Instituto de Eletrotécnica e Energia

Centro Nacional de Referência em Biomassa

Possibilities of sustainable woody energy trade and impacts on developing countries:

Country Case Study Brazil

prepared for GIZ under subcontract with IINAS

prepared by

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Acronyms

ABRAF	Brazilian Association of Forest Plantation Producers
AMS	Associação Mineira de Silvicultura
BNDS	Banco Nacional do Desenvolvimento - Brazil
BRACELPA	Associação Brasileira de Papel e Celulose) 2013: Panorama da Industria Brasileira de Celulose e Papel, Relatório Estatístico; São Paulo
CENBIO	Centro Nacional de Referência em Biomassa
CGEE	Centro de Gestão e Estudos Estratégicos/Center for Strategic Studies and Management
CNI	National Confederation of Industry – Brazil
DIRET	Education and Technology Directorship – Brazil
EMBRAPA	Brazilian Agricultural Research Corporation
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FSC	Forest Stewardship Council
GEF	Global Environment Facility
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
IBGE	Brazilian Institute of Geography and Statistics
IEA	International Energy Agency
IDB	Inter-American Development Bank
IIED	International Institute for Environment and Development
IINAS	International Institute for Sustainability Analysis and Strategy
M	Million
MMA	Ministério do Meio Ambiente – Brazil
MME	Ministério de Minas e Energia- Brazil (Ministry of Mines and Energy – Brazil)
RED	Renewable Energy Directive (EU 28/2009)
SAE	Secretaria de Assuntos Estratégicos da Presidência da Republica-Brazil
SFM	Sustainable Forest Management
SRC	Short rotation coppice
t	tones
UN	United Nations
UNICA	Sugar Cane Industry Association – Brazil

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Introduction

This report presents a country case study on Brazil as part of the BMZ/GIZ project "Possibilities of sustainable woody energy trade and impacts on developing and emerging countries"[1]. The case study was carried out by CENBIO under subcontract with IINAS.

It is divided into the following sections:

- Section 1 gives a general overview on Brazil
- Section 2 addresses the production and demand for solid biomass for each type of wood.
- Section 3 presents the solid bioenergy use in the Brazilian energy mix by wood products.
- Section 4 on solid bioenergy potentials provides general information on wood bioenergy in Brazil, including the current situation of wood plantations in Brazil and scenarios for 2020.
- Brazilian regulation and sustainability issues for woody bioenergy are analyzed in Section 5, including environmental legislation and recent policies such as the agro-environmental zoning for biofuels.
- Despite the fact that currently there is not significant export of wood bioenergy from Brazil, respective export options are discussed in Section 6, considering the current perspectives worldwide.
- Final considerations are presented in Section 7, discussing the existing barriers and presenting some policy proposals to incentivize the sustainable production of wood bioenergy for export in Brazil.

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1 **Summary** of this study:
IINAS (International Institute for Sustainability Analysis and Strategy) 2014: Possibilities of sustainable woody bioenergy trade and impacts on developing countries - summary report; Fritsche U, Iriarte L, Gress HW; commissioned by GIZ; Darmstadt, Madrid
http://www.iinas.org/tl_files/iinas/downloads/IINAS_2014_Sust_Woody_Bioenergy_summary_report_GIZ.pdf
Full report including the Brazil Case Study and Annexes:
IINAS (International Institute for Sustainability Analysis and Strategy), CENBIO (Centro Nacional de Referência em Biomassa) 2014: Possibilities of sustainable woody bioenergy trade and impacts on developing countries - final report; Fritsche U et al.; prepared for GIZ; Darmstadt, Madrid, Sao Paulo
http://www.iinas.org/tl_files/iinas/downloads/IINAS_CENBIO_2014_Sust_Woody_Bioenergy_GIZ_full.pdf

1 General Overview on Brazil

Brazil is located in the central-eastern South America and the 5th largest country in South America. With a total area of 8.5 million km², of which 8.4 million km² correspond to land and 0.1 million km² to water, much of its area has a tropical climate. The relief consists of plateaus and plains, and the weather in the Northern Brazil is semi-arid; Northeastern region is dry for the most part and South and Southeast Brazil are considered tropical and subtropical.

Brazil is a country that brings together numerous comparative advantages that make it able to act as a leader in the global agricultural, agroindustrial and silviculture sectors, particularly those dedicated to energy. Brazil features biomass production with huge potential for exploitation. The natural and geographical conditions are favorable; there is a lot of farmland with adequate characteristics of soil and climate conditions, making it the country's largest gathering of quantitative comparative advantages to lead the production and use of biomass energy on a large scale.

According to the Annual Energy Balance (MME 2012) biomass currently represents about 27% of primary energy supply, in which wood is an important source of energy occupying more than 10% of the primary energy used in the country, totaling 84 MtOE of wood for energy. The consumption shares are 34% charcoal (for iron/steel sector), 28% industrial (mainly for heat/power in pulp and paper sector), 28 % residential sector (cooking purposes) and 10% in agriculture (mainly for heat purposes).

It is also a form of energy less understood and has great potential gains in the near future. It is estimated that wood energy has been responsible in 2010 for the production of 34 MtOE same order of magnitude as other renewable sources.

2 Production and demand for solid biomass in Brazil

2.1 Roundwood and firewood production

It is estimated that the round wood production of pine, eucalyptus and other species accounts for around 261.6 Mm^3/year considering the current area of forest plantations and the mean annual increment in each region. From the total estimated, 74.7% correspond to eucalyptus and 22.5% to pine. The other species round wood products only represent 2.7% of total production (Table 1).

Table 1 Estimates of wood production from Eucalyptus, Pine and other species in Brazil, 2011

Specie	Planted Area (ha)	MAI	Production (m^3/year)	%
Eucalyptus	4.873.952	40,1	195.445.475	74,7
Pine	1.641.892	35,9	58.943.923	22,5
Others	489.281	14,7	7.192.431	2,7
Total	7.005.125	-	261.581.829	100,0

Source: adapted from ABRAF (2012); MAI = Mean Annual Increment (m^3/ha year). The weighted MAI was adopted (in view of planted area) in areas with Eucalyptus, Pine and "others" plantations; production (m^3/year) was calculated by multiplying planted area by weighted MAI of each species.

At the same time, this estimate does not represent the supply of wood effectively available in the period considered, but an estimated potential supply since plantation age is variable. The rotation length commonly used is 3m x 3m (between line and line) but depends on the spacing variations of the anatomy of the intended end use and planting the forest. In the case of forest bioenergy, short rotations are used for smaller spacing.

An overview of the roundwood production in Brazil is provided in Table 2.

Table 2 Roundwood production in Brazil

Year	Total roundwood production (Mm^3)	Industrial roundwood (Mm^3)	Fuelwood production (%)	Imports of roundwood (1,000 m^3)	Exports of roundwood (1000 m^3)
2001	223.3	89.9	59.8	90.0	563.0
2011	284.0	139.9	50.7	28.8	106.7

Source: FAOSTAT (2013)

2.2 Roundwood consumption

In 2011, the Brazilian round wood consumption of forest plantations was 170 Mm^3 and approx. 36% of all wood produced was used for pulp production.

The production of sawn wood, vegetal charcoal based steel industry, industrial wood panels and plywood accounts for 15.2%, 10%, 7.4% and 3.7%, respectively. The remainder (26.3%) is for fuelwood and other forest products (ABRAF 2012).

The following tables show the Brazilian roundwood consumption for industrial use by segment and type in volume and mass.

Table 3 Brazilian round wood consumption for industrial use by segment in 2011

Segment	Wood Consumption (m^3)			
	Eucalyptus	Pine	Others	Total
1. Pulp & Paper	53.239.020	8.102.946	5.000	61.346.966
2. Firewood	35.709.030	6.382.268	2.583.521	44.674.819
3. Wood Industry	4.760.506	27.287.855	21.162	32.069.523
4. Charcoal	16.987.058	-	-	16.987.058
5. Industrialized Wooden Panels	4.658.345	7.751.980	108.250	12.518.575
6. Treated Wood	1.500.000	-	-	1.500.000
7. Others products	774.144	285.701	-	774.144
Total	117.628.103	49.810.750	2.717.933	169.871.085

Segment	Wood Consumption (ton)			
	Eucalyptus	Pine	Others	Total
1. Pulp & Paper	23.957.559	3.889.414	2.900	27.849.873
2. Firewood	16.069.064	3.063.489	1.498.442	20.630.994
3. Wood Industry	2.142.228	13.098.170	12.274	15.252.672
4. Charcoal	7.644.176	-	-	7.644.176
5. Industrialized Wooden Panels	2.096.255	3.720.950	62.785	5.879.991
6. Treated Wood	675.000	-	-	675.000
7. Others products	348.365	137.136	-	485.501
Total	52.932.646	23.909.160	1.576.401	78.418.207

Source: adapted from ABRAF (2012), BRACELPA (2013), AMS (2013)ABIPA (2013)

2.3 Pulp and paper

According to BRACELPA (2013), there are 222 companies in the pulp & paper segment operating in 18 Brazilian states. In the international market, the country is the leader among pulp products.

The national pulp industry grew around 5.8 % per year. In 2011, pulp production totaled consumption of 53 Mm^3 of roundwood from eucalyptus, supplied 100% by planted forests.

The total production of cellulose 59% is exported, 30% is used for own consumption (manufacture of paper) and 11% goes to the domestic market (BRACELPA 2013). Brazil is among the major producers worldwide when it comes to pulp (7% of global production).

Cellulose is the most important raw material from the forest in terms of production value (about $ 120 billion/year) (SAE 2011) in view of its high specific value compared to the other forest products.

According to BNDES (2013), several projects are scheduled for implementation at different levels of progress, which could provide additional production capacity of 23 Mt/year by 2020 (180% of total production in 2010). If this program is successful, Brazil is likely to become the second largest global producer of pulp.

In terms of energy values recovered black liquor (byproduct of the manufacturing process of cellulose) is 198×10^9 MJ representing 46.6% of industrial energy demand (MEN 2012).

2.4 Mechanically processed wood (wood industry)

The mechanically processed wood sector comprises the industries which produce sawn wood, plywood, veneer and other higher added value products (HVAP) such as doors, windows, frames and furniture parts, among other processed products.

The productive structure of the sector is spread out, since it is constituted by a large number of smaller companies typically of the family business type. The main consuming segments of the Brazilian market are furniture and civil construction.

In 2011, the consumption of wood for plywood totaled 4.14 Mm^3 of roundwood with average growth of 2.3% per year and lumber consumption to 27.3 Mm^3 of round wood produced with average growth of 1.8% per year, totaling 31.2 Mm^3 of roundwood supplied 100% by planted forests for this sector.

In the future, it is expected that recent results from the international market and the increment in domestic demand will be maintained, in view of Brazilian economic growth and the investments required for hosting the World Cup and the Olympic Games in the country.

2.5 Industrial wood panels

The industrial wood panels sector comprises the industries which produce MDP Panels (particle board), MDF, OSB and fiber boards. The industries in this segment are important raw material suppliers to the furniture, civil construction, packaging, automotive and electric electronic industries.

The annual production of industrialized wood panels used 13 Mm^3 roundwood, with average growth of 8.3% per year.

The prospects for this market are highly favorable, since the technological streamlining of the industrial park (supply of new products and quality improvement), the performance of civil construction/real estate (as a result of reduced interest rates and improved income) and the appeal to sustainability in the use of alternative sources to solid wood, stand among the numerous factors which are decisive to the development of this sector.

The segment of wood panels represents a smaller volume of products, approximately 2/3 of the total volume consumed lumber. The Brazilian wood panel sector is not among the major producers, and does not completely supply the domestic market, as there are imported panels.

The expansion plans of Brazilian industry for the planned target of 10.2 Mm^3 per year of wood panels in 2012 were insufficient to change the current situation, the balance between supply and demand in the domestic market.

In this sense, an increase in the nominal capacity of national installed production is predicted to occur in the next 5 years, when the expansion of new lines and industrial units will allow the future supply of the domestic market and the growth of furniture exports (ABRAF 2012).

2.6 Treated wood

Brazil has approximately 300 wood preservation plants, distributed predominantly across the southern and southeastern regions, where the largest reforested areas can be found. These industries have an installed production capacity of 2 Mm^3, although the production of the sector corresponds to 1.5 Mm^3. Thus, around 33% of installed capacity is currently idle.

The national market consuming treated wood can be divided into four segments: rural, electric, railways and civil construction.

The main products of the segment are gateposts, crossheads and round posts, where eucalyptus wood is commonly used. Pine, in turn, has occupied an ever larger space in the production of treated wood for the market.

2.7 Other products

On a smaller scale, production of other forest products such as chips, shavings, sawdust, poles, gateposts and many other products continues to take place. However, the absence of statistics about the market, due to the geographic spread of production of these products, prevents the real measurement and analysis of potential of these markets.

3 Biomass for bioenergy

Table 4 summarizes, by geographic region, the characteristics of productive chains of firewood and charcoal. The supply chains of other industries are varied and complex and not included (SAE 2011).

The relevance of wood (firewood + charcoal) in total energy generation in the country is huge, amounting 61.7 Mm^3 of consumed wood from planted forest.

According to the National Energy Balance for 2011 (MME 2011), wood represented 10% of total energy supply, i.e. it is the fourth leading primary source in the Brazilian energy matrix.

Wood still occupies a central role in terms of strategies related to the production and use of energy. About a third of wood energy was aimed at families and rural household's consumption is native forest, but in 2011 the domestic consumption dropped by 3.4% (MME 2012).

The feature that differentiates Brazil's use of this energy source is that most of those used for industrial food and beverage, pulp and paper, pig iron and iron-alloys, ceramics and plaster has increased by 9.1% in the same period of time (MME 2012).

The activity that uses most of the energy industry is timber of pig iron and iron-alloy, employing green charcoal (instead of coal) as thermo-reducer in the industrial process.

Table 4 Characteristics of productive chains of firewood and charcoal in the Brazilian regions

	Characteristics				
Region	Woody bioenergy	Derivation	Consumers	Incentive program	Technological level
North	firewood charcoal	native native	1,2,3	absent/private	baixo
Northeast	firewood charcoal	plantation native	3,4,5	absent/private	medio
Midwest	firewood charcoal	native native	3,4,6	absent/private	medio
Southeast	firewood charcoal	plantation plantation	3,4,7	exists/public and private	alto
South	firewood charcoal	plantation plantation	4,7	exists/public and private	alto

Source: adapted from SAE (2011); 1 = sawmill; 2 = ceramic; 3 = steel mill; 4 = pulp and paper; 5 = plaster; 6 = grains; 7 =others.

3.1 Fuelwood

Fuelwood is an important source of thermal energy. Its importance in Brazil is perceived in industry, trade and rural households.

In 2011, Brazil produced 61.7 Mm^3 of wood for energy (fuelwood and charcoal) from planted forests, representing 36 % of all production from Brazilian planted forest. The Brazilian southern region consumed 69% of this total.

Although fuelwood consumption by households is traditionally an indicator of regional economic underdevelopment, in Brazil this increase results mainly from industrial growth (metallurgy, agribusiness, pottery and food industry), and the term "energy forests" was created for the plantation of eucalyptus and pine aimed at supplying wood for energy generation, especially for industrial processes.

In Brazil the existing fuel wood stoves have been replaced by LPG in most households – or, in some cases, they co-exist with LPG stoves (Lucon, Coelho, Goldemberg 2004). Some 40 years ago, fuel wood and charcoal represented more than 80% of the residential energy consumption, since most of the cooking in rural areas and cities alike, leading to a progressive deforestation near the more populated areas and the consequent increase in cost (Coelho, Goldemberg 2013)

Bottles with LPG (13 kg bottles) are distributed/sold by private companies all over the country and sold with affordable prices (initially they were subsidized), even in Amazonian remote villages. This 13 kg bottle is available in several specialized stores or distributed by trucks or boats (in Amazonia). LPG delivery infrastructure is highly developed in all regions, including rural zones.

The following table shows the Brazilian fuelwood consumption by sector.

Table 5 Fuelwood consumption in Brazil

Fuelwood and charcoal	***2009***	***2010***	***% 2010/2009***
Fuelwood	*79,385*	*84,045*	*5.9 %*
Main uses:			
- *Production of charcoal*	*25,178*	*27,860*	*10,7 %*
- *Residential*	*24,287*	*23,471*	*-3,4 %*
- *Industrial*	*21,172*	*23,108*	*9.1 %*
- *Rural*	*7,777*	*8,140*	*4.7 %*

Source: MME (2012); data is given in 1,000 tons

In this context, forests planted for energy purposes present a very positive scenario. As a renewable source, firewood from planted forests can contribute to the sustainable growth of the industrial sectors that consume forest biomass.

Estimates of the National Energy Efficiency and SAE (SAE 2011) indicate that consumption of bioenergy from wood could triple in less than 20 years, reaching 2.9 PJ (70 MtOE) by 2020 and 3.8 PJ (90 MtOE) by 2030 if effective public policy intensification of already existing production of steel-green and formulated an effective policy of introducing biomass burning wood sustainably produced in electricity generation especially in isolated systems, replacing diesel and fuel oil.

3.2 Charcoal in Brazil

In the past, the growth on the consumption of fuel wood was due to the increasing production of charcoal, which is directly related to steel production. The quick growth in demand for charcoal has generated pressure on native forests, deforestation and consequently causing emission of greenhouse gases. Later on the use of native forests was replaced by planted forests and nowadays only part of charcoal is still from native forests, as discussed in this document.

Charcoal is used in the chemical reaction of thermo-reduction, as well as a source of thermal energy to produce metallic iron from iron ore since the beginning of the steel industry. Since there is no sulfur in its composition, charcoal improves the quality of pig iron and steel produced thus increasing the final price of the product.

In the Brazilian iron and steel industry, the products manufactured with charcoal represent 30% of the pig-iron industry, 14,6% of steel production and 98% of the iron-alloy production. It is important to observe that carbonization process efficiency is low. According to existing studies, it is necessary to invest in new technologies and methods to produce charcoal more efficiently, mainly because charcoal represents 60% to 70% of pig iron production costs (Muylaert, Sala, Freitas 1999).

The charcoal consumption is related to the Industrial sector. Industrial activities that consumed more charcoal are the production of pig iron (85%), production of iron alloy (10%) and cement manufacturing (5%). In the Brazilian iron and steel industry, the products manufactured with charcoal represent 30% of the pig-iron industry.

The option to use charcoal or imported mineral coal for the iron reduction is economic. The price of coal is 19.0% and 29.7% lower than the charcoal from native forests and planted origin, respectively. The price of charcoal produced from illegally native forest varies between 10 and 12% of the price of charcoal from planted forests, so the use of charcoal becomes economically competitive, especially considering the rising price of coal.

The charcoal production in Brazil still uses the same technology of the last century. There was no significant evolution of the technology at the same proportion of the national iron/steel sector increase. There is an estimate that the iron and steel industry sector in Brazil consumes 95% of total charcoal produced (Uhlig, Goldemberg, Coelho 2008; MEN 2011) using 6.8 million tons of charcoal / year, which is equivalent to near 25 million tons of firewood. Brazil is the largest charcoal-based pig iron producer.

The charcoal based steel industry in the country includes the large integrated steel mills that produce steel in various forms and have their own Eucalyptus forest base to produce charcoal for the reduction of iron ore, and the independent steel mills that produce pig iron.

According to Minas Gerais Association of Forestry 2009 (AMS 2013), production of charcoal in Brazil demanded 39.7 Mm^3 of planted roundwood, yet 57% of charcoal in Brazil comes from native forests. A expansion of nearly 1 Mha of planted forests in new areas would be needed for a sustainable supply of wood for charcoal.

Pig iron is produced in two regions in Brazil. The first one is at Minas Gerais state, located near the centre of Southeast Brazil. Back in the 15^{th} century, iron mines and charcoal were already produced in these areas Firewood was usually used native forests.

The other region is East Amazonia, along the railroad between the Carajás mineral district and the Itaqui harbour, in Pará State. The furnaces in Carajás have been in operation only recently, in the last two decades. Since then, their production has grown significantly at an annual rate of 17.5% and currently reached 40% of total Brazilian pig iron production. The pig iron production in this area comes from charcoal that originates from logs and residues (FAO 2012b).

The charcoal consumption in residential sector can be traced in the Northeast municipalities, mainly in Maranhão and Piaui States, where 20% of the houses use charcoal for cooking (FAO 2012a). It is believed that the source of charcoal for these houses comes from excess charcoal supplied to pig iron production at Carajás Region in Pará and Maranhão States.

The charcoal consumed in the Southeast of Pará and in the East of Maranhão comes from places close to the plants, as compared to the long distance covered by the charcoal consumed on the southeastern part of the country, where charcoal was transported beyond 800 kilometers. Apparently, charcoal production from forestry plantation is primarily near the biggest pole at Sete Lagoas, municipal district of Minas Gerais State. In reality, charcoal production do not take place near Carajás Pole.

The option to use charcoal for the reduction of iron ore in the industry is economic. The price of charcoal produced from native origin illegally varies between 10 and 12% of the price of charcoal from planted forests (Coelho, Goldemberg, Uhlig 2008) thus the use of charcoal becomes economically competitive, especially considering the last increasing global demand for iron.

The sustainability of the production of pig iron from charcoal, with the level of dependency of native forests is still difficult and the most affected by deforestation in the Amazon and Cerrado.

According to AMS (2013); IBGE (2005), which obtains information directly from the steel sector, it was found that 25% of charcoal have not declared origin. The area of planted forests in Brazil is practically constant over the last 25 years, but it does not meet the growing need for wood for industry and for energy use.

There are cases of successful business planting of forests for charcoal production in Brazil, including Clean Development Mechanism (CDM) projects financed by the Prototype Carbon Fund. The expansion of the area of forest plantations for carbon in idle or degraded pastures reduces the pressure on native forests of Brazil.

However, there are barriers preventing widespread adoption of forest plantations for carbon. Some of the barriers are (Ambiente e Sustentabilidade 2013):

- Lack of credit to finance the initial costs of production (early revenue income is usually generated after 7 years of planting)
- Difficult access to credit (forest plantations are often not accepted as collateral for loans),
- Higher transaction costs relative to coal production, deforestation and negative working conditions,
- Inefficient technologies for the carbonization process (contributing to the emission of greenhouse gases (GHG) emissions, including methane),
- Weak institutional arrangements.

With 62 cast iron plants, the state of Minais General is the largest producer of Brazil iron and steel. Accounted for 60% of national production, which has major concerns on the availability of wood for energy, the state recently passed a law banning the use of charcoal from deforestation by 2018. In order to supply the industry with charcoal from Eucalyptus plantations,the state of Minas Gerais has about 1.5 Mha of new plantations (Ambiente e Sustentabilidade 2013; PROFOR 2013). According to project Approval Date September 2002, financed by the Prototype Carbon Fund in Minas Gerais (WB 2013b-c), expanding the area of forest plantations for charcoal on idle or degraded pasture land would reduce the pressure on native forests in Brazil.

There are therefore many challenges to be faced by the sector and governments. The promotion of pig iron charcoal – green pig iron – is in need of an urgent removal of customs barriers, forest production incentives and a robust international promotion program of the Brazilian product qualities, as part of the government and private effort to add value to iron ore. Certainly, a challenging goal is to increase the production of “green steel”, helping to reduce greenhouse gas emissions, and to mitigate the causes of climate change, while adding added value to green steel products through measures to reduce the imbalances that compromise the competitiveness of the sector.

Projections of CGEE (Centro de Gestão e Estudos Estratégicos/Center for Strategic Studies and Management 2008) presupposes the increased use of charcoal for integrated steel mills, including partial replacement of coal coke, and for independent producers of pig iron, and indicate a growth of energy consumption, 22.6 Mm^3 in 2010 to 39.2 Mm^3 in 2014.

This corresponds to an average annual growth of 15% per year over the period 2010-2014. If the estimated consumption for 2014 is extrapolated to the horizons of 2020 and 2030 the average annual rate of only 7% per year, charcoal consumption would amount to 59 Mm^3 in 2020 and 113 Mm^3 in 2030.

In terms of energy, such volumes of charcoal are equivalent to 1.3 PJ (30 MtOE) in 2020 and 2.5 PJ (58 MtOE) in 2030.

With the high exploration potential of natural and planted forests, Brazil must improve its policy and actions in this area, considering the renewability. The charcoal from planted forests is a renewable source of energy and important raw material in steel production in Brazil. it should be carefully considered to ensure sustainability and improve social and environmental conditions in their production.

3.3 Wood pellets

Brazil has twelve industrial pellet plants in operation, as well as new projects announced (Escobar 2013), most of them located in the South.

Among the factors that lead to the consolidation of the pellet market in the national scenario, we highlight reduced dependency on fossil fuels, the availability of waste generated by the wood sector, and growing demand stimulated by governmental incentive mechanisms.

Brazilian production, consumption, import and export of pellets are still incipient; however, in the medium and long terms, the demand will tend to grow and stimulate production, domestic consumption and exports. The following table shows the projection of the installed capacity and production of wood pellets in Brazil.

Table 6 Capacity and production of wood pellets in Brazil

Code	Company Name / Location	Capacity (ton/year)	Production (ton/year)
BRA01	Madersul, São Paulo	18.750	4.800
BRA02	Piomade, Rio Grande do Sul	3.750	2.880
BRA03	Koala Energy, Santa Catarina	22.500	1.000
BRA04	Briquepar, Paraná	30.000	12.000
BRA05	Energia Futura, Rio Grande Do Sul	18.750	4.800
BRA06	BR Biomassa, Paraná	22.500	8.000
BRA07	Ecopell, São Paulo	22.500	5.000
BRA08	Ecoxpellets, Paraná	37.500	5.600
BRA09	Eco-Pellets, Minhas Gerais	1.125	100
BRA10	Línea, Paraná	30.000	1.000
BRA11	Copellets, São Paulo	7.500	4.800
BRA12	Elbra, Santa Catarina	22.500	10.000
		237.375	**59.980**

Source: adapted from ABIPEL (2013)

3.4 Wood residues in Brazil

Wood residues generated annually in Brazil are estimated as 30 Mt. The main source of residues is the timber industry which contributes to 91% of wood residues, following wood wastes from construction (3 %) and 6% from urban areas (STCP 2011; SAE 2011; MMA 2009), as shown in Table 7.

Table 7 Estimated Amount of Wood Residues Generated in Brazil

Segment	Wood residues 10^3 ton/year	%
Timber Industry	27.750	90,7
Civil Constructions	923	3,0
Urban Areas	1.930	6,3

Source: compilation by CENBIO

The major sources of these resources are the following:

- Forest-based industries: the source of residues wood processing. In this class are framed sawmills, veneer mills, panels, etc;
- Industry reforestation: source of waste generated in the exploitation of forest and wood, in the case of energy crops;
- Exploration of Native Forests: Source of exploitation and residues wood for energy.

Only a portion of the waste generated has some economic exploitation. The majority of wood waste generated in the Amazon region, for example, is simply abandoned or burned without energy purposes (Referência 2013).

On the other hand, such situation is shown quite different when it comes to industrial wood residues generated in Southern and Southeastern Brazil. In this case, industrial wood residues are utilized mainly for production of reconstituted products (pulp and wood panels) and for power generation (thermal and electrical), or in the field for nourishing the soil. In this state of origin 10% to 20% of forest waste wood remains in the field, in the form of branches and trunk remains after cutting the trees, acting as nutrients to the soil (Referência 2013; Hora, Vidal 2011). Table 8 shows the availability of wood residues from native or planted forests.

Table 8 Forest operations and waste generation (% of roundwood)

Operation (%)	Natural Forest		Planted Forest	
	Product	Residue	Product	Residue
Lumber	30-40	60-70	80-90	10-20
Primary and secondary processing	10-20	10-20	30-40	40-50
Total	**10-20**	**80-90**	**30-40**	**60-70**

Source: Adapted from FAO (2007) and BNDS (2011); note that part of these residues are used for different purposes (MMA 2009)

The use of direct and indirect waste such as wood (shavings, sawmill scraps, ground charcoal and black liquor) are leveraged in co-generation systems, power plants and refineries biomass. The industry's most intensive use of residual biomass for self-generation is the pulp and paper sector, which has an installed capacity of about 1,500 MW (Muller 2005). According to ANEEL (National Agency of Electric Energy), Brazilian states with higher utilization are Paraná and São Paulo, with a potential that could be generated between 27.53 MW and 82.9 MW (Hora, Vidal 2011).

3.4.1 Allocation of wood of residues generated

- *Timber Industry residue*

The disposal of wood waste generated by the logging industry is diversified. In general, the destination given to industrial wood residues is associated with a number of factors, which shows: i) the type of raw material (wood from native forest or plantation forest), ii) the technology involved in wood processing, iii) the size of the timber industry, and iv) the location of industry in relation to consumption centers.

Particularly in the Amazon region, the majority of wood waste generated or accumulated is burned in the same area of the industries, resulting in economic losses.

If the 30 Mt of wood wastes generated annually in Brazil were used for electricity generation, it is estimated that it would be possible to generate around 12 TWh/year which would represent almost all electricity consumed in Northern Brazil (Muller 2005; MMA 2009).

In some cases, the wood wastes are processed into briquettes which are used for cutlery, toys and other products, representing 8% of wood wastes.

- *Construction residue*

The residues of construction (RC) are predominant in urban solid waste produced in Brazilian cities and their generation is highly dispersed.

The allocation of RC varies significantly between cities. The most common destinations are: i) landfill in civil works, ii) sanitary landfill iii) specific landfill (inert landfill), iv) recycling stations; v) irregular disposal.

Most Brazilian municipalities improperly dispose construction wastes, in many cases illegally and irregularly (MMA 2009).

- *Residue of Urban Environment (Pruning)*

According to a survey conducted by CENBIO in 2006 (CENBIO 2013), the main electric utility in the country that performs urban (trees) pruning, it was found that a sample of 16 municipalities throughout the country, approximately 70% discard these wastes in dumps or landfills.

A study by AES Eletropaulo (Energy Company of the State of São Paulo) in partnership with the CENBIO found different ways and the main destination for these wastes, which occur in the concession area of AES, which are directly in the soil, in landfills, dumps in; composting; uncontrolled burning, reuse and recycling for use as fuel in boilers.

3.4.2 Barriers to recovery wood residues in Brazil

The potential utilization of wood residue and still little explored in Brazil, especially those generated in the Amazon region by wood industry.

The full utilization of the potential of wood waste in Brazil depends on the breakdown of a series of barriers that does not allow their recovery as a byproduct. These barriers are discussed below based on MMA (2009).

- *Technologies applied*

Although there are modern technologies available, in most timber industries, particularly those operating in the Amazon region, technology currently used is outdated. Most industrial tropical timber process is based on national machinery and equipment. Domestic manufacturers of machinery and equipment have been protected for years by high import taxes, which delayed the technological development of solid wood industry in Brazil.

- *Logistics for handling, transport and storage of wood residue.*

Whatever type of wood residue, the sources are numerous and often dispersed, the volumes generated are small. This requires a fairly complex logistics for the utilization of wood residue in Brazil, resulting in higher costs for collection, handling, transportation and storage.

- *Low value of wood residues*

The low value of wood residues is also a barrier to their valorization in Brazil. This fact is associated basically to two main aspects: i) low price of round wood, particularly tropical timber in Amazon region, and ii) non-existence of an adequate domestic market for wood residue in Brazil (except the market for wooden pine residues in Southern Brazil).

- *Public policies*

The public policies geared to solid residues are quite limited, though the recent (MMA 2013a) Law No. 12.305/10, establishing the National Policy on Solid Waste (PNRS) includes important tools to allow the progress necessary to the country in addressing the major environmental, social and economic impacts of inadequate management of solid waste.

The law establishes the shared responsibility of waste generators: manufacturers, importers, distributors, marketers, citizens and holders of services management of municipal solid waste pre-consumer and post-consumer.

- *Integrated operation*

The vast majority of the timber industry, both in the Southeast and in the Amazon region, is not integrated. The lines of primary processing fields are not integrated with the secondary processing lines, thus generating distinct sources of wood residues generation and, almost always, quite distant, being one of the biggest obstacles to the organization of residues wood.

Today, with the technological advances achieved both in generation and in the area of forestry in Brazil, there are promising expectations regarding the use of forest biomass as a feedstock for power generation. Within this context the role of short rotation plantations will be important in Brazil for biomass production in an economically, socially and environmentally sustainable.

4 Solid bioenergy potentials in Brazil

Key for future bioenergy in Brazil is bioenergy from forest plantations, as agricultural residues present important difficulties related to logistics and economic issues[2].

4.1 Plantations in Brazil (2010-2012)

Brazil is the largest producer of wood from planted forests (mainly eucalyptus); currently wood reforestation has become a technologically, economically and environmentally viable process whose purpose is the production of raw materials for various industries that depend on wood. Another point to be noted is that eucalyptus trees are being studied in Brazil since 1960, which was a determinant of increased development and production of today.

Plantations of eucalyptus, pine and unconventional species

In 2011 the area planted with Eucalyptus totaled 4.9 Mha presenting an increase of 2.5% (0.12 Mha) compared to 2010 (ABRAF 2012). The main factor responsible for this growth was the establishment of new plantations in anticipation of future demand from industrial projects in the pulp and paper sector.

The area planted with pine totaled 1.6 Mha in 2011, 6.5% less than the previous year (ABRAF 2012). This result corroborates the trend towards the substitution with eucalyptus plantations in the areas previously planted with pine.

In 2011, the area occupied by plantations of non-conventional species, such as Teak, Acacia, Araucaria, Populus, Rubber Tree and Parica, among others, was 0.4 Mha (listed under "others"). Compared to 2010, the area planted with these species decreased by 7.8%.

The total area of forest plantations in Brazil is 7 Mha of with 70 % is eucalyptus, 24% pine and 6% others (Table 9).

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[2] As a preliminary reference, the Atlas of Biomass for Brazil (CENBIO 2013) presents the potential for bioelectricity from agricultural residues in different municipalities in Brazil. For this evaluation, the total amount estimated for solid biomass agricultural residues in the country is 11, 500 MtOE. This is amount is for the whole country, considering the more than 5,000 municipalities in an area of 8,500,000 km^2. Thus, a real evaluation of bioenergy from agricultural residues needs further economic and logistic studies.

Table 9 Total area of forest plantations in Brazil by species in 2011

Species	Plantation Area (ha)		
	2010	2011	%
Eucalyptus	4.754.334	4.873.952	69,6
Pine	1.756.359	1.641.892	23,4
Others	527.830	489.281	7,0
Total	7.038.523	7.005.125	100,0

Source: adapted from ABRAF (2012)

The states of Minas Gerais, São Paulo, Parana, Bahia, Santa Catarina, Mato Grosso do Sul and Rio Grande do Sul stood out, together holding 87.7% of the total planted area. This is due to the location of major industrial units in the segments of paper and pulp, industrialized wood-based panels, charcoal-based steel industry, mechanically processed wood and energy.

The production forest in Brazil can be considered short rotation for decades, producing Eucalyptus with a productivity of 287 m^3/ha, after 7 years, while in Sweden, to get that same production, it would require 10.2 ha (SAE 2011). In this context, the establishment of fast-growing forests in the country incentive higher production of forest biomass for energy supplies in a short period of time and gains a prominent position in the national context.

Currently several Brazilian universities and centers are conducting research (SAE 2011) on forestry systems to achieve greater biomass production per unit of area in a shorter space of time assuming the resulting characteristics of up to 40 t of dry wood per ha in 18 months (Garcia et al. 2011), i.e. twice the traditional planting average that gets 25 t of dry wood per ha per year in 5-7 years.

Presently there are no data for commercial production of these short rotation forest systems in Brazil and the values obtained until now are represented in scale test.

4.2 Scenarios for wood plantations in Brazil for 2020

Over the next 10 years, several projects are scheduled in Brazil for producing pulp, particleboard, reconstituted wood panels (MDF/MDP), charcoal and wood pellets for energy generation, which will require increasing the area of planted forests (ABRAF 2012).

The increasing international market share influences major investments in this sector, for the expansion of the planted area and for the management of natural forests, as in the wood processing industries.

Under current conditions, the area of planted forests in the country could increase from 7 Mha to over 12 Mha by 2020 mainly from degraded lands from pasture, as discussed above. The yield in tons depends on the density calculated by species based on the mean annual increment (MAI, in m^3/ha*year). This extension would require investments from private sector US$ 20 billion to generate 200,000 jobs in rural areas (STCP 2011).

Table 10 shows the projection of the planted forests of eucalyptus and pine for each Brazilian state for the current period until 2020.

Table 10 Scenarios for the total area planted with eucalyptus and pine (2020) by regions and state with current policies

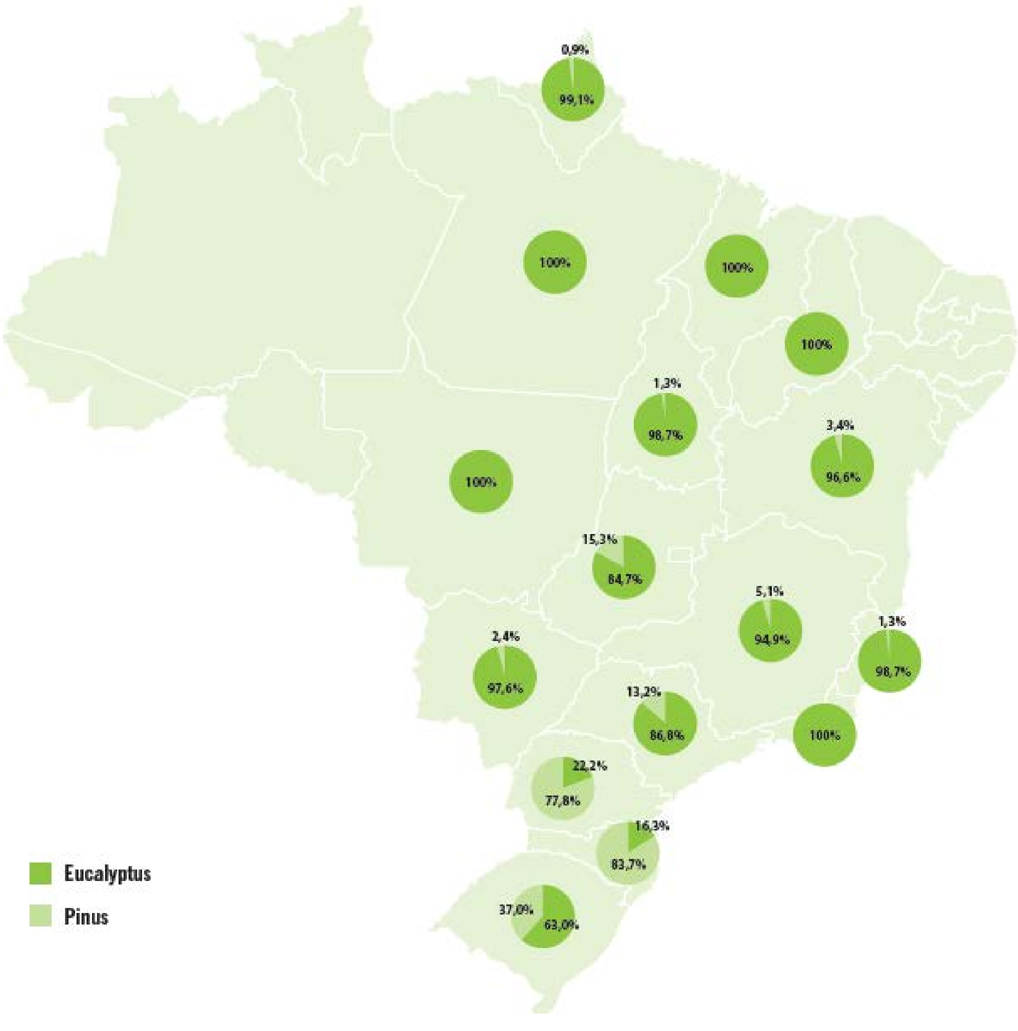
Region / State	*2010*	*2014*	*2020*
North	**392**	**615**	**831**
Pará	144	229	323
Amapá	63	115	161
Tocantins	71	117	272
Outros	114	154	74
Northeast	**780**	**1.378**	**1.747**
Bahia	632	899	1.065
Maranhão	140	317	433
Piauí	5	142	195
Outros	3	20	54
Midwest	**434**	**736**	**1.045**
Mato Grosso do Sul	313	533	702
Mato Grosso	63	112	189
Goiás	58	92	154
South	**535**	**874**	**1.104**
Paraná	160	267	258
Santa Catarina	102	169	260
Rio Grande do Sul	273	438	586
Southeast	**2.597**	**4.092**	**5.146**
Minas Gerais	1.356	2.241	3.007
São Paulo	1.033	1.526	1.739
Espírito Santo	205	321	363
Rio de Janeiro	3	4	38
Total *Eucalyptus sp.*	4.738	7.694	9.873
Total *Pinus sp .*	1.762	2.240	2.127
Total	6.500	9.934	12.000

Source: adapted from SAE (2011); data is given in 1,000 ha.

Despite the fact that the scenarios showed in the table above are for pine and eucalyptus, pine plantations occur mainly in Southern Brazil.

In fact, there is a trend for expansion for eucalyptus plantations because areas of pine have presented a retraction over the period of analysis except in the southern region of the country. The following figure shows the percentages of eucalyptus and pine by states.

Figure 1 Area and distribution of Eucalyptus and Pine plantations in Brazil, 2011



Source: adapted from ABRAF (2012)

According to the Department of Strategic Affairs of the Brazilian Federal Government (SAE 2011) plantations can increase up to 16 Mha by 2020 if a national policy is approved to encourage forestry plantations.

5 Brazilian regulation and sustainability of woody bioenergy

5.1 Environmental laws applicable in woody bioenergy production

Brazil is ruled under the Civil Law. Under the title “On Social Order”, the Brazilian Federal Constitution (enacted 5 December 1988) included article 225 containing environmental directives and principles in order to deal with impacts, pollution control, licensing, preservation and protection of natural resources, education, awareness and transparency. The Constitution defines the environment as an asset for common use by the people and a right of future generations. Among the most important infra-constitutional laws in the environmental area must be cited:

a) The National Policy for the Environment (Law 6938/1981, with important definitions (of environment, impact, environmental quality degradation, pollution, polluter and environmental resources);

b) Public Civil Action (Law 7347/1985), which advocates environmental values, disciplining public civil action of responsibility for damages caused to the environment, to the consumer, to properties and rights of artistic, aesthetic, historical, tourist and scenic value.

c) The Environment Crime Law (Law 9605/1998) makes it possible to incriminate individuals, institutes co-responsibility

d) the New Forestry Code (Law 12727/2012) and the National System of Conservation Units (“Sistema Nacional de Unidades de Conservação - SNUC”, Law 9985/2000);

e) the Legislative Decrees 1/1994 and 144/2002, through which the country adhered to the United Nations Framework Convention of Climate Change and ratified the Kyoto Protocol, respectively;

f) Legislative Decree 2/1994, ratifying the UN Biodiversity Convention;

g) Legislative Decree 34/1992, ratifying the Basel Convention (on the Control of Tran boundary Movements of Hazardous Wastes);

h) the Water Code (Decree 24643/1934) and the Water Law (Law 9433/1997), base of the National Policy of Water Resources;

i) air and water quality control standards, CONAMA Resolutions 3/1990 and 20/1998 respectively;

j) Law 8723/1993 and its amendments (including the following CONAMA Resolutions), new model vehicle (including ethanol fuelled) emission limits;

k) Law 9795/1999, National Energy Policy;

l) Law 8974/1995, Biosafety Law;

m) Law 8171/1991, Agricultural Policy;

n) Decree 49974-A/1961, National Code for Health

Multilateral Environmental Agreements (MEAs) ratified by the country became internal law. State and municipal laws also apply, since environmental protection is a common duty at all governmental levels.

Regarding bioenergy, some of the most relevant applicable environmental laws are those related to environmental licensing of industrial plants; protection of forests and water resources; boilers air emission limits; prescribed pesticide; limits to harvest burning practices and territorial zoning in some states (e.g. São Paulo).

5.2 Environmental and social aspects

5.2.1 Environmental aspects

The following compilation of Brazilian environmental legislation guides the practices of the biofuels sector.

The São Paulo State has the stricter environmental legislation in the country and the better enforcement (Lucon et al. 2009).

The growth of the Brazilian agriculture raises concerns about the availability and limitations of suitable crop areas. It also raises questions about the future expansion trends and its impacts on biodiversity. Two issues arise from this questioning: deforestation and land use agricultural zoning.

Land Use

Brazil has 105 Mha of degraded areas available for growing energy forests as well as for other uses. There are species of eucalyptus that can be grown on degraded or considered unsuitable for the production of other cultures. The following table presents data on land use in Brazil.

Table 11 Brazilian land use in 2012

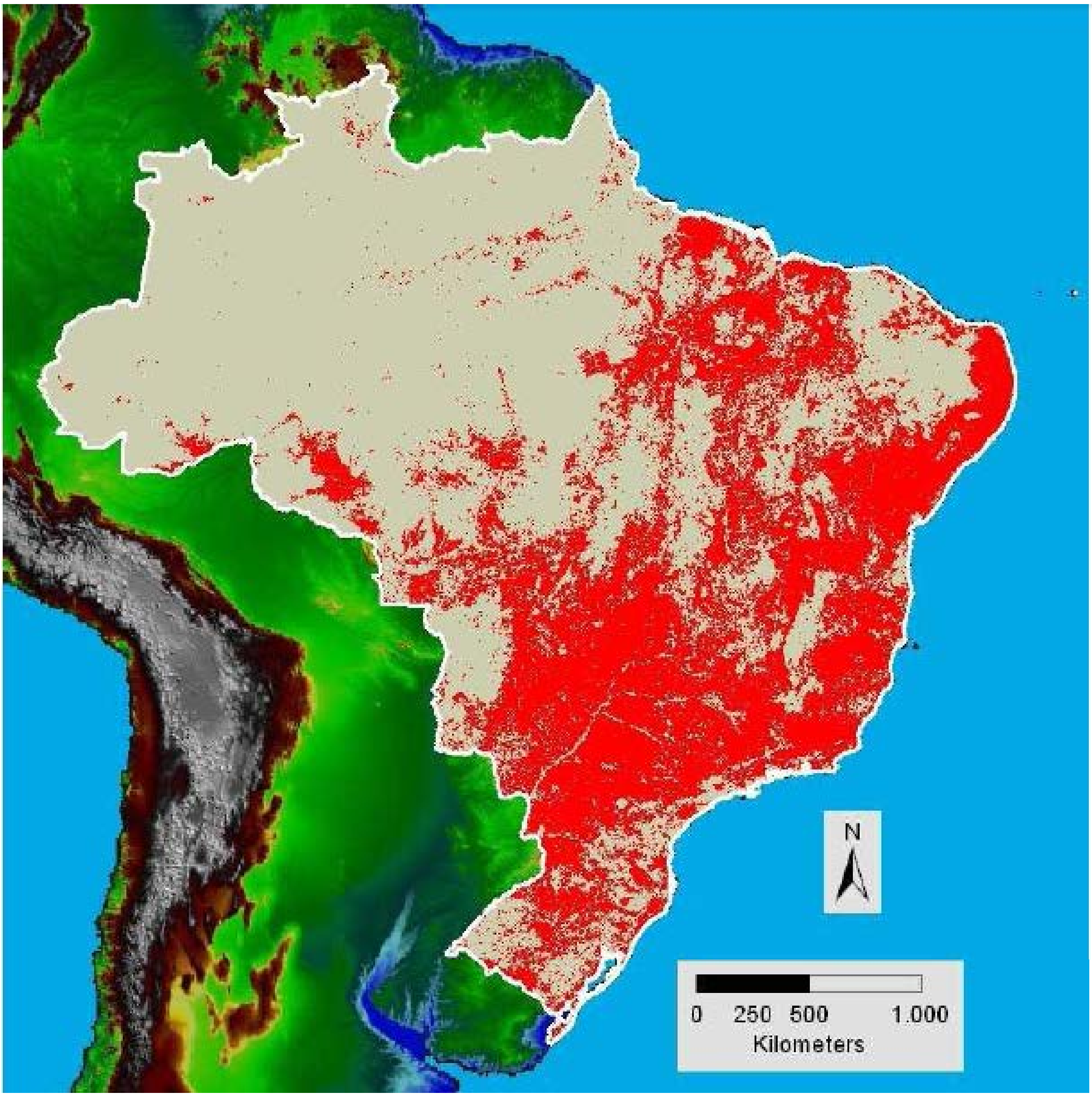
	Million Hectares (Mha)
Land area of Brazil	851
Arable land	355
Cultivated area	77
- soybeans	22
- corn	15
- sugarcane	26
- oranges	1
- forestry	7
Pasture	172
Possibly available arable land	**106**

Source: IBGE (2012); data prepared by UNICA

The intense sunlight and the abundance of water resources are an advantage to Brazilian large amount of land that is now available for the planting of forests and which will aggregate million hectares over the next 20 years by increasing agricultural productivity. This is an important issue because the increase on land availability is only possible if inefficient pastureland (less than 1 head per hectare) can be used in a more efficient way - for example up to 1.6 or 1.8 heads/ha, as happened in Sao Paulo State (Goldemberg, Coelho, Guardsabassi 2008).

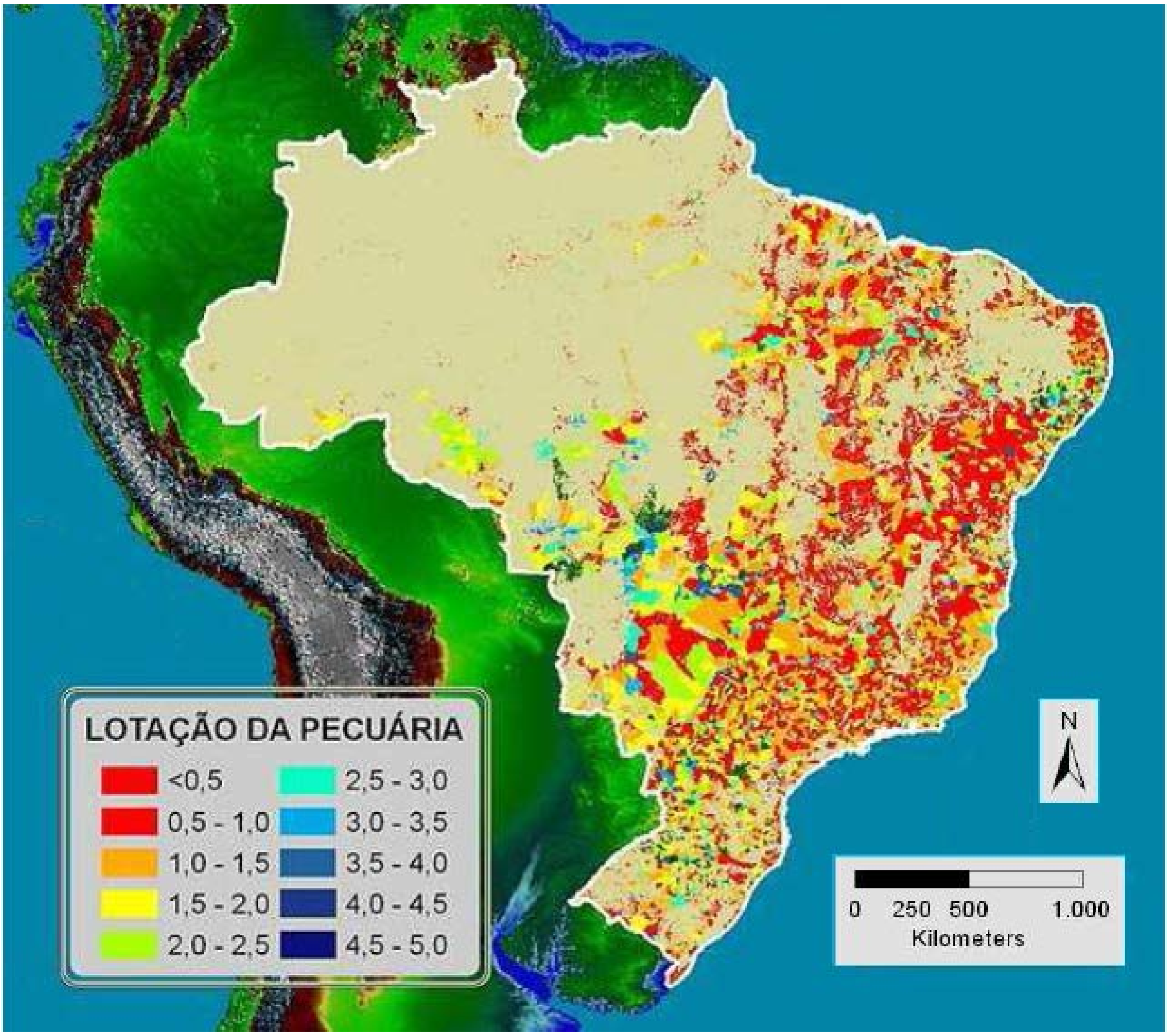
From the 851 Mha of the country, 350 Mha are arable land (38%), more than three fifths of the land in the country (62%) are well preserved (native forests) and can remain as indicated in Figure 2 (SAE 2011). From the total arable land, 170 Mha are now occupied by livestock, predominantly extensive as shown in the following figures.

Figure 2 Arable land in Brazil



Source: SAE (2011)

Figure 3 Land use by livestock in Brazil



Source: SAE (2011); scale represents heads per hectare

In the scenarios performed by the Ministry of Agriculture, Livestock and Supply for the future of the livestock sector, it is expected that the intensification of livestock mentioned above and improved breeding techniques will raise productivity considerably, to the point of increasing meat production in areas too much concentrated, converting by 2030, 70 Mha currently planted extensively (IGBE 2012). So from the 172 Mha used for pasture, 70 Mha will be available for other purposes.

According to this study, from these 70 Mha, it is predicted that 10 Mha would be occupied by soybean and other grains, 5 Mha to meet family farmers needs and 25 Mha for crops for energy purposes (sugar cane, oil palm, elephant grass, etc.), without any deforestation. From this perspective, there are still 30 Mha subject to occupation with other cultures, for example, food, forest plantation and others. Therefore, such new plantations will not touch native forests.

Land use change/Deforestation

Forestry practices are directed by the New Forestry Code (Law 12727/2012). Deforestation, however, is connected to the National Environmental Policy as a whole. Key mechanisms regulating land clearing practices are those related to conservation units, the Legal Reserve and other protected areas.

This act lays down general rules on the protection of vegetation (Permanent Preservation Areas and Forestry Legal Reserves). It also defines, the supply of forest raw materials, the origin of forest products as well as the control and prevention of forest fires, and provides economic and financial instruments for achieving their goals.

According to the biome, the legal reserve corresponds to a given percentage of the total area that must be protected by law (these are native forest protected where it is not allowed any deforestation for any purpose).

According to the biome, the following shares are protected (mandatory):

(i) 80% for rural properties in the Legal Amazon forest area;

(ii) 35% for rural properties in the Legal Amazon "cerrado" grasslands – Brazilian savannah – (being possible to apply 15% compensating in other areas);

(iii) 20% for rural property in forests or other native vegetation areas elsewhere in Brazil;

(iv) 20% in rural properties located in general field ("campos gerais") areas, anywhere in the country.

The recent new Forest Code (May 25, 2012) allows areas with forests in the Legal Amazon to be reduced by 50% since the state has more than 65% for protected area and that a state law authorizing the reduction of statutory reserve farms.

In permanent preservation areas (APP) rivers for up to 10 meters wide, should compose a range of at least 15 meters (riparian forests). There were set rules to larger rivers. Such riparian forests are expected to be protected by law but due to the lack of enforcement there is a huge deficit of riparian forests in the country. Existing policies and legislations try to recover such areas, mainly in the State of Sao Paulo (Goldemberg, Coelho, Guardsabasi 2008). The definition of this new rule encourages farmers to sign a protocol for legal adjustment for APP, otherwise due fined.

The Federal Government sanctioned Decree 7830 of October 17, 2012 in order to create a national database and unified to diagnose environmental status of rural properties in Brazil. The following table presents the main Federal policies and programs that could be used to incentivize forestry activities and industries using wood as a feedstock.

Table 12 Major Federal public policies in Brazil for sustainable production

Policy	**featured**
National Energy Policy and National Policy for Conservation and Rational Use of Energy	Rational use of energy sources in line with other goals (protecting the environment, promoting energy conservation and use of alternative sources)
Incentive Program for Alternative Sources of Electric Energy (PROINFA`	Development of States and competitiveness of energy produced from alternative sources, including biomass.
National Environment Policy (NEP)	Development of national research and technology Preservation and restoration of environmental resources with a view to its rational use and permanent availability.
	Polluter Pays Principle
	Environmental licensing requirement for potentially polluting activities, such as forestry and industrial.
National Energy Plan 2030	Investment in energy efficiency technology (equipment, buildings and more efficient processes, encouraging energy optimization and reduction of energy waste at low-income populations; replacement energy sources and efficiency gains systemic)
	Improved tariff regulation
	Broadening the information base
	Articulation work
Agroenergy Policy	Concern about environmental sustainability
	Concern for optimization of productivity and energy capacity of planted forests and full utilization of forest biomass for energy purposes
	Investment aimed at social inclusion

National Forest Policy	Need for reforestation and forest maintenance supply for large consumers of raw forest
	Agreement between the private lands involving third parties and indication of the areas of origin in the Forest Plan Supply
National Policy on Climate Change	Development of forest energy and a cleaner steel industry
	Strengthening of intersectoral actions and improving the efficiency of the supply and distribution of energy
	Creation of new economic mechanisms, technical, and political
	Adjustments in the regulatory framework for commercial forestry
	Need to analyze the impact of fiscal incentives to be offered
	Conducting more detailed studies on the reuse of heat and power cogeneration
	Application development of forest products in energy production Review of the current banking requirements for afforestation and reforestation activities and reforestation activities
National Policy on Solid Waste	Adoption of practices which respect the local and regional diversity
	Integrated and decentralized solid waste
	Establishment of reverse logistics
	Forecast imposition of inductive and credit lines

Source: own compilation by CENBIO

Biodiversity

The Secretariat for Biodiversity, at Federal Ministry of Environment, takes care of the principles and strategies for knowledge, protection and restoration of the environment, sustainable use of natural resources, the valuation of environmental services and the integration of sustainable development in the formulation and implementation of public policies, transversely and shared, participatory and democratic at all levels and spheres of government and society.

It is the organ inspect each licensing process in the country should consider biodiversity issues under Law No. 10.683, of May 28, 2003, which provides for the organization of the Presidency and ministries, constituted as an area of competence of the Ministry of Environment the following subjects:

I - national policy environment and water resources;

II - policy of preservation, conservation and sustainable use of ecosystems and biodiversity and forests;

III - propose strategies, mechanisms and instruments for economic and social improvement of environmental quality and the sustainable use of natural resources;

IV - policies for the integration of environment and production;

V - environmental policies and programs for the Amazon, and

VI - ecological-economic zoning.

Environmental Licensing

Environmental licensing (or permitting) is a legal (constitutional) obligation, previous to the installation of any process or activity potentially polluting or likely to cause environmental degradation. The main directives for environmental licensing at Federal level are expressed in Law 6938/1981 and CONAMA Resolutions 1/1986 and 237/1997. Besides, the Ministry of the Environment issued "opinion 312/2004", about the respective legal competences (duties) of States and the Federal Government for licensing, based on the scale of the impact.

Different assessments are required, at different stages of the licensing process (ie, for the previous license, the installation license and the operation license, with respective acronyms "LP", "LI" and "LO"): (i) Environmental Impact Assessment and Environmental Impact Report ("Estudos de Impacto Ambiental e Relatório de Impacto Ambiental - EIA/RIMA"); (ii) Preliminary Environmental Report ("Relatório Ambiental Preliminar – RAP"); Environmental Basic Plan ("Plano Básico Ambiental – PBA"); Environmental Control Report ("Relatório de Controle Ambiental – RCA") and Environmental Control Plan ("Plano de Controle Ambiental – PCA"). Other modalities of reports and studies may be required, according to the stage of the licensing process.

Environmental zoning and bioenergy

This section discusses existing policies related to land use. The theme is discussed in a separated section due to its importance in terms of environmental policies.

Due to the expansion of sugarcane production and other biofuels in recent years, concerns about the impacts of land use change have led federal and state governments to adopt policies aimed at determining the appropriate areas for these crops. That can be considered also in plantations for woody bioenergy from Brazil. In this section, the existing zoning for biofuels in Brazil (sugarcane and oil palm) is presented which could be also implemented for wood bioenergy. However, this has not happened in Brazil until now.

Environmental zoning is a recent and important policy related to land use. For this reason it has been discussed in a separated section (Coelho et al. 2012).

The State of Minas Gerais was the pioneer in this process and launched its economic-environmental zoning in 2007 (Figure 4). This is based on social, economic and environmental data that show regional characteristics, potential and vulnerabilities. It is an orientating tool that can support policy makers and entrepreneurs from different sectors.

This Ecological-Economic Zoning (ZEE) was prepared from the methodological guidelines proposed by the Ministry of Environment in accordance with the guidelines of the Environmental Legislation and the Environmental Policies of the State of Minas Gerais, guided by the following issues:

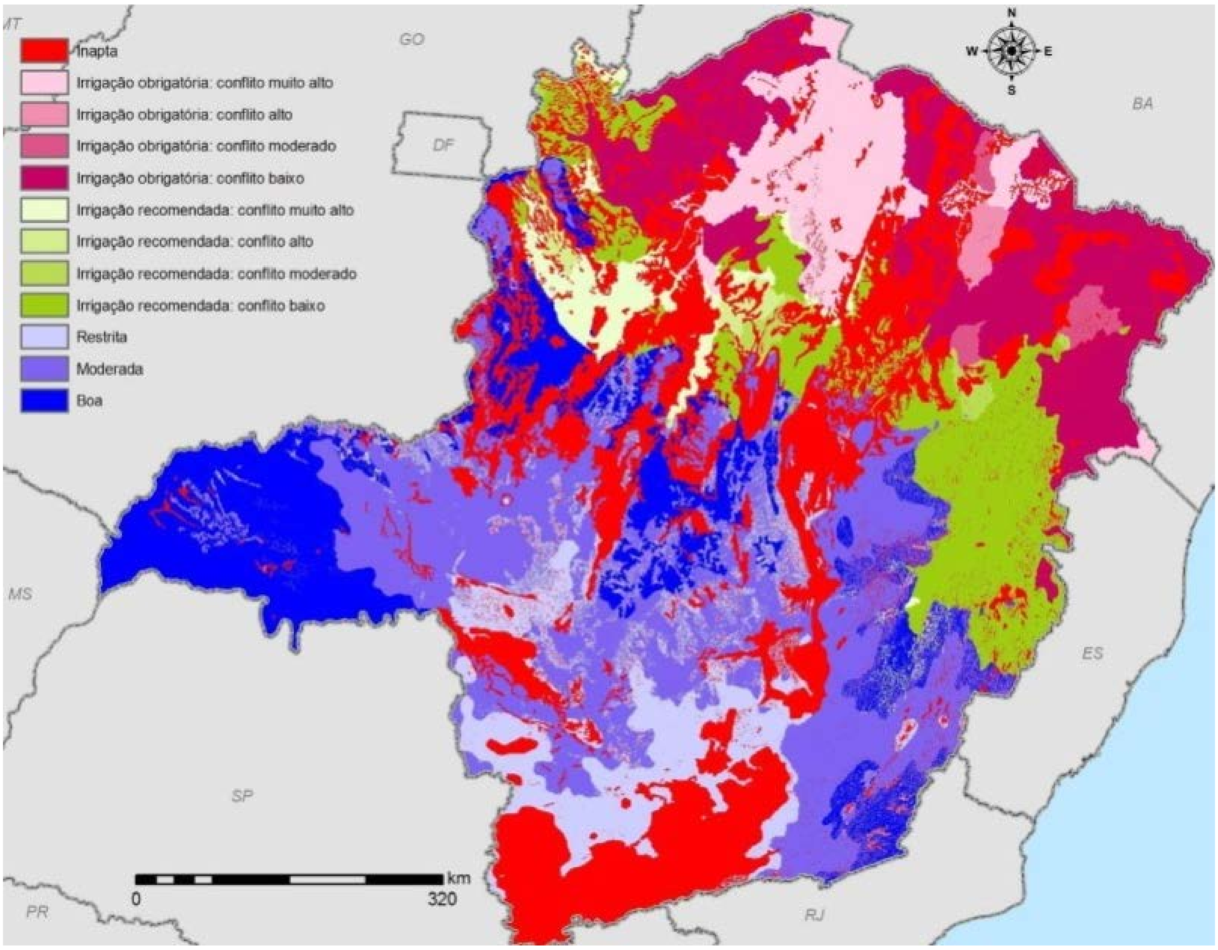
(i) regarding the regional units (Copam - Minas Gerais State Council for Environmental Policy),

(ii) regarding Watershed State,

(iii) referring to meso and micro-regions, and

(iv) for the planning council (MMA 2013b).

Figure 4 Ecological and Economic Zoning of Minas Gerais State

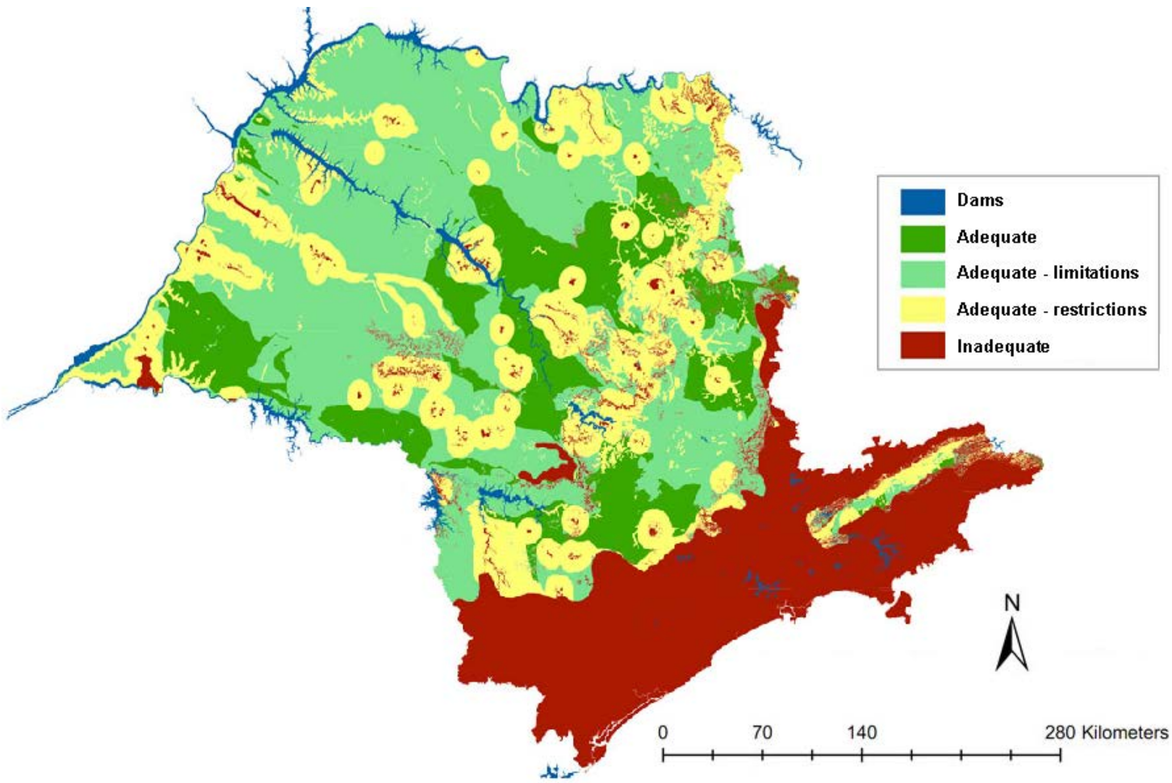


Source: MMA (2013b)

The State of São Paulo launched agro-environmental zoning in September 2008. It was conducted by the State Secretariat for the Environment in a partnership with the State Secretariat for Agriculture and Food Supply aiming to discipline and organize expansion and land use by sugarcane sector, in addition to support public policy.

This zoning comprises information about soil and climate potentials, surface water availability, underground water vulnerability, restrictions to mechanized harvesting, biodiversity protection areas, biodiversity connectivity, biodiversity protection importance and integral protection units. All the information has been consolidated in thematic maps that overlaid determine the suitability of areas to sugarcane cultivation within the state.

Figure 5 Final sugarcane agro-environmental zoning in São Paulo



Source: EMBRAPA 2009

The Resolution SMA 88/ 2008 that defines parameters and guidelines for environmental licensing of sugarcane facilities has been based on the agro-environmental zoning information. For example, applications for permits in the red zone of the map (Figure 5) are not even accepted. Each area (colors) of the map has specific requirements to be accomplished by the entrepreneurs.

The parameters (water consumption, air pollutant emissions, existing biomes, soil and topographic restrictions, mainly including the mandatory introduction of the green cane harvesting) established in the Resolution must be accomplished by existing mills and new ones.

The text stipulates a set of measures to be followed, regarding environment and also anticipates the legal deadlines for the elimination of sugarcane harvest burning and immediately halting burning practices in any sugarcane harvests located in expansion areas as already mentioned. In addition, the Protocol targets the protection and recovery of riparian forests and water springs in sugarcane farms; controls erosion and the content of water runoff: implements water conservation plans; stipulates the proper management of agrochemicals; and encourages reductions in air pollution and solid wastes from industrial processes.

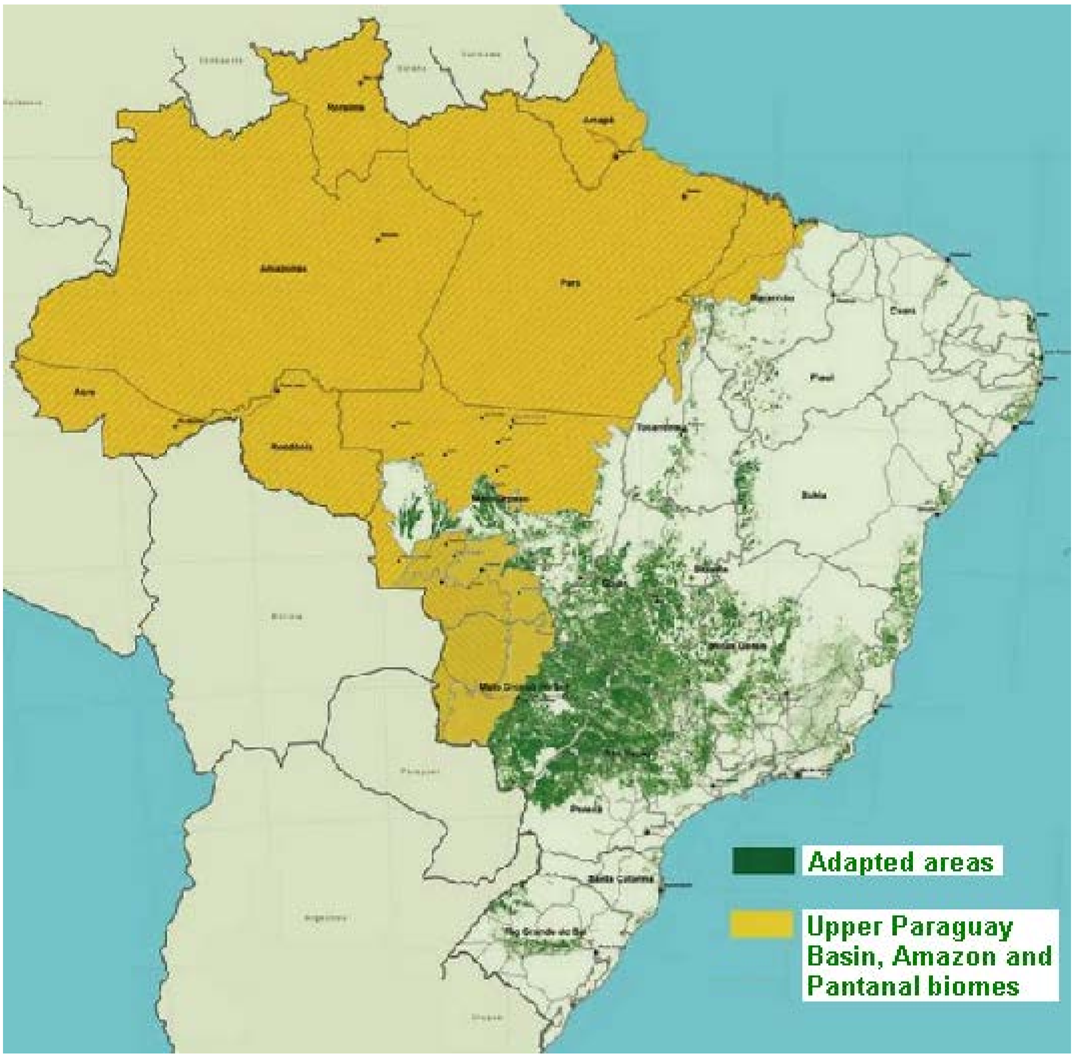
The Federal Government launched two national agro-ecological zonings: for sugarcane in September 2009 (EMPRAPA 2009) and for oil palm in 2010 (EMPRAPA 2010). The Federal zoning involved dozens of institutions and researchers of agricultural and environmental issues. In this process maps were produced showing soils, climate and rainfall and topography.

The agro-ecological zoning consist in an important policy tool and has innovated by taking into account environmental, economic and social aspects as an answer for these challenges in the sustainable expansion, mainly of the sugarcane production and the investments on the sugar and ethanol sectors. This regulation allows a guidance to credit policies and use for public banks as a condition for the production financing.

Land was classified and its use delimited by determining in detail (1:250.000) those areas of highest yield potential, based on minimum productivity; it takes into account environmental regulations and areas which should be preserved and it seeks to reduce competition with areas devoted to food production.

This identified areas where sugarcane crop expansion could take place (Figure 6 – indicated areas in green color). It forbids sugarcane cultivation in 92.5% of national territory. It also identified 64 Mha (EMPRAPA 2009) that comply with environmental and productivity requirements, mainly from the intensification of cattle raising which is currently very inefficient (less than 1 head/ha). The zoning did not consider economic issues and social issues that are already covered by the existing legislation.

Figure 6 Agro-ecological sugarcane zoning (ZAE)



Source: EMBRAPA 2009

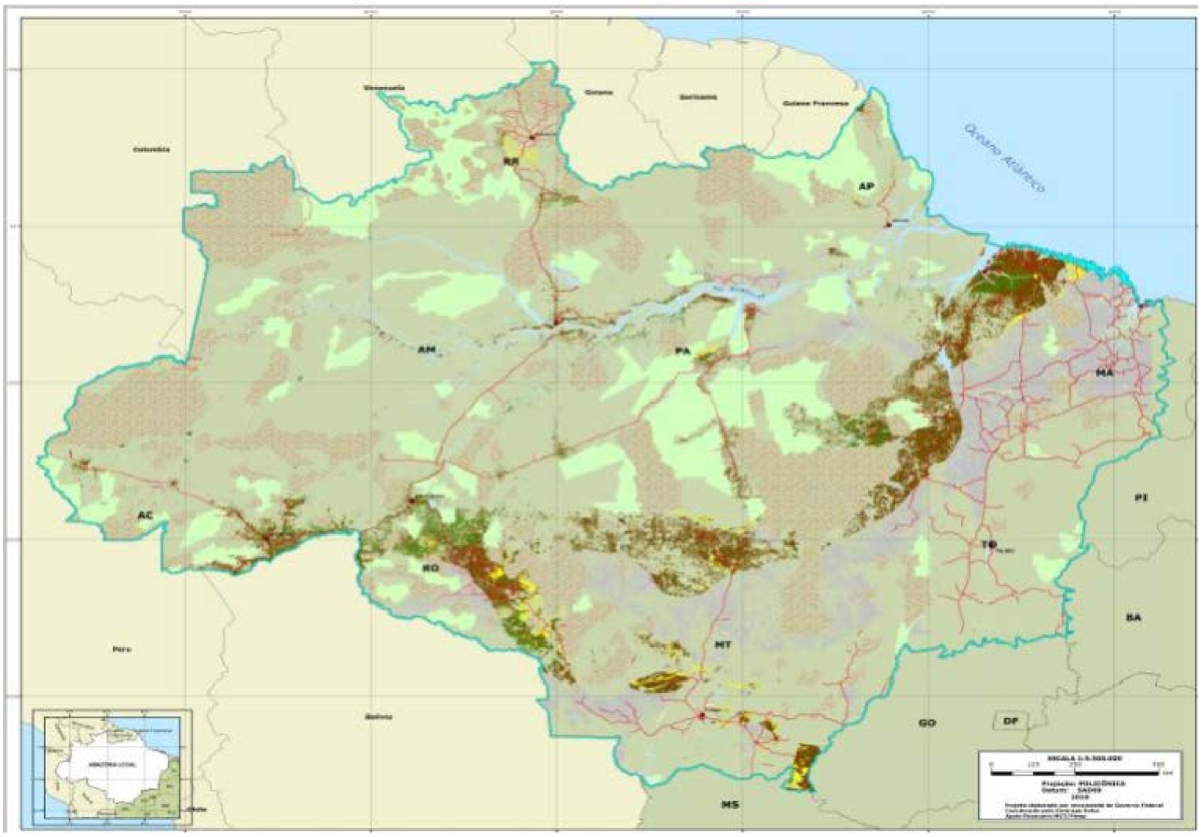
For the sugarcane agro-ecological zoning were considered some rules to make the mapping of the national territory, it was an important and innovative initiative because it considered not only environmental aspects but technological criteria and productivity (EMPRAPA 2009). The guidelines set were:

- Exclusion of areas with native vegetation, prohibiting in the entire national territory to remove native vegetation for the expansion of sugarcane cultivation
- Exclusion of areas for cultivation in the Amazon and Pantanal biomes, and in the Upper Paraguay River Basin

- Identification of areas with agricultural potential without need of full irrigation, to select areas in which sugarcane production uses the lowest volume of water possible
- Identification of areas with slope below 12%, that allow the use of machinery on the harvesting
- Respect for food security guiding the expansion of sugarcane production so as to avoid any sort of risk to food production or to food security
- Prioritization of degraded areas or pasture, indicating land currently underutilized or occupied by livestock or degraded pastures as suitable for sugarcane production.

Similar to sugarcane zoning, EMPRAPA also developed zoning for oil palm that resulted in 30 Mha available for production free from undesirable impacts (Figure 7). Respective reports, maps and methodological issues are given in EMPRAPA (2010).

Figure 7 Agro-ecological palm oil zoning



Source: EMBRAPA (2010)

Nowadays also other States like Mato Grosso do Sul have launched their own environmental economic zoning, not only for sugarcane but also for eucalyptus plantations grown for pulp and charcoal production, which are mainly allowed in degraded areas and previously used for cattle pasture.

This was in fact the first zoning to be implemented in Brazil and it includes eucalyptus plantations because Minas Gerais is the state with the highest wood production from plantation and the more strict environmental legislation for wood plantation in Brazil.

5.2.2 Social aspects

Nowadays most of wood production from wood plantation in Brazil follows the social and labor legislation in Brazil, mainly the pulp and paper sector. Social problems happen only in the illegal charcoal production from native forest, which still happens in a few regions in the country.

The Brazilian labor legislation regulates all kind of employment activity in the country. The main provisions derive from Decree-Law 5452/1943 ("Consolidação das Leis do Trabalho – CLT") and the related Law 9958/2000 (on previous conciliation, labor dispute settlements). Federal Law 11718/2008 disciplines short-term rural contracts, retirements and financing. Brazil is signatory of 1926 United Nations Slavery Convention.

Other relevant provisions regard student internship (Law 11788/2008); rural savings and crediting (Law 11524/2007); profit sharing for workers (Law 10101/2000); inclusion of handicapped working force (Law 8213/1991); occupational hazards (Decree 6577/2008); prohibition of child labor (Decree 3597/2000, ILO Convention 182 and ILO Recommendation 190); Portaria SUP/DER-039/2008 (rural labor force transport by bus); Portaria 42/2007 (interval between working shifts) and "Portaria" 202/2006 (workforce health and safety in confined spaces).

6 Brazilian export options for woody bioenergy

According to FAO (2012b), Brazil reported no export of firewood or wood chips. For charcoal, FAO (Faostat 2013) reports imports of 110460 t and exports of just 927 t. Thus, there is still a huge deficit of (sustainable) charcoal to meet the demand of Brazilian industries (Leite, Roque, Macedo 1997).

No plans for expansion to export markets were found, since there is still a huge deficit of (sustainable) charcoal to meet the demand of Brazilian industries.

In fact this means that a significant share of charcoal used in iron/steel industries are produced from wood from deforestation of native forests. According to scenarios from ABRAF (2012), for 2009-2014, there is still a deficit of charcoal from planted wood for iron/steel sector.

For the period 2005-2009 the deficit of charcoal from planted wood was 14.7 Mm^3.

Global trade of wood from various types of forests moves annually around US$ 50 billion, and of this total, approximately US$ 12 billion are from native rainforests. Brazil's participation in this market, however, has been quite modest, given that sells only 2% of all timber from forests and 4.5% when it comes to the marketing of wood originating from tropical forests.

Thus, the participation of Brazil in the global timber market is rather insignificant, relative to the size of its territory (Omachi 2004).

The Brazilian ports are not able to export biomass. Storage conditions are not appropriate for this market and pellets cannot be subjected to moisture, otherwise they lose their heating value.

But it is worth investing in this area. For example, Brazil has a potential to generate 4.5 megawatts (MW) only from Eucalyptus biomass residues, which are the 7 million hectares of reforested areas (Referência 2013).

Recently, Brazil intends to enter the international trade of wood pellets, with the current European demand of 18 Mt per year (REN21 2012). Brazilian industries are already preparing to export, a market expected to grow rapidly. However, nowadays, Brazilian participation in the world market for solid bioenergy is insignificant.

In brief, it will be possible to expand domestic consumption and increase the export of forest products especially wood bioenergy. In 20 years, Brazil will be able to triple the export of forest products, reaching 10% of world trade of these items, equivalent today to US$ 20 billion (SAE 2011).

The current obstacles are economic, financial and legal. First, it takes great effort in public investment to overcome the deficiencies of the transport infrastructure. Second, stimulus for long-term financing and the creation of legal devices that address the socioeconomic importance of planted forests.

The existing funding systems in Brazil, as discussed ahead, could be important to increase investments for Brazilian exports.

Funding systems

Beside the financing with own resources, forest-based enterprises come to rely more in recently featured calls like TIMO (Timber Investment Management Organizations), created in the 1970s in the USA and introduced in Brazil in the last decade, i.e. a form of participation of private investment funds (PIF). Today there are about ten PIF for development projects in forestry which capture resources in Brazil and abroad.

A new schema of fund raising based on fiscal incentives could have been a success mainly for forestry purposes; however, there are several legal questions related to the restriction on land acquisition by foreigners that did not contribute to the implementation of the schema.

In addition to private funding, via TIMOs, aimed primarily at rural enterprises organized, medium and large, there are lines of public financing for medium, small and micro producers wishing to invest in forest plantation.

Public programs woodlot, though relatively scarce in resources were of great importance to the development of the forest sector, between 1965 and 1987. During that period of tax incentives and credit to reforestation there was considerable expansion of planted areas, and enormous development of the forest industry, mainly in the charcoal and pulp and paper industries (SAE 2011).

The federal government currently offers three funding lines nationwide: PRONAF Forestry, Eco PRONAF and PROPFLORA, whose characteristics are presented below (BNDS 2013).

Several CDM projects for wood plantations exist in Brazil but the low cost of carbon credits do not contribute to implement it further. Also there are proposals from the Brazilian Government for the protection of native forests under discussion in United Nations Forum.

PRONAF Forestry and Eco PRONAF:

Is an initiative of the Ministry of Agrarian Development (MDA) in partnership with the Ministry of Environment (MMA) and imposed in 2002 and 2007. Resolutions by the Central Bank of Brazil, lines of credit and PRONAF Forest Eco PRONAF are mostly for family farmers. Investments are focused on agroforestry (SAF), the main objectives and reforestation forestry for timber and non-timber products, renewable energy and recovery of environmental preservation areas.

PROPFLORA:

Originally called the Commercial Forest Program was established in July 2002 by the Ministry of Agriculture, Livestock and Supply (MAPA), by Resolution 2992 of the Central Bank of Brazil. Resources are BNDES. The funding aims to plant forests, mainly for industrial use. Visa also the restoration and maintenance of preservation areas and legal reserves.

BNDES Forest:

Aims to support reforestation activities, conservation and reforestation of degraded or converted, and forest management sustainable in native areas. Funding can occur in two ways: (i) funding the planting of tree species for energy or redox with positive environmental externalities, and (ii) financing the reforestation of degraded or converted to forest management. There is maximum participation of BNDES for the funding for the planting of tree species for energy.

7 Final considerations for Brazil

Policy for the Brazilian forestry development should address the issues discussed here considering specific aspects of the four major industry segments. If successful in institutional advancements, Brazil could accelerate the sustainable expansion of forest plantations, reaching an average growth of 1 Mha/a (SAE 2011).

Although existing public policy initiatives well intentioned (PROINFA Agroenergy Policy 2006-2011 MME, National Agroenergy, BNDES-Forest), further policies are needed to incentive wood biomass production. As discussed in Secretariat of Strategic Affairs of the Presidency of Brazil, there are several incentives for biodiesel production (including agricultural production of some oil crops) but not for wood plantations.

Considering forestry in Brazil, it is important to note that in this sector, the prospects for expansion of forest plantations can ensure future demand for wood that are linked to the production of high added value, given that the country has with the characteristics required for the production of wood for energy, with possible expansion to serve the market of pellets (Escobar 2013).

Brazil can become able to produce sustainable and economically competitive wood bioenergy to export, due to favorable cost of raw materials and the absence of significant technological barriers to production. It is necessary to remove the existing difficulties and to create policies to incentive investments in this sector aiming a higher participation in the international market.

References

AMS (Associação Mineira de Silvicultura) 2013: Evolução do consumo de carvão vegetal conforme sua origem (Brasil) http://www.showsite.com.br/silviminas/html/AnexoCampo/__consumo.pdf (accessed March 26, 2013)

Buongiorno J, Raunikar R, Zhu S 2011: Consequences of increasing bioenergy demand on wood and forests: An application of the Global Forest Products Model; in: Journal of Forest Economics Vol. 17, no. 2, pp 214-229

Coelho S T, Goldemberg J, Uhlig A 2008: O uso de carvão vegetal na indústria siderúrgica brasileira e o impacto sobre as mudanças climáticas; in: Revista Brasileira de Energia vol. 14 no 2, pp. 67-85

EMBRAPA (Brazilian Agricultural Research Corporation) 2009: Agro-ecological Sugarcane Zoning http://www.cnps.embrapa.br/zoneamento_cana_de_acucar

EMBRAPA (Brazilian Agricultural Research Corporation) 2010: Agro-ecological Palm Oil Zoning http://www.cnps.embrapa.br/zoneamento_dende

FAOSTAT Forestry database 2013: Global production and trade of forest products in 2011; Rome: FAO *http://faostat.fao.org/site/626/DesktopDefault.aspx?PageID=626#ancor*

GEF (Global Environment Facility) 2010: Strengthening Sustainable Forest Management and the Development of Bio-energy Markets to Promote Environmental Sustainability and to Reduce Greenhouse Gas Emissions in Cambodia under the Global: SFM Programme Framework for Projects under the GEF Strategy for Sustainable Forest Management; GEF Project Document Washington DC http://www.thegef.org/gef/sites/thegef.org/files/documents/document/4-26-10%20-Web%20Posting%20-%203635_3.pdf

IBGE (The Brazilian Institute of Geography and Statistics) 2005: Geoscience._Produção da extração vegetal e da silvicultura; Coordenação de Agropecuária; Rio de Janeiro

IDB (Inter-American Development Bank) 2008: Herramientas para mejorar la Efectividad del Mercado de Combustibles de Madera en la Economía Rural. Informe diagnóstico Paraguay; Washington http://www.ssme.gov.py/arch_temp/MMC_Infor_Diag.pdf

IEA Bio (International Energy Agency Bioenergy) 2013: Bioenergy Trade Reports; Utrecht www.bioenergytrade.org

Lamers P et al. 2012: Developments in international solid biofuel trade - an analysis of volumes, policies, and market factors; in: Renewable & Sustainable Energy Reviews vol. 16 no. 5, pp. 3176-3199

Leite E T, Roque C L, Macedo A P 1997: Produtos Solidos de Madeira; BNDS – Banco Nacional do Desenvolvimento; Rio de Janeiro

Lucon O, Coelho S, Goldemberg J 2004: LPG in Brazil: lessons and challenges; in: Energy for Sustainable Development vol. 8 no. 3

MMA (Ministerio do Meio Ambiente) 2009: Projeto PNUD 00/20 - Levantamento sobre a geração de resíduos provenientes da atividade madeireira e proposição de diretrizes para politicas, normas e condutas técnicas para promover o seu uso adequado; Curitiba

MME (Ministério de Minas e Energia-Brazil) 2012: Balanço Energético Nacional - Resultados Preliminares 2011; Rio de Janeiro

Muller M 2005: Produção de madeira para geração de energia elétrica numa plantação clonal de eucalipto em Itamarandiba; MG. Tese de Doutorado – Universidade Federal de Viçosa; Minas Gerais

Muylaert M, Sala J, Freitas M 1999: The charcoal's production in Brazil - process efficiency and environmental effects; in: Renewable Energy vol. 16, p. 1037-1040

SAE (Secretaria de Assuntos Estratégicos da Presidência da Republica) 2011: Diretrizes para a estruturação de uma Política Nacional de Florestas Plantadas; Brasilia

Suzano (Suzano Renewable Energy) 2013: Industria de Papel e Celulose e Energias Renovaveis http://www.suzano.com.br/portal/suzano-energia-renovavel.htm (accessed February 15, 2013)

UNECE (United Nations Economic Commission for Europe), FAO (Food and Agriculture Organization of the United Nations) 2011: Forest Products Annual Market Review 2010-2011; Geneva Timber and Forest Study Paper 27; Geneva http://www.unece.org/fileadmin/DAM/publications/timber/FPAMR_2010-2011_HQ.pdf

UNECE (United Nations Economic Commission for Europe), FAO (Food and Agriculture Organization of the United Nations) 2012: Forest Products. Market Review 2011-2012 http://www.unece.org.unecedev.colo.iway.ch/fileadmin/DAM/timber/publications/FPAMR_2012.pdf