**SAVANNAH BIOMES**

When we talk about Brazilian biomes, we are forced to include the concept of morphoclimatic domains widely promoted by Ab’Saber in his studies on physical Brazilian geography. Biomes differ or constitute homogenous regions (domains) due to weather, soil and relief. Brazil, given its extensive territorial size (8,512,000 km2), in North-South direction, crosses different latitudes, most of which are in the tropical region of the Southern Hemisphere.

In the East-West direction, differences are mostly in terms of relief and type of soil due to a long geological history and greater or lesser proximity with the ocean.

Biomes are composed of all living organisms and their interactions with the environment. They constitute all global vegetation with a similar appearance and forms of life. Those that contain many forms of life are the richest in number of plant and animal species, with high temperatures, regular rainfall and developed soil, indicating the absence of physical limits in the environment. However, they can be degraded by inadequate, continuous and excessive human action.

According to Mantovani, in a chapter he authored in the publication *O Patrimônio Ambiental Brasileiro* [Brazilian Environmental Heritage], Brazilian savannahs were classified as follows: Cerrado as savannah per se; and Caatinga as steppic savannah. The complex formation of the Pantanal was jointly referred to as Cerrado in a more recent publication by the Ministry of Environment (MMA).

**CERRADO**

The Cerrado region covers between 1.5 million and 2.1 million square kilometres and is mainly located in central Brazil with small areas in the north-east of Paraguay and east of Bolivia. The Cerrado biome has a central position in relation to other South American biomes. It borders two of the largest South American forest regions (Amazon Rainforest and Atlantic Forest) and two of the largest semi-arid regions (Chaco and Caatinga).

It can be divided into plateaus (altitudes generally above 500 metres) and depressions (altitude generally below 500 metres). In the plateaus, dominant vegetation is the Cerrado, in its widest range of structural forms; gallery or riparian forests are interspersed in the Cerrado along its main rivers.

As a Brazilian biome, the savannah or Cerrado occurs in northern Amazon, in Roraima, and in central Brazil. It originally covered around 25% of Brazilian territory for more than 20 degrees of latitude, with continuous distribution in the states of Mato Grosso do Sul, Goiás, Tocantins, Distrito Federal, central-southern of Mato Grosso, western Bahia and Minas Gerais, southern Maranhão and Piauí, and parts of the states of São Paulo and Paraná. This fairly adapted vegetation evolved during millions of years, from the start of the Quaternary period, and is one of the oldest biomes in Brazil.

Climate of the Cerrado is tropical with two well-defined seasons – dry, which starts at the beginning of May and ends in September, and rainy, from October to April −, average annual rainfall is between 600 and 2000 millimetres and there are frequent short mini-droughts (*veranicos* or rainless periods) in the rain season. In terms of morphological domains, support is provided by the Central Brazilian Plateau and the Guianas Plateau. Main soil types where the Cerrado flowers are red latosol and podzolic soils. They are deep, sandy, well-drained soils that do not restrict tree root growth.

As the Cerrado region includes plateau areas and gets abundant rainfall in the summer, it has several river springs and, consequently, important water recharge areas that contribute to most Brazilian hydrographical basins. The largest of these basins have sources from the rivers that supply them and from rivers in the Cerrado region: the Amazon, the hydrographical region of Araguaia-Tocantins, the North/Northeast Atlantic, the São Francisco, the East Atlantic and from rivers Paraná/Paraguay.

Contrary to the forest, which, since the start of European colonization has been considered the symbol of fertile soil and is therefore valued for sugarcane cultivation and later for coffee in the 19th century, the importance of the Cerrado was only recognized in the 20th century. This recognition was mostly due to the depletion of forested soil in south-eastern Brazil and due to easy mechanization in a period of agricultural modernization and industrialization.

By occupying flatter ground, from the top of the plains of the Central Brazilian Plateau and the peripheral depression of the state of São Paulo, the Cerrado has a range of features and represented a large agricultural frontier in the interior of Brazil until the 1960s. At that time and during the following decade, several symposiums on the topic of the Cerrado were held, and the annals were published by the University of São Paulo. These symposiums played an important role in showing the technical and financial feasibility of exploiting and encouraging research on this biome and its use for agricultural and livestock raising activities. Since then, the agricultural frontiers for the Cerrado have expanded, based on monoculture and mechanized agriculture that depends on chemical inputs and pesticides.

Consequently, there are only 356,630 square kilometres left intact, or less than 20% of the original biome, justifying its definition as a biodiversity hotspot. The Cerrado was identified as one of the richest and most endangered biomes in the world. Plant endemism is the first criterion to define a hotspot. Degree of endangerment is the second criterion of a hotspot and is defined when a biome has already lost more than 70% of its original cover.

This biome comprises a combination of high grasses, shrubs, subshrubs and short twisted trees that are 4-8 metres high and have thick bark that provides protection from fire. The biome can be thick, with an abundance of trees and intertwined crowns, but the canopy is not dense and light can penetrate to the soil. The trees are lovely when they blossom. There are also several startling orchid genera. The varied natural biome and flat relief with abrupt escarpments, waterfalls and crystal-clear rivers are of outstanding scenic beauty.

The Cerrado presents a variety of forms in a continuous sequence that ranges from a denser form with higher trees, called *cerradão*, to herbaceous vegetation with sparser trees, called *campo cerrado*. As the Cerrado has a lower leaf mass than the forest, total organic matter returned to the soil is not very abundant and it is quickly mineralized, resulting in a soil with low humus content. On the other hand, its gramineous plants dry in the drought season and form a mass of matter close to the soil that easily suffers combustion. Consequently, fire has been associated to the Cerrado in its natural, accidental form or as an agricultural practice to clear field and facilitate sprouting.

Most of the trees have wide, hard and tough leaves. Other trees are leguminous with delicate needle-like leaves. Almost all the Cerrado species are perennial, with the exception of gramineous species, which are annual. As the climate in which the Cerrado occurs is characterized by a dry season and considering that the soils that provide its support are deep and usually have a low water retention capacity, the Cerrado species adapted to endure this critical period of the year when supply at the top layer of the soil is relatively low. Many plants develop xylopodium or roots that store water. Other species develop deep roots that sometimes manage to penetrate groundwater. Others do not reach groundwater levels but they absorb water at depths of up to 10 metres. In this way, many of its trees keep their leaves during the dry season and continue to breathe freely because their root systems find enough water in deep layers of soil. Woody vegetation, in spite of its misleading xeromorphic physiognomy, is not limited due to lack of water, but by a deficiency of nutrients in the soil (phosphorous, sulphur, nitrogen, zinc, molybdenum, boron), that is, by oligotrophy.

Fire accentuates oligomorphism and influences the preservation and propagation of the Cerrado. Repeated fires, to which the Cerrado has been subject to for more than 40,000 years, may have increased the sulphur deficiency. Furthermore, toxicity caused by aluminium in the soil is also responsible due to its scleromorphic characteristics. Plants of the Cerrado are adapted to high levels of aluminium in their leached soils. The high aluminium levels cause reduced availability of phosphorous, calcium, potassium, magnesium, nitrogen and other nutrients.

Soils covered by the Cerrado are generally quite leached, acid, with pH between 4.5 and 5.5, and poor in nutrients, to which the vegetation is also adapted. But the Cerrado is not merely highly adapted, it also has a high level of biodiversity. In the early 1960s, when more detailed studies on the Cerrado started, a total of 537 arboreous plant species of 242 genera pertaining to 70 families were registered. However, every time a new area of the Cerrado is studied, many other species are discovered. There are hundreds of species scattered across the Cerrado and a similar or higher number of local species in each area. Its landscape diversity establishes an important floristic diversity, which ranks it as one of the richest savannahs in the world, with 6429 catalogued species until 1998, of which more than 40% are endemic woody species. Today, almost 12 thousand species have already been identified.

This endemism, in addition to the species that are also typically found in other ecosystems, is the result of its long and dynamic evolutional history and interfaces with other biomes considering that the Cerrado borders other biomes of the lowlands, such as the Caatinga and humid tropical forests. The Ministry of Environment acknowledges that its biodiversity is still not fully known, although it is the richest and most endangered tropical savannah in the world.

A study published by the Ministry of Environment, *Cerrado: Ecologia, Biodiversidade e Conservação* [Cerrado: Ecology, Biodiversity and Conservation], in 2006, states that knowledge on the Cerrado is accumulating, but what is known and the capacity to transform this knowledge into practical actions has been inferior to the pace in which this biome is disappearing.

In terms of wildlife, contrary to African savannahs that have carnivores and other large animals that move in herds, in the Cerrado species are smaller and more isolated. Anteaters, pampas deer, jaguars, maned wolves, armadillos, tapirs, several psittacidae, pigeons, macaws, toucans, rheas, seriemas, partridges, quails and other bird species, and lizards and snakes are the most frequently found species. Above all, the Cerrado is rich in several species of herbivorous insects, termites and ants. These insects are mostly responsible for accelerating decomposition of plant matter, relocating some nutrients and determining the floristic composition of the community by means of the selective consumption of some species.

Ichthyofaunal species diversity in rivers of the Cerrado is also quite expressive, with more than 500 of the 3000 fish species in South America.

The Cerrado is a resilient vegetation that has been continually burned for at least 10,000 years since the first indigenous communities settled there. For 4000 years, the jê group included the cultivation of corn and beans and fishing with *timbó*, a vine that dazes fish. Then came the explorers, pioneers and miners, who initiated the agriculture of food crops for their livelihood, and cattle raisers who used the native pastures for extensive grazing and burned the grass every year to facilitate sprouting of gramineous plants and the elimination of shrubs.

In recent decades, especially after the capital of Brazil was changed to Brasília, in 1960, the beautiful landscapes of the Cerrado have made way for massive monocultures as far as the eye can see and large silos for the agribusinesses of soybean, cotton, corn, bean and sugarcane cultivation and beef cattle raising. In the case of cattle raising, native grasses have been replaced with grass of African origin, also adapted to fire and with a high competitive capacity. Production is for the southeast of Brazil, which is extensively urbanized, and for export. Deforestation is intense due to its favourable characteristics for agriculture and cattle raising and to the demand for charcoal for the steel industry of Minas Gerais and, recently, of Mato Grosso do Sul.

Currently, the region is responsible for 41% of agricultural production in Brazil, mostly based on agribusiness. The states of the south-eastern region presented the highest volume of production and harbour the largest grains cultivation area in the 2012/2013 harvest. Mato Grosso alone produces 25% of national agribusiness production. Productivity per area is one of the highest in the world, and grains production has occupied areas that were previously used for cattle raising. However, production efficiency is lost due to the lack of storage and transport infrastructure and to the inefficiency of Brazilian ports to where these grains are transported: Paranaguá and Santos. Producer associations report post-harvest losses ranging from 10% to 12% due to the terrible road conditions and shortage of storage facilities. Consequently, producers justify the need to plant larger areas to compensate the losses.

Cattle raising, which was previously very extensive and needs large areas of land, is currently targeting higher productivity and environmental sustainability in new management practices and health of livestock. Beef cattle dropped from 24 million heads to 21 million in the last few years and has been increasingly integrated to crops and forests planted by the pulp and paper industry.

Destruction of these biomes has led to very negative impacts on land and water ecosystems. Biodiversity has been reduced, and ecosystem services, such as nutrient cycling, water flow and aquifer recharging, among others, have compromised the quality of life of local populations and the sustainability of economic and social activities of the region itself and surrounding regions, such as the Pantanal. Only 1.8% of the Cerrado is preserved by law in integral protection conservation units, considering that the national average is 3.7%, and the South American average is 4.5%.

**PANTANAL**

The Pantanal is the largest floodplain in the world, with a total of 150 thousand square kilometres, of which approximately 100 thousand square metres are wetlands. It is located in the lower River Paraguay depression, embodying the western part of the states of Mato Grosso and, mainly, Mato Grosso do Sul.

In the context of morphoclimatic domains in South America, the Pantanal is considered a transition region between domains of the Cerrado, Amazonia, Chaco and Atlantic Forest, according to Ab’Saber. Due to this characteristic, it is called the Pantanal complex. It is the largest periodical floodland region in the American continent. According to Pádua and Coimbra, it can be considered an extension of the Brazilian Cerrado that, due to the low altitude, nature of soil, rainfall and influence of the Hylean Amazon, acquired its own features and formed a peculiar and homogenous region. It forms an internal delta, a large floodplain, chiefly occupied by fields on alluvial hydromorphic soil where sediments are deposited and several rivers from the plateau come together.

Its climate is analogous to that of the Cerrado, with a well-defined dry season, lasting from two to four months in the winter, and a rainy season in the summer. Annual rainfall varies from 2000 millimetres in the North to 1250 millimetres in the Southeast. During the rainy season, groundwater approaches the surface and causes flooding in vast regions due to the poor draining capacity of the soil or flooding of rivers. These periodical floods fertilize the Pantanal and cause an explosion of primary productivity with sprouting or germination of water plants and an increase of water animals that serve as food for large populations of migratory birds, including intercontinental migrants from Argentina to Canada, according to Mantovani.

Well-drained areas, such as hilltops, are covered in Cerrado vegetation. Part of the Pantanal consists of permanent wetlands and natural pastures formed by native grass species. The rest of the Pantanal comprises periodically flooded areas. There are huge lakes covered with water hyacinths, small temporary canals, bays, lagoons and water courses, creating a landscape of exceptional beauty. Between the bays, there are forest stands with ipê trees, pau d'arco trees, cambara trees and palm trees. When in blossom at the same time, the landscape spotted with hues of green, yellow and lilac, and the largest wildlife concentration of the Americas, makes the Pantanal one of most popular tourist attractions in Brazil, especially for visitors who are interested in nature tourism.

The Pantanal forms an extremely dense mosaic of different environments and harbours a rich land and water biota. However, considering it is an area of transition, the fauna does not have endemic species.

Avifauna of the Pantanal consists of elements with distribution centres in adjacent areas. As there are several contact zones, species or subspecies related to the avifauna are found in the Pantanal. To watch and photograph birds in the Pantanal is one of its most appealing attractions. Storks, jabirus. kingfishers, night herons, horned screamers, hawks, rheas, seriemas, parrots, hyacinth macaws and blue-winged macaws are so abundant that they are a constant part of the landscape. Reptiles, such as alligators, are seen by the hundreds in rivers, lakes and small canals. The yellow anaconda is very frequent in the region. There are also capybaras, deer, tapirs, collared peccaries and wild boars, bush dogs, monkeys, giant and neotropical otters. Cougars or mountain lions, jaguars and ocelots are also easily spotted when travelling by boat along the narrower rivers.

These wild animals co-exist with extensive beef cattle raising, with herds of millions of heads of cattle, especially Nellore of Indian origin, or its cross-breeds, which have been traditionally raised in the region for many decades.

The Pantanal, per se, is only crossed by a dirt roadway, the Transpantaneira. Transport and circulation in the region is basically done on small motorized boats.

In relation to the Pantanal ichtyofauna in Mato Grosso, a total of 265 species were recorded in 1999. This survey was based on the bibliography and collections of the Zoology Museum of the University of São Paulo dating back 20 years. There are still new species to be defined and species described in other areas that are found in the region, although the number is low. Piranhas are very abundant in rivers and are regarded with apprehension by tourists and native bathers. Alligators are respected by the residents of Pantanal due to their role as predators for piranha control.

Direct anthropic alterations in aquatic ecosystems (uses of water for navigation, power generation, pollutant deposit, irrigation, flood control, introduction of exotic species, etc.) or indirect alterations in drainage basins (deforestation, aggradations, on-land agriculture, pastures and other diffuse degradations) cause changes to the structure and processes of these ecosystems and ultimately interfere with the survival capacity of different species of that community, according to the Ministry of Environment.

Fish communities suffer the huge impact of the following alterations: elimination of key migratory species; progressive elimination of larger community elements; reduction of average size; reduction of capture quality; replacement of native species by exotic species; capture fluctuations; reduced captures; and increase in the need for human intervention to maintain the system.

In addition, there are conflicts among different groups of fishermen. Professional and sports fishermen compete for the same fishery resources that, according to their perception, are steadily depleting. The absence of federal and state fishery extension and control institutions and their dubious reputation for also acting as “environmental police” only worsen the problem. Regardless, fishing is a promising opportunity for the regional economy insofar as it is practiced in a sustainable manner with recourses that are annually renewed by the water cycle to conserve their existing variability.

The most endangered systems in the region that should be a conservation priority, according to the Ministry of Environment, are headwaters of drainage basins and floodplains of the large rivers.

The Cerrado and Pantanal are also areas were endangered or almost endangered species of avifauna in adjacent regions spend most of their biological cycles. Species of the Atlantic Forest and southern field region migrate to the region of the Cerrado and/or Pantanal in the winter of their respective reproduction regions. The region also lacks studies to understand the migration patterns of birds that live and circulate there. Recorded seasonal movement ranged from the simplest short-distance inter-habitat movements to long-distance intercontinental movements. It is generally estimated that around 60% to 70% of avifauna in the Cerrado and Pantanal regions conduct some form of annual seasonal movement.

Many of these migrant species that have been to these regions are endangered due to alterations that are occurring in their reproduction areas.

In the Pantanal, a total of 132 mammal species were identified, only two of which are endemic. The most vulnerable species to degradation processes are at the top of the food chain, such as carnivores that are quite sensitive to the reduction and fragmentation of their habitat.

The Pantanal area has a low human population density and a landscapes that are still almost unaltered. The main and oldest economic activity is extensive cattle raising. However, as a large amount of water from the Pantanal comes from other regions, its preservation and that of its water sources involves actions in other domains or biomes, such as the drainage that flows to the Pantanal from the Cerrado or tropical rainforest.

The fragile equilibrium of Pantanal ecosystems, defined by periodical flooding dynamics, is being threatened by new economic development trends in the entire Central-West region of Brazil. Extensive, large-scale agriculture and cattle raising lead to erosive processes, aggradations of rivers, increased number of isles and expansion of existing isles, pollution from the use of biocides and deforestation of forested areas. There is also the introduction of exotic species that can negatively and unpredictably impact fauna and flora of the Pantanal. Large industrial projects, such as sugarcane plantations, that have been implemented in the Central-West of Brazil also pose a risk if their effluents are not adequately treated before they are bumped into the rivers that flow into the Pantanal.

Furthermore, traditional fishing and cattle raising models are being replaced by intensive exploitation with deforestation and alterations to natural areas in the interior of the Pantanal. Tourism has also increased solid and liquid waste production, created pressure for food items, especially fish, and disturbed bird nesting sites. Fishing was regulated by law to protect reproductive periods and young fish and prohibit the export of fished specimens outside the region. Inspection, however, is still insufficient.

Gold prospecting is another activity that causes a serious impact on the Pantanal due to the contamination of sediments and aquatic fauna by toxic products, especially mercury, and the aggradation of meandric river course regions.

Professional hunting, which has historically decimated regional wildlife, is fairly restricted due to the Environmental Crimes Law of 1998.

For the Pantanal, the Ministry of Environment adopted a similar approach to that of the Cerrado and defined priority regions for preservation. It also included the concepts of ecological corridors. The conservation strategy for Pantanal observes the region as a whole, with priority areas that must be connected considering the interdependence of their diverse ecosystems. The strategy also seeks to guarantee the role of the Pantanal as a corridor for the dispersion of species and integration of surrounding biomes, therefore emphasizing its importance in the context of neotropical biogeography.

The National Park of the Mato Grosso Pantanal (*O Parque Nacional do Pantanal Mato-Grossense)*, with 135 thousand hectares, in Mato Grosso, is the main restrictive conservation unit of this biome.

**CAATINGA**

According to Mantovani, the term steppic savannah, which was initially used in Africa to describe tropical biomes with a deciduous, thorny formation and discontinued herbaceous cover, finds in the Caatinga its equivalent in Brazil. The province of the Caatinga in northeast Brazil is 2º54’ to 17º21’ S covering around 1.1 million square kilometres, or 12% of Brazilian territory. It includes the states of Ceará, Rio Grande do Norte, most of Paraíba and Pernambuco, south-eastern Piauí, western Alagoas and Sergipe, northern and central Bahia and a strip of Minas Gerais, along rivers São Francisco and medium Jequitinhonha. The archipelago of Fernando de Noronha is also included in this biome.

The name “caatinga” is from the native Tupi-Guarani language meaning “white forest” due to the whitened appearance of shrubs and trees in the dry season when the leaves fall and only white, shiny trunks of tree and bushes remain in the dry landscape. The local custom considers the rain season as winter although this period actually coincides with the summer solstice.

In north-eastern Brazil, the Caatinga is mostly found in the inter-plateau depressions, but there are exceptions, such as the low tableland of the Raso da Catarina in Bahia, the Faixa da Borborema in Paraíba, or the Platô Apodi in Rio Grande do Norte, where caatinga vegetation is also found on the plateaus.

In general, this province extends across undulated pediplains with isolated rocky outcrops and large rocky surfaces.

As a result of the origin and climate, the soil is sticky and shallow with slightly decomposed bedrock and irrelevant depths due to the limitation of chemical decomposition, and with a large number of solid rock outcrops. There is a mosaic of complex soils with varied characteristics even within short distances. There are also saline soils with a high concentration of sodium chloride that goes to the surface and concentrates after evaporation. This process can be accelerated by irrigation.

The climate is semiarid, hot, with average annual temperatures of over 18º C and annual rainfall of 200 to 700 millimetres. In comparison with other Brazilian regions, it has more extreme meteorological parameters: higher solar radiation, less clouds, higher average annual temperature, lower relative humidity rates, potentially higher evapotranspiration and, above all, less, more irregular rainfall that, in most of the area, is limited to a very short period of the year. Six out of eleven months are dry, during which intermittent river flow is interrupted. Catastrophic phenomena are also very frequent, such as drought and flooding, and they have modelled animal, plant and human life in the Caatinga. It is, however, the absolute absence of rain during some years that has had the greatest impact on life in the region. There is a risk of desertification in extensive areas, especially in Ceará, and the desertification process is already underway in the southeast of Piauí, caused by deforestation and overgrazing.

The Caatinga mostly comprises low trees and shrubs, lots of which have thorns, microphylls and some xerophytic characteristics. Several of these species have morphological adaptations that allow water storage, like the roots of the imbu tree. Succulence is mostly observed in arboreous cacti, with thorny leaves, like the mandacaru, the facheiro and the xique-xique, and in bromeliaeds. Lianas are scarce.

The Agreste, a woodland region, and the Sertão, the backcountry, are terms used to refer to the Caatinga and its phytogeographical concept. Agreste is used to describe the narrow strip of vegetation between the limits of the Serra do Mar in the East, with an abundance of forests, and the drier interior in the West.

The physiognomies of the Caatinga are very variable, providing numerous and varied habitats depending on the rain regime and type of soil, and include dry forests ranging from 15 to 20 metres high called “arboreous caatinga”. Intermediary physiognomies are also common. However, the closed thorny scrub variation with low scattered trees is currently the most common form of Caatinga, called Sertão. There are two significant patches in this formation, so typical of rural depressions: one in the North and another in the South, separated by a series of mountain ranges.

Cattle has been penetrating the Sertão in large rural estates since the 17th century, and the culture of arboreous cotton has spread since the 19th century in small rural properties. Consequently, hundreds of years of agricultural overuse, deforestation and large goat herds have resulted in extensive degradation of the Caatinga and its soils.

Wood from the Caatinga has also been used in lime ovens and for cooking food, hindering the regeneration of this biome, which already has low primary production.

For decades, there have been debates on whether the Caatinga is natural or induced by man. A publication by the Ministry of Environment, *Ecorregiões da Caatinga (Ecoregions of the Caatinga)*, states that, although the influence of man in this area is considerable, to consider it a secondary vegetation would be an overstatement.

The level of endemism of its plant species is expressive. In areas of the Caatinga there seem to be at least 183 endemic species of a total of 437 species, representing 42% of succulent and woody species of the Caatinga. In this way, the Caatinga is a lot richer in species than any other dry forest in South America, similar to the uniform plateaus of the Chaco and equivalent to those of floristic provinces of California and the Canary Islands.

Its fauna is poor in carnivorous mammals, partly due to low primary production throughout the year and partly because they were hunted. The poverty of the human population in the region and long periods of drought that hinder food production create a huge pressure on the wildlife, especially larger animals like the ocelot, bush dog, otter and the common marmoset. Other animals that are becoming scarce are armadillos, lizards, pigeons and many other birds.

ThThe Caatinga has a high potential for archaeological, anthropological and paleontological findings. The Serra da Capivara National Park in the municipality of São Raimundo Nonato, southern Piauí, has rupestrian inscriptions in the sandstone, showing the presence of an ancient civilization, probably of Tapuias Indians. The area has high tourist potential as, in addition to cultural aspects, it consists of huge dissected sandstone blocks of immense and exceptional scenic beauty. It is also one of the restricted conservation units to embody a representative sample of the Caatinga biome. Other representative units include some nature reserves and ecological stations.

The semi-arid region is and has always been the main hub of origin of human migrations to the Southeast, North and Central-West (especially Brasilia) of Brazil. Maranhão and Piauí are, to this day, the Brazilian states with the lowest and highest income concentration levels in the country.

In recent decades, irrigated agriculture has developed in the Caatinga domain, especially fruit for export and for the domestic urban market. Good examples are grape cultivation in the River São Francisco valley and the interior of Rio Grande do Norte with the cultivation of pineapple, melon and cotton for the textile industry.

One of the most controversial projects to protect the water limitations of the Caatinga is the transposition of River São Francisco. The mega project under construction foresees thousands of kilometres of pipes and canals, tunnels, pumping stations and reservoirs to take water from the largest perennial river in the region, the São Francisco, to the semi-arid region with a branch towards Rio Grande do Norte and another towards Ceará and several sub-branches. These water should be used for irrigation and urban supply projects. However, their complexity, extremely high cost, and the risk of soil salinisation due to inadequate irrigation and concentration of land have generated concerns and protests from environmentalists.

There are some promising projects of the Anti-Desertification Department (*Departamento de Combate à Desertificação*) of the Ministry of Environment that comprises technologies for the sustainable use of land and practices that emphasize co-existence with naturally arid environments and protection against droughts. There are also recent experiences of sustainable water use in areas undergoing the desertification process, like Gilbués, in Piauí, and Sergipe, that will be replicated in all of the Northeast with the support of the United National Development Programme (UNDP). This initiative targets the fight against soil erosion, depletion of water resources and the construction of concrete plate cisterns for watch catchment on the roofs of family homes to be used during the dry season. Some of these social Brazilian technologies have been disseminated by United Nations organs for other regions around the world to fight desertification.