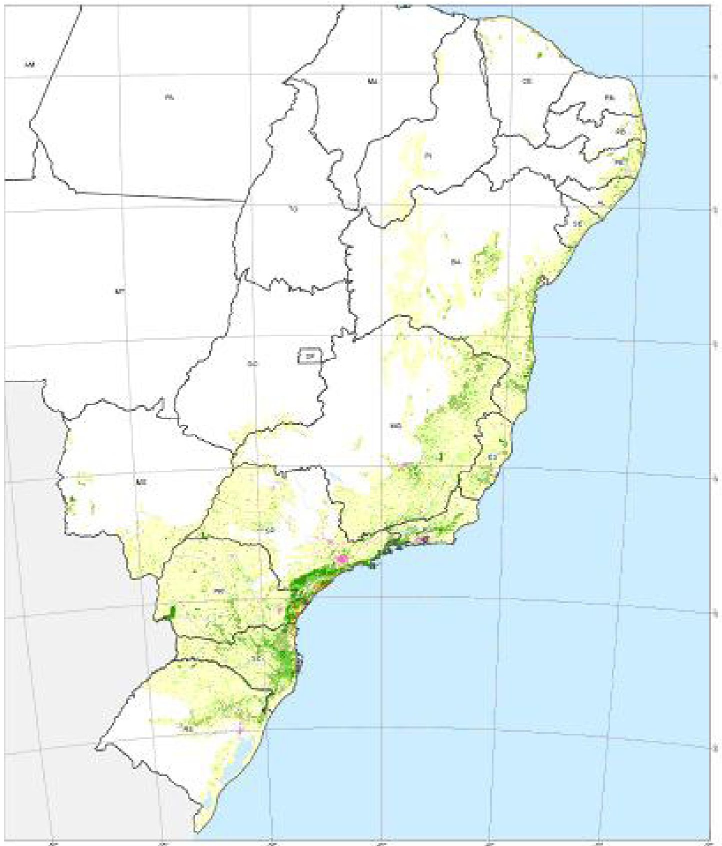
The high degree of interference in the Atlantic Forest is well known. Since the beginning of European colonization, with the occupation of the first territorial spaces near the coastal region and the exploitation of Brazil wood — the tree from which a much used dye by the textile industry at the time 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.

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.

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.

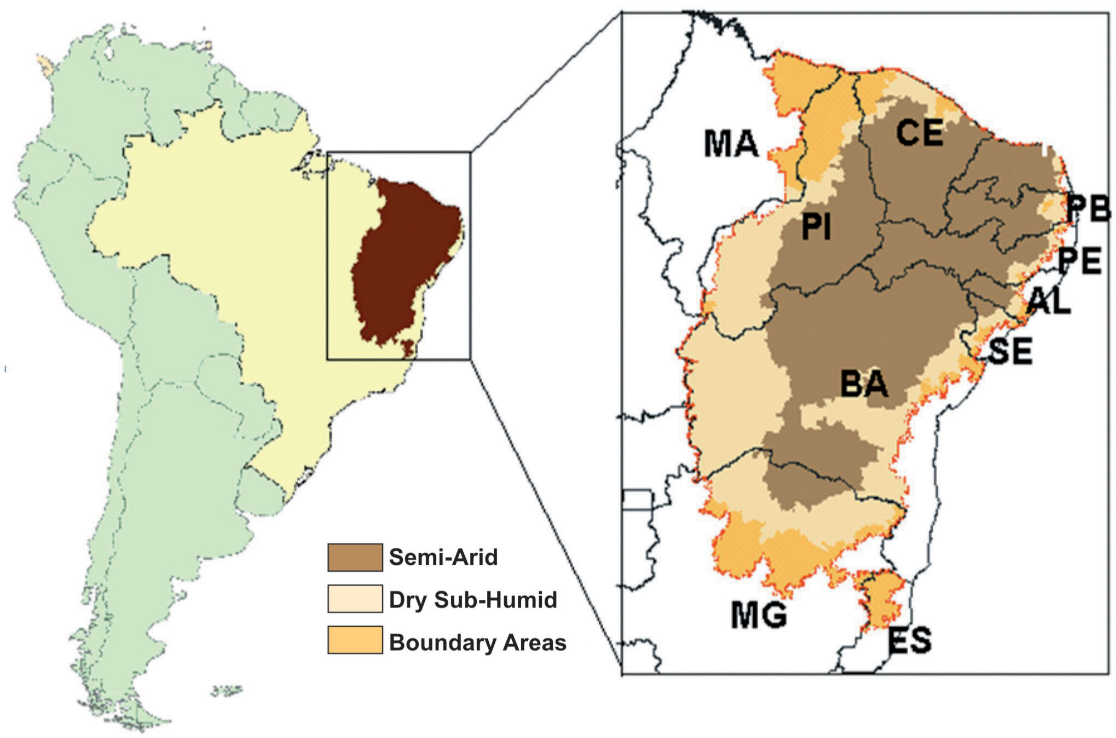
Under the United Nations Convention to Combat Desertification, those areas prone to desertification have arid, semi-arid and sub-humid dry climates. These climate classes, as far as the desertification issue is concerned, are determined according to the Aridity Index (THORNTHWAITE, 1941), adopted to 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.

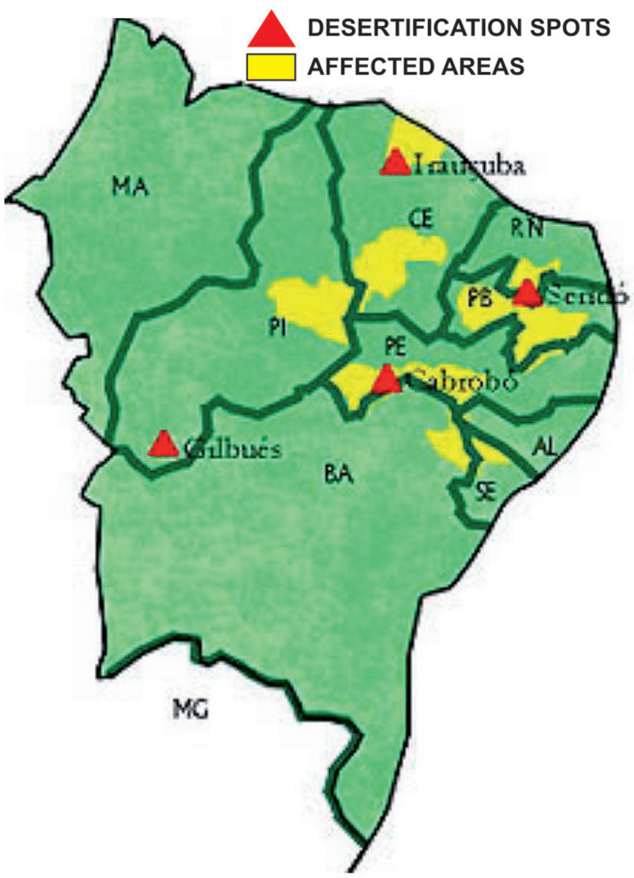
Figure 4.3 Areas of Brazilian territory prone to desertification



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] .

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

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.

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.

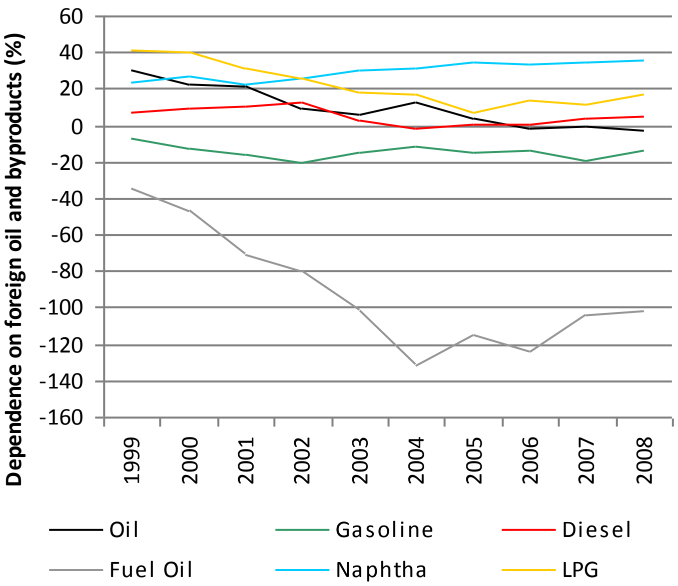
43 On June 28, 1990, and transformed into Conama Resolution nº 03/1990. See Part III, Section A.3.6, on the Motor Vehicle Air Pollution Control Program - Pronar.

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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