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PRIORITY A.2.3.: Managing Arid and Semi-arid Ecosystems

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ANNEX 4-2-2: Report on Best Practices & Failures - Brazil

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COMPETE

Competence Platform on Energy Crop and Agroforestry Systems for Arid and Semi-arid Ecosystems - Africa

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CENBIO
Centro Nacional de Referência em Biomassa

COMPETE PROJECT
Competence Platform on Energy Crop and Agroforestry System for Arid and Semi-arid Ecosystems – Africa

REPORT ON TASKS 4.2 & 4.3

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BRAZIL, JANUARY 2009.

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TASK 4.2: DOCUMENTATION ON IMPROVED ENERGY CROPS AND AGROFORESTRY SYSTEMS IN BRAZIL

4.2.1 Introduction

This section describes Brazilian landscapes and gives facts about the use of natural resources, with emphasis on the semi arid lands. It describes Brazilian's main socioeconomic and geographical features, and the most useful plant species of semi arid environment are presented. This document also presents some case studies of traditional agricultural systems and projects developed by CENBIO, illustrating successful strategies that may be deployed to produce fuel crops.

4.2.2 Brazilian scenario

Brazil is the biggest country of Latin America in extension and the fifth largest worldwide. According to data from the Brazilian Institute for Geography and Statistics – IBGE (2008), it covers almost half the territory of South America and occupies an area of 8.514.877 km². From this total area, 4,77 million km² correspond to natural forests. It is composed by 26 States and the Federal District, with a population of 183.987.291 inhabitants, where 84,2 % of them reside in urban area. In the last 67 years, the Brazilian population increased by approximately, 140 million inhabitants (see Table 1).

Table 1. Brazilian Population 1940-2007

Year	Population	Urban Population
1940	41.236.315	31,2 %
1950	51.944.397	36,1 %
1960	70.070.457	44,7 %
1970	93.139.037	55,9 %
1980	119.002.706	67,6 %
1991	146.825.475	75,6 %
2000	169.799.170	81,2 %
2007	183.987.291	---

Source: IBGE, 2007

The urbanization in Brazil has increased by approximately 40% in the last 40 years. The most populous Brazilian States are the State of São Paulo with 39.827.570 inhabitants, which corresponds to more than 20 % of the Brazilian population, and the State of Minas Gerais, with 19.273.506 inhabitants. However, the State of Rio de Janeiro is the most populated one, with around 353 inhabitants per km². On the Map 1, right below, it is possible to visualize the Brazilian States in accordance with the population density.

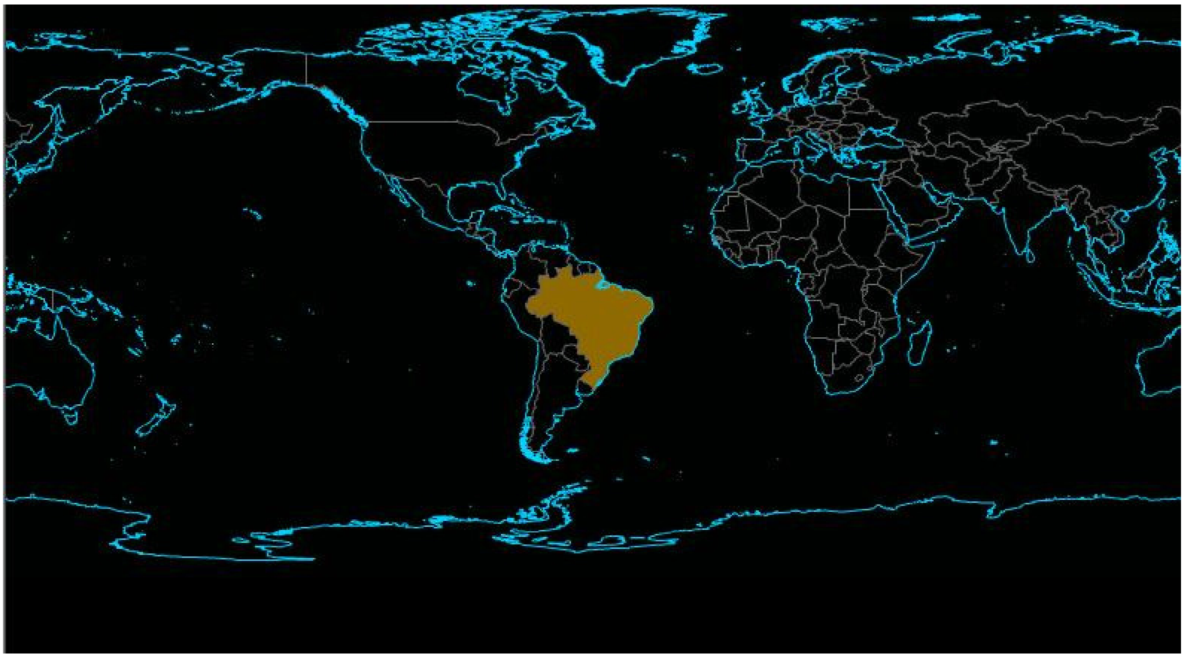
Map 1. Brazilian States, in accordance with population density
Source: IBGE, 2000

It can be observed that there is a great concentration of people in the capitals of the States that compose the South, Southeast and Northeast regions, with over 100 inhabitants per km².

Around the most populated areas, it can be found from 50 to 100 inhabitants per km², and the least populated areas are located in the Center-West and North regions.

Located in South America, Brazil (Map 2) is bordered by ten countries: French Guiana, Suriname, Guyana, Venezuela and Colombia, to the north; Uruguay and Argentina, to the south; and Paraguay, Bolivia and Peru, to the west. The only South American countries that do not have frontiers with Brazil are Ecuador and Chile.

Brazil is divided in five regions: North, Northeast, Center-West, South and Southeast. It is crossed by the Equator line and the Tropic of Capricorn. The run of the Atlantic ocean is to all the east coast of the country, offering 7.367 km of marine coast. Due to the vast territory and the diversity of the relief forms, besides the vertical height above sea level and dynamics of the air currents and masses, Brazil has a great diversity of climate and vegetation.



Map 2. Geographic Location
Source: IBGE, 2008a

4.2.3 Brazilian Biomes

The forests covering in the world totalize 40 million km² (FAO, 2006), from which 50 % are located in Europe and South America. From the 8,66 million km² that are in the South-American continent, 61 % are located in the Brazilian territory, making Brazil the second country in forestal covering in the world, only behind Russia.

Approximately 56 % of the Brazilian territory is covered by natural forests, 0,7% by planted forests and the remainder by different uses such as urban areas, infrastructure, cattle breeding and agriculture. In Brazil, there are around 22 % of the botany species and 20 % of the freshwater of the planet (SBS, 2006).

According to IBGE (2006), Brazil is divided in six biomes: Amazon Forest, Caatinga, Cerrado, Pantanal, Atlantic Forest and Pampa (Map 3). Biome is an extensive ecological life community, animal and vegetable, constituted by the gathering of vegetation patterns, with similar geoclimatic conditions and shared histories of changes, resulting in a proper biological diversity. The approximate area of each Brazilian biome can be seen in Table 2.

Map 3. Brazilian Biomes
Source: IBGE, 2006

Table 2. Approximate area of the Brazilian biomes

Brazilian Continental Biomes	Approximate Area (km²)	Area / Total Brazil
Amazon Biome	4.196.943	49,3 %
Cerrado Biome	2.036.448	23,9 %
Atlantic Forest Biome	1.110.182	13,0 %
Caatinga Biome	844.453	9,9 %
Pampa Biome	176.496	2,1 %
Pantanal Biome	150.355	1,8 %
Total Area Brazil	8.514.877	100 %

Source: IBGE, 2006

Amazon Biome

The Amazon Biome occupies more than 49 % of the Brazilian territory and it is recognized as the biggest existent tropical forest, which is equivalent to 1/3 of the moist tropical forests, occupying 2/5 of South America. It is in this biome that one can find 1/5 of the availability of freshwater of the world. The Amazon Forest is a self-sustainable ecosystem, because it keeps its own nutrients in a permanent cycle. It is also considered a carbon whirlpool, contributing for the global climatic balance. Amongst the Amazon ecosystems, one can cite the firm land forests, cultivated plains, open fields, igapós (periodically inundated parts of riverine woodland), cerrados (open pastures with patches of stunted vegetation) and flooded forests. They shelter more than 1,5 million vegetable species, three thousand fish species, 950 kinds of birds, besides diverse insects, reptiles, amphibians and mammals (IBAMA, 2007).

The richness of the Amazon biodiversity and its ecological balance, allied to the great economical value of its natural resources, demand a new conscience from the national and worldwide society, directed to sustainable development.

Cerrado Biome

The Cerrado vegetation is thus named due to its diverse ecosystemic formation. It is typically constituted by relatively short trees (up to 20 m), dispersed, scattered amongst bushes, subshrubs and a short vegetation constituted, in general, by gramineous plants.

The Brazilian Cerrado is recognized as the richest savannah worldwide in biodiversity with the presence of diverse ecosystems, a very rich flora with over 10.000 species of plants, being 4.400 of them endemic (exclusive) to this area.. The fauna presents 837 species of birds; 67 genera of mammals, embracing 161 species and nineteen endemic ones; 150 species of amphibians, 45 of which are endemic; 120 species of reptiles, being 45 of them endemic; only in the Federal District, there are 90 species of termites, a thousand species of butterflies and 500 species of bees and wasps (IBAMA, 2007).

With the interiorization of the capitals and openings of new highway networks as from the decade of 1960, the Cerrados, that until then remained practically unchanged, began to give place to the cattle breeding and extensive agriculture. Such changes have relied on the implantation of new energetic and transport infrastructures, besides the diversification in the use of soils, what allowed new profitable agrarian activities.

Amongst the federal conservation unities in the Cerrado, there are ten national parks, three ecological stations and six areas of environmental protection.

Atlantic Forest Biome

According to data from the Brazilian Institute of the Environment and Natural Renewable Resources – IBAMA (2007), the Atlantic Forest can be seen as a diversified mosaic of ecosystems, presenting differentiated floristic structures and compositions, due to differences of soil, relief and climatic characteristics existent in the vast occurrence area of this biome in Brazil.

Currently, around 7,3 % of its original forestal covering remain, identified as the fifth most threatened area and fifth richest in endemic species worldwide. In the Atlantic Forest there are 1361 species of the Brazilian fauna, with 261 species of mammals, 620 of birds, 200 of reptiles and 280 of amphibians, being that 567 species only occur in this biome. It also has around 20 thousand species of vascular plants, from which 8 thousand of them also only occur in the Atlantic Forest. In the south of Bahia, it was identified, recently, the greatest botanical diversity worldwide for ligneous plants (454 species in an only hectare).

Its current area is highly reduced and fragmented with its forestal remainders located in areas of difficult access, that shelter diverse traditional populations, including indigene nations. Besides, in it there are hydric springs which are essential for provision of about 70% of the Brazilian population.

Pampa Biome

The fields of the South region of Brazil are called *pampas*, word of indigene origin for plane region. It is a biome characterized by a vegetation composed by gramineous and creepers, some trees and bushes being found next to water courses.

The campestral vegetation shows a seeming uniformness, presenting on the planest tops a low herbaceous carpet (60 cm to 1 m), thin and poor in species, becoming thicker and richer on the hillsides, prevailing gramineous, compound and leguminous; the most common genera are: Stipa, Piptochaetium, Aristida, Melica, Briza. Seven genera of cacti and bromeliaceous plants present endemic species of the region. The alluvial Forest presents countless arboreal species of commercial interest (IBAMA, 2007).

Pantanal Biome

The Pantanal biome, one of the most valuable national patrimonies, is the biggest continental humid area in the planet, with approximately 210 mil km², being that 140 mil km² are located in Brazilian territory. It distinguishes itself for the richness of the fauna, where 263 species of fish, 122 species of mammals, 93 species of reptiles, 1.132 species of butterflies and 656 species of birds share the space (WWF, 2008).

This biome is characterized by strong rains that help in the balance of the ecosystem. According to the Worldwide Fund for Nature – WWF Brasil (2008), with the beginning of the rains in the month of November, the water level of the rivers rises resulting in floods that cover up to 2/3 of the Pantanal area. From the month of May, the water level diminishes and, when the land dries again, a mixture of vegetable, animal, seeds and humus residues remains on the surface, resulting in the soil fertility.

As a transition area, the Pantanal region exhibits various terrestrial ecosystems, besides aquatic and semiaquatic ecosystems, interdependent in higher or lower degree. The plateaus ate covered by vegetations predominantly open, such as clean fields, dirty fields, cerrados, determined, mainly, by edaphic, climatic factors, and also by humid forests, extensions of the amazonense ecosystem (IBAMA, 2008).

The Pantanal biome was recognized in 2000 as Biosphere Reservation. These reservations, declared by Unesco, are instruments of integrated sustainable management and handling that remain under the jurisdiction of the countries in which they are located (WWF, 2008).

Caatinga Biome

The Caatinga biome is the main ecosystem existent in the Brazilian Northeast region, stretching itself through the domain of semi-arid climates. It is a unique biome, because despite being located in area of semi-arid climate, it presents a big variety of landscapes, where the occurrence of seasonal and periodic dryness establishes intermittent regimes to the rivers and leaves the vegetation with no leaves.

It is dominated by kinds of vegetation with xerophytic characteristics (dry vegetable formations, that constitute a heated and thorny landscape), with strata composed by gramineous, bushes and short-sized or medium-sized trees (3 to 7 meters high), deciduous (leaves that fall), with great quantity of thorny plants (example: leguminous), intertwined with other species as the cactaceous and the bromeliaceous (IBAMA, 2007).

4.2.4 Agroforestal System

The agroforestal system, form of use where ligneous arboreal species (fruitful and/or wood) with agricultural cultivations and/or animals, aims at the optimization of production per unity of area, through the efficient use of resources, diversification of production and interaction among the components.

One of the determinant aspects of the sustainability of the agroforestal systems is the presence of trees capable of capturing nutrients of deep layers of the soil, in a way that it promotes its recycling proportionating greater vegetable covering and conservation of the edaphic resources. In this context, the systems can be planted in alternated areas by failed agricultural activities, in order to contribute with the reduction of deforestation of new forestal areas.

In Brazil, there are four kinds of agroforestal systems: agrosilvicultural systems that combine trees with yearly agricultural cultivations; agrosilvopastoral systems that combine trees with agricultural cultivations and animals; silvopastoral systems that combine trees with animals; and brushwoods enrichment systems with species of economical importance.

4.2.5 Energetic Plantations

The energetic plantations are systems that aim at larger production of biomass per unit area, in a smaller time period possessing great potential of electric energy generation. Brazil has a clean energetic matrix compared to other countries. The participation of renewable energies in the Brazilian energetic matrix is almost 45 %, while the rough average in the other countries is of 13 % (BEN, 2007).

In great part, the renewable component of the energetic matrix exists due to the hydroelectric generation of energy, but the derivatives from sugarcane, firewood and vegetable coal have an important contribution. Over 25% of the energy used in Brazil has vegetable origin. The National Energetic Balance - BEN (2007) registers that from a total use of 226,1 Mtep (million tons equivalent of petrol oil), 61,4 Mtep were of vegetable biomass, distributed in almost equal parts between firewood and sugarcane.

In Brazil, great part of the energetic biomass is commercially produced, where the sugarcane is used for the production of sugar, electricity and ethanol fuel; and the firewood, transformed in vegetable coal, is used in the metallurgical companies.

The National Institute of Energetic Efficiency – INEE (2008) estimates that currently around 25 wasted Mtep, today, could become useful energy through cultural changes. This indicates that the biomass energy transformation in useful energy is done with low efficiency. That happens due to the absence of specific and adequate energy policies.

Brazil aims also to the expansion of the biodiesel production through the biofuels. Besides the ethanol obtained in the sugarcane processing, studies were intensified to identify the most adequate oleaginous to the biodiesel production.

4.2.5.1 Energy Forests

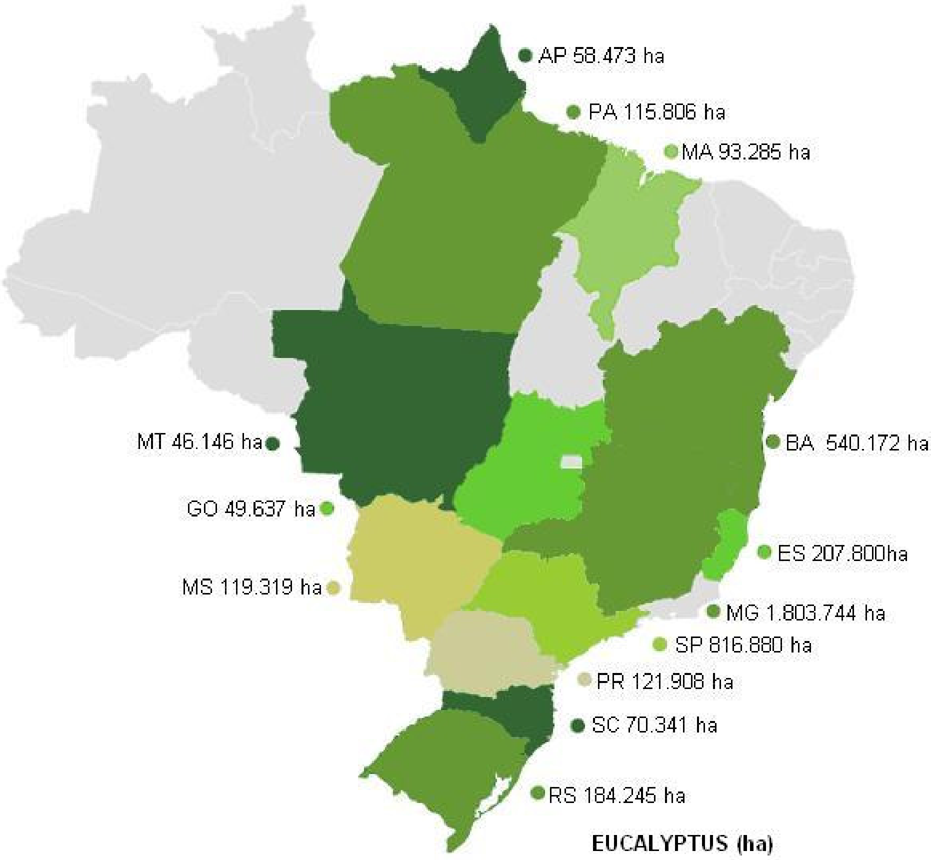
The term "energy forests", in general, means industrial forestal plantations aimed at the energy production, composed mainly by Eucalyptus and Bracatingas that substitute wood from native forests. In the context of the carbon market, the energetic forests plantations can have two kinds of benefits, through the kidnapping of carbon during the growth of the plants and also through the reduction of emissions in the substitution of the energetic matrix from fossil fuels to biomass.

The consumption of wood from planted forest has been getting an important role in the energy generation, in the segments that use firewood as main energetic raw material. This can be justified by the raise of price of the fossil fuels and by the importance of the use of renewable sources of energy (REFERÊNCIA, 2008).

According to data from BEN (2007), the wood corresponds to almost 13 % of the energy offering in Brazil. The national production of firewood originating from native forests totalized, in the year of 2005, 45,1 million m^3, being the State of Bahia the main producer, with participation of 24,8 %. In the segment of planted forests the production on the same year was of 36,1 million m^3, where the State of Rio Grande do Sul was characterized as the biggest producer accounting for 37,1 % of the national total (IBGE, 2007).

The production of firewood and coal in Brazil has in its edaphoclimatic conditions, in its eucalyptus silviculture and in its biodiversity, very important allies. With the technologies existent in the country, the commercial forestal plantations of eucalyptus allow productions of 45 m^3/hectare. Map 3 shows the area and distribution of forests planted with eucalyptus in Brazil from the year of 2005 until 2006, by means of which it is possible to visualize that the bigger concentration of this plantation is located in the States of Bahia, Minas Gerais and São Paulo.

The capacity of sustainable production of the Brazilian forests is estimated in 390 million m³ yearly. From this total, approximately 73 % are produced from eucalyptus. The use of eucalyptus as main source does not make impracticable the use of various other native species of diverse Brazilian regions, such as angico, taxi-branco, bracatinga, Brazilian pine, palmaceous, among others.



Map 4. Area and distribution of forests planted with eucalyptus in Brazil 2005-2006
Source: ABRAF, 2007

4.2.5.1.1 Main Forestal Species

The main species planted by the diverse segments (Figures 1 to 2), according to SBS (2006) and Embrapa (2008), are:

Acácia Negra (*Acacia mearnsii*): Originating from Australia, it is the third most planted vegetable species in Brazil, concentrated in the State of Rio Grande do Sul, showing good adaptation and being very used in the recuperation of soils and battle against the erosion. The area occupied by the species, according to ABRAF (2007), is of approximately 156 thousand hectares. It is used in the production of firewood and coal, besides other applications.

Araucaria or Pinheiro do Paraná (*Araucária angustifolia*): native tree from Brazil, concentrating itself in the State of Paraná. The pine tree's firewood is not of good quality, but the pine knots are great in the energy production, substituting even the coking coal. It is an excellent fuel with calorific value of approximately 8.000 kcal/kg.

Angico - branco and cascudo (*Anadenanthera colubrina and peregrina*): natives from tropical America, this species is recommended for terrain recovery or for repairing forest reposition. It produces good quality firewood and coal.

Bracatinga (*Mimosa scabrela):* native species from the cold climate regions in Brazil with bigger continuous area of handling on the South region of the country. The main use is for energy, since the bracatinga's wood supplies firewood and coal of excellent quality, with calorific power of 4,6 to 4,8 kcal/kg and of 7,2 to 7,5 kcal/kg, respectively.

Eucalyptus (*Eucalyptus spp.*): it was introduced in Brazil in 1904, with the goal of supplying the necessities of firewood, posts and railway sleepers in the Southeast region. The Eucalyptus Planted Forests are strategically distributed in the South and Southeast regions of Brazil. These forests aim at assuring the supply of raw material for the industries of paper and cellulose, metallurgy of iron by vegetable coal and firewood.

Figure 1. Planted species in Brazil: Acácia Negra, Angico and Araucaria
Source: http://coralx.ufsm.br, 2008

Taxi branco (*Sclerobium paniculatum*): native plant from the Amazon Forest, with plantation of approximately 15 thousand hectares in the North region of the country. It is a pioneer species, rising as alternative for recuperation of degraded areas and capable of producing excellent quality wood for energy.

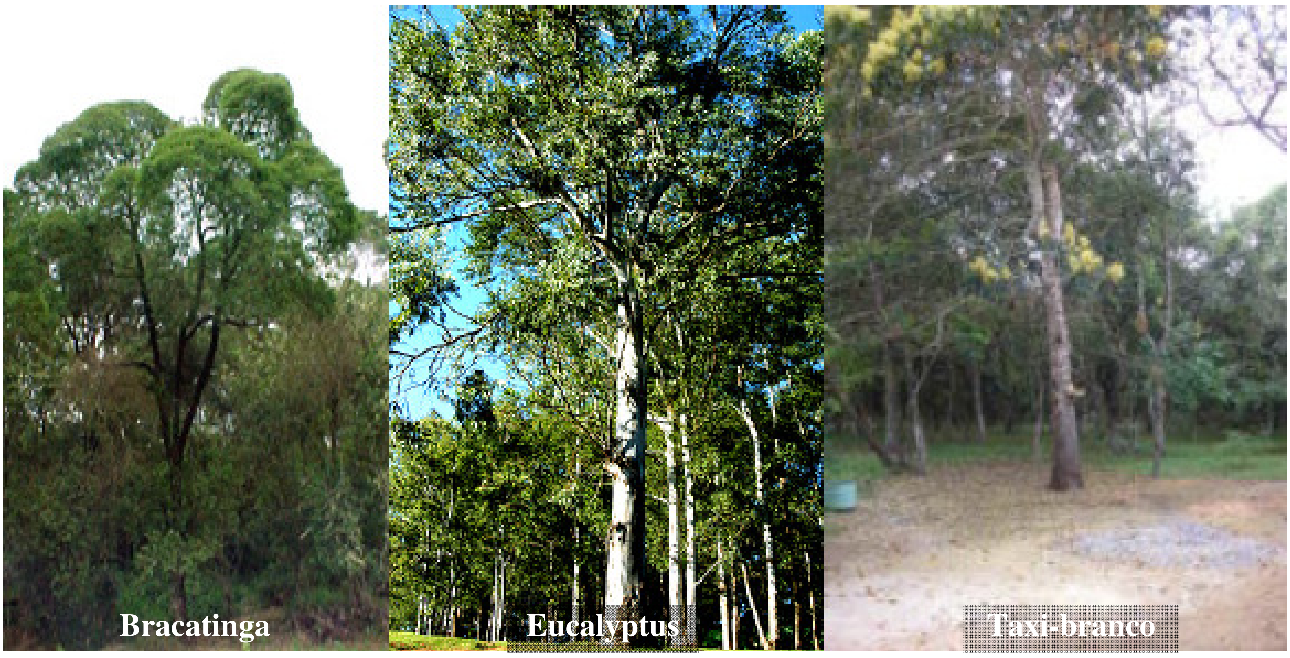


Figure 2. Species planted in Brazil: Bracatinga, Eucalyptus and Taxi-branco
Source: www.ufgd.edu.br/ , www.unicamp.br e www.lcmasiero.com.br, 2008

4.2.5.2 Sugarcane

The sugarcane (Figure 3), originating from Asia's southeast, is cultivated in an extensive territorial area presenting better efficiency in tropical climates. Initially cultivated in the Brazilian Northeast region, it expanded itself to the Southeast region, mainly in the State of São Paulo. Despite being produced in almost all the Brazilian states, nowadays, São Paulo detains around 60 % of the national production (MAPA, 2007).

Figure 3. Sugarcane
Source: SCHUCH, 2007

The recommended plantation of sugarcane is executed among the months of January and March in the Center-South region and among the months of May and July in the North-Northeast region. The climate in Brazil is exemplary for its production, since it presents a hot and humid season, that provides the germination and development of the species and other, cold and dry, promoting the maturation and accumulation of sucrose.

One of the great advantages of sugarcane is its multiple use (animal nourishment, fodder), however its main destination is for fabrication of sugar and alcohol, becoming important to the Brazilian agribusiness. Each ton of sugarcane has the energetic potential of 1,2 barrels of petroleum (UDOP, 2008). The characteristics of the sugarcane culture, such as cycle, numbers of cuttings and production of sugar and alcohol are detailed in the Table 3, right below.

Table 3. Characteristic of the sugarcane culture

Item	Dado
Cycle	5 years
Number of cuttings	5 cuttings
Productivity of sugarcane	85 ton/ha
Sugar efficiency	138 kg/ton
Alcohol efficiency	82 L/ton

Source: MAPA, 2007

According to data from the Sugar Cane Industry Union – UNICA (2008), until 2015 Brazil will be able to generate 15 % of its electric energy from sugarcane, 12 % more than the current generation, helping minimize the predicted energy scarceness. The electricity production from the sugarcane bagasse will be able to increase to 11.500 MW until 2015 and to 14.400 MW until 2020.

In the 2006-2007 harvest, the sugarcane production was of approximately 428,3 million tons, being registered the production of 17,9 million m³ of alcohol. Then, in the last harvest (2007-2008), according to data from the Ministry of Agriculture, Cattle Raising And Supply - MAPA (2008), the ethanol production reached approximately 21,7 million m³ (Table 4), while the sugarcane production reached 549,9 million tons, as it can be verified in the Table 5.

Table 4. Brazilian alcohol production 2002-2008

Region	Harvests (m³)					
	02/03	03/04	04/05	05/06	06/07	07/08
North/Northeast	1.471.141	1.723.416	1.825.786	1.508.085	1.770.726	1.572.892
Center/South	11.014.285	12.916.507	13.382.123	14.298.845	16.160.925	20.105.570
Total Brazil	**12.485.426**	**14.639.923**	**15.207.909**	**15.806.930**	**17.931.651**	**21.678.462**

Source: MAPA, 2007

Table 5. Brazilian production of sugarcane 2002-2008

Region	Harvests (ton)					
	02/03	03/04	04/05	05/06	06/07	07/08
North/Northeast	50.243.383	59.990.025	57.392.755	48.345.359	54.405.520	74.375,900
Center/South	265.878.367	297.120.858	324.054.347	334.136.643	373.912.899	475.529.500
Total Brazil	**316.121.750**	**357.110.883**	**381.447.102**	**382.482.002**	**428.318.419**	**549.905.400**

Source: MAPA, 2007

In Brazil, the sugarcane agroindustry has adopted policies of environmental preservation and recuperation in the area of remaining vegetation of the Atlantic Forest that are worldwide examples in agriculture. Besides these policies, it also develops actions with the goal of accomplishing the sustainable exploitation of the monoculture, reducing the environmental damages with actions as, for example, modern techniques of soil handling, biological pest control (avoids the application of pesticides), besides the use of the sugarcane bagasse in the electric energy generation (SINDALCOOL, 2007).

4.2.5.3 Oleaginous plants

The oleaginous plants are plants whose fruits have a high quantity of oil and can be used for production of vegetable oil, raw material for fabrication of biodiesel. Its production has increased in Brazil, however, the productivity growth potential is still huge.

In the year 2004, the Brazilian Program of Technological Development for Biodiesel – PROBIODIESEL was released, in which the use of vegetable oils for biodiesel fabrication began constituting a concrete alternative in the Brazilian energetic matrix. Then, in the year 2005, the Law 11.097/05 was instituted, which establishes minimal percentages of blending of biodiesel to diesel oil, making obligatory a blend of 2 % from 2008 on.

Nowadays, in Brazil, the raw material for oil production is concentrated in the soybean culture, since around 90 % of the vegetable oil produced yearly proceeds from this oleaginous plant. However, the soybean production on a large scale, followed by the raise of the cultivated area, will cause damages to the environment that may let it strategically unsustainable (BIODIESEL, 2007). To avoid that, studies are being done for production of biodiesel from plants traditionally cultivated in each region, like the palm tree in Pará and the Amazon Forest and the castor-oil plant in Piauí, Ceará, Bahia and Rio Grande do Norte. In the Map 4, it is possible to visualize the distribution of the oleaginous plants in Brazil, whose characteristics are described next.

Map 5. Distribution of the oleaginous plants in Brazil
Source: BIODIESEL, 2008

4.2.5.3.1 Soybean

Soybean (Figure 4), originating from China, has Brazil as second greatest producer, only behind the United States, and the worldwide greatest exporter. According to MAPA (2007) in its National Balance of Sugarcane and Agroenergy referring to the year of 2007, in the 2006/2007 harvest 58 million tons of soybean (Table 6) were produced, and the exportations in the year of 2005 summed up, approximately, 40 million tons. The oil from this culture can be used for human consumption or biodiesel fabrication, being currently one of the main challenges for the value increase to the product.

Figure 4. Soybean plantation
Source: CÔRREA et al, 2007a

Table 6. Production of soybean in Brazil, in millions of tons, 1998-2008

Year	1999/00	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08*
Total	32,34	38,43	41,92	52,02	49,79	51,45	53,43	58,19	59,58

*Estimated Source: IBGE, 2008b

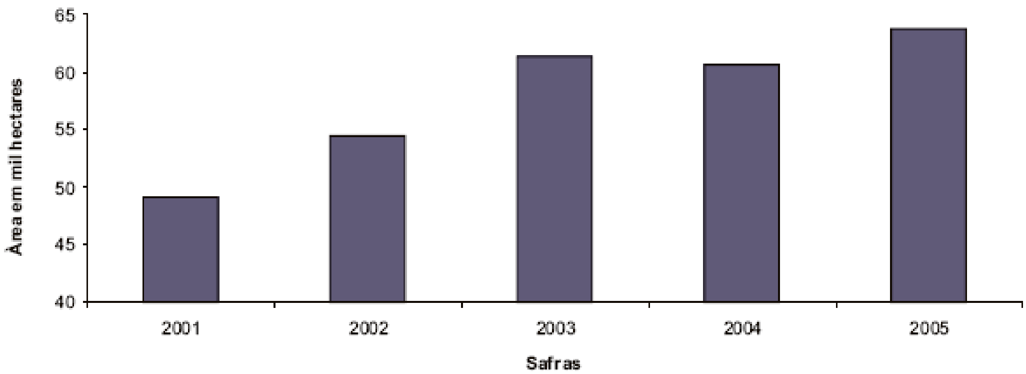
The soybean production is concentrated in the Brazilian Center-West region, responsible for 50 % of the production. The largest producer is the State of Mato Grosso with a production of 16 million tons. According to data from MAPA (2007), the soybean has a cycle of 105 to 135 days, with average productivity (grains) of 2.800 kg/ha and efficiency in vegetable oil of 560 kg/ha.

4.2.5.3.2 Palm tree

The palm tree (Figure 5), originating from the Gulf of Guinea, western coast of the African continent, was introduced in Brazil during the XVII century, where it adapted itself to the humid tropical climate of the Bahia shore. The oil from palm tree is known as dendê oil, currently found in the States of Bahia (10 %) and Pará (89 %), its main producers.

Figure 5. Palm tree
Source: www.lcmasiero.com.br, 2008

The palm productive cycle is of 25 years and the maximum production is obtained 7 years after the planting, during the 8th and 16th years. According to data from MAPA (2007), its medium productivity (in grains) is 15.000 kg/ha, with efficiency in vegetable oil of 4.000 kg/ha. The dendê oil production, showed in the Graph 1, reveals that in the year of 2005 the highest degree of 63,78 thousand planted hectares was reached.



Graph 1. Planted dendê area in Brazil
Source: MAPA, 2007

According to Embrapa (2008), the palm oil nowadays occupies the 2nd place in worldwide production of oils and greasy acids, with the possibility of surpassing the soybean in the beginning of the next century. Its use happens in the industries of eatable oils and oilchemistry. Among the vegetable oils, the dendê oil is one of the most qualified ones to substitute diesel oil due to its low production cost, high productivity and production zones, not competing with other food cultures.

4.2.5.3.3 Castor-oil plant

The castor-oil plant (Figure 6) is originating from Ethiopia and its culture has spread itself around the world, being found, predominantly, in countries in development. In the 2006/2007 harvest, Brazil produced 87 thousand tons of castor-oil seeds, and the expectations for the 2007/2008 harvest are of more than 130 thousand tons (Table 7). Brazil is the third biggest worldwide producer, only behind India and China; while the biggest Brazilian castor-oil plant producer is the State of Bahia, dominating around 80% of the national production (IBGE, 2008b).

Figure 6. Castor-oil plant
Source: EMBRAPA, 2008

Table 7. Production of castor-oil bean in Brazil, in a thousand tons, 1998-2008

Year	1999/00	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08*
Total	107,4	79,9	72,4	86,3	107,3	209,8	103,9	87,1	130,5

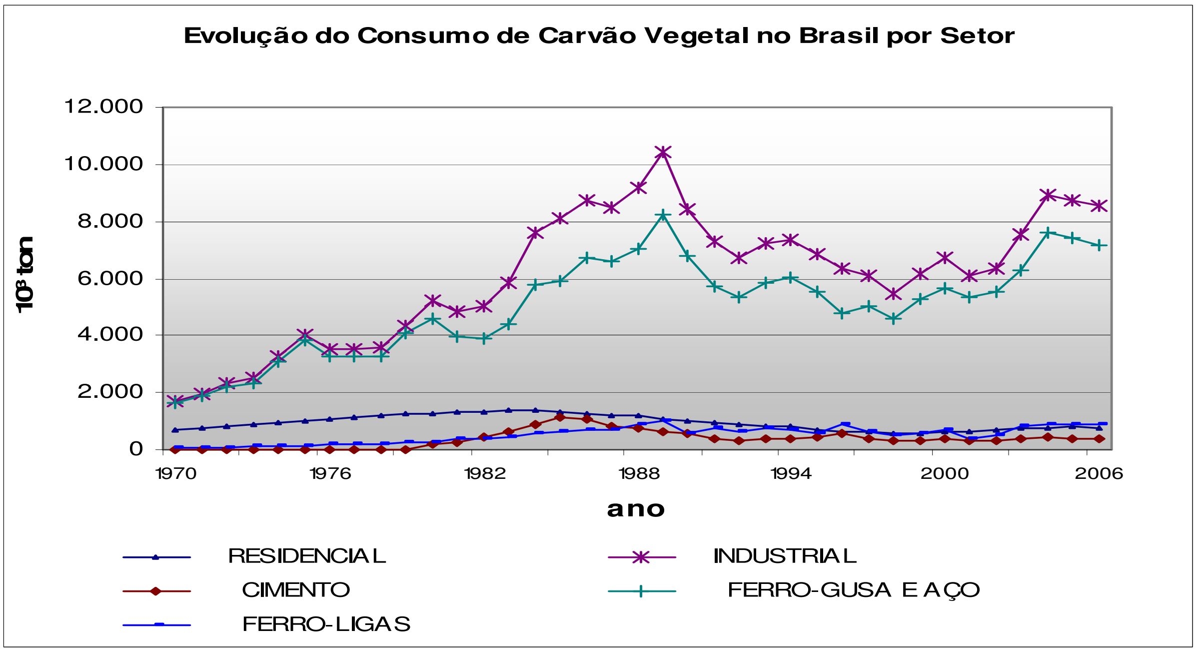
*Estimated Source: IBGE, 2008b

The productive cycle of the castor-oil plant is of 150 to 250 days, with average productivity of 1.000 kg/ha. As for the efficiency in vegetable oil, it is determined for 470 kg/ha (MAPA, 2007). One of the great advantages of the castor-oil plantation is the great tolerance to periods of dryness that the castor-oil plant has, becoming a viable culture in the semi-arid regions.

4.2.5.3 Vegetable Coal

Vegetable coal is produced from firewood by means of carbonization or pyrolysis. The average inferior calorific power of coal is 7,365 kcal/kg (30.8 MJ/kg) and the proportion of volatile material varies from 20 to 35%, fixed carbon varies from 65 to 80% and the ashes (inorganic material) from 1 to 3%. (NETO et. al., 2007)

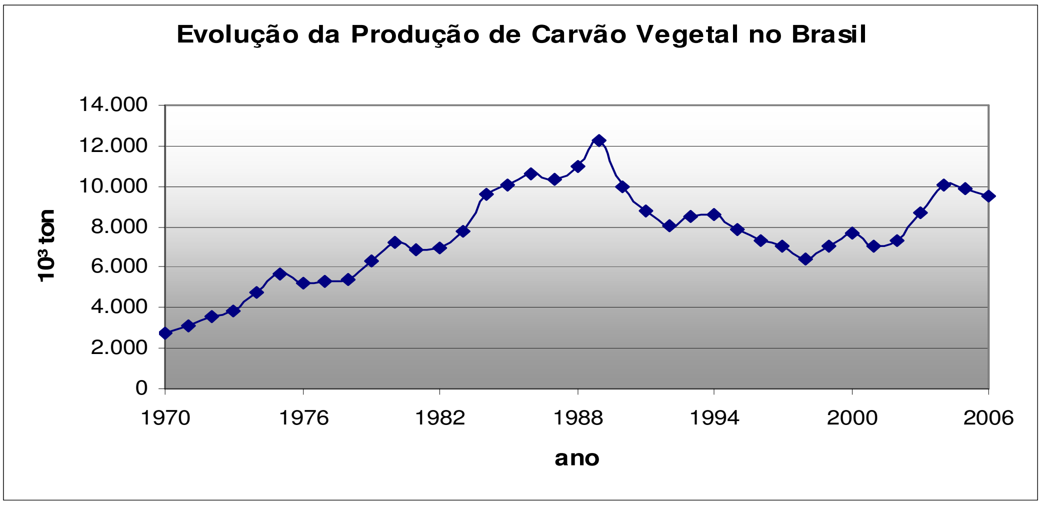
The vegetable coal consumption in Brazil is concentrated in the industry and ironworks sector, as reductor of iron ore. Besides this sector, industries of concrete, iron-bindings and the residential sector distinguish themselves in this consumption. Graph 2 presents the evolution of the vegetable coal consumption in Brazil by sector.



Graph 2. Evolution of Vegetable Coal Consumption in Brazil by Sector
Source: BEN, 2007

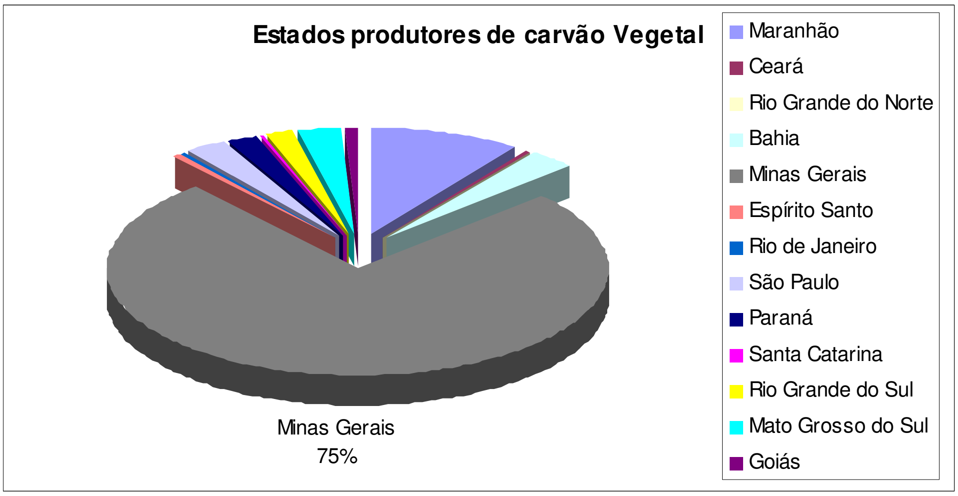
Firewood carbonization is practiced in a traditional manner in masonry furnaces with warming and cooling cycles that last until several days. The rectangular furnaces equipped with steams condensation systems and tar recoverers are the most advanced ones currently in use in the country. The cylindric furnaces with small production capacity, without mechanization and tar recovering systems are still the most used ones in the charcoal works.

According to the Brazilian Energy Balance (BEN), the vegetable coal production in Brazil obtained a stressed increase in the decade of 1980, and after a small fall it began increasing again, as shown in Graph 3.



Graph 3. Evolution of the Vegetable Coal Production in Brazil
Source: BEN, 2007

Minas Gerais is today the greatest vegetable coal producer state in Brazil, with 75% of the legal production, thus elevating the Southeast region (Graph 4).



Graph 4. Vegetable coal producer states
Source: IBGE, 2007

The main Brazilian researches regarding the vegetable coal are performed by Embrapa and IPT aiming at the substitution of firewood by other biomasses, specially the *capim-elefante*, which has been presenting good results due to its high productivity, with the possibility to be an alternative to extractivism (EMBRAPA, 2008). Neto et. al. (2007) states that in the scope of the new technologies researches, the modification of the furnaces distinguishes itself, increasing the refraction area, improving the income with the reutilization of the gases, for reheating, with great economic viability.

4.2.6. Deforestation and Burn in Brazil

According to conservative estimations, Brazil has approximately 13% of the planet's biota (LEWINSOHN; PRADO, 2005). Seven great ecosystems are part of the Brazilian territory, including the biggest tropical forest and the biggest flooded plain in the planet, Amazon Forest and Pantanal, respectively. The other five great ecosystems are the Cerrado, the Atlantic Forest, the Caatinga, the Southern Fields (Pampas) and the Coastal Systems (IBAMA, 2004).

Since the beginning of Brazil's colonization, the deforestation of the native forestal covering has been happening. Deforestation began in the 16th century at the Brazilian coast, with the exploration of brazilwood, the sugarcane plantation and the sugar mill movements. From the 17th century on, the deforestation expanded itself to the interior of the country due to the mining (provision of wood to the mines) and opening of areas for the cattle breeding.

In the 18th and 19th centuries, the deforestations prevailed in the Southeast and South regions, due to the coffee activity in Rio de Janeiro, Vale do Paraíba, São Paulo and the North of Paraná, and also because of the exploitation of araucaria on the South of the country.

The colonization of the country adopted a predatory standard which, in part, still prevails nowadays, based on the use of fire and in the sensation that the natural resources are inexhaustible. Clearly it's not just parts of the Amazon Forest that disappear, consumed by fire and by the electric saws.

The first forest to feel the weight of the axes was the Atlantic Forest, which is also the most devastated one: 751 thousand km^2 were cut down, or 30% of what was cut down until nowadays in Brazil (ZORZETTO, 2008).

The second ecosystem to have its landscape modified was the Cerrado, which in just 40 years lost 800 thousand km^2 of vegetation, yielding space to extensive cattle farms and concentrating more than half of the national production of corn, soy and beans.

The Caatinga, the only entirely Brazilian ecosystem, lost 300 thousand km^2 of natural vegetation (12% of what was cut down in the country) to agriculture, goat breeding, plaster stone exploitation, ironworks and, more recently, the fruits culture aside the margins of the São Francisco river (ZORZETTO, 2008).

The Pampas, completely occupied nowadays, lost 87 thousand km^2 of its original vegetation, 3.5% of what was devastated in national territory, to the industry, meat cattle breeding and the plantations of corn, soy bean, grape and rice. The ecosystem that remained the most intact is also the one that occupies the smallest area in the country: the Pantanal, protected by the waters that periodically cover fields and forests during various months in the year, lost only 17 thousand km^2 of its natural vegetation since the beginning of the colonization, which represents less than 1% of the deforested area of the country, as presented in the Table 8.

Table 8. Total deforestated area in each ecosystem (km^2).

Ecosystem	Total original area		Remaining area		Deforestated area		Total
	Thousand km²	%*	Thousand km²	%**	Thousand km²	%**	%***
Amazon Forest	4.230.5	49.8	3.595.2	84.98	527.5	12.47	21.14
Cerrado	2.047.2	24.1	1.236.8	60.41	798	38.98	31.99
Atlantic Forest	1.059	12.5	285.6	26.97	751.4	70.95	30.68
Caatinga	825.8	9.7	518.3	62.76	299.6	36.28	12.01
Pampas	178.2	2.1	73.7	41.36	86.8	48.71	3.48
Pantanal	151.2	1.8	131.2	86.77	17.4	11.51	0.70
Country area	**8.491.9**	**100**	**5.840.8**	**68.78**	**2.480.7**	**29.21**	**100**
	* about the country area		** about the total area		*** about deforestated total		

Source: ZORZETTO, 2008

In the 20th century, the transference of the occupation frontier, pushed by the opening of great axles and by great public and private colonization projects, allowed the North region (Legal Amazon region) to become systematically and intensely deforested (Map 6).

The expansion of the agricultural frontier and the deforestation of the Legal Amazon region are intimately connected to the context of the reorganization of the Brazilian agriculture, along with the country's accelerated industrialization from the decade of 50 on. The construction of Brazil's capital Brasília, initiated in 1956, had as its biggest goal the attempt to modify the Brazil's occupation standard that was concentrated next to the coastal zone in the last 350 years, and thus initiating a more effective occupation of the country's interior area (MAHAR, 1988).

One of the first infrastructure works was the construction of the Belém-Brasília road (BR-010) in 1958, indicated as the great responsible for the beginning of deforestation in large scale in the Legal Amazon region (MORAN et al., 1994; NEPSTAD et al., 1997). Subsequently, other highways, such as BR-364 in Mato Grosso, Rondônia and Acre, and the PA-150 in Pará, stressed even more this fact (MORAN, 1993 apud CARREIRAS, 2005).

Map 6. National territory with prominence to the Legal Amazon region

Source: IBAMA, 2003

These works served as means to the human colonization and forest conversion into agriculture and pasture in the region. In the year of 1966, a plan was created for the development (Superintendency for the Development of Amazonia – SUDAM) and a bank of regional development (Bank of Amazonia – BASA). This plan predicted the attribution of fiscal incentives to small owners or companies that intended to invest in projects in Amazonia (MORAN et al., 1994 apud CARREIRAS, 2005). The small owners received loans on quite favourable interest taxes in the first years, mainly for the culture of rice, corn and beans.

Companies and big owners were benefited with great fiscal incentives, through the non payment of taxes, in great part for the establishment of big areas of extensive pasture (MORAN, 1993 apud CARREIRAS, 2005). A significant part of deforestation in the Legal Amazonia is attributed to this last way of fiscal incentives, being minimal the percentage of deforestation attributed to small owners that practice, in most of the cases, a subsistence agriculture (FEARNSIDE, 1993 apud CARREIRAS, 2005).

In the end of the 1970 years, after the inauguration of the Transamazonic highway and by request of the Superintendency for the Development of Amazonia (SUDAM), the Brazil National Institute for Space Research (INPE) did the first balance of the devastation with the aid of the images sent by Landsat-1, satellite from Nasa, the North-American space agency. It was discovered that 2.5% of the region was already degraded.

Tem years later, when the burnings in the region began to draw international attention and the deforestation rate grew to 10%, the country decided to adopt a deforestation control policy and created, in 1988, the Program for the Estimation of Deforestation in the Brazilian Amazon (PRODES).

Along of 20 years and at the cost of the devastation of 17% of the Amazon biome, Brazil developed a tracking system of the approximately 5 million km^2 of the Legal Amazon region qualified as “enviable” by the Science magazine, issue 316, from April 27th, 2007.

The deforestation in the Legal Amazonia concentrated itself in the South and East regions, in the called “arc of deforestation and burnings”, which goes from Acre until Maranhão.

Nowadays, the devastated areas from the Amazon Forest, the Cerrado, the Atlantic Forest, the Caatinga, the Pampas and the Pantanal add up to 2,5 million km^2 (250 million hectares) of native vegetation removed since the beginning of the colonization by the Europeans. This is the equivalent to 30% of the Brazilian territory or to the sum of the surfaces of the North and Southeast regions. It is valued that the deforestation, in all the Brazilian territory, is superior to 300 million hectares of forests (IBAMA, 2003).

The deforestation and the burnings of the Amazon region constituted the most serious concerns from the environmentalists in the last decades, for causing unpredictable unbalances to the environment, with unknown consequences. The illegal wood extraction and the deforestation for alternative soil use, mainly for the formation of extensive pasture areas and agricultural plantations, correspond to the greatest threat to the forests. Only in the last seven years, over 136 thousand km^2 of the Legal Amazonia were devastated, as presented by the Table 9.

The deforestation of the Legal Amazon region releases in the atmosphere, every year, around 4% of the worldwide carbon emissions, a quantity that countries as England emit per year. This fact presents Brazil as one of the greatest worldwide emitters of carbon, right behind the United States, China, the countries from the former Soviet Union, Japan and India.

Table 9. Rate of yearly deforestation in the Legal Amazonia (km^2/year)

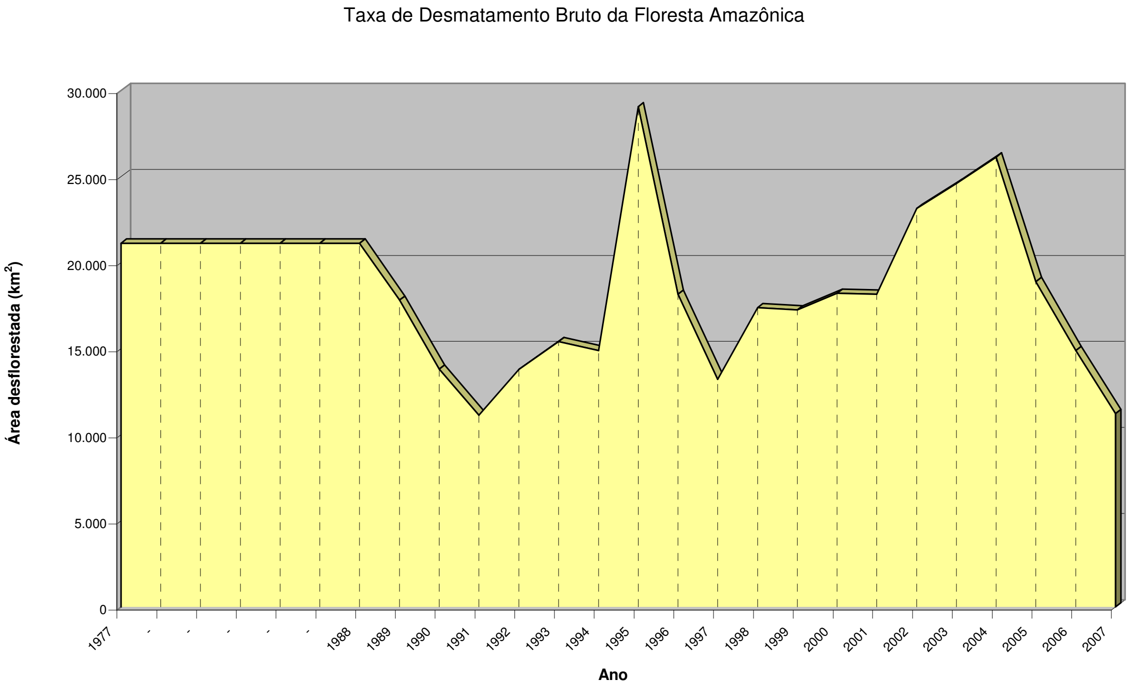
States\Year	2001	2002	2003	2004	2005	2006	2007
Acre	419	762	1061	729	539	323	136
Amazonas	634	881	1587	1211	752	780	582
Amapá	7	0	25,00	46,00	33,00	30	0
Maranhão	958	1014	993	755	922	651	631
Mato Grosso	7703	7892	10405	11814	7145	4333	2476
Pará	5237	7324	6996	8521	5731	5505	5569
Rondônia	2673	3067	3620	3834	3233	2062	1465
Roraima	345	84	439	311	133	231	306
Tocantins	189	212	156	158	271	124	59
Legal Amazon region	**18.165**	**21.238**	**25.282**	**27.379**	**18.759**	**14.039**	**11.224**

Source: Adapted from INPE, 2008

The Brazilian Federal Government implemented an action plan of prevention and control of the deforestation and burnings in the Amazon region and, from 2004 to 2007, the yearly deforestation rate in the Legal Amazonia fell from 27 thousand km^2 to, approximately, 11 thousand km^2, one of the smallest rates from the last 20 years. Indeed, the governmental strategies to expand the protected areas, fight the infractors and attack the corruption are among the most important means to fight the deforestation and the burnings.

Since the middle of the 70 decade, Brazil has been investing in the use of spatial technology and data by remote sensing to evaluate and monitor its natural resources. This investment allows that currently the country not only estimates the yearly rate of gross deforestation in the Legal Amazonia (approximately 60% of the national territory), but also has a deforestation alert system that allows the taking of immediate control actions in the areas that are being affected by illegal activities (Graph 5).

Brazil has an ambitious space program that embraces a launching station, platform of data collection and Earth observation satellites of its own and in conjoint, as for example, the China-Brazil Earth Resources Satellite - CBERS. The availability of the images was essential to the definition of policies and measures, especially in the Amazonia, which still keeps approximately 83% of its original vegetation covering (BRAZIL, 2004).



Graph 5. Rate of Gross Deforestation in Amazonia
Source: adapted from INPE, 2008

On July, 2003, the Interministerial Permanent Working Group was created through a presidential decree with the goal of proposing measures and coordinating actions that aim at the reduction of the deforestation rates in the Legal Amazonia, by fiscal incentives to raise the economical feasibility of the already deforested areas and to generate jobs and income through activities of regeneration of the degraded areas (BRAZIL, 2004).

The goal is to promote the reduction of the deforestation rate in Brazilian Amazonia by means of a group of integrated actions, among which there is the territorial zoning, supervision and control, encouragement to the activities and sustainable production infrastructure, involving partnerships among the federal and state governments, city halls, the civil society and the public sector.

The plan foresees measures that have the potential of causing immediate effects, besides other priority actions that can take more time to generate effective results, but that must be initiated immediately because of their importance in the structuring of solutions at long term.

Among the measures to be implemented in Amazonia, in order to reduce the deforestation rate, there are: (BRAZIL, 2004).

- valorization of the forest to preserve the biodiversity, forestal management of wood and non-wood products, and environmental services;
- incentives for sustainable recovery of the already deforested areas, in order to reduce the pressure over the native forests;
- territorial zoning;
- continuous improvement of the instruments of supervision, licensing and control; and
- decentralized management of the public policies, through partnerships between the federal and state governments and the municipalities.

4.2.7 State-of-the-art

In this chapter, it is presented the state-of-the-art of the gasification technologies, of use of vegetable oils and sugarcane residues for energy generation, as well as researches developed in Brazil, especially through projects developed by CENBIO.

4.2.7.1 Gasification

Biomass gasification has as its goal to turn solid fuels into a gaseous fuel mixture with better transportation characteristics, better combustion efficiency and that can be used as raw material for other processes. The gasification process is defined as partial combustion of the biomass, where the oxygen is in lesser quantity in relation to what would be needed to the total biomass burning, producing carbon monoxide (CO) and hydrogen (H_2) and, depending on the conditions, methane (CH_4), light hydrocarbons (HC), nitrogen and water steam (H_2O) in different ratios.

The composition of the gases and the concurrent production of solid fuels (coal) and condensable liquid fuels (pyroligneous) depend on factors such as the kind of gasification furnace, the way of energy supplying to the process, the introduction or no introduction of water steam alongside the fuel, the retention time of the load, withdrawal system of gases and other products and, at last, the organic matter used.

The produced gases can be used as fuel in ovens, engines and turbines, direct reducer in metallurgical furnaces or raw material for production of syngas for methanol, ammonia water, etc. The biomass gasification process is resultant from complex reactions, which are still not very well known in their entirety. However, in an introductory way and in theoretical terms, it can be subdivided in the following stages:

1. Pyrolysis or thermal decomposition, which happens at temperatures next to 600 ºC.
2. Oxidation of part of the fixed carbon of the fuel, method that constitutes the source of thermal energy for the process of volatilization and gasification.
3. Gasification itself, which includes heterogeneous reactions between the gases and the residual coke, as well as homogeneous reactions among the products already formed.

4. Tar cracking – thermal destruction process of the molecules of the compositions that constitute tar with the obtainment of CO, CO_2, CH_4 and another gases as products.

5. Partial oxidation of the pyrolysis products.

Depending on the organization of the gasification process (relative movement of the biomass and of the gasification gas), these stages happen in different regions of the gasifier or in its volume simultaneously.

4.2.7.1.1 Main types of Gasifiers

Most gasifiers currently in commercialization or in development stage can be classified, according to the type of bed used, in one of the two conceptions: fixed bed gasifier and fluidized bed gasifier.

Fixed bed gasifiers

Most gasifiers in operation or construction stage in the world are fixed bed, indicated for gasification in small scale. Among these gasifiers, two great groups can be detached: the ones of drowndraft gases circulation, and the ones of updraft gases circulation.

The updraft gasifier (with coal burning) is the most antique and simple project, largely used for biomass gasification. In Brazil, some companies of production of CaO (lime) still use them, gasifying wood logs for generation of fuel gas for feeding the calcination furnaces.

In this configuration, the fuel is fed by the top of the gasifier through a rotative valve (or feeding door) and descends in countercurrent to the air or oxygen that is introduced by the grate, and the fuel ashes, still with some fraction of carbon not converted into gas, come out by the gasifier bottom, as showed in Figure 7.

The main advantages of the updraft gasifiers are based in the operational simplicity and the ability to gasify materials with high proportion of water and inorganic matter, such as residual mud from the sewer treatment, however, the generated gas usually contains tar, which should be removed in case the gaseous mixture is applied in internal combustion engines, turbines or for syngas generation.

In the drowndraft gasifier, constructively similar to the updraft gasifier, the air and the gas flow downward, in the same direction of the fuel, and this change of direction causes a great difference to a fuel with high proportion of volatile matter such as biomass. The air injected in this gasifier can burn up to 99.9 % of the tar liberated by the fuel.

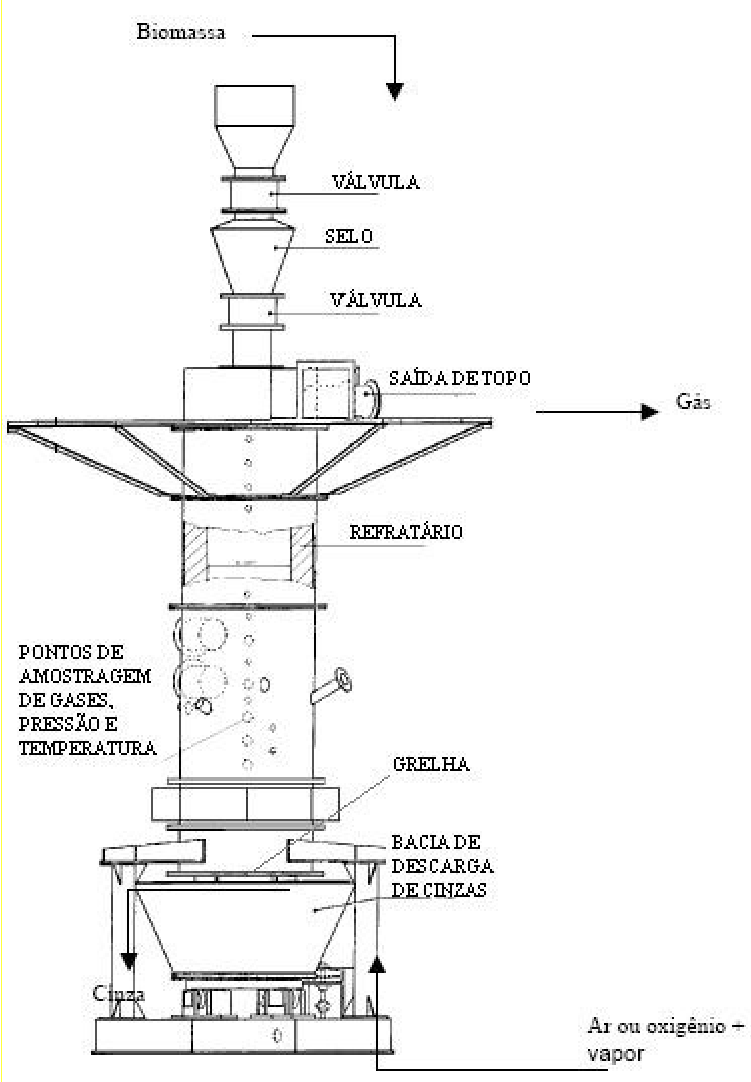


Figure 7. Updraft gasifier
Source: CENBIO, 2002

Variations of the drowndraft gasification unit have been built and tested, and the model developed by MUKUNDA et al (1994), from the Indian Science Institute - IIS has been presenting good results in evaluation tests in laboratories and in field, in India, reason why two units were brought to Brazil for evaluation tests of performance with local biomasses.

These gasifiers work in depression and they are open to the atmosphere in the top, through which around $^2/_3$ of the gasification air enters and the remainder is injected through beaks located above the grate. They have body of metallic material and, in regions submitted to high temperature, refractory material is used (Figure 8).

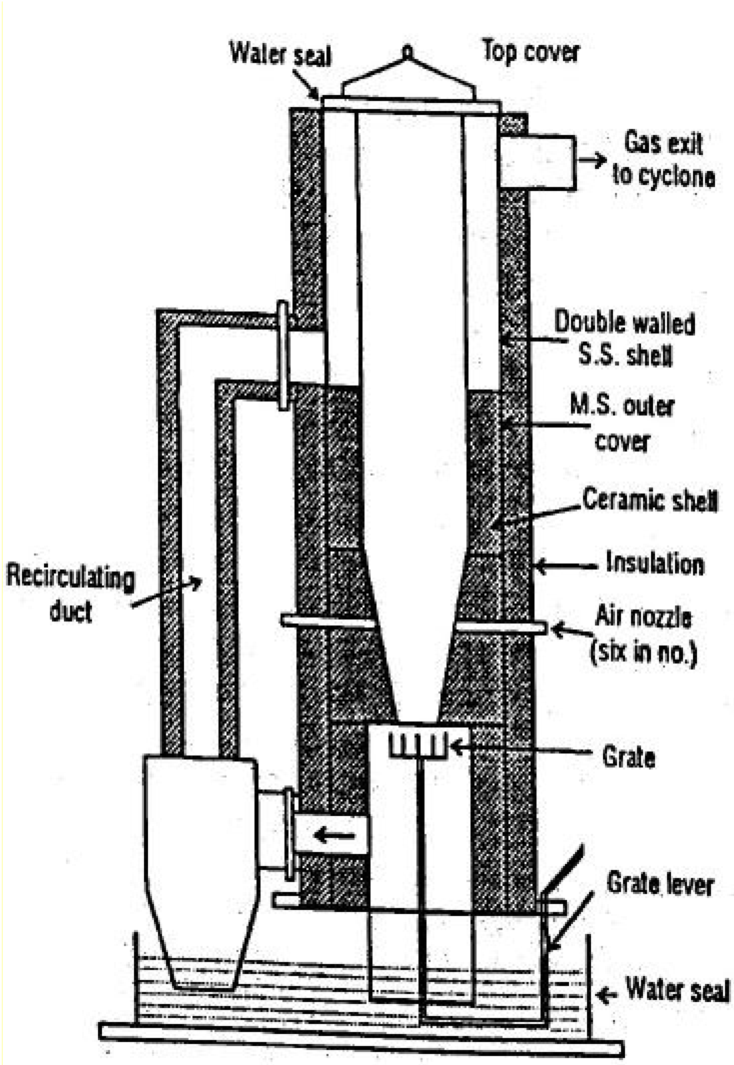


Figure 8. Drowndraft gasifier
Source: CENBIO, 2002

The typical composition of the gas generated in the IIS gasifier is presented in Table 10, below.

Table 10. Typical composition of generated gas in the IIS Gasifier (% Vol. b. s.)

CO	H_2	CH_4	CO_2	N_2
19 ± 1	18 ± 2	1,25 ± 0,5	12 ± 2	Complete

Source: CENBIO, 2002

Among the advantages of the drowndraft gasifiers, there are the high tar consumption (99 to 99.9 %), allowing the transportation and use of the gas in engines with a minimum of cleanness, the retention of inorganic matters in the coal matrix and ashes removed through the bottom of the gasifiers. However, the fuel must present smooth granulometry and low humidity, and 4 to 7 % of the carbon of the fuel is not converted, going out as ashes through the bottom of the gasifier.

Fluidized bed gasifiers

The fluidized bed gasifiers can be of bubbling bed or of circulating bed, where the basic difference consists in the speed with which the matter crosses over the bed. The gasifier of bubbling bed was the first fluidized bed gasifier to be projected, with speed of 1 m/s. In the one of circulating bed, the matter crosses over in higher speed (7 a 10 m/s), allowing a better mixture of the air with the fuel to be gasified.

The biomass combustion in fluidized bed has been largely used due to its characteristic of being able to operate with fuel with high humidity (until 65 % of humidity). They are recognized as being more flexible regarding the fed fuel, but they should not be considered as able to operate with any kind of fuel.

Operations at pressures a little bit higher than the atmospheric pressure are very difficult, demanding flood-gates system, feeding through screws and special sealing systems. However, there are many advantages in operating these gasifiers by pressures in the order of 10 to 20 bar, since gas turbines and synthesis processes usually use gases at high pressures. Besides, the gasificator capacity rapidly increases with the pressure.

4.2.7.1.2 Gasification Researches in Brazil

The North and Northeast regions of the country concentrate most of the Brazilian communities with no access to the electricity distribution network; however, the solutions adopted for this question have frequently showed themselves as unsatisfactory.

The electricity supply model that exists in the other parts of the country does not attend to the unique characteristics of these regions. The centralized electricity production and the distribution through transmission networks are impractical in a scenery in which the consumers are distributed throughout a very large region.

Most of the communities have a partial electrification system through small generator groups powered by diesel oil, however, due to the high maintenance cost of the equipments and of diesel oil, the engines are either abandoned or they operate during few days in the month.

Therefore, the use of small scale electricity generation units, by using regional fuels such as biomass, presents itself as an economically viable alternative for these places. Due to the significance of this theme, currently, some organizations are doing researches about gasification in Brazil, such as the University of Campinas – UNICAMP, that built fluidized bed reactors for biomass gasification, accomplishing tests with rice peels, sawdust and sugarcane bagasse. The Institute of Technological Researches of the State of São Paulo – IPT projected and built in the last years some pilot installments, which remain assembled in the Laboratory of Industrial Combustion - LCI, for execution of labors of self-motivated experimental investigation, besides taking care of labor of interest from the industrial sphere. Installed in the LCI, there is a a fixed bed gasifier (Figure 9) and fluidized bed gasifier (Figure 10).

Figure 9. Fixed bed gasifier
Source: CENBIO, 2002

Figure 10. Fluidized bed gasifier
Source: CENBIO, 2002

In the year of 2007, the Research Group on Treatment of Ores, Energy and the Environment - TEMA, of the Federal University of Pará – UFPA, developed the project "Montagem e Testes de um Sistema com Gaseificador de Biomassa, para Geração Distribuída de Eletricidade" (Assembling and Tests of a System with Biomass Gasifier, for Electricity Distributed Generation), to be installed in waterside communities in the southeast of Pará.

The Federal University of Itajubá counts on a Laboratory of Gas Turbines and Biomass Gasification that has a fluidized bed gasifier for biomass (Figure 11), linked to a 30 kW gas microturbine, for accomplishment of tests.

Professor Luiz Augusto Horta Nogueira, from this university, developed the Project Integrated System of Wood Gasification for Electricity Production (WBP/SIGAME), aiming to demonstrate the commercial viability of the electricity generation, from wood, through the use of the gasification technology integrated to a gas turbine, operating in combined cycle, whose goal intended the installment of an usine with liquid potency of around 32 MW (Figure 12).

Figure 11. Itajuba Fluidized bed gasifier
Source: NEST, 2008

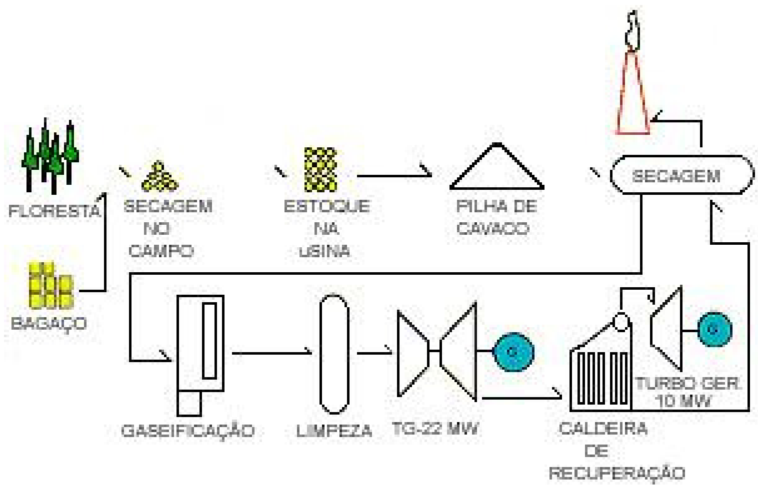


Figure 12. Project WBP/SIGAME
Source: MCT, 2008

The project was conceived to be developed in 5 stages, being: Stage 1 – Initial studies; Stage 2 – Development of equipments, basic engineering and institutional infrastructure; Stage 3 - Implantation; Stage 4 – Operation in demonstration regime; and Stage 5 – Commercial operation. It started in 1991, with expectations of conclusion in 2003 and operation in 2004, however, the project is paralyzed, due to the existent uncertainties regarding the technology (APOLINÁRIO, 2006).

The Brazilian company Termoquip Energia Alternativa Ltda developed a drowndraft gasifier, specifically for firewood gasification and production of electricity and, currently, it produces gasifiers made to order.

4.2.7.1.3 Projects developed by CENBIO

The GASEIFAMAZ Project - "Comparison among Existing Biomass Gasification Technologies in Brazil and Abroad and Human Resources Formation in the North Region", financed by the Studies and Projects Funding Body - FINEP, was developed from the year of 2002 to 2005, having as its partners IPT, the Biomass Users Network from Brasil – BUN, and the University of Amazonas - UFAM.

This Project, with the goal of supplying, in a sustainable way, the demand of electric energy in isolated communities, imported a 20 kW gasification system, from the Indian Institute of Science (IISc), and installed it at IPT (Figure 13) for accomplishment of tests, in order to evaluate the operation conditions of these gasification systems and of gas cleaning, and electricity generation.

Figure 13. Indian gasifier installed at IPT
Source: CENBIO, 2002

After the conclusion of the tests at IPT, CENBIO transferred and installed the gasification system in the Aquidabam Settlement (Figures 14 to 16), in the State of Amazonas, where it is fed with the residues of the agricultural activity of the region, with notability to the cupuaçu peels.

Figure 14. Aquidabam Settlement
Source: CENBIO, 2002

Figure 15.Shelter of the gasification system
Source: CENBIO, 2002

Figure 16.Gasifier installed in the community
Source: CENBIO, 2002

To begin the gasification process, vegetable coal was used, standard procedure, which aims to avoid the excessive tar accumulation in the system. After this process, the system operated normally with cupuaçu peels, reaching a substitution of 80% of diesel oil. The main results obtained in the tests are presented in Table 11.

Table 11. Main tests results

Superior Calorific Power (MJ/Nm³)	5.7
Thermal Power (kW)	67.1
Electrical Potency (kWe)	20
Outflow of Biomass Feeding (kg/h)	≈ 18
Outflow of Discharge of Ashes (kg/h)	1.3

Source: COELHO et. al., 2004

Throughout the development of the project, it was discovered the need to link the energy generation to the productive activity, since it is very important for the continuity of the project. The use of the biomass gasification system in the electricity generation in the Aquidabam Settlement can represent a reduction of up to 80% in the fossil fuel consumption, main responsible for the emission of the greenhouse gases emission. Besides, it provides the production of clean and renewable energy that uses the biomass available in the isolated communities for electricity generation.

With the experience acquired in the GASEIFAMAZ project, CENBIO developed the GASEIBRAS project – "Biomass Gasification Technology Nationalization and Human Resources Formation in the North Region", financed by the National Council for Scientific and Technological Development – CNPq and by the Ministry of Mines and Energy – MME, during the years of 2005 to 2007.

The suggestion of this project was, through the experience acquired in the GASEIFAMAZ project, to develop and build a fixed bed gasification system with capacity of 20 kW, with national technology, of easy operation and maintenance, fed with *in natura* biomass residues locally available, to be installed in the Timbó community (Figure 17), in the municipality of Manacapuru, in the State of Amazonas; it is a community in which live approximately 380 people.

Figure 17. Timbó Community
Source: CENBIO, 2003a

The 20 kW system (Figure 18) was developed and tested by IPT, however, before its conclusion, the Timbó community was electrified by the *Programa Luz para Todos* (Light for Everybody Program), from the Brazilian Federal Government. Due to the great difficulty in selecting other community to receive it in fit time, before the enclosure of the Project, the gasification system remained at IPT for demonstration and improvement.

The GASEIBRAS project, as well as the GASEIFAMAZ project, had a particular significance, because besides contributing to the research installments that already work in the electricity generation area, it will be able to be replicated in other isolated communities in the country, collaborating with the energetic provision for Brazilian people without access to electric energy, mainly in the Amazon region.

Figure 18. Gasifier of the GASEIBRAS project
Source: CENBIO, 2003a

4.2.7.2 Vegetable Oils

Brazil has approximately 200 species of oleaginous plants, but most of them do not have directioned studies, making necessary the development of researches to improve this activity (ABA, 2007). The culture of oleaginous plants vary according to climate conditions, soil, infrastructure, productive arrangement, among others, being indicated to the Brazilian semi-arid regions the culture of castor-oil plant, cotton and jatropha, while in the North region the expansion of the palmaceous plants culture occurs. In the Brazilian Center-South regions, the possibilities of culture are the ones of sunflower and soybean (ABA, 2007a).

The vegetable oils are renewable resources of forestal or agricultural origin, and their use implies environmental, social and economic advantages. They can be used *in natura* or modified by the transesterification process, which consists in a reaction between ethylic or methylic alcohol with a catalyzer, obtaining biodiesel.

Biodiesel has been added to diesel oil in small proportions for use in the Brazilian automotive fleet, sparing any modification in the engines. As for the vegetable oil *in natura*, it can be used in multifuel engines for electricity generation, a system that has been showing itself successful in isolated communities in the North and Northeast regions, that do not have access to energy.

Therefore, as fuels commonly used, the vegetable oils must also possess specific physical-chemical properties for the good functioning of the engines. The evaluation of the burning quality requires the analysis of important characteristics such as calorific power, cetane rate and viscosity. The calorific power of the vegetable oil allows to establish the maximum potency reached by the engine. The cetane number defines the combustion power of the oil, conditioning the performance of the engine and, the bigger this number is, the smaller will be the ignition retardation. The vegetable oils present very high viscosity values, being able to exceed in 10 times the viscosity of the diesel oil, reaching rates 100 times greater, as in the case of castor oil.

The viscosity has influence in the pulverization mechanism of the fuel jet, thus affecting the injection system and, therefore, the preheating of the oil can be done in order that there is an adequate atomization by the injectors. In case it does not happen, the burning will not be perfect, forming depositions in the injectors and cylinders, resulting in bad performance, greater emissions and reduction in the useful life of the engine.

The vegetable oil extraction process begins with the precleanness and classification of the seeds, since the presence of strange matters can damage the equipments, reducing the efficiency of the oil. The posterior stage consists in the removal of the peels of the seeds by breakers and separation systems.

To make the cooking and the pressing easier, the grains pass through a grinding process through a mill of knives or of hammers. They then follow to the cooking process in equipments capable of controlling the temperature, humidity and time of permanency, whose goal is the liberation of the oil contained in the seeds. Finally, in the pressing, there is the obtainment of the raw oil, following later to the filtration process, where mass particles present in the oil are separated. The refinement of the vegetable oil happens in various stages, depending on the kind of oil, the variety of the oleaginous plant, the quality of the raw oil and the application that one wishes to give to the final product.

Proper equipments lines were developed for extraction of vegetable oils, in order to attend the needs of the familiar agriculture. The existent extraction plants are destined to different production capacities, presenting all the necessary stages for the obtainment of the vegetable oil.

Among the advantages of biodiesel use such as substitution to diesel oil fuel, we can stand out the reduction of emission of pollutants and the possibility of obtainment in isolated places like communities in the North region of Brazil.

4.2.6.2.1 Vegetable oil researches in Brazil

In 1983, due to the raise in the petroleum price, the Brazilian Government implemented the National Vegetable Oils Energy Program - OVEG, where it was tested the use of biodiesel and fuel mixtures in vehicles, that circulated more than a million kilometers. At the end of the tests, it was verified the economical feasibility of these fuels; however, since the price of the biodiesel was more expensive than the one of diesel oil, the production of biodiesel in commercial scale became impracticable.

In 2000, it was launched the PROBIOAMAZON program, in partnership with the Ministry of Science and Technology – MCT and the Ministry of Rural Development – MDA, with perspective of production of approximately 500 thousand tons of palm oil per year in the North Region of the country.

In level of research and development, biodiesel already integrates the agenda of important public and private entities, such as the MCT and the Ministry of Mines and Energy - MME, research institutions, the National Petroleum Agency - ANP, Embrapa and Petrobras, besides initiatives promoted by various States of the Federation and by entities such as the Tecnologias Bioenergéticas Ltda. (Tecbio), the Brazilian Association of Vegetable Oil Industries (Abiove), the National Agriculture Confederation (CNA) and the Brazilian Reference Center on Biofuels – CERBIO.

MCT started, in 2002, the Brazilian Biofuel Technological Development Program – PROBIODIESEL, whose goal was to develop production technologies and the consumption market of biofuels from the production of oleaginous plants and national ethanol, generating jobs and income in the different regions of the country.

In the end of 2003 it was created the Program's Interministerial Executive Comission, which approved, in April, 2004, the National Plan of Biofuel Production and Use - PNPB, whose goal is to produce biodiesel from different oleaginous sources, in various regions, through the implantation of a sustainable program, promoting social inclusion, besides guaranteeing competitive prices, quality and supply. In the course of 2003 and 2004, projects were elaborated in partnership with 23 States, which sanctioned among themselves a Cooperation Agreement, allowing the mapping of the competency installed in the country, working as a basis for the structuring and implantation of the biodiesel network in Brazil.

CERBIO, one of the executive laboratories of PROBIODIESEL, evaluates the competitive, economic, social and environmental feasibility of each project. Its mission is to create innovative technological solutions in the biofuels área, developing projects such as the Program of Tests and Rehearsals in Engines with Biodiesel, Technological Biodiesel Development, Program of Communitary Vegetable Oil Mini-Usines, among others.

The two other executors of the Program are IPT and the National Institute of Technology – INT, responsible for the accomplishment of operational tests, proposing routes for the program and resolving the existent problems. CENBIO was responsible, along with the State University of Santa Cruz –UESC and with COPPE from the Federal University of Rio de Janeiro, for doing a comparative study of environmental pre-viability between the type D diesel oil and the soybean oil ethylic ester, consonant with the GT3 stage – Socio-Environmental Analysis of the PROBIODIESEL Program. In this study the chosen environmental categories were comparatively quantified, alongside the life cycle of biodiesel and of diesel, besides identifying the best alternatives for biodiesel production from soybean oil, as well as critical points on the environmental point of view, susceptible to improvements.

4.2.7.2.2 Projects developed by CENBIO

The PROVEGAM Project – Implantation and test of a vegetable oil energetic utilization demonstration unit, financed by FINEP, had as its goal to expand the supply of electric energy in isolated communities through the installation of a conventional diesel engine adapted to work with *in natura* palm oil. The Project was installed in the Vila Soledade community (Figure 19), in the municipality of Moju, State of Pará, where approximately 700 inhabitants reside.

Figure 19. Vila Soledade community
Source: CENBIO, 2003

Before the implementation of the project, the energy was supplied to the community by means of a 75 kVA diesel generator group, which due to the high cost of the fuel only operated three hours per day. The new generator group, adapted with converter kit imported from the German Biocar company was initially tested in Embrapa Pará, where it was noticed the existence of cloggings with consequent losses of potency and halts of the diesel-generator.

Therefore, the development of a feeding system for the use of palm oil in the diesel-generator was decided, whose task of the project and construction of the equipment (Figure 20) was attributed to the Laboratory of Thermal Machines - LMT of the COPPE/UFRJ. This system, that became called Conversion Kit, also gathers the function of reducing the viscosity of the *in natura* palm oil through heating, using the cooling water of the engine as heat exchanger.

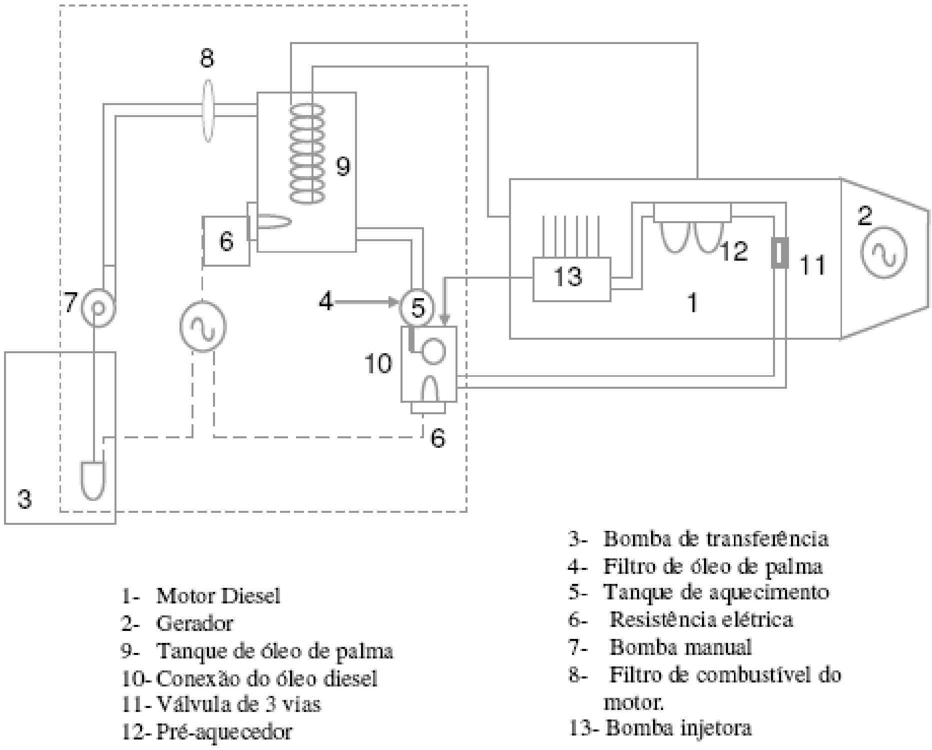


Figure 20. Conversion kit for palm oil
Source: CENBIO, 2003

Initially, the palm oil is heated in the tank (5) at a temperature of 60 ℃, so that it can be aspirated and pressurized by the pump (7) and filtrated (8) before being allowed by the preheating tank (9). In the tank, the cooling water of the engine passes through the cooling worm, heating the palm oil at approximately 75 ℃. There is the possibility that the oil is heated in the tank through an electric resistance (6), in the beginning of the functioning of the diesel-generator.

After the tests of the system at Embrapa, the same system was installed in the Vila Soledade community, where it remained in tests, being executed change of the lubricative oil with 200 hours of functioning. Due to the accumulation of residues, the filters began to be substituted every four days and the injector nozzles were changed after 500 hours of functioning. With 750 hours, the cleaning in the admission filter was done and its change was recommended, besides the detection of presence of abrasive elements in the fuel oil. Despite the need of substitution of the pistons and of the retention valves, the remaining components were in perfect operation conditions.

The project implemented in Vila Soledade promoted the development of the region in the social and economic aspects. In the end of 2004, after the implantation period, 80% of the residences had access to electric energy, resulting in a significative raise in the purchase of household appliances and lamps. The availability of continuous good quality energy allowed the investment of the inhabitants in açaí processing machines, freezer and refrigerators, used for freezing and commercialization of regional products, besides the food of the families themselves. Another benefit was the beginning of the classes of the night course in the municipal school of the community that will amplify the educative attendance to the community, including the alphabetizing of adults.

In Vila Soledade there is a project of culture of oil palm tree in familiar agriculture system that contemplates 100 families and 1000 hectares, generating the necessary fruits to the feeding of the engine with vegetable oil that consumes 18.000 kg of palm oil yearly. Each planted hectare generates approximately 4 tons of oil per year and, therefore, for the feeding of the engine only 4,5 hectares of planted area would be needed, which represents a small part of the planted hectares.

With the availability of energy integrated to the familiar agriculture, it is possible to process and aggregate value to regional products, obtaining productive advantages and allowing the fixture of the man in the rural area with appropriate life conditions.

With the experience acquired in the PROVEGAM Project, CENBIO developed the Energy Generation Program Using Vegetable Oils in Adapted Diesel Engines at the Amazon Region – PROVENAT, financed by MME and by the National Council for Scientific and Technological Development – CNPq, whose main goal was to implant an electricity generation and distribution system from a conventional diesel-generator, equipped with a conversion kit, developed and improved with the goal of being replicated in other communities of the Amazon region. This project was implemented in the Igarapé-Açú community, in the municipality of Moju, State of Pará, where around 120 families live.

The Project still contemplates the implantation of 500 hectares of oil palm trees in allotments of 10 hectares for each one of the 50 selected families. The goal of this action, which was a counterpart of the Moju City Hall, is supplying the *in natura* oil engine, in the second part of the project, besides appeasing additional income to the communitarian people.

The electricity generation system implanted in the community is composed by a WEG generator, model GTA 200 MI, activated by a MWM diesel engine, model TD 229 EC-6 (Figure 21), connected to a conversor kit, whose purpose is to take the vegetable oil to conditions of being admitted in the injection system of the engine, without causing great problems in the combustion process.

Figure 21. MWM engine
Source: CENBIO, 2008

The electric network construction project was elaborated by the Electric Utility of Pará - CELPA and consisted in the installation of an electric network of 1050 meters of extension, with 41 concrete posts (Figure 22).

The PROVENAT project became operational on December 14^{th}, 2007, in the Igarapé-Açu community, where an initial test was performed with duration of 5 hours and, once the correct functioning of the engine was verified, the start-up was activated. All the system is monitored from a data acquisition system (Figure 23) and the obtained data analysis will allow to determine the technical and economic feasibility of the use of *in natura* palm oil as a fuel.

Figure 22. Posts in the Igarapé-Açu community
Source: CENBIO, 2008

Figure 23. Data acquisition system
Source: CENBIO, 2008

Inside the Association of the Tillers of Igarapé-Açu, the Energy Communitary Council was created, which is responsible for the operation and maintenance of the system, whose cost will be distributed among the inhabitants, according to the quantity and kind of equipments of each residence. This project qualified human resources and allowed the development of productive activities besides improvements in the life conditions of the population.

In 2008, CENBIO initiated the Life Cycle Analysis of the Castor-Oil Plant Ethylic Ester Project, of the Thematic Network Program of Research in Bioproducts, financed by Petrobras. The project, with duration of 12 months, has as its goal to elaborate the study of life cycle analysis (LCA) of the liquid biofuel obtained from the ethylic transesterification of sugarcane ethanol and castor oil, considering the agricultural and industry stage, for posterior use in Diesel cycle engines.

4.2.7.3 Sugarcane

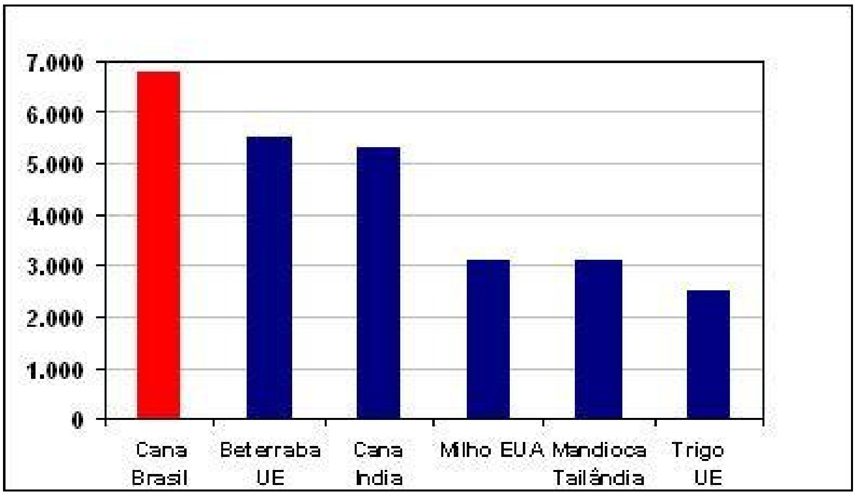
The Brazilian sugar and ethanol sector has been acquiring space in the national and international market due to its diversification and productivity improvement. According to the Sugar Cane Industry Union – UNICA (2008a), Brazil is the greatest worldwide sugarcane producer with 6.92 million hectares planted in the 2007/08 harvest, resulting in a production of 515,875,087 tons of sugarcane (CONAB, 2008).

The sugarcane culture in the Center-South and North-Northeast allows two harvest periods, from May to April and from September to August, respectively, and the Center-South region concentrates around 82 % of the national production (CÔRREA et al, 2007). This culture occurs predominantly in tropical and subtropical climates, inside a latitude of 35º to the north and to the south of the equator (SILVA et al, 2006).

The main products of sugarcane processing are sugar and ethanol, which represent 86.47 % of the total harvested sugarcane, being the other 13.53 % retained for sugar cane brandy production, animal feeding, seeds, production of *rapadura*, brown sugar and other finalities (CÔRREA et al, 2007). The sugarcane processing subproducts are the sugarcane bagasse and the vinasse.

Graph 6 compares the productivity of raw materials for ethanol production, in which the sugarcane in Brazil has the advantage of having greater productivity, approximately 7.thousand liters per hectare, against the ethanol produced from corn, in the USA, of 3 thousand liters per hectare.

The sugarcane bagasse, residue proceeding from the sugarcane processing, is used by the factiries for energy cogeneration, for self consumption and commercialization of the generated surplus. The bagasse, obtained after the extraction of the sugarcane juice, is burned in boilers and the liberated energy transforms the water into steam. This steam is used in the activation of the turbines, where occurs the transformation of the thermical energy into mechanic energy. The turbines are responsible for the activation of the equipments of the sugar factories such as millstones, prickers and shredders, besides the activation of the generators for electricity production.



Graph 6. Productivity of ethanol from different raw materials

361 of the 457 factories existent in Brazil are located in the Center-South region and the other 96 of them are in the North-Northeast (Map 7), and all of them are self-sufficient in energy production, but only 10 % of them sell their surplus in the market.

Map 7. Localization of the Usines in Brazil in 2007

The Energy Research Company – EPE (2008) concluded the registering process of usines interested in participating of the Commercialization Auctions of New Undertakings of Electric Energy that will take place in 2008 for contractings to the attendance of the national markets in the years of 2011 (A3) and 2013 (A5). For the A3 Energy Auction, 98 thermoelectric factories powered by sugarcane bagasse were registered, representing a capacity of 5,271 MW and for the A5 Auction 67 factories were totalized, summing up an installed potency of 3,804 MW. Of this total, 61 factories (potency of 3,445 MW) enrolled themselves for the two commercialization processes.

The sugarcane is the raw material that allows the smallest production costs of sugar and ethanol, since the energy consumed in the productive process is produced from its own residues. The ethanol production in the 2007/08 harvest was of 20,883,954.7 thousand liters, in which the North-Northeast contributed with 9.6 % (Table 12).

Table 12. Estimation of ethanol production in the 2007/08 harvest

Region	Sugarcane destined to the ethanol production (t)	Ethanol (one thousand liters)
North	913,900	68,987.8
Northeast	24,570,000	1,936,007.0
Center-West	34,603,700	2,814,879.7
Southeast	170,250,200	14,276,041.3
South	21,252,900	1,788,038.9
Brazil	**251,590,700**	**20,883,954.7**

Source: CONAB, 2008

The ethanol produced from sugarcane can be used in the car or industry sector. The ethanol fuel can be anhydrous (used for blending in gasoline) or hydrated (used in the fueling of vehicles with engine powered by ethanol or bottled for domestic consumption). The extra-neutral ethanol is used only for industry purposes.

The increase of the consumption of this fuel in the last years has as its cause, mainly, the development of the *flexfuel* technology, in which the vehicles can operate with gasoline or ethanol, in any ratio. Around 90 % of the current national vehicles are launched in *flex* models. The sugar and ethanol industry also supplies ethanol for the beverage, chemical, cleanness and pharmaceutical sectors. 59.6 % of the total produced volume is destined to hydrated alcohol, 40.29 % to the anhydrous alcohol, and the neutral (industrial) alcohol corresponds to only 0.11 % (CÔRREA et al, 2007).

In the month of February, 2008, the country consumed 1.432 billion liters of alcohol (anhydrous and hydrated), overcoming the gasoline consumption for the first time in 20 years, in 21 million liters. This increase is due to the drop in the price of the commercialized ethanol, alligned to the increase of sales of cars with *flex* technology (ANP, 2008).

In the sugarcane processing for ethanol production, the vinasse is generated, which is a highly pollutant residue, with around 2 to 6 % of solid constitutants, rich in organic matter and mineral nutrients. Of all the effluents produced in the alcohol distilleries, vinasse is the one that has the greatest pollutant potential and every produced liter of ethanol generates 13 liters of vinasse (UDOP, 2008a).

The discard of vinasse presented itself as a great problem due to the environmental damages caused by their discard in the water courses. A solution found was the use of this subproduct *in natura* in sugarcane planting areas, process known as fertirrigation, that gained space since it does not require high investments and it does not involve complex technology. However, its excessive use without control compromises the environment by its infiltration in the soil, risking the potability of the groundwaters.

Brazil is also the greatest worldwide sugar producer and exporter, followed by India, dominating around 40 % of the market. In the 2007/08 harvest, 47 % of the sugarcane production was destined to the production of 29,647.2 thousand tons of sugar (Table 13). The exportations of sugar in the 2007/08 harvest reached 19,343,985 tons, which is equivalent to around 67 % of the produced total (MAPA, 2007a).

Table 13. Estimation of sugar production in the 2007/08 harvest

Region	Sugarcane destined to sugar production (t)	Sugar (one thousand tons)
North	203,500	25.1
Northeast	35,926,900	4,71.3
Center-West	15,990,900	2,133.6
Southeast	152,292,300	20,373.3
South	19,069,900	2,543.9
Brazil	**223,483,500**	**29,647.2**

Source: CONAB, 2008

Another residue deriving from the sugar and ethanol sector is the filter pie, composed by a mixture of grinded bagasse and decantation mud, generated in the process of clarifying sugar. For each ton of grinded sugarcane it is produced from 30 to 40 kg of pie, organic compound rich in calcium, nitrogen and potassium (LEITE, 1999). This residue is used in agriculture, put into the furrow alongside the sugarcane moult. However, just like vinasse, the filter pie is a highly pollutant source, and its application and storage must be rigorously controlled.

Some environmentalists see the sugarcane in a negative way, claiming that its expansion will displace the production of food and it will harm the environment, but the planted area in Brazil is of 5.5 million hectares, while the sugarcane culture occupies only 2.4 % of the total planted area. Of the 90 million hectares, 22 million are ready for the sugarcane planting (SZWARC, 2007), showing that the country has sufficient land for its production without harming the food production. Besides, the ethanol production will contribute to the preservation of the environment, substituting the non-renewable energy for renewable energy and the increase of the sugar and ethanol sector will bring economic benefits, with the generation of new jobs.

4.2.7.3.1 Researches in Brazil

Among the sugarcane development programs, outstands the National Ethanol Program – PROALCOOL, created by the Brazilian government on November 14th, 1975, in an attempt to ease the energy problem, with the goal of reducing the petroleum importation, since at that time the world experienced the first petroleum shock. Brazil imported around 80% of the consumed petroleum, and with the raise in prices between 1973 and 1974, the country faced the increase in importation that passed from US$ 600 millions to more than US$ 22 billions. The Program made feasible the continuity of supply of automotive fuels based in the use of biomass, by means of the incentive to the ethanol production in the sugar units and independent distilleries, the financing to the development of appropriate engines by the car industry, and a wide fuel distribution system.

The Program started to fall apart when the international price of the petroleum decreased, making ethanol fuel little advantageous, for both the consumer and the producer. Aggravating the problem, the price of sugar increased in the international market, at the same time that the price of petroleum decreased, therefore making more advantageous to the owners of sugar factories to produce sugar instead of ethanol.

With the intention of commercializing the production of sugar and ethanol, the Sugarcane, Sugar and Ethanol Producers Cooperative of the State of São Paulo (Copersucar) was founded in 1959, composed by ten factories from São Paulo and two regional cooperatives. Between the years from 1974 to 1987, Copersucar doubled its sugar productive capacity and, in 1975, it released the line of domestic alcohol and the crystallized sugar, which was then commercialized only for industrial finalities. Searching for the expansion of its markets, Copersucar currently keeps a logistic complex integrating the port operations between the port of Santos (State of São Paulo) and Paranaguá (State of Santa Catarina), thus offering better options of shipping to their users, reducing costs and increasing competitiveness (COPERSUCAR, 2008).

In 1969, a research laboratory was created at Copersucar, the Copersucar Technology Center – CTC, which in 2004 became a private association kept by companies from the sector. CTC aims at the technological development of the sugarcane, sugar, ethanol and bioenergy sectors, and its research lines embrace the different stages of the productive and industry processes in these sectors. From the CTC laboratories came out 60 of the more than 100 varieties of sugarcane currently commercialized, adapted to the climatic and soil diversities and resistant to plagues (CTC, 2008).

Facing the expansion of the sugarcane culture and the necessity of organization of the sugarcane sector, the Sugar Cane Industry Union – UNICA was created in 1997, representing more than 100 productive units, grouped in two syndicates, the one of the Ethanol Fabrication Industry in the State of São Paulo (Sifaesp) and the one of the Sugar Industry in the State of São Paulo (Siaesp).

UNICA is dedicated to the expansion of the sugar and ethanol markets, defending the universalization of the production of the ethanol use as fuel and the expansion of the worldwide market for sugar, besides the elimination of the subsidies to exportation. It does the yearly raising of the sugarcane harvests and of the production of sugar and ethanol, whose predictions for the sector are recognized for their accuracy, result of a meticulous data raising (UNICA, 2008b).

DEDINI Key Industry S/A has been aiming, in more than 87 years of activity, to promote the technological development of the sugar and ethanol sector, among others. It has sugar factories and distilleries complete with self manufacturing of the equipments and integrated systems, from the sugarcane processing until the ethanol and sugar production, generation of steam and energy surplus cogeneration (DEDINI, 2008).

A project of ethanol extraction from the sugarcane bagasse is being developed in this industry, by means of the DRH technology (Dedini Fast Hydrolysis), increasing the competitivety potential of this culture. In the year of 2002, the installation of a Project Demonstration Unit (UDP) was installed in the São Luís Usine, in Pirassununga, in semi-industrial scale, with capacity equivalent of 5 thousand liters of ethanol per day, whose tests were accomplished between the years of 2003 and 2004, and the adjustments of the process to the industrial conditions in 2005. Its operation began in the year of 2006, with the goal of testing, in industrial scale, the parameters of the process and the engineering solutions applied, since it is a pioneer initiative at worldwide level (CÔRREA et al, 2007).

4.2.7.3.2 Researches and Projects developed by CENBIO

In the year of 2006, CENBIO did the Strategic Environmental Evaluation of the Expansion of the Sugarcane Production in the State of São Paulo, aiming at the elaboration of a study on the expansion of the sugarcane culture in the great productive regions in the State of São Paulo, identifying the places of expansion of the culture and the cultures it is replacing.

From the data obtained in the statistic raising, thematic maps on the sugarcane culture expansion in the studied region were generated, as well as retraction maps of the cultures suppressed by its culture. For the elaboration of the maps, the extraction of data referring to the sugarcane harvest areas was done, from the listing of the municipalities of each region, declared in the requirements for the yearly burning of the cultures by the sugar and ethanol factories of the Integrated System of Environmental Management - SIGAM, of the Environment Secretariat of the State of São Paulo. The data from SIGAM are available since 2003, reaching until the 2006 harvest, referring to the sugarcane area (in hectares) harvested yearly in each municipality.

Parallel to the analysis of the sugarcane data, it was done the raising of the main agricultural cultures developed in each municipality, from the data from the Institute of Agricultural Economy – IEA, where the predominant culture of each region was identified and also extracted the data of pastures, number of cattle heads and plantation of corn, eucalyptus and orange, typical cultures of the regions. From the data found and listed above, an analysis of the correspondence between the evolution of the mentioned cultures and the evolution of the sugarcane culture was done, and the results were made available in the end of 2006.

On October 23rd, 2007, it was launched in Brazil the Project Bioethanol for Sustainable Transport – BEST, financed by the European Union and coordinated by the Stockholm City Hall, in Sweden, whose goal is to encourage the use of ethanol, in substitution to diesel oil, in the public transportation in Brazil and worldwide. CENBIO is responsible for the development of two goals of the project: I – to operate a bus with adapted diesel engine to be fed with a blending of ethanol and an additive and II – to operate hybrid vehicles (electric/combustion) using Brazilian gasoline (20 to 25 % of ethanol).

In order to accomplish the first task, a single bus will be used (Figure 25), imported from Sweden by Scania of Brazil, and the demonstration will be done with the São Paulo Metropolitan Urban Transport Company (EMTU) in one of its operatives, METRA and SPtrans. The other partners are the São Paulo Sugar Cane Industry Union (UNICA) that will provide the ethanol; SEKAB Group, that will supply the additive for the ethanol; Petrobras, that imported the additive, will blend it to the ethanol and distribute the fuel in the operative; Marcopolo, which assembled the bus body; Copersucar, that was responsible for the importation of the first allotment of the additive; Scania Latin America, that imported the engine and the chassis from Swedish Scania; and CENBIO will follow the demonstration by means of data raising and elaboration of reports.

Figure 25. Bus powered by ethanol
Source: CENBIO, 2007

The adapted diesel engine to work with ethanol is developed by the Swedish Scania company, its only manufacturer, and it is commercially available and technically improved, whose efficiency can be demonstrated by the 600 buses that circulate in Sweden and use this technology. According to the manufacturer, the adaptation of the diesel engine does not require significative changes. The engines have mechanic injection and compression rate of 22:1, being that in the conventional diesel engines this rate is of 18:1 (SENNA, 2007). The diesel bus of the BEST project is equipped with this engine, however, Scania already brought to Brazil a new generation engine (269 kW or 230 HP), and among the modifications performed, it presents compression rate of 28:1, electronic injection and injectors with greater volumetric capacity (Figure 26).

For the use of ethanol in these engines, it is necessary the addition of 5 % of an additive, since ethanol does not have property of self-ignition by compression, characteristic of the diesel engine. Therefore, the addition of the additive makes the combustion happen with greater speed and better energetic efficiency (BENTO, 2007).

Figure 26. Engine
Source: CENBIO, 2007

For the accomplishment of the second task, the Prius vehicles (Figure 27) manufactured by Toyota will be used. Two vehicles will be granted by Toyota and one vehicle will be granted by Petrobras, which will also supply the fuels for tests.

Figure 27. Prius Toyota vehicle
Source: TOYOTA, 2008

The use of this technology represents a huge progress and the expectation is that its advantages, from the example of BEST in São Paulo, will attract the attention of other regions of Brazil to the technology. The obtained results will allow identifying the technical-economic barriers that eventually interpose themselves to the viability of the implantation of this technology in the public transportation of Brazil.

In the year of 2008, CENBIO initiated the Project Georeferenced Raise of Sugarcane Residues in Potential in the Country, Aiming at its Use for Ethanol Fuel Production through Enzymatic Hydrolysis Technology, of the Thematic Network of Research in Bioproducts Program, financed by Petrobras. The project, with duration of 18 months, has as its goal to evaluate the potential of residual biomass from the sugarcane culture (considering only residues of straw/edges and sugarcane bagasse) existent in the country, for use of enzymatic hydrolysis technology in the ethanol fuel production, with results presentation in form of georeferenced data.

The mapping of the potential of this kind of biomass is fundamentally important to the analysis of the feasibility of the enzymatic hydrolysis technology, because it will dimension the available residues potential for use of the technology, aiming at an environmentally adequate expansion of the sugarcane production, avoiding future environmental impacts. Two potential georeferenced scenarios of biomass production will be esteemed, considering the situations of mechanized harvest and manual harvest.

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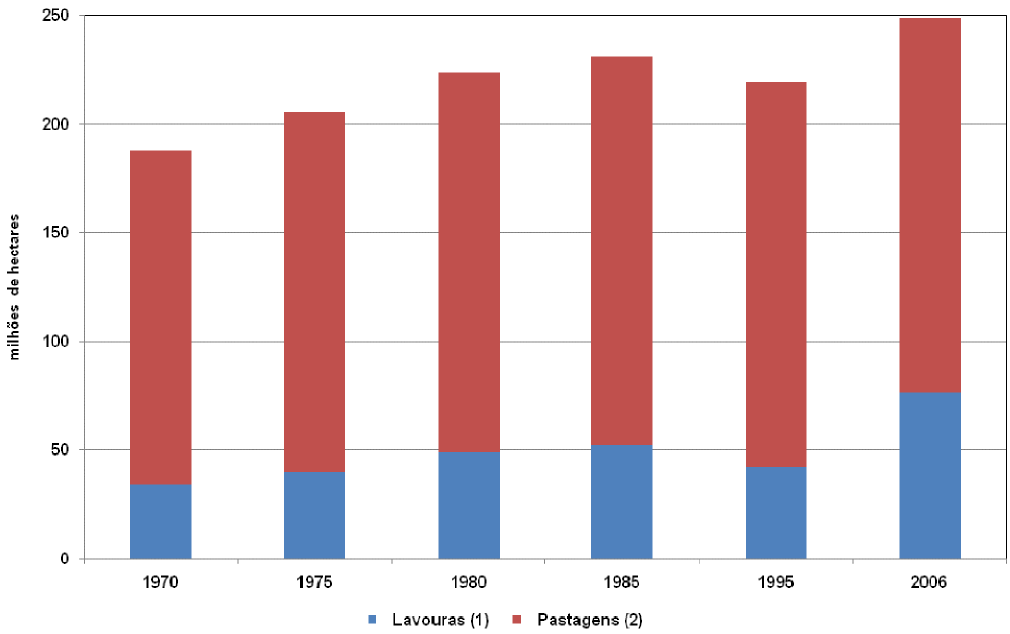
TASK 4.3: BEST PRATICES – SUCCESSES AND FAILURES FROM BRAZIL

4.3.1 Introduction

This section includes a literature review for documenting best practices on improved agricultural and agro-forestry systems in Brazil. This review includes best practices in land use, water management, policy measures for sustainable use of renewable natural resources, financing mechanisms and climate change issues and their risks in agriculture.

Agriculture has played a key role in the development of human civilization - it is widely believed that the domestication of plants and animals allowed humans to settle and give up their previous hunter-gatherer lifestyle during the Neolithic Revolution. Until the Industrial Revolution, the vast majority of the human population labored in agriculture. Development of agricultural techniques has steadily increased agricultural productivity, and the widespread diffusion of these techniques during a time period is often called an agricultural revolution. A remarkable shift in agricultural practices has occurred over the past century in response to new technologies

In Brazil, the productive area grows each year. In 2006, 249 million hectares of crops and pastures were explored (IBGE, 2007b), 44% of the area possible to used by agriculture (Graph 1).



Graph 1. Agriculture and cattle raising areas in Brazil, in million of hectares
Source: IBGE (2007b)
Notes: (1) Permanent and temporary crops. (2) Natural and grown pastures

4.3.2 Land Use

Although Brazil explores less than a half of its area possible to hold agriculture, 84.5% of non-forest areas are used by agriculture or cattle raising. In order for this land extension not to suffer problems related to soil management, such as erosion, compaction, and increase in soil salinity, it is fundamental that agricultural practices and specific measures in soil preparation are adopted.

4.3.2.1 Agricultural Practices

The following agricultural practices[1] were identified in Brazil by IBGE (2007b) in agricultural and cattle raising establishments:

Crop Leveling – crops are done obeying the natural curves of the land, so that the plants work as natural barriers that contain or decrease the speed of rainwater, avoiding the water runoff and the formation of erosion

Use of terraces – technique used in hilly cultivated areas, with the goal of protecting crops of higher value, such as fruit trees, grapevines, among others.

Crop rotation – altering crop of grasses, vegetables and others, having possible periods of rest

Use of crops for reform and/or renovation and/or recovery of pastures – use of pasture areas with temporary crops with the finality of recovering its fertility

Rest of soil – technique of letting the land used for cropping rest, for undetermined time, so it can recover its fertility.

Agricultural burning – practice of burning vegetable mass for cleaning pastures, cleaning soils or to facilitate sugarcane harvest.

Protection and/or conservation of slopes – practice that consists in using trees or bushes to preserve hills with high slopes, which are subject to erosion.

[1] This was the first time this subject was inquired in 2007 Agricultural and Cattle Census by IBGE. The preliminary results do not make the participation of this agriculture practices public.

Besides agricultural practices, for appropriate soil management, some measures in soil preparation are fundamental.

4.3.2.2 Soil Preparation

To enable the use of land for crops production, it is necessary to prepare soil, which consists in a set of operations carried out with the goal of creating favorable conditions for sowing, development and production of crops, for unlimited time.

In Brazil, three are the main soil preparation forms:

Conventional Crop production (harrowing plus plowing) or deep harrowing – the soil is prepared through harrowing followed by plowing, with harrowing crates or heavy crates.

Minimum tillage (only plowing) – soil preparation is characterized by less utilization of implements. Basically, crates are used and eventually, the scarifier plow which revolves soil, enhancing its draining and physical condition.

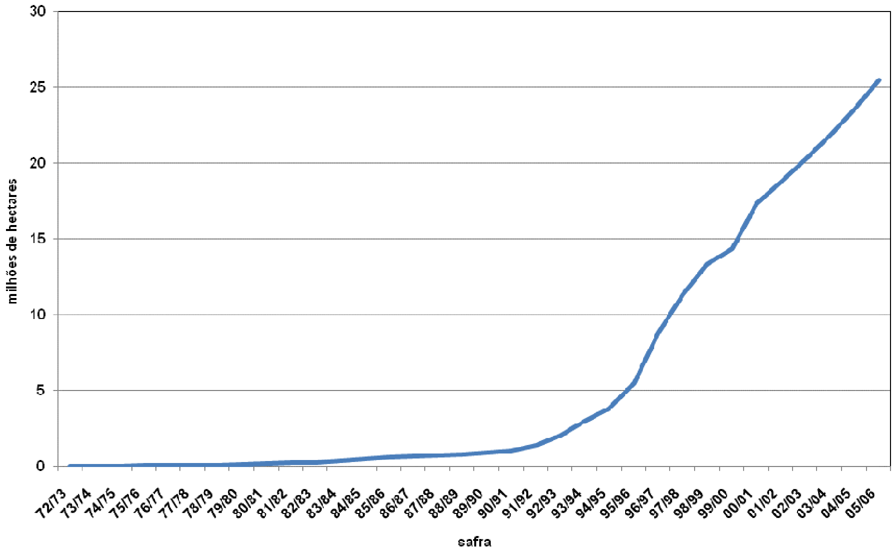
No-tillage on Straw – crops are done in furrows opened in soil covered with straw, with no need of plowing or harrowing of land surface, maintaining the rest of previous crops in the soil. According to the Brazilian Federation of No-Tillage on Straw (Federação Brasileira de Plantio Direto na Palha, 2008), the zero tillage system evolved from around 180 hectares in 1972/73 to 25.5 million hectares in 2005/06, considering summer and winter crops and *safrinha*[2]. It is the second country in the use of this soil preparation technique in the world, behind United States.

As a measure of soil conservation, minimum cropping and direct crop[3] have been each time more used in crops soil preparation in Brazil (Graph 2), one third of crops use direct crop in soil preparation. (Brazilian Federation of No-Tillage on Straw, FEDERAÇÃO BRASILEIRA DE PLANTIO DIRETO NA PALHA, 2008).

In opposition to conventional agriculture, where the soil suffers intense movement, no tillage system is based in the non-preparation of soil and in the permanent cover of soil with crops rotation. The soil is manipulated at the moment of sowing, when it is open a furrow where the seeds and fertilizers are put. The most important control that happens in this crop system is the one of weeds, through integrated management of plagues, diseases in general and infesting plants.

[2] *safrinha* – is the crop between two harvest. In Brazil, this period is between January and March.

[3] The same as they did with agriculture practices, IBGE researched for the first time the types of soil preparation in agriculture and cattle ranching establishments, however the information was not divulged in preliminary results



Graph 2. No tillage cropping area in Brazil
Source: FEDERAÇÃO BRASILEIRA DE PLANTIO DIRETO NA PALHA, 2008

No tillage system brings several benefits that will decrease the costs of production and environment impact, such as higher retention of water in the soil, less soil compaction, less erosion, less nutrients loss, economy of fuel (diesel) and less number of operations, including harrowing and plowing. What also contributes to a decrease in the use of tractors, and, consequently, less soil wear.

No-tillage was used by the first time in Rolandia, north of the State of Paraná, by the farmer Herbert Bartz in 1972. The innovative idea showed a new path to agronomy, it is considered conservative and its technology is well developed for grains such as wheat, corn, soybean, bean and cotton. There are, however, agro ecology circumstances that limit the use of this system, such as: impossibility of draining, reduced range of friability, clayey soil texture and very high rates of organic matter decomposition (Table 1).

Table 1. No tillage advantages and disadvantages

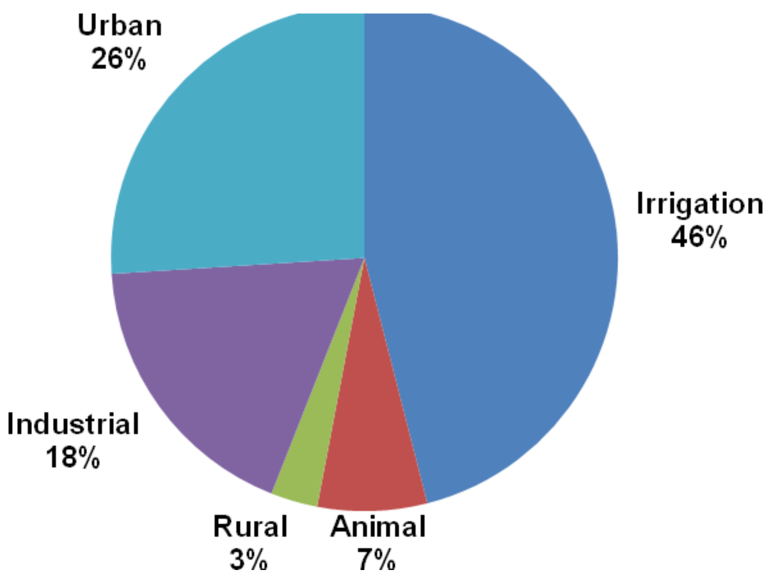
Advantages	Disadvantages
Reduces soil erosion	Transition from conventional to no tillage system is not easy
Preserves water	Necessary equipments are expensive
Enhances soil quality	High dependence on herbicides
Reduces costs of fuel and labor force	The predominance of weeds, diseases and other pests result in unpredictable changes
Reduces lakes and streams pollution due to sediments and fertilizers	In the beginning, may require more nitrogen fertilizer
Carbon sequestration	Possible delay in germination and reduced production

Source: HUGGINS;REGANOLD, 2008

4.3.3 Water Management

The practice of irrigation has been fundamental to assure the supply of agricultural products. The future demand in food production is critically dependent on irrigated agriculture. Among the benefits of irrigation, one may highlight: enhancement of finance performance of agricultural business and of the life quality of rural communities, possibility of expansion of agricultural frontier and decrease in the risk involved in agricultural activity. Irrigated agriculture also favors the expansion of work opportunities in the country.

The water demand (withdraw) in Brazil is 1.592 m^3/s, with around 53% of this total (841 m^3/s) being consumed and not returning to river basins (ANA, 2007). Around 26% of withdrawal will flow to urban supply, against 46% to irrigation and 18% to industry. Only 3% are directed to rural supply (Graph 3).



Graph 3. Water withdrawal by sector in Brazil, 2000
Source: ANA, 2007

4.3.3.1 Irrigated lands and irrigation methods

In 2002, the irrigated area in Brazil was 3,3 million hectares, from which 1,6 million hectares with pressure irrigation and 1,7 million of hectares with surface irrigation, which represents 5.5 percent of the cultivated area, table 2 (CHRISTOFIDIS, 2008). It was considered as irrigation the practice of applying water, not rainwater, directly in the soil surface, cultivated with crops or pastures, in determined quantities and timing intervals, with the purpose of providing water to plants, in appropriate conditions for their growth and production. The irrigation methods are:

Flooding – consists in the leveling of the terrain for flooding or inundation of cropping area;
Surface irrigation (Furrow) – consists in the leading and distribution of water through furrows or irrigation canals, located between the rows of planted crops;
Sprinkler irrigation (centre-pivot) – method in which the area is irrigated by a mobile system, built by a bar with sprinklers, which moves around a fixed point;
Spray/Sprinkler irrigation (other methods) – fixed and mobile sprinklers, except centre-pivot;
Localized/Micro irrigation (drip irrigation, micro-spray, etc.) – leading water through pipes, and its distribution is done drop by drop.

Table 2. Irrigated area in Brazil, per irrigation method, in hectares [ha]

Irrigation Method	**Area [ha]**	**%**
Flooding	1.107.370	33,8
Furrows	592.297	18,1
Sprinkler (central pivot)	713.649	21,8
Spray irrigation (other methods)	614.811	18,8
Localized irrigation (drip irrigation, micro-spray, etc.)	246.087	7,5
Total	**3.274.214**	**100,0**

Source: CHRISTOFIDIS, 2008

With the current knowledge of soil and water resources, the irrigation potential of Brazil is estimated at 29.5 million ha, table 3. This includes only areas where irrigation can be developed and excludes the areas of high ecological value in the northern region (Amazonas and Tocantins basin). In the savanna areas (cerrados) of the centre-west region, the potential for irrigation has expanded substantially in recent years, following recent advances in soil management and irrigation techniques applicable in that region.

Irrigation techniques differ within Brazil (Graph 4). In the south, southeast and centre-west, rice paddies, as well as some vegetable and orchard crops, are irrigated by simple flooding or using furrow irrigation. Over 990,000 ha of paddy rice are grown with basin irrigation in Rio Grande do Sul. Water is diverted from numerous small streams and conveyed to the farm-gates through earth canals. At least 1.7 million ha in Brazil are estimated to be under traditional systems of this sort. They are used where water availability is ample. This technology, together with proper land preparation and some mechanization, yields a good return. Modern irrigation technologies, which have a higher water-use efficiency and require less labor, are preferred by large farmers in the *cerrados*, for crops such as wheat, soybean, maize, and cotton, and by the producers of vegetables and fruits near the metropolitan areas in the northeast.

Table 3. Irrigation potential in Brazil by regions, in thousand hectares

Region	**Lowlands "várzeas*" [1000 ha]**	**Highlands [1000 ha]**	**Total [1000 ha]**	**%**
North	9.298	5.300	14.598	49,4
Northeast	104	1.200	1.304	4,4
Southeast	1.029	3.200	4.229	14,3
South	2.207	2.300	4.507	15,2
Centre-West	2.326	2.600	4.926	16,7
Total	**14.964**	**14.600**	**29.564**	**100**

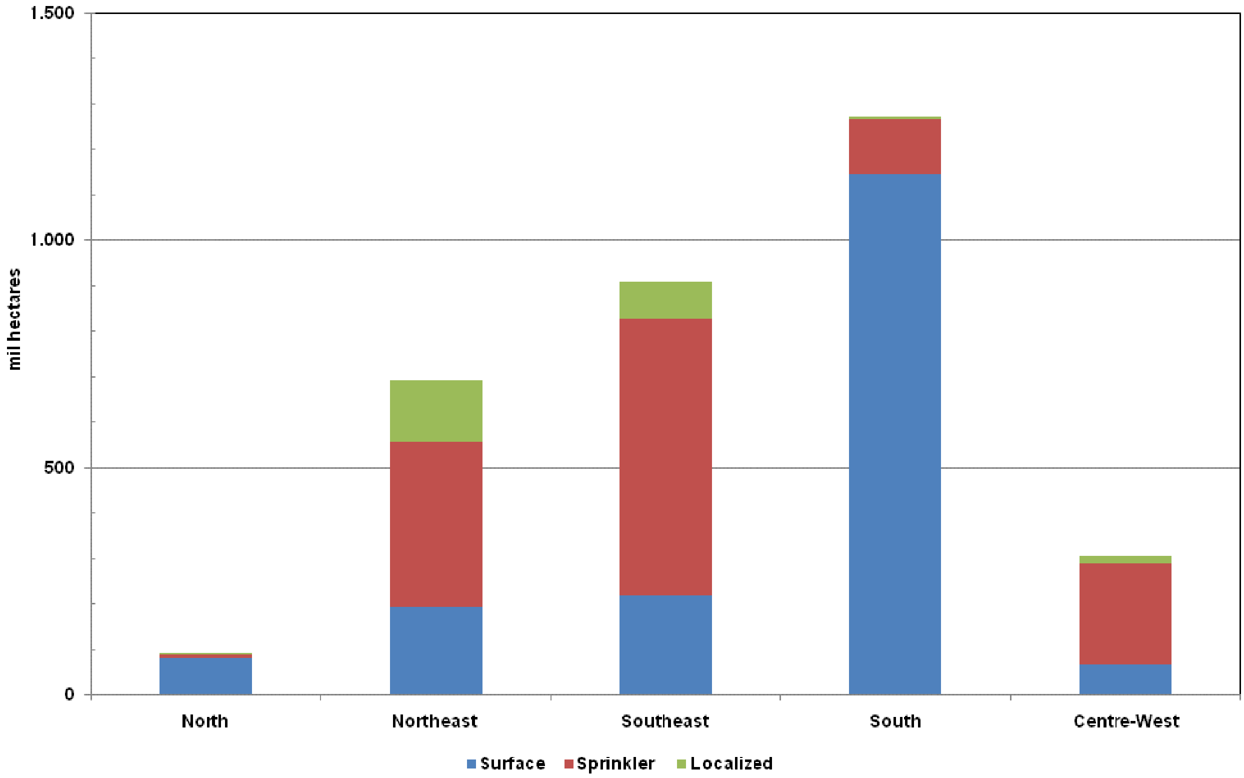
Source: CHRISTOFIDIS, 2008
Note: * *várzeas* are seasonally-flooded or flood-prone lowlands.

These technologies, which are increasingly used in private and public irrigation schemes, range from mobile sprinkler lines to state-of-the-art modern centre-pivot and other self-propelled irrigation equipment. In the northeast there is a strong increase in the use of micro-irrigation equipment, due to the water scarcity in the area. In recent years, the area with surface irrigation has decreased and that with sprinkler irrigation for grain production and micro-irrigation for fruit and vegetables has increased. Total efficiency of water use is estimated, on average, at 40-65 percent for surface, 60-85 percent for sprinkler and 78-97 percent for micro-irrigation methods (FAO, 2008).

Little information is available in drainage, salinity and waterlogging in Brazil. The surface with drainage equipment is around 1.28 million ha, mostly in the areas with irrigation equipment. Within the framework of the Provarzeas program in the 1980s, around 400,000 ha were drained.

The natural saline areas in Brazil are quantified on average at 86 million ha, located especially in the driest areas with average precipitation below 1,000 mm/y. The area salinized by irrigation is estimated at 15,000 ha, mostly in the northeast (FAO, 2008).

The extension of the areas with natural waterlogging, called "varzeas", is 13.35 million ha. Up to now, waterlogging problems caused by irrigation practices have only been recorded in the Nupeba project for an area of 170 ha. Codevasf is in the process of designing and implementing a drainage system to prevent waterlogging (FAO, 2008).



Graph 4. Irrigated area by irrigation techniques for regions of Brazil in 2002
Source: CHRISTOFIDIS, 2008

4.3.3.2 Water harvesting practices

Brazil is one of the few large dimension countries in the world to register rain in all its territorial extension. In the semi-arid, although there is variation in precipitation, it rains an average of 700 billions cubic meters of water per year (ASA, 2008).

Programs of water harvesting are common in areas with water supply restriction, such as the Brazilian semi-arid. In the northeast area, two programs were identified, carried out by civil society, which aim to enhance the live quality in the semi-arid and allow water supply for human consumption and for food production (ASA, 2008).

1 Million Cisterns Program (Programa 1 Milhão de Cisternas - P1MC)

The One Million Cisterns Program for human consumption was an initiative of the NGO Articulation for the Semi-Arid (Articulação do Semi-Árido - ASA) in July, 2003 and aims to benefit around 5 million people in the entire semi-arid region, with potable water, for drinking and cooking. Each cistern is capable of storing 16 thousand liters of water, collected from rain, through pipes installed in the roofs. The most of the 226.800

cisterns already built in this program, up to August 2008, are made with pre-molded slabs.

The cistern is built by masons of the target localities and by the own families, who carry out general services of excavation, acquirement and supply of sand and water. Masons are paid and the contribution of families in the building of cisterns is considered to be a counterpart in the process. If the water of the cistern is used in an appropriate way – for drinking, cooking and brushing teeth – it can last for approximately 8 months.

Program One Land and Two Waters (Programa Uma Terra e Duas Águas - P1+2)

The goal of P1+2 is to go beyond rainwater collection for human consumption, moving towards the sustainable use of land and appropriate management of water resources for food production (animal and vegetal), promoting food security and income generation.

The number "1" means sufficient land to develop productive processes aiming food and nutritional security. Number "2" corresponds to two ways of water utilization – potable water for families and water for cattle raising and agriculture production, in a way that farmer's families and people influenced by them live with dignity.

In January 2007, P1+2 started its demonstrative phase, in which aims a bigger interaction among productive and sustainable land management experiences and water resources. In a participatory way, the idea is to trigger a process of mapping, exchanging, systematizing and implementing experiences.

The proposed activities for demonstrative phase of P1+2 will target 96 communities from 10 States (AL, BA, CE, MA, MG, PB, PE, PI, RN, SE), where there will be built 144 rainwater collection technologies for food production. These technologies will benefit 818 families.

There are several relevant experiences of rainwater collection developed in the Brazilian semi-arid, in its majority carried out by family farmers, which can be multiplied. For the demonstrative phase of P1+2, four water storage technologies are being used:

Cistern adapted to farming

It is formed by a collection area (to collect rainwater which drops from the unevenness of ground or from paved areas such as a sidewalk), by a water tank (which must be bigger than the cistern for human consumption) and an irrigation system (which can be hand-operated or by pumping or drip systems). With the water of a 50 thousand liters cistern (not used for domestic consumption) it is possible to irrigate a "productive garden" [4] of vegetables, water plants or have water for chickens and bees.

Underground dams

Conserves the rainwater infiltrated in the underground areas, funds of valleys and areas where rainwater flows through a dam dug deep until the impervious layer of soil. It has a great impact over the stability of the productive system, increasing the resistance in drought periods, when the dam area looks a green island in the middle of the dry vegetation. It assures the autonomy in relation to food, allows raising a higher number of animals and decreases the dependence of external inputs.

Stone tank

Enables the storage of great volumes of water collected in horleys, taking advantage of their natural inclination. In some places it is necessary to build walls enabling the containment or the guiding of water towards the tanks, and consequently, a greater accumulation of water. It is one technical innovation based in the value of family farmers' knowledge in the strategies of water use and management. The stone tank storages water for domestic purposes, for animal feeding and irrigation of a vegetables' "productive garden".

Barreiro Trench

They are deep and narrow tanks, dug in crystalline underground with one or more compartments and more than three meters deep, with bottom and walls of stone (piçarra), which does not let water to infiltrate. Small kennels are built to direct runoff water to these compartments. It is important to make small rock barriers inside the

[4] A "productive garden" corresponds to an area of 10 m^2.

water diversion to retain sand. Since it is narrow and deep, its evaporation surface is smaller. The *Barreiro Trench* storages water for animals and for irrigation of a 'productive garden" of vegetables.

4.3.3.3 Use of wastewater

With exception of the sugar-ethanol sector, recycled water is not a very widespread practice in Brazil. In sugar-ethanol sector, all wastewater, known as *vinasse*, is used as fertilizer. Although it has high polluting potential, it also has a very high fertilizing value. The application of vinasse in cropping is an adopted practice in all plants, with well known and defined technology. There are numerous tests that have confirmed the positive results in cropping productivity, associated to the economy of mineral fertilizers. The great advantage in employing vinasse is that it may substitute in great part the nutrients of mineral fertilization, and many studies demonstrate the increase in sugarcane productivity, due to its application. Vinasse production varies in function of different processes employed in alcohol production. In a general way, each liter of ethanol produced in a distillery generates among 10 to 15 liters of vinasse. In 2004-2005 cropping, 14,8 million of litters of ethanol were produced, and the vinasse resultant production was 207,2 million dam^3/year (BARROS, 2008).

There are other initiatives of no potable water reuse in the industry sector, in addition to unplanned practices in different sectors, as in the agriculture sector - mainly for irrigation of some vegetables and fodder crops. It is a non institutionalized procedure and it has been developed up to now with no planning or control. Most times, the adoption of the practice is totally unconscious by the user, who uses highly polluted water from streams or rivers that run nearby for vegetables irrigation, not knowing that it may be a very dangerous practice to public health, provoking negative environmental impacts.

In Campos Basin, sugarcane agro-industry producers use water recycling technology, in addition to vinasse, the water resultant from poultry, swine and cattle raising becomes a source that attends the high demand for irrigation in the region, contributing for the economy of fertilizers, since it is rich in nutrients.

The State of São Paulo has specific experiences in the reuse of treated sewage in agriculture. They have practices of reuse in irrigated agriculture of annual crops, as maize and sunflower, hydroponics in flowers and irrigation of pastures for hay production.

Other national experiences can be highlighted in reuse practice, such as the application of sewage, which receives primary treatment in the region of Serido, in Rio Grande do Norte, for irrigation of *capineiras,* in the urban outskirts, with major highlight to the cities of Santa Cruz, Campo Redondo, Caicó, Currais Novos, Goianinha, Eduardo Gomes and Parelhas (BERNARDI, 2003).

There were not identified statistics on activities of water reuse of post-treated sewage for other sectors. This is due to the lack of knowledge on this kind of technology.

Considering that there are activities of water reuse for cropping purposes in certain Brazilian regions, which are carried out in an informal way, without the appropriate environmental and public health safeguards, it is necessary to institutionalize these activities and promote the sector through the creation of a management structure, legislation preparation, information dissemination and the development of technologies which are compatible with our technical, cultural and socio-economic conditions.

Initiatives for fomenting and divulging this technology and investing in ways to establishing political, legal and institutional bases for water reuse were taken with the creation and activities of the Technical Group of Reuse, in the instance of the Technical Chamber of Science and Technology, in the National Council for Water Resources and in the Oversight for Charging and Conservation of the National Agency of Waters (BERNARDI, 2003).

4.3.4 Policy measures and management strategies legal and institutional frameworks

The country has developed many policies to use renewable natural resources in a sustainable way and implement improved energy crops and agro-forestry systems, besides programs for poverty eradication. The most important ones are explained in the next paragraphs.

4.3.4.1 For sustainable use of renewable natural resources

Forest Grant Program (Programa Bolsa Floresta)

Forest Grant is a program of the Amazon State government, which aims to recognize, value and compensate traditional and indigenous populations of the state, for their role of conservation of forests, rivers, lakes and streams (GOVERNO DO ESTADO DO AMAZONAS, 2008).

This benefit is given to the population who do not cause deforestation. Families that deforest an area up to 50% above what is determined for that year by Forest Grant Program, receive a warning and must explain the motive for cutting down the trees. After they are listened, these families continue in the program for another year. If they continue to cut down trees, they are excluded from the program and the financial aid is suspended.

The person who deforests an area bigger than 50% of what is set by Forest Grant Program is excluded in the first year and the benefit is suspended. Families who receive two warnings in a roll of three in alternate years are also excluded. Deforestation is measured annually in the field or through satellite images.

Forest Grant Program does not interfere in productive activities. The inhabitants continue to farm, fish and manage forests, rivers and lakes. Agriculture, extraction, forestry, handicrafts and fishing activities which are ecologically correct are maintained.

As in all protected areas, inhabitants have to follow the rules of the Plans for the Use and Management of Protected Areas. 2102 families who live in 6 protected areas were registered. The money for paying the benefits comes from interest of existing resources of the State Fund for Climatic Change, of the Amazon State government (Fundo Estadual de Mudanças Climáticas) (GOVERNO DO ESTADO DO AMAZONAS, 2008).

Program of Social and environmental development of Rural Family Production (Programa de Desenvolvimento Socio-ambiental de Produção Familiar Rural, Proambiente)

The program of Social and Environmental development of Rural Family Production (Proambiente) gathers concepts of rural production and environment conservation, and it is born in the discussions that happen in rural social movements of Legal Amazon about the need of overcoming the dichotomy among rural production and environment preservation.

The application of rural credit modalities in the region, through the Constitutional Fund of North Funding (Fundo Constitucional de Financiamento do Norte, FNO), during the 90's, did not succeed to overcome certain paradigms towards a proposal of sustainable rural development adapted to the local context, while it has been of great importance for rural family production sector, since it allocated around one billion of reais (roughly 0.5 billion US$) and reached 100 thousand family units production (25% of the total of the region's units) (MMA, 2008b).

One of the great innovations of Proambiente is the remuneration of environment services to compensate the costs of opportunities to qualitative changes in the land use, focusing on production systems identified with the specificities of each biome.

The Program allows the remuneration of environmental services offered to the Brazilian and international society, such as deforestation reduction, atmospheric carbon sequestration, reestablishment of ecosystems hydrological functions, conservation, biodiversity preservation, soil conservation, reduction of landscape inflammability, change of the energy matrix and agrochemicals elimination.

Proambiente Program gathers in the same public policy the following concepts (MMA, 2008b):

- Social Control and Local Participatory Management between Municipal and State Governments and organized Civil Society.
- Territorial Planning, through the formation of Poles (composed by a set of producers associations and cooperatives), based in social, cultural, geographic and natural aspects. The formation of Poles also encourages the collective joining to the Proambiente Program.

- Qualified technical assistance and rural extension, with production and environment preservation concepts internalized by technical staff and beneficiary families.
- Specialized and regionalized rural credit, with the participation of families in the elaboration and application of technical projects offered by operating banks.
- Elaboration of the Pole Sustainable Development Plan, approaching aspects of outside the properties, such as integration, improvement marketing and Sales of the Pole production and infra-structure, with implementation in partnership with the city halls of the territorial base of the Pole.
- Elaboration of the Plans for Production Units Use, approaching the goals of the management and critical points of qualitative conversion of land use, time and space scale of natural resources use and definition of the Production Areas, Permanent Preservation Areas and Legal Reserve.

Ecological ICMS

Ecological ICMS is a tributary mechanism which was adopted by several Brazilian states to subsidy and to encourage conservation initiatives. It allows Brazilian cities to receive part of financial resources raised from the Tax collected over Circulation of Goods and Services (Imposto sobre Circulação de Mercadorias e Serviços – ICMS), in recognition to an environment service to society (LOUREIRO, 2008).

Ecological ICMS began in Parana State, in 1991. The cities felt their economies weakened due to the restriction of use caused by the need of preserving water sources of neighbor municipalities and due to the existence of protected areas, while the State Public Power felt the need of modernizing its public policies tools.

Born as a kind of “compensation”, Ecologic ICMS evolved, transforming itself along the time into direct and indirect incentive to environment conservation. Due to its cost, legal and constitutional adequacy, Ecologic ICMS operates the principle of protector-beneficiary.

The Program was later developed in the States of Sao Paulo (1993), Minas Gerais (1995), Rondonia (1996), Rio Grande do Sul (1998), Mato Grosso do Sul (2001) and Mato Grosso (2001), and it is in implementation or regulation phase in Pernambuco, Tocantins and Amapá, and is under debate or negotiation in legislative instances in the states of Bahia, Goias, Pará, Santa Catarina, Ceará and Rio de Janeiro.

Ecologic ICMS creates rules for the portion of collected ICMS to which the cities have the right to receive. In the case of Paraná, this composition is funded in two dimensions: one quantitative and another qualitative (LOUREIRO, 2008).

The quantitative dimension takes into account the surface of the protected area in relation to the total area of the city. This relation is corrected by a multiplier that characterizes the level of restriction in the use of the protected area.

The qualitative dimension considers, besides aspects related to the existence of flora and fauna species, necessary inputs available to the protected area, aiming maintenance and enhancement of its management process.

The protected areas considered for the effect of calculation are: Conservation Units, Indigenous Land Areas, Faxinais[5], Permanent Preservation Areas and Legal Forest Reserves.

The most significant results relate to the increase in the surface of protected areas and evolution of the protected areas management quality.

In the State of Parana, for example, there was a raise in 159.77 % of the protected areas surface (Table 4). It is important to highlight the increase in the surface of the *varzea* ecosystem in the Complex of Ilha Grande and in state Private Reserve of Natural Patrimony (Reserva Particular de Patrimonio Natural – RPPNs[6]).

Besides the increase in protected area, the tax collection of municipalities also increased. In the state of Parana, one of the best examples is the municipality of Guaraqueçaba, which tax collection increased 600%.

In the state of Minas Gerais, the municipalities of Betim, Contagem, Ipatinga, Uberlandia and Coimbra had an important increment in its income tax, due to the ICMS after they invested in systems of final garbage disposure (LOUREIRO, 2008).

[5] Faxinais are a special type of protected area. It is a rudimental and communitarian agriculture system, keeping the native forest where animals (pork, kid, poultry) are created.

[6] RPPN is a private area to protect the biological diversity. It is an owner`s voluntary act without losing its land property.

Table 4 Evolution of the protected area surface, in the state of Parana, until 1991, and from 1992 until 2001, registered and target of offering credit from Ecologic ICMS to the respective municipalities, in hectares.

Management level	Until 1991	From 1992 to 2001	Evolution (%)
Federal	584,622.98	694,186.26	18.74
State	118,163.59	964,554.92	716.28
Municipal	8,455.50	226,674.89	2,462.60
Indigenous Lands	81,500.74	83,245.44	2,14
Federal RPPN	0,0	1,706.13	-
State RPPN	0,0	33,154.72	-
Faxinais	0,0	18,927.11	-
Permanent Preservation Areas	0,0	17,107.69	-
Legal Reserve	0,0	16,697.73	-
Special Farms	0,0	1,101.56	-
Other connection forests	0,0	3,245.62	-
Total	794,763.81	2,064,594.07	159.77

Source: LOUREIRO, 2008

4.3.4.2 For improving energy crops and agro-forestry systems

The Proalcool Program

The “Brazilian Alcohol Program” (Proalcool) – to produce ethanol from sugarcane – was established during the 70´s, as a consequence of the oil crises, aiming to reduce oil imports, as well as a solution to the problem of the fluctuating sugar prices in the international market. The program has strong positive environmental, economic and social aspects, and has become the most important biomass energy program in the world.

In Brazil, ethanol is used in one of three ways: (a) as octane enhancer in gasoline in the form of 20 to 26% anhydrous ethanol and gasoline, in a mixture called gasohol; or (b) in neat-ethanol engines in the form of hydrated ethanol and (c) in any combination of (a) and (b) in cars with engines designed to run with gasoline and ethanol (flex fuel cars). The decision to use sugarcane to produce ethanol in addition to sugar was a political and economic one that involved government investments. Such decision was taken in Brazil in 1975, when the Federal Government decided to encourage the production of alcohol to replace gasoline, with the idea of reducing petroleum imports, which were putting great constraints in the external trade balance (MOREIRA; GOLDEMBERG, 1999).

Ethanol consumption has been growing overall by its addition to gasoline as a carburant. The increase in the production and use of ethanol as a fuel was made possible by three governmental actions during the launching of the ethanol program: (a) the decision that the state-owned oil company, Petrobras, must purchase a guaranteed amount of ethanol; (b) the provision of economic incentives for agro-industrial enterprises willing to produce ethanol, offering loans with low interest rates from 1980 to 1985; (c) steps to make ethanol attractive to consumers, by selling it at the pump for 59% of the price of gasoline. This was possible because the government at that time set gasoline price. Nowadays, there are no subsidies for ethanol production and it is sold in general for 60 to 70 percent of the price of gasoline at the pump station in a free market, due to significant reduction on production costs. These results show the economic competitiveness of ethanol when compared to gasoline. Considering the higher consumption rates for neat-ethanol cars and for flex fuel cars using neat ethanol, ethanol prices at the station could be as much as 80% of gasoline prices.

In fact, policies have led to a significant and successful change in the economy. The Alcohol Program in Brazil was possible because of the high price of gasoline and the special policies established to favor the program. In the period 1975-1989 a total of USD 4.92 thousand million was invested in the program (MOREIRA; GOLDEMBERG, 1999). However, savings with oil imports were much higher, reaching USD 43.5 thousand million (2001 USD) from 1975 to 2000 (GOLDEMBERG; COELHO; LUCON, 2003). The large amounts of ethanol produced allowed a substantial decrease in alcohol production costs. Ethanol price paid to producers fell quickly after 1985, due to technological progress and economics of scale. The progress ratio of the technology has shifted from 92% in the period 1980-1985 to 75% in 1985-2002. The lower the progress ratio, the more prices have dropped. Thus, an efficient technology penetration is the one that have achieved low progress ratios (PRs). In October 2002 US dollars, ethanol progress ratios were 93% (1980-1985) and 71% (1985-2002).

It is well known that the strongest argument against renewables, in general, is their high cost and therefore their lack of competitiveness with conventional fuels – a common characteristic of new products and infant industries. This was indeed the case in the beginning of the commercial use of such renewable sources but, as consumption of renewable energy increases, its cost falls, as demonstrated by the Brazilian ethanol program.

Social considerations are today strong determinants of the Program. Presently, ethanol production generates some one million jobs in Brazil, with a relatively low index of seasonal work. The environmental standpoint is another to mention. All gasoline used in Brazil is blended with anhydrous ethanol. In addition to the alcohol-gasoline (gasohol) vehicles, there is a 1.0 million fleet running with pure hydrated ethanol in the country and 4.1 million of flex fuel cars running with gasoline and ethanol in any mixture in a single tank of fuel (ANFAVEA, 2008). Initially, lead additives were reduced as the amount of alcohol in the gasoline was increased and they were completely eliminated by 1991. Aromatic hydrocarbons were eliminated, sulphur and carbon monoxide significantly reduced. Alcohol hydrocarbons exhaust emissions are less toxic than gasoline's, with lower atmospheric reactivity. Acetaldehydes from alcohol use are less aggressive to human health than aldehydes from gasoline and diesel (CETESB, 2002).

With almost null greenhouse emissions balance, in the 1975-2000 period ethanol has saved gasoline emissions of about 110 million tonnes of Carbon (BRASIL, 2004). In 2000, 9.2 million tonnes of carbon dioxide were avoided due only to the gasoline replacement by ethanol (COELHO; PALETTA; FREITAS, 2000; GOLDEMBERG; COELHO; LUCON, 2003)

4.3.4.3 For poverty eradication

The Biodiesel Program

Brazil mix 3% of biodiesel to petroleum diesel since 2008, for that, it is necessary a cropping area of 1,5 million ha, which is equal to 1% of 150 million ha cropped and available for agriculture in Brazil. This number does not include the areas occupied by forests and pastures (COMISSÃO EXECUTIVA INTERMINISTERIAL, 2008).

Brazil foresees biodiesel production will be around 1.1 to 1.2 billion of liters in 2008, the first year of obligation to mix biodiesel to petroleum diesel. This puts Brazil as third bigger producer and consumer of this fuel, behind Germany and USA (MDA, 2008c).

Besides the economic and environmental advantages of biodiesel, there is the social aspect, of fundamental importance, overall if we consider the possibility of synergism combining all these potentialities. The rules allow the production from different oil plants and technological routes, enabling the participation of agribusiness in family agriculture.

The cultivation of raw materials and biodiesel industrial production has a great potential of employment generation, especially when we consider the use of family agriculture.

In the semi-arid, the annual liquid income of a family who cultivates 5 ha with castor plant and an average production of 700 to 1,200 kilogram per ha, may vary from R$2.5 thousand to R$ 3.5 thousand. Besides that, the area may be consorted with other cultures as beans and corn.

To encourage this process, Federal Government launched the Social Fuel Stamp (Selo Combustível Social), a set of specific measures aiming the social inclusion of agriculture (COMISSÃO EXECUTIVA INTERMINISTERIAL, 2008). The social responsibility of projects or companies which produce biodiesel allows the access to better conditions of financing from BNDES and other financial institutions, besides giving the right to participate in auctions for biodiesel purchase. The manufacturing companies have the right to some taxes exemption; however they must assure the purchase of a share of raw material in pre-determined prices, offering security to family farmers. Family farmers must participate as partners or quota holders in oil extraction industries or in biodiesel production in a direct way or through production associations or cooperatives.

Family farmers have access to credit lines from PRONAF, through banks that operate with this program, and technical assistance offered by the companies who hold the Social Fuel Stamp. With this, the producer may increase his/her income, without leaving its main activity of food cropping. Farmers maintain their maize and manioc production, and in the *safrinha* they cultivate oil crops. Credit limit and financing conditions must follow the same rules of the PRONAF group he or she belongs to (COMISSÃO EXECUTIVA INTERMINISTERIAL, 2008).

Program Light for All (Programa Luz para Todos)

Federal government began in 2004 the National Program for Universal Access and Use of Electric Energy – Light for All, with the goal of bringing electric power for rural population (MME, 2008).

The majority of families without access to power live in areas with the lowest Human Development Index, in families with very low income. Around 90% of these families receive less than 3 minimum wages (minimum wage is US 150/month) and 80% are in the rural area.

The goal of the Program is to bring power to these communities so they may use it as a vector for social and economic development, contributing to the reduction of poverty and increase in family income. Besides that, the arrival of power facilitates other social programs, such as the access to health and education services, sanitation and water supply.

The connection of power in the houses is free and includes three points of light and two electrical sockets in each house (MME, 2008). Two million of families of the rural area were benefited from this program, from each 130 thousand are agrarian reform settlers (MME, 2008).

National Program for Education in Agrarian Reform (Programa Nacional de Educação na Reforma Agrária, Pronera)

The National Program for Education in Agrarian Reform, of the National Institute of Colonization and Agrarian Reform (Instituto Nacional de Colonização e Reforma Agrária, Incra), has the mission of broadening the levels of formal education of settled rural workers (INCRA, 2008b).

Youth and adults from settlements participate in courses of basic education (literacy, primary and middle education), vocational courses, and different college courses and post-graduation. Pronera builds the capacities of educators to work in the schools of agrarian reform settlements, and also local coordinators, to replicate and organize community education activities.

The program supports projects in all levels of education.

<u>Education of Youth and Adults (Educação de Jovens e Adultos, EJA)</u>:

The project promotes literacy courses and continuation of formal education in fundamental and middle school. Project comprehends three basic actions:

- Promote literacy courses and educate youth and adults in the fundamental and middle school;
- Build capacities and train educators in fundamental school, so that they may replicate knowledge in agrarian reform settlements;
- Form and educate local coordinators to act as social agents and planners of community education activities.

Middle School and Vocational Training:

The project carries out activities for the formation of teachers in Pedagogy course and education of youth and adults technicians in agrarian reform areas. The goal is to build capacities in the settlements of professionals able to contribute to the enhancement of communities' life quality and promotion of development in agrarian reform settlements.

Higher Education:

The project has the goal of promoting professional formation, through graduation and pos-graduation courses, in several areas of knowledge for the promotion of sustainable development in settlements. They promote the dialog and scientific research among communities and universities, developing appropriate methodologies for the territorial diversities.

Pronera is a partnership of INCRA with social movements and rural workers' unions, public education institutions, community education institutions with no lucrative ends and municipal and state governments (INCRA, 2008b).

Program of Rural Libraries "Chest of Letters" (Programa de Bibliotecas Rurais Arca das Letras)

The Program of Rural Libraries was created to encourage reading and facilitating the access to books in settlements, family farmers' communities and former slaves' communities (*quilombos)*.

The Program of Rural Libraries assures the participation of communities in the formation and implementation of libraries. The inhabitants indicate the place for the installation, the themes of their interest and their Library Agents, who are volunteers in charge for lending the books and for encouraging reading in the community.

The books are selected according to the cultural profile of each community. Later, the collection of books is formed. Each library has 220 titles obtained by donation, covering children literature, literature for youths and adults, didactic books, research and technical books, including issues of rural population interest and their specific realities (MDA, 2008a).

4.3.4.4 For land use

Program for Technical, Social and Environmental Assistance to Agrarian Reform (Programa de Assessoria Técnica, Social e Ambiental à Reforma Agrária, Ates)

The Program for Technical, Social and Environmental Assistance to Agrarian Reform seeks to ally the traditional knowledge of settlers with technical knowledge. With this union, it is expected that settlements become unities of structured production, competitive and integrated to the dynamics of municipal and regional development, in a socially and environmental just way (INCRA, 2008a).

The services of Ates are a set of techniques and methods of permanent, public and free nature, with emphasis in agroecology, cooperation and popular economy. Coordinated by INCRA, count with public and private partner institutions, entities that represent rural workers as well as non-governmental organizations which work with agrarian reform.

The program works with technical staff specialized in agrarian, social, environmental and economic sciences. The groups work in settlements elaborating development or recovery plans for settlements projects, in rural extension, ongoing capacity building, aiming the formation of competencies and change in attitudes and procedures that enhance life quality and promote sustainable rural development (INCRA, 2008a).

National Program for Hydrographic Micro Basins and Soil Conservation in Agriculture (Programa Nacional de Microbacias Hidrográficas e Conservação de Solos na Agricultura)

The National Program for Hydrographic Micro Basins and Soil Conservation in Agriculture has the goal of promoting rural development in an integrated and sustainable way, having the hydrographic micro basin as the unit for producers' planning and organization, as strategy to promote enhancement in agricultural productivity and use of appropriate technologies, under the environmental, economic and social point of view (MAPA, 2008).

The activities that aim rational use and management of natural resources, mainly soil, water and biodiversity, aim to promote a sustainable agriculture, increase food supply and enhance the levels of work and income in rural areas.

Micro basins are natural geographic units more appropriate for the establishment of use and management plans, monitoring and evaluation of human interference in the environment.

The planning and implementation of works in hydrographic micro basins are carried out starting from the organization of the community towards common goals. The feature of the physical and biotical environment (native vegetation, climate, kinds of soil, topography, actual use of land, available water resources, fauna), allied with social economic aspects (agrarian structure and situation, market, transportation infra-structure, energy, telecommunications, financial agents), allow the establishment of priorities and goals, in short, medium and long term, the division of responsibilities and joint efforts to assure productivity enhancement, environment stability, generation of work and income and well being in rural areas..

The program works in all national territory, respecting the regional and local peculiarities. Organized communities, partnership between public and private institution, agreements of technical cooperation are the basis of the adopted strategy. As a priority, the following actions are developed (MAPA, 2008):

- Capacity building of technical staff and farmers in Planning of Hydrographic Basins and Water and Soil Preservation;
- Validation and divulgation of technologies in soil management and conservation;
- Introduction of practices of soil cover;
- Practices of organic agriculture and agro forestry;
- Implementation of gardens;
- Recomposition of gallery forests and protection of fragile areas;
- Practices of preservation and sustainable use of water resources;
- Fix of land secondary roads;
- Lime and gypsum of crops soil;
- Practices of contention and control of *voçorocas*[7];
- Demarcation of level curves and construction of terrace systems;
- Implementation of demonstrative projects of plagues integrated management;
- Production and divulgation of technical/educative material;
- Support and carry out technical events (day-in-field, seminars, work meetings);
- Recuperation of degraded areas;
- Introduction of the No-Tillage System

[7] Geological phenomenon that consists in the formation of great holes of erosion, caused by rain and weather.

State Program for Hydrographic Micro Basins (Programa Estadual de Microbacias Hidrográficas)

The State Government of Sao Paulo implemented in 2000 the State Program for Hydrographic Micro Basins, which promotes actions to assure the conservation of natural resources, to enhance productivity, increase income, and reduce costs of producers. These actions, besides assuring profit to farmers, generate work and increase tax collection in municipalities, stops social exclusion and rural exodus, preserving the environment (SÃO PAULO, 2008).

The goal of the program is to promote sustainable rural development. In order to do that, besides technical assistance and rural extension to family farmers, the program carries out financial incentive, where the producers pay small amounts, enabling the implementation of practices that promote the conservation of natural resources and acquirement of equipments and services necessary to cattle raising and agriculture activities, which the producers would not be able to get without the program.

In the case of individual practices, the grants vary from 60 to 90% of the total value. The Program gives financial support to:

- Services of Moto mechanization in the control of ravine and *voçorocas*,
- Installation of fences to protect springs,
- Installation of *biodigestor* septic tanks,
- Control of erosion, building of terraces and constructions of retention boxes or basins,
- Acquisition of lime,
- Construction of retention tracks,
- Implementation of systems of pastures division,
- Construction of water storage tanks (*abastecedouros)*
- Acquisition of agriculture implements, in addition to the donation of seedlings for recuperation of gallery forests and springs preservation.

National Action Program for Combat and Mitigation the Effects of Drought (Programa de Ação Nacional de Combate e Mitigação dos Efeitos de Seca, PAN Brasil)

National Action Program for Combat and Mitigation the Effects of Drought gives financial and technical support, through partnerships with funding agencies, for the elaboration and implementation of the Plans to Combat Desertification and Drought in the nine northeastern states, in addition to Espirito Santo and Minas Gerais, where are situated the areas most susceptible to drought (MMA, 2008a).

Brazil is the fifth country in world ranking of populations most affected by soil degradation. The estimative is that 46 million people, the majority living in the northeast semi-arid, already suffer the direct consequences of desertification.

One of the planned tasks in PAN Brasil is to establish strategies for implementing the Convention of the United Nations for Combat to Desertification and Mitigation of Droughts Effects, from which the country is signatory for ten years.

PAN Brasil, which gathers nine ministries, the Codevasf, The Bank of the Northeast of Brazil, the SUDENE, DNOCS, the National Agency for Waters (ANA), Embrapa, and the National Association of Municipal Environmental Institutions (ANAMMA), in addition to the government of eleven states and representatives of civil society, identified localities to implement the projects of drought effects mitigation and combat to desertification. With the projects, the communities and governments may prepare themselves to face long periods of drought, adopting soil protection measures, and water and food storage, among other initiatives to minimize the effect on population (MMA, 2008a).

PAN-Brasil assured resources of around one million reais (US$ 400,000) to support small projects of combat to desertification in 2009. This is the double of what is applied in 2008 in nine of the 11 states with areas susceptible of desertification. They are projects of up to R$ 25 thousands, proposed and carried out by organizations of the civil society (MMA, 2008a).

4.3.4.5 For water use

At present there is a tendency for developing basins and State water master plans. This is done in order to secure the use of water in the various sectors and reduce future risks in water use. Up to now, fourteen states have advanced their plans for water resources management and river basin management: São Paulo, Minas Gerais, Espirito Santo, Goiás, Mato Grosso do Sul, Mato Grosso, Distrito Federal, Ceará, Rio Grande do Norte, Bahia, Alagoas, Sergipe, Rio Grande do Sul and Santa Catarina. Furthermore, a large number of committees, consortium and associations at water basin level have been created. Various Master Plans at water basin level have been elaborated and others are in the process of preparation (ANA, 2007).

The main trend with the "*New Irrigation Project" (Novo Projeto de Irrigação)* is towards increased private participation and privatization of public schemes. Ministry of Environment initiated a complete study of irrigation, which intends to map the actual sites of the irrigation schemes and select potential areas for irrigation projects without risk of water conflict.

State Program for Collection and Management of Rainwater (Programa Estadual de Captação e Manejo de Água da Chuva, Pecmac)

The State Program for Collection and Management of Rainwater (Pecmac) is an initiative of the State Government of Rio Grande do Sul and seeks alternatives for the use of rainwater in projects of collection and storage in cisterns (PÁGINA RURAL, 2008).

Rural workers interested in the construction of reservoirs in their proprieties receive technical assistance to attend their need. With the project, the rural producer may obtain financing for their work. R$ 2 million are available for Pecmac, using resources of PRONAF.

Program for Night Irrigation (Programa Irrigação Noturna, PIN)

Program for Night Irrigation is an initiative of the State Government of Paraná and has the goal of facilitating the access of farmers to the irrigation technique, with the reduction of electric power fee used between 9 pm and 6 am. The proposal is to assist more than 15 thousand proprieties and reset irrigation timing for other 15 thousand. The plan is that the Program for Night Irrigation is used in more than 50 thousand hectares and double the agricultural production in the state in the middle term (PARANÁ, 2008).

The program consists in the reduction of 60% to 70% in the electric power fee from low and high voltage, in addition to the supply of up to 200 meters of electric power networks, complementation of up to 500 meters of free power network and the rest with 50% of financing. The costs with installation for power measurement may be divided in up to 24 months, with no interests, besides the easy access to credit for buying and installing irrigation equipments.

The program reduces the energy consumption in peak times, settles the supply of crops, enhances water utilization, and rationalizes the use of pesticides, in addition to that, contributes to the insertion of small farmers in the market in a competitive way and serves as a tool to increase productivity and production.

Funds for the Agribusiness and for Water Resources (Fundos Setoriais do Agronegócio e de Recursos Hídricos)

The Funds for Agribusiness and Water Resources, maintained by the National Council for Scientific and Technological Development (Conselho Nacional de Desenvolvimento Científico e Tecnológico, CNPq/MCT), support researches in themes that prioritize water and soil conservation and increase in water production in family production rural units and have available R$ 10 million (US$ 5 million) in 2008 (CNPQ, 2008).

The project must prioritize themes as reestablishment of ecosystems hydrologic functions; adoption of agriculture techniques that promote the sustainable use and conservation of water; technologies for recovery and protection of springs, gallery forests and permanent preservation areas; conservation and valorization of environmental services; and sewage treatment and proper allocation of waste on farms.

4.3.5 Trade issues and financing mechanisms

Agriculture is an economic activity highly dependent on financing, both for investment in infra-structure and, mainly, for production. Modern agriculture depends on machinery, equipments and inputs that are each time more expensive. In industrial production, normally, the period between buying inputs and selling the final product is only a few days or weeks. On the other hand, even in annual crops, the period between production beginning with soil preparation, and finishing with commercialization is never less than four or five months. A great part of rural producers expenses concentrate also in the first steps of the production cycle, increasing the need and dependence of financial resources for its feasibility.

Rural credit was, historically, the main tool for agriculture policies in Brazil. With the government effort for industrialization, agriculture had to assume a role, among others, of resources supplier for the country, through exportation. Government, then, created a broad system of subsidized rural credit, which could facilitate the acquisition of machinery and equipments, in addition to modern inputs that would enable the adoption of new production technologies. At the boom of this policy, in the 70's, there was abundant volume of credit at very low interest rates. Some producers benefitted a lot from this policy, while others never had access to cheap and abundant credit in this period. (SILVA JÚNIOR, 2008).

Starting from the 80's, the volume of available credit decreased and interest rates significantly increased. Serious debts crisis began in the sector, aggravated by the economic instability and several economic plans implemented in the 80's and 90's. The agriculture sector modernized and continued to depend each time more on resources for investments and financing of the production. This dependence was most evident in business agriculture with the debts crisis, but the problem of financing was even more critical in family farming.

The shortage, difficulty or impossibility of access to credit creates conditions highly unfavorable to rural producer while creating opportunities to those other agents to act, offering credit in critical times for agriculture production and obtaining highly advantageous benefits in the payment of the debt, which typically occurs in harvest time. This situation is especially unfavorable for the producer when the crop buyer is also the financer of the production. That is to say, besides the fact of the crop production being seasonal and products being perishable, they must pay off its debt exactly at the time of most unfavorable prices. This situation is very common in business and family farming.

Certainly, political pressure is important in crisis situations and search for renegotiation of debts, once or several times, changes in dollar exchange rates and economy policy significantly affect debt value. However, in the decision of cropping and searching for financing, the rural producer does not count with the appropriate assistance. Obviously, it is not expected that farmers became financial specialists, even more when we know the reality of the field and the difficulties and problems in technical assistance and rural extension. However, there is no other alternative for rural producers than to know and use in an appropriate way the available financing tools.

In addition to direct funding provided by traders, there are other tools:

Rural Product Ballot (Cédula de Produto Rural, CPR)

The Rural Product Ballot (CPR) can be understood as a “document” issued by rural producers or cooperatives which allows them to raise funds. The application for loan becomes not personal, that is to say, the producers does not need to obtain resources from his buyer or seller of inputs. He or she uses the CPR through a bank, which liberates the financing resources for the rural producer. The bank sends the document to any economic agent that wants to buy this “paper”. The producers may pay his debt through the delivery of products or financing resources. Since the CPR is regulated by specific policies, this is a safe tool and broadly known. (SILVA JÚNIOR, 2008).

National Program for Strengthening of Family Farming (Programa Nacional de Fortalecimento da Agricultura Familiar, PRONAF)

Another tool for financing family farmers is the credit lines of PRONAF. They were created in the mid 90’s and the offered volumes have increased significantly, so far. For the 2007/2008 crops, 12 billions of reais (US$ 6 billions) were allocated in several credit lines, to support the family producer with greater access to technology, even to agrarian reform settlers. (BNDES, 2008).

The goal of PRONAF is to fund agriculture and cattle raising activities and also non-agriculture and cattle-raising activities explored through direct employment of rural workers and their families’ labor, understanding non-agriculture or cattle raising activities the services related to rural tourism, handicrafts, family agribusiness and other services delivery in rural areas, which are compatible with the nature of rural exploitation and with the best employment of family labor (BNDES, 2008).

PRONAF has lines for activities with agro ecology, forest production, agro industries and also for specific groups. There are six different credit lines from PRONAF (BNDES, 2008) described below:

Conventional PRONAF

Funding support to investments for implementation, enlargement or modernization of infra-structure of agriculture and cattle raising production and services, in rural establishments or in rural community areas, according to specific projects.

Agroindustry PRONAF

Funding support to investments, including infra-structure, which aim the improvement, processing and marketing of agriculture and cattle raising production, of forest products and of extrativism, handicrafts products or rural tourism exploitation.

Women PRONAF

Funding support to credit proposals of women farmers, according to technical project or simplified proposal.

Agroecology PRONAF

Funding support to investments in agroecology or organic production systems, including the costs relative to the implementation and maintenance of the business.

PRONAF ECO

Funding support to investments in the implementation, utilization and/or recovery of renewable energy technologies, water storage, small hydro energy exploitations, forestry practices and adoption of conservationists practices and of correction of soil acidity and fertility.

More Food PRONAF

Funding support to investments for production of maize, bean, rice, wheat, cassava, vegetables, fruit and milk.

With all the above credit lines PRONAF has been very useful but some negative aspects can be identified. As in business agriculture, in some regions there is a high rate of unpaid debts among family farmers, to whom PRONAF is not available anymore. With this situation, a cycle starts where the farmer has no more access to credit, because one has unpaid debts and cannot leave this cycle, once one has not conditions of investing or financing his production, due to the lack of credit.

PRONAF presents another problem: the availability of the resource in the bank does not assure that it will arrive to rural family workers. It is not difficult to understand the difficulties of a rural worker family with low level of formal education in their interaction with financing agents. There are, however, several successful experiences with PRONAF, in which the technical assistance is carried out by professionals that have knowledge in the rural credit mechanisms (BNDES, 2008).

National Program for Land Credit (Programa Nacional de Crédito Fundiário)

Land Credit is a program that enables rural workers with no land, owners of small lands and youth rural workers the access to the land through financing for acquisition of rural buildings/lands (MDA, 2008b).

Investments in basic infrastructure (houses, electric power, water supply, roads) are also funded, as well as the settling of the productive unit (technical assistance, initial investment in production) and community projects. There are additional credits for projects that aim the improvement of life in the semi-arid and recovery of environmental liabilities. It is only possible to finance the acquisition of lands that show no risk of being expropriated for agrarian reform (MDA, 2008b).

The National Program for Land Credit is part of the National Plan for Agrarian Reform. It is the result of the Loan Agreement with the World Bank. The resources for acquisition of buildings and lands come from Federal Government.

The Land Credit is carried out in a non-centralized way, in partnership with state governments and with rural workers unions and family farmers unions and counts with the participation of the Municipal and State Councils for Sustainable Rural Development.

There are three lines of financing (MDA, 2008b):

Combat to Rural Poverty

For the poorest areas and poorest rural workers;

Our First Land

For youths sons of family farmers and students of agriculture technical schools and *Escolas Família Agrícola* (Farmer Family School);

Consolidation of Family Agriculture

For family farmers that want to enlarge their proprieties.

Interests rates may vary between 3 and 6.5% per year, according to financing values, which vary from R$ 5 thousand to R$ 40 thousand (US$ 2.5 to 20 thousands).

In the case of the credit lines *Combat to Rural Poverty* and *Our First Land*, which counts with resources from the World Bank, the funding of investments is not reimbursable (MDA, 2008b).

Installation Credit

The granting of Installation Credit allows the initial support to settlers of the National Program for Agrarian Reform in the Settlement Projects created or recognized by the National Institute of Colonization and Agrarian Reform (Instituto Nacional de Colonização e Reforma Agrária, Incra). The benefit must assure the food security of settlers' families, through acquisition of food and farming inputs; construction and rebuilding of houses; water security of projects located in the semi-arid, with construction of small water collection systems, water storage and distribution; and the application in production liabilities (seeds, seedlings, animal matrix, etc.), for income generation (INCRA, 2008c).

Installation Credit has been granted since 1985, and it is an important tool in the implementation of settlement projects. Its values and modalities have been set through the years in order to provide dignified conditions for occupation, production and maintenance of families in rural areas. There are five modalities and correspondent set values. (INCRA, 2008c):

- Initial support: R$ 2,4 thousand (US$ 1,200) per family;
- Acquisition of building materials: R$ 5 thousand (US$ 2,500) per family;
- Foment: R$ 2,4 thousand (US$ 1,200) per family;
- Semi-Arid Additional: Up to R$ 1,5 thousand (US$ 1,250) per family;
- Recovery of building materials: Up to R$ 3 thousand (US$ 1,500) per family.

The Installation Credit Program works with a multidisciplinary staff of technicians in INCRA Regional Oversight and Advanced Units. The application of resources is carried out with the participation of settlers associations or representatives, guided by the Technical Assistance, in the choosing and receipt of products, which are paid directly to the supplier: local markets, building material stores and farming inputs stores (INCRA, 2008c).

Other rural credit lines

Rural credit is accessible, but it is not an easy credit. The institution that offers rural credit establishes conditions for its liberation, including, sometimes, the need of technical follow up and supervision of the planned activity. The funding institution will also ask for guarantees, such as liens, mortgages, among others. Taxes and fees related to the operation will also be charged, including rural security prize and additional of Agriculture and Cattle Raising Activity Guarantee Program (Proagro). Interest rates vary according to the rural credit line that is been applied. Once the credit is granted, it will be released in a single or in several installments. The payment of the loan can also be done in a single payment or in several payments.

In the case of resources controlled by Government, limits vary between R$ 60 thousand and 400 thousand per producers (US$ 30,000 to 200,000), with interest rates of 8.75% per year, equalized by National Treasure, distributed in different rural credit lines (BANCO CENTRAL DO BRASIL, 2008):

Program for Modernization of Farming Tractors Fleet and Associated Implements and Harvesters (Programa de Modernização da Frota de Tratores Agrícolas e Implementos Associados e Colheitadeiras, Moderfrota)

To facilitate the acquisition of farming tractors and associated implements and equipments for preparation, drying and improvement of coffee, funded as an isolated item or not.

Program for incentive of the Use of Soil-Corrective (Programa de Incentivo ao Uso de Corretivos de Solos, Prosolo)

To encourage the appropriate use of soil-corrective.

National Program for Recovery of Degraded Pastures (Programa Nacional de Recuperação de Pastagens Degradadas, Propasto)

For recovery of degraded areas and pastures.

Program for incentive to the Mechanization, Cooling and Bulk Transportation of Milk Production (Programa de Incentivo à Mecanização, ao Resfriamento e ao Transporte Graneleiro da Produção de Leite, Proleite)

To encourage the enhancement in the quality of milk production.

Program for Beekeeping Development (Programa de Desenvolvimento da Apicultura, Prodamel)

To encourage the development of beekeeping in Brazil.

Program of Support to Tree Fruit Production (Programa de Apoio à Fruticultura, Profruta)

Support the developing of tree fruit production.

Program for Development of Small Animals Raising (Programa de Desenvolvimento da Ovinocaprinocultura (Prodecap)

To enhance the management, feeding and genetic of animals, increasing production and productivity of small animals raising.

Program for Development of Cashew Production (Programa de Desenvolvimento da Cajucultura (Procaju)

For enhancing cashew agribusiness in the Northeast Region.

Program for Systematization of Lowlands (Programa de Sistematização de Várzeas, Sisvárzea)

To increase the production of grains in lowlands, especially maize, in all national territory.

Program for Support to the Development of Wine Production (Programa de Apoio ao Desenvolvimento da Vitivinicultura, Prodevinho)

To modernize wine production in the South Region.

Program for Sustainable Development of Flower Plantation (Programa de Desenvolvimento Sustentável de Floricultura, Prodeflor)

To accelerate the development of Brazilian flower production and quality.

Program for Incentive to the Construction and Modernization of Storage Units in Rural Proprieties (Proazem)

To increase the installed capacity for storage in rural proprieties.

Program for Support to the Development of Fish Farming (Programa de Apoio ao Desenvolvimento da Aqüicultura, Aqüicultura)

To increase the production of fish, shrimp and shellfish in regime of aquaculture.

Program of Support to Irrigated Agriculture (Programa de Apoio à Agricultura Irrigada, Proirriga)

To support the development of irrigated agriculture, in order to assure greater stability in production, overall of vegetables, grains and fruits.

Program for the Cooperative Development for Adding Value to Agriculture and Cattle Raising Production (Programa de Desenvolvimento Cooperativo para Agregação de Valor à Produção Agropecuária, Prodecoop)

To increment the competitiveness of agriculture industry complex of Brazilian Cooperatives, through modernization of production systems and commercialization.

Program of Support to the Development of Cocoa Production (Programa de Apoio ao Desenvolvimento da Cacauicultura, Procacau)

To increase the productivity of cocoa production, through cloning and density.

Program of Commercial Planting of Forests (Programa de Plantio Comercial de Florestas, Propflora)

To implement and maintain forests destined to industry use.

4.3.6 Climate change issues

Despite technological advances, such as improved varieties, genetically modified organisms, and irrigation systems, weather is still a key factor in agricultural productivity, as well as soil properties and natural communities. The effect of climate on agriculture is related to variability in local climates rather than in global climate patterns. Consequently, agronomists consider any assessment has to individually consider each local area.

On the other hand, agricultural trade has grown in recent years, and now provides significant amounts of food, on a national level to major importing countries, as well as comfortable income to exporting ones. The international aspect of trade and security in terms of food implies the need to also consider the effects of climate change on a global scale.

The 2001 IPCC Third Assessment Report concluded that the poorest countries would be hardest hit, with reductions in crop yields in most tropical and sub-tropical regions due to decreased water availability, and new or changed insect pest incidence. In Africa and Latin America many rainfed crops are near their maximum temperature tolerance, so that yields are likely to fall sharply for even small climate changes; falls in agricultural productivity of up to 30% over the 21st century are projected (IPCC, 2001).

Climate change induced by increasing greenhouse gases is likely to affect crops differently from region to region. More favorable effects on yield tend to depend to a large extent on realization of the potentially beneficial effects of carbon dioxide on crop growth and increase of efficiency in water use. Decrease in potential yields is likely to be caused by shortening of the growing period ant decrease in water availability.

In the long run, the climatic change could affect agriculture in several ways:

- productivity, in terms of quantity and quality of crops;
- agricultural practices, through changes of water use (irrigation) and agricultural inputs such as herbicides, insecticides and fertilizers;
- environmental effects, in particular in relation of frequency and intensity of soil drainage (leading to nitrogen leaching), soil erosion, reduction of crop diversity;
- rural space, through the loss and gain of cultivated lands, land speculation, land renunciation, and hydraulic amenities;
- adaptation, organisms may become more or less competitive, as well as humans may develop urgency to develop more competitive organisms, such as flood resistant or salt resistant varieties of rice.

They are large uncertainties to uncover, particularly because there is lack of information on many specific local regions, and include the uncertainties on magnitude of climate change, the effects of technological changes on productivity, global food demands, and the numerous possibilities of adaptation.

Most agronomists believe that agricultural production will be mostly affected by the severity and pace of climate change, not so much by gradual trends in climate. If change is gradual, there may be enough time for biota adjustment. Rapid climate change, however, could harm agriculture in many countries, especially those that are already suffering from rather poor soil and climate conditions, because there is less time for optimum natural selection and adaption (IPCC, 2001).

For Brazil, the prevision is that global warming causes significant changes in Brazilian agriculture map, generating production losses at around R$ 7.4 billion in 2020 and of R$ 14 billion in 2070 (PINTO; ASSAD, 2008). The results are part of the study called “Global Warming and Future Scenarios of Brazilian Agriculture”, which evaluates the impact of the increase in temperature on agriculture in 2020, 2050 and 2070. The research assessed the following crops: cotton, rice, beans, coffee, sugarcane, sunflower, cassava, maize and soybean. The study was done based in the technology of Climatic Risks Zoning, a public policy that guides all structure for farming credit in Brazil, since it informs the risk level of more than 5000 Brazilian cities concerning the most common crops in the country. The study does not include the Amazon since this region does not belong to the Climatic Risks Zoning, tool which based all the projections.

Based on the 2007 Zoning for the crops, cropping scenarios were simulated for Brazil in 2010 (closer representation to current conditions), 2020, 2050 and 2070, having the current perspective of global warming, projected by IPCC (2000). Two IPCC scenarios were adopted: A2, which estimates an increase in temperature of 2°C to 5.4ºC up to year 2100 – and scenario B2, which foresees an increase in temperature between 1.4°C and 3.8ºC in 2100. Climatic scenarios were then simulated based in these conditions, for each country municipality in 2020, 2050 and 2070.

The increase in temperature shall promote a growth in evapotranspiration and, consequently, an increase in water deficiency. The dry regions will be even drier. Scenarios indicate a strong impact on Northeast region with the increase in temperatures. Semi-arid shall turn into arid, and the *Agreste* into semi-arid. The poorest areas, all the area correspondent to the northeastern *Agreste*, today responsible for the biggest part of corn regional production, and the region of *cerrado* in northeast – south of Maranhão, south of Piauí and west of Bahia, where soybean crops dominate – will be the most affected. Cassava will be in danger of disappearing from the northeastern semi-arid. In the southeast, climate warming will affect mainly coffee cropping, which will have few conditions of surviving in this area. On the other hand, the south region, that today is the most restricted area for crops adapted to tropical climate, due to the high risk of frosts, shall became appropriate to the cultivation of cassava, coffee, sugarcane, but no longer to soybean. Some areas from the Midwest, which present a high productive potential, must remain a low risk area, becoming, however, each time more dependent on irrigation in the dry season.

Soybean, main crop exported by the country, with a production of around 52 million t/year and production value of R$ 18.4 billion (US$ 20 billions) (IBGE, 2007a), may suffer an economic loss of R$ 4 billion in 2020, result of a reduction of almost 24% in the area proper for cropping in Brazil. The losses may get to R$ 7.6 billion in 2070, due to a decrease of 40% of the area appropriate to cultivation. The region that shall suffer most the impacts is the South region.

Having as a base the Brazilian coffee production, of around 2.5 million tonnes and production value of R$ 9.3 billion (IBGE, 2007a), global warming will bring losses for this crop of at least R$ 882 million in 2020, with a decrease of 9.48% in the area proper for cultivation. In the worst scenario (A2), the decrease in the area of low risk reaches 33% in 2070, which represents a loss of R$ 3 billion. Currently, the state of greatest coffee production in Brazil is Minas Gerais, followed by Espirito Santo, Bahia, Sao Paulo and Paraná. However, with the climatic changes forecast, it is possible that coffee has not many chances of surviving in the Southeast, migrating for the South region.

The forecast for cassava is that the increase in temperature will not be advantageous for the crop throughout the country. In 2020, the northeastern semi-arid shall no longer be a low risk location and other regions would still not be warm enough for the cropping. There will be a loss of 3.1% in cassava production area, with a financial loss of R$ 137 million. In the following decades, the situation will improve for this root, which will find more favorable areas in the South of the country, due to the decrease in the risk of frosts, and in Amazon, for the decrease of water surplus. The increase of the appropriate area starts with 7.29% in 2050, reaching 16.61% in 2070, in scenario B2. In scenario A2, the increase in the area reaches more 13.49% in 2050 and 21.26% in 2070, with earnings between R$ 589 million and R$ 929 million.

With the production of around 11.5 million tonnes (IBGE, 2007a), rice is considered a high risk crop, due to its extreme sensibility to climatic changes. Currently, the greatest production of rice is found in regions with the appropriate level of rain, especially in mid-north of Mato Grosso. In 2020, rice production may have suffered a loss of R$ 417 million and a reduction in its area appropriate for cultivation of almost 10%. In 2070, financial losses shall be around R$ 600 million in the two scenarios.

Brazilian bean crop in 2006/2007 was 3.52 million tonnes (IBGE, 2007a), almost stable in relation to the previous crop. Using this data as a reference, the foreseen loss will be of R$ R$ 155 million, due to a reduction of 4.3% in the area appropriate for cultivation in 2020, and it is possible that the financial loss reaches R$ 473 million, with the decrease in the low risk area of up to 13.3%. This decrease shall be greater in the Northeast area.

Of the different crops, sugarcane shall be the most favorable one until the end of this century. This crop, which counts today with a cultivated area of around 6 million ha, will have a potential area of 17 million ha in 2020, in scenario B2. With this expansion, the value of production, which was almost R$ 17 billion in 2006, may go up to R$ 29 billion in 2020, in scenario B2.

Areas in the south of Brazil, which today have restrictions to sugarcane cropping, may transform themselves in areas of productive potential, in 10 or 20 years. Places of Mid-West, which today represent a high productive potential, shall remain as low risk areas; however they will be each time more dependent on complementary irrigation in the dry season. With the increase in temperature in the following decades, the crop will need more irrigation and the total area must fall to 15 million ha until 2070 in scenario B2, decreasing the profit for R$ 24 billion.

According to scenario A2, sugarcane shall have a potential area of 16 million ha, decreasing for 14 million in 2070. In this scenario, the value of production may rise to R$ 27 billion in 2020, and back to R$ 20 billion in 2070 (PINTO; ASSAD, 2008).

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