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Sustainable Bioenergy:

Field Evaluating of Brazil's "Social Biodiesel" Program

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Contents

Foreword ..... **iv**

1 Introduction **1**

2 The Programa Nacional de Producao e Uso do Biodiesel (PNPB) **2**

3 The Brazilian poverty eradication program “Fome Zero” **3**

4 The Brazilian biodiesel program **7**

4.1 Definition 7
4.2 Biodiesel Production Technology 7
4.3 Sources of biodiesel and feedstock 8
4.4 Benefits of biodiesel 8
4.5 Economic aspects of biodiesel 9
4.6 The specifics of the biodiesel policy in Brazil (smallholder producers, geographical focus, incentives and marketing mechanisms etc) 10
4.7 Legal framework and institutions 10
4.8 Specification of the Brazilian biodiesel, Quality and norm 11
4.9 Geographical focus 11
4.10 Main drivers for biodiesel production and supply of feedstocks 12
4.11 Key economic, environmental an social issues in biodiesel production from soybean, castor oil, oil palm and jatropha 12

5 Case studies of the biodiesel programme, based on experiences in northeast Brazil **14**

5.1 Theory and practice of biodiesel based on castor oil: technical and economic feasibility, risks 14
5.2 The Social Fuel Seal 15
5.3 The ANP biodiesel auctions 16
5.4 Experiences of smallholder producers and cooperatives 16
5.5 Required inputs: capital/technology and labour (incl. skills and seasonal distribution) 18
5.6 Net employment and income effects when compared with other land-uses or uses of working time 18
5.7 Theoretical and actual contribution to poverty reduction 18
5.8 Contribution to local development 18

6 Conclusions and recommendation 21

References 24

Appendix: Ethanol in Brazil 1

The Brazilian Ethanol Sector 1
Brazilian biofuels policy framework: national, regional and local policies 4
Outlook in the bioethanol sector 6
Concentration in the industry 7

Foreword

The objective of this paper is to contribute to the analysis of the Brazilian policy on to biodiesel, with specific consideration given to social and environmental aspects of sustainability.

Biofuels, namely alcohol and biodiesel, become increasingly popular on a global scale due to their potential as low-greenhouse-gas emitting, renewable energy sources.

Brazil is a country blessed with abundant natural resources and agricultural land, and has emerged in the last decades as a world leader in the production of biofuels, especially bioethanol.

Most research and discussion concern the Brazilian experiences and prospects with ethanol from sugarcane. This study is not to contribute to that, but to focus on the less known – but more interesting - Brazilian national policy to combine biodiesel development with explicit social goals.

The scope of our work is to evaluate this policy in the larger social, economic and environmental context, using local evidence and direct information from “the field”.

Although the implementation of the Brazilian policy, which began in 2004, is still within its initial stage, it seems possible to identify and elaborate on the forces contributing to or against its successful contribution toward the sustainability of the Brazilian biodiesel program, specifically related to the issues of food security, natural resource and biodiversity preservation, and social inclusion.

This brief study is meant as a **first step**, and its – preliminary - results need deepening, review, and extension.

We invite interested parties to share their views on our findings, and to consider contributing to additional research.

Germany, December 2007. The Authors

1 Introduction

The Brazilian Government, under the presidency of Lula da Silva, is determined to replicate the success of its ProAlcool program[1] with the production and utilization of biodiesel. For that, Brazil has an almost unique conjunction of factors –geographical location, climate conditions and vast territory adequate for the cultivation and large-scale plantation of various species of oil plants such as mamona (*Ricinus communis*, castor bean), soybean and palm oil, among others.

The objective of the Brazilian biodiesel policy is to direct part of the production to rural communities, engaging small farmers and producers in Brazil's poorest regions in the biodiesel value chain in order to improve their socio-economic situation.

The production of plant oils as raw material for biodiesel depends on geographical and climatic settings. This is on of the reasons why the main focus of Brazil's social biodiesel program is the semi-arid and poorest Northeast region, where the main feedstock for the production of biodiesel is ricinus (castor).

The complex ecological and socio-economic diversity of the Northeast's agriculture provides a special challenge for the implementation of the program that aims to couple renewable energy production with social inclusion policy, and regional development.

Brazil made the fight against the poverty of the rural population and the social inclusion of family agriculture a priority of its domestic policy. For that aim, it initiated the national biodiesel program (PNPB). The promotion of "Agricultural Familiar" (family agriculture) in the biodiesel production chain process is one of the pillars of the PNPB in its drive to support a sustainable socio-economic and environmental development of the Brazilian Northeast rural zone.

With this brief study, we attempt to analyze the PNPB and to provide an overview of the intentions behind the biodiesel program with a focus on its socio-economic sustainability through field observations conducted in the three Northeast states of Bahia, Piaui and Pernambuco.

Some additional insight gained on the Brazilian bioethanol activities are summarized in the Appendix of this study.

1 For details, see Annex.

2 The Programa Nacional de Producao e Uso do Biodiesel (PNPB)

Although since 2006, Brazil is self-sufficient in oil production, it still has to import an increasing amount of diesel fuel that represents, for 2006, a value of US$ 1.3 billions, an increase of 47 % compares to 2005 (Duffey 2007). The reduction of this diesel import dependency is one of the main motivations, besides ecological and socio-economic development considerations, behind the promotion and acceleration of the PNPB.

With an initiative of the Brazilian federal government, The Programa Nacional de Producao e Uso do Biodiesel (PNPB) was officially initiated in December 2004. The program was elaborated under the direct supervision of the Presidency and an inter-ministerial executive commission (CEI), composed of 14 ministries. The ministry of Mines and Energy (MME) is in charge of the operational management of the program, which involved the following institutions: the national Petroleum Agency (ANP), Petrobras, the Brazilian national oil company, Embrapa and the Brazilian national development Bank (BNDES).

In order to provide regional and local technical assistance support, the Government also created the Brazilian Biodiesel Technology Network (RBTB), comprising research institutions in 23 states of the Federation.

The PNPB's main objective is to combat poverty and social inequality in rural areas, particularly, in the North and Northeast region, with respect to energy access. The program's policy and institutional features include: biodiesel legislation, legal framework for protecting investors, mandatory limit for biofuel production, social marketing of products, and tax exemptions.

Its implementation contemplates the specific regional characteristics, as oleaginous feedstocks are concerned and does not exclude any alternatives. In addition to the agribusiness aspects, it prioritises the participation of small-scale family agriculture, encouraging the formation of cooperatives and consortia by small producers.

The program has also instituted a 'Social Fuel' seal that aims to promote social inclusion throughout the new fuel's production and value chain. It establishes the conditions for industrial producers of biodiesel to obtain benefits and credits.

In order to receive the seal, an industrial producer must purchase feedstock from family farmers and enter into a legally binding agreement with them to establish specific income levels and guarantee technical assistance and training (CNPE 2005).

The introduction of biodiesel in the Brazilian energy matrix took place effectively with law 11.09/2005 issued by the Brazilian government in 2005. This law foresee a mandatory mixture, denominated B2, of 2 % biodiesel addition to fuel diesel sold in the country, from January 1st 2008 (MME 2005). Under the supervision of the National Energy Policy Council (CNPE) this obligation will be gradually increased to 5 per cent and 20 per cent respectively, by 2013 and 2020.

In addition to the setting of targets for biodiesel-diesel percentage blends, the regulation also involves a framework that includes differential rates depending on the oilseeds used, where they are grown, and whether large agribusiness concerns or family farmers produce them. Biodiesel feedstocks and the fuel itself are exempted from Industrial Products Tax (IPI).

3 The Brazilian poverty eradication program “Fome Zero”

The *Fome Zero* (“Zero Hunger”) plan put forward a bold strategy aimed at unifying and further consolidating existing social programs – especially the “Bolsa Familia”.

The policy of taking food security as a state priority was backed by institutional changes with the objective of strengthening the apparatus of the government and providing the necessary reach in the remotest areas of the country.

The program Fome Zero is coordinated by the Ministério do Desenvolvimento Social e Combate à Fome (Ministry of Social Development and Combat against Hunger) and consists in a government strategy to guarantee a right to access basic food. The program ranges from giving direct financial aid to the poorest families; to many diverse areas, such as creating cisterns in Brazil's semi-arid, creating popular restaurants with low prices, educating about healthy eating habits, distributing vitamins and iron supplements, supporting family farming, giving access to credit by micro credit, and a few other programs.

The Zero Hunger (ZH) initiative is a multifaceted set of policies and programs for food security. It involved nearly all ministries, all three levels of government (federal, state and local) and all of Brazilian society. The ZH initiative, coordinated by the Citizenship Institute, is the result of work by experts, NGOs, research institutes, unions, other organizations of civil society and social movements related to food issues from all over Brazil.

As of June 2003, Zero Hunger was assisting 193 communities in 10 Northeastern States, or 58,259 families. Currently, the program Bolsa familia is supporting 11.1 millions families in all Brazil (MDS, 2007).

Hunger, Food Insecurity and Poverty in Brazil

According to ZH (2007), more than 27 million people are today living in a state of food insecurity. The main cause of food insecurity in Brazil is not a shortage of food, but insufficient purchasing power.

Millions of unemployed, underemployed and so-called “informal” (i.e. unregistered) workers and their families lack sufficient quantities of quality food to meet their basic nutritional needs and maintain good health. Poverty also afflicts around 15 million people in rural areas of Brazil.

Most of these very poor Brazilians live in small villages and medium-sized towns in the countryside (20 million people) and in large metropolitan areas (9 million people), where unemployment rates and the costs of out-of-home meals and non-food expenses (such as housing, transportation, health care, education) have increased

substantially. According to Belik (2003) Brazil's poor population is concentrated in the Northeast part of the country (47.5% of all poor people in the country). The poor rural population in the Northeast combined with the population of poor in small and medium-sized towns in that region account for 40.2% of the total population (poor and non-poor) of Brazil

Although there is a heavy concentration of poverty in the less developed Northeast region (50%), even the Southeast, Brazil's most industrialized region, has a high proportion of poor people (4.5 million). Zero Hunger addresses poverty not as an isolated or occasional phenomenon, but as the result of an economic growth pattern characterized by extremely low wages, rising income concentration and unemployment.

The structural causes of food insecurity

The Structural aspects of Brazil's development model, such as income concentration, low wages, high unemployment rates and stagnant economic growth—especially in job creating sectors—are ultimately the root causes of food insecurity in the country.

Millions of families with extremely low purchasing power are trapped in a vicious cycle of hunger, aggravated by weak income and job creation policies, as well as insufficient farm policies. As a consequence, the poorest people are excluded from the food consumption market, which causes further drops in food production, with consequent declines in employment opportunities, thus perpetuating unemployment, social exclusion and economic marginalization.

The Zero Hunger initiative includes a combination of structural policies to tackle the underlying causes of poverty—such as job and income creation, universal social security, and land reform—as well as a set of emergency policies aimed at ensuring immediate access to food for the population at greatest risk, by reducing food prices and promoting self sufficiency and subsistence production.

Fome Zero: the Political Solution to Hunger in Brazil

The work of the Zero Hunger initiative is organized in three main activity areas:

(a) Implementing structural, specific and local policies—coordinated by the Special Ministry for Food Security and Combating Hunger (MESA);

(b) Formulating and carrying out a participatory National Food and Nutritional Security Policy, with the active participation of the organizations of civil society, in the National Food and Nutritional Security Council (CONSEA); and

(c) Establishing a major national solidarity movement to eliminate hunger, with the involvement of both the government and the organizations of civil society.

• Structural policies include job and income creation initiatives, strengthened land reform, universal social security, basic health care, incentives for family farming

(*Pronaf*), educational incentives, minimum wage programs and social development in the semi-arid region of the Northeast.

• The *Bolsa Familia* specific policies are focused on promoting food security and working to eliminate hunger and malnutrition among the neediest segments of the population. These policies include the food stamps program, emergency food support, maintenance of security food stocks, expansion of the workers food program, donations of emergency basic food baskets, working to eliminate malnutrition among mothers and children, and expanding the school meals program, as well as food and consumption educational programs.

• Its local policies are basically successful programs that are already operating at the local level, implemented by states and local governments, in partnership with the organizations of civil society.

In metropolitan areas, these programs include: creating low-cost restaurants that supply high-nutritional quality and low-price meals; establishing a food bank that increases the availability of food to the entities that are responsible for feeding needy populations, establishing new relationships with supermarkets and other retailers in order to recruit them as partners in implementing food security policies through their participation in food stamps programs, modernizing food supply facilities and commercializing local agroindustrial products, etc.

In addition to these initiatives, local proposals for small villages and medium-sized towns include incentives for urban farming and support for local produce.

In rural areas, the emphasis is on support for family farming, technical assistance, improved access to credit, infrastructure investments and support for production and self-sufficiency.

Funds for Zero Hunger

The government's commitment to eradicating hunger includes the creation of a permanent federal budget category allocating funds to cover not only the policies of the Zero Hunger initiative, but also those allocated to education, health care and land reform.

The Fund to Fight Hunger and Eradicate Poverty was created in 2001 to pay for actions targeting poor families. The fund receives both budget allocations and donations from individuals and corporations located in Brazil and abroad. The government has opened bank accounts in Brazil and abroad in order to receive cash donations from companies and individuals interested in supporting the Zero Hunger initiative.

Both small and large-scale food donation campaigns organized by city governments and the National Food Supply Company (CONAB), respectively, provide additional funds for the Zero Hunger initiative. Additional funding is expected to come from the

economic growth arising from the implementation of income and job creation policies that are part of the ZH initiative.

The challenges of Zero Hunger and other social and economic policies

The Fome Zero faces two main challenges: first, working in conjunction with a fully engaged civil society to strengthen the institutional capacity to implement what is a complex and multifaceted set of programs; and, second, mobilizing the required funds in ways that are consistent with economic and fiscal stability.

The National Program for Generating Income (PRONAGER) and the National Program for Family Farming Empowerment (PRONAF) contribute on an appropriate scale directly to the implementation of the ZH initiative. Brazil's actions and initiatives aim to reduce by 50% the number of undernourished people in Brazil by 2015.

Other social and economic policies are:

- Adult's literacy, educational level improvement and professional capacity building
- Micro-credit policies and,
- Sanitation infrastructure, water supply, and public works.

4 The Brazilian biodiesel program

In difference to the ProAlcool program which was initiated purely for economic reasons, the Brazilian biodiesel program (PNPB) is more a government social and environmental initiative that is an attempt to solve the chronic poverty of rural Brazil by the means of economic empowerment through the integration of small farmers into the biodiesel production chain structure. From the Brazilian government's perspective, the introduction of biodiesel into the national energy matrix, will reduce the country dependency from diesel fuel import, thus significantly cut hard currency spending, but also promote the social inclusion of millions of Brazilian and at the same time protect the environment through the use of one more renewable energy source.

4.1 Definition

Biodiesel is an alternative diesel fuel substitute for diesel engines that consists of the mono-alkyl esters of fatty acid produced from vegetable (oleaginous) oil and animal fat. It can be used either pure, or in blends with fossil diesel fuel. Biodiesel is non-toxic, biodegradable, and essentially free from sulphurs and aromatics. It works in any diesel engine with few or no modifications and offers similar characteristics to those of fossil diesel.

4.2 Biodiesel Production Technology

Biodiesel is produced from vegetable oils and animal fats in a process called transesterification, and it is the esters created in this process that are used as fuel. The industrial production process of biodiesel in Brazil occurs mainly through oil transesterification and the steps could be described as follow:

The vegetable oil, animal fat or recycled oil is stored and, after acid correction, is transferred to the principal reactor.

In a second reactor, the catalyst (KOH or NaOH) and the alcohol (MeOH or EtOH) are homogenized and transferred to the principal reactor. The reaction is completed in 40 min, in temperatures between 30 and 40°C. The biodiesel (superior layer) is then separated from the raw glycerine (inferior layer) by decantation (on batch process) or by centrifugation (on continuous process). The inferior layer, beside raw glycerine, contains part of the alcohol that could be recovered and reused in the process. The raw glycerine could be purified and used, for example, in the cosmetic industry.

The separation step is one of the most important in the biodiesel production, since it is essential for the specification of the product according to legislation. The fuel should have similar characteristics to those of fossil diesel and, in case it does not reach the claimed specification, should be reprocessed. In order to assure the product purity and avoid engine and also environmental damage, levels of free fatty acid, alcohol, water, and glycerine should be at a minimum.

The yield of biodiesel from the process can vary from 70 to 90% depending on the type of feedstock, reagents and operational conditions. The transesterification is

affected by alcohol:oil molar ratio, catalyst, temperature, reaction time and the content of water and free acids.

Transesterification can occur in different temperatures depending on the type of oil employed. The reaction of castor oil with methanol occurs most satisfactorily at temperatures in the range from 20 to 35 °C (Ranalli, 2006).

4.3 Sources of biodiesel and feedstock

The source for biodiesel production is chosen according to regional availability. The biodiesel feedstock is characterized by the type and concentration of fatty acids present: generally, monounsatured or polyunsaturated. The perfect feedstock for biodiesel is composed of 100% mono unsaturated fatty acid. Feedstock with similar composition can be used interchangeably in processes designed for those compositions, depending on prices. Rapeseed oil, palm oil, sunflower oil, soy oil and castor oil are the most common industrial biodiesel production feedstock.

The fuel properties (freezing point, cetane number and viscosity) vary with fatty acid composition and the presence of minor compounds such as sterols, antioxidants and phosphatides.

4.4 Benefits of biodiesel

The main driver behind the use of biodiesel is its environmental friendliness and with the increasing oil price, it become more and more attractive as fuel.

Over the past few years, there has been a growing awareness to the importance of the environment and its degradation, climate change that is being contributed to in part by the increasing emissions resulting from production and consumption of fossil fuel based products. There is a desire to shy away from the use of these products. Thus a push for the use of alternative fuels because of the aspiration to reduce dependency on the availability of oil that is becoming scarce as global demand continues to rise.

4.4.1 Emissions

The main push behind alternative fuels is emission reduction. The combustion of diesel fuels is known to emit noxious gases, unburned hydrocarbons (volatile organic compounds), carbon monoxide, particle matter, NOx, sulfates and CO_2 considered to be the global warming main proponent.

Different biodiesel blends reduce emissions at different rates. Pure biodiesel produces fewer emissions than a petroleum diesel and biodiesel mixture. The amount of emission reduction is directly related to the ratio of biodiesel to diesel.

4.4.2 Biodiesel and Kyoto

Biodiesel can displace a portion of the oil used for transportation and, because it is biologically based, may reduce the impact of global warming.

According to the Life Cycle theory biodiesel at full implementation would reduces CO2 production by 75%. This will be a great step toward the goal of reaching Kyoto.

4.4.3 Energy efficiency

Biodiesel appears to have a significantly better net energy balance (NEB) than ethanol. It has a NEB of 3.2 (USDA-DOE, 1998).

4.5 Economic aspects of biodiesel

The combination of high oil prices and government incentives has caused a surge in interest in biodiesel worldwide.Biodiesel provides a major new market for agriculture products and encourage the development of greater diversity in crop production as oleaginous with greater oil yield become economically viable.

- *Cost of producing biodiesel*

The cost of producing biodiesel is generally more than the cost of producing its fossil fuel counterpart. The cost of producing biodiesel varies substantially with the choice of feedstock, since the cost of feedstock is the largest single component of biodiesel production cost. The prices of biodiesel feedstock vary over time based on domestic and internationally supply and demand conditions.

As diesel fuel prices rise relative to biodiesel or biodiesel feedstock, and/or as biodiesel production costs fall through lower commodity prices or technological improvements in the production process, biodiesel becomes more economical. In addition, States' assistance and subsidies helps to make biodiesel more competitive with diesel fuel.

Several countries have their own incentives, regulations and programs in support of renewable fuel research, production, and consumption.

- Long-term supply issue

The biodiesel industry still faces several hurdles despite governments economic and agricultural policies incentives to boost biodiesel production: The retail distribution network for biodiesel is not fully established yet, in some countries there is a tendency to limit and cut the different forms of subsidies and potential domestic oil feedstock are relatively less abundant, making the long run outlook more uncertain.

Biodiesel production confronts the same limited ability to substitute for oil imports because there is not enough feedstock available and area expansion to meet an increasing biodiesel demand is controversial, as it would likely come at the expense of some other crop such as corn, cotton, or wheat to name a few.

A further possibility is a shift towards the production of higher-oil content crops or to increase non-food feedstock that could be produced on marginal land such as mamona or jatropha.

The bottom line is that a small increase in demand of oils and fats for biodiesel production could quickly exhaust available feedstock supplies and push vegetable oil prices significantly higher due to the low elasticity of demand for vegetable oils in food consumption.

Rising vegetable oil prices could reduce or eliminate biodiesel's competitive advantage against fossil fuel, even with moderate subsidies. At the same time, increased oilseed demand could disturb feed markets.

4.6 The specifics of the biodiesel policy in Brazil (smallholder producers, geographical focus, incentives and marketing mechanisms etc)

Although since 2006, Brazil is self-sufficient in oil production, it still has to import an increasing amount of diesel fuel that represents, for 2006, a value of US$ 1.3 billion, an increase of 47 % compares to 2005 (Carmelio 2007). The reduction of this diesel import dependency is one of the main motivations, besides ecological and socio-economic development considerations, behind the promotion and acceleration of the PNB.

4.7 Legal framework and institutions

With an initiative of the Brazilian federal government, The Programa Nacional de Producao e Uso do Biodiesel (PNPB) was officially initiated in December 2004. The program was elaborated under the direct supervision of the Presidency and an inter-ministerial executive commission (CEI), composed of 14 ministries. In charge of the operational management of the program are the ministry of Mines and Energy (MME) and the following institutions are also involved: the national Petroleum Agency (ANP), the oil company Petrobras, the federal agricultural research institute Embrapa and the Brazilian national development Bank (BNDES).

The government also created the Brazilian Biodiesel Technology Network (RBTB), In order to provide regional and local technical assistance support. It comprises research institutions in 23 states of the Federation.

The PNPB is essentially a non-restrictive program. Its main objective is to combat poverty and social inequality in rural areas, particularly with respect to energy access. The program's policy and institutional features include: biodiesel legislation, legal framework for protecting investors, a mandatory limit for biofuel production, social marketing of products, and tax exemptions.

The regulatory framework is made up of laws and decrees dealing with biodiesel-percentage blends, forms of use and taxation. The tax rules include differential rates depending on the oil seeds, used, where they are grown and whether large agribusiness concerns or family farmers produced them.

Its implementation contemplates the specific regional characteristics, as oleaginous feedstocks are concerned and does not exclude any alternatives. In addition to the agribusiness aspects, it prioritizes the participation of small-scale family agriculture, encouraging the formation of cooperatives and consortia by small producers.

The program has also instituted a 'Social Fuel' seal that aims to promote social inclusion throughout the new fuel's production and value chain. It establishes the conditions for industrial producers of biodiesel to obtain benefits and credits. In order to receive the seal, an industrial producer must purchase feedstock from family

farmers and enter into a legally binding agreement with them to establish specific income levels and guarantee technical assistance and training (CNPE, 2005).

The introduction of biodiesel in the Brazilian energy matrix took place effectively with law 11.09/2005 issued by the Brazilian government in 2005. This law introduces a mandatory mixture, denominated B2, of 2 % biodiesel addition to fuel diesel sold in the country, from January 1st 2008 (MME, 2005). Under the supervision of the National Energy Policy Council (CNPE) this obligation will gradually increase to 5 per cent and 20 per cent, respectively, by 2013 and 2020.

In addition to the setting of targets for biodiesel-diesel percentage blends, the regulation also involves a framework that includes differential rates depending on the oilseeds used, where they are grown, and whether large agribusiness concerns or family farmers produce them. Biodiesel feedstocks and the fuel itself are exempted from Industrial Products Tax (IPI).

4.8 Specification of the Brazilian biodiesel, Quality and norm

The PNB is not restrictive as far as feedstock is concerned. It allows the use of diverse oleaginous and animal fat. This flexibility allows the participation of both agribusiness and small producers, thus a generalized national acceptance and support for the program.

The guidelines on biodiesel production and percentage blends with diesel fuel were established by the CNPE and implemented through two specific resolutions issued by the National Petroleum Agency (ANP). They regulate the activities of biodiesel producers, set out specifications for the new fuel, and establish portion of the value chain.

The ANP standard formulates that regardless of the feedstock used and the conversion path adopted, the specification of the biodiesel produced is the same, although a biodiesel characteristic differs depending on the feedstock used to obtain it.

The Brazilian biodiesel specification (ANP 42/2004) is closer to the American norm (ASTM D6 751) and the European (EN 14214) one, with the difference with the latter that there is no restriction for the use of ethanol nor methanol and that basically any fat feedstock are permitted.

The ANP is currently working on new specifications that will be closer to the European norms. This is done in order to harmonize the Brazilian biodiesel standard with the US/EU norms. This is step will facilitate the trade and export of Brazilian biodiesel into the world market.

4.9 Geographical focus

In Brazil, biodiesel is produced from a wide variety of oleaginous and depends on the feedstock regional availability. Brazil already produces a wide range of oilseeds that can be used as biodiesel feedstocks, such as mamona (castor beans), palm oil, sunflower, babassu palm, soybeans and cotton.

The options to produce biodiesel are divers: in the North region, palm oil and babassu are the most used source; in the Northeast, mamona (castor bean), dende (palm oil), cotton seed and soybean; in the Central-West, South and Southeast, soybean, cotton seed, castor bean, rapeseed and sunflower seed.

Since Brazil is one of soybean world's biggest producers, the major party (90%) of its biodiesel production stem from this feedstock.

Due to its "social inclusion" pillar, the core of the PNB is mostly geographically focused on the north and northeast regions that produce non-food oleaginous such as mamona, cotton and jatropha.

Soybean, mamona, because of the large agriculture areas and palm oil to its high level of oil, provide excellent options for biodiesel feedstock in Brazil. In the Northeast, besides mamona, palm, sunflower, cotton and soybean can be cultivated in all states. Palm oil is an important alternative for the sustainable development of some regions of Brazil's regions, including Amazonia (Pinto & al, 2006).

4.10 Main drivers for biodiesel production and supply of feedstocks

Encouraged by the experience accumulated through ProAlcool, the Brazilian government and the private sector expect to achieve the same technological and economic performance for the biodiesel production program. The commercial use of biodiesel is governed by a specific regulatory framework that makes biodiesel competitive, taking into account the wide variety of oilseeds available, measures to guarantee supply, compliance with fuel quality standards, and the Government social inclusion policy.

The main drivers behind the biodiesel production and the supply of feedstock for this sector are:

- Diversity in feedstock supply
- Availability of ethanol
- Modest investment requirement for creating biodiesel production capacity
- Important production of soybean and significant available capacity for vegetable oil production and,
- The mandatory biodiesel blend directive that guarantees an important market potential.

Add to that, are the different levels of federal and regional tax incentives, access to credit and technical assistance for all stakeholders in the production chain.

4.11 Key economic, environmental an social issues in biodiesel production from soybean, castor oil, oil palm and jatropha

The National Biodiesel Program's objective is the production of fuel from oils extracted from plants such castor bean, palm, soy, jatropha. The Government's original plan was for most biodiesel to be produced from castor beans cultivated by impoverished

small farmers in the northeast of the country. Biodiesel is expected to play an important role in alleviating poverty.

According to the biodiesel program, biodiesel producers that buy *mamona* and palm oil from small rural producers in the North and Northeast regions can apply for tax breaks. Each family producing 5 ha of *mamona*, with an average of 700–1200 kg per ha can earn R$2500– 3500 per year just selling the seeds (primary production with no additional aggregated value), which gives a range of R$160–275 per month (IGBE, 2006).

In the North region, palm oil is one of the best options for meeting biodiesel demand, with a potential of 3.2 million tonnes of production on 720 000 ha, sufficient for 140 000 families. The net income of a 5-ha family unit can reach six times the minimum wage. Rough estimates indicate that for a demand level of 1.85 billion l of B5 produced from *mamona*, *dende* and soybeans, around 260 000 jobs can be created. The program has a high potential for the jobs creation given its preference to the integration of small rural farmers into the production chain.

However, the entrance of soy, source of 90% biodiesel produced in Brazil, in this context could transform the country into a great producer and exporter of biofuels.

For soybean, a well-established agro-industrial sector in the country, the potential for B5 is around 1.8 billion l of oil, requiring the cultivation of an additional 3 million ha.

The international market for biofuels is expected to grow due to the high price of petroleum and to the commitment made by the developed countries that signed the Kyoto Protocol to reduce their emission of pollutant gases.

Brazil is the second world's biggest soybean producer and still has a huge area, generally estimated at about 80 million hectares that could be planted with soy.

The biodiesel boom has arisen at a very convenient moment for Brazilian soy farmers, who had begun to produce at a loss, squeezed between the low world price of soy and unsustainable production costs partly due to an expensive diesel price. Today their problems are disappearing: export prices have risen because of the biodiesel boom and transport costs are falling because of cheap biodiesel, produced locally with vast government subsidy.

However, there are environmental and economic arguments against the uncontrolled expansion of soybeans.

The most powerful groups in agribusiness – ADM (the world's largest soya processor), Cargill (the world's largest grain trader), CentralSoya, Bunge, Mitsubishi and others are cashing in on the new opportunities. Along with ADM, a host of other corporations are investing in the sector. ADM has chosen Brazil as the centre of its South American biodiesel operations and has selected Rondonópolis in the state of Mato Grosso do Sul for its biggest investment: a new biodiesel refinery, the biggest in Brazil, will shortly come on stream.

The government expected investment in biodiesel to reach US$1.5bn by 2013, by which time Brazil should be producing 2 billion liters of the fuel.

There is a lot to worry about, as soy is currently being cultivated in a regime of monoculture in huge properties. The increase in this type of plantation affects the production of food for human consumption, threatening locally Brazilian population's food security because Family farmers who are responsible for most of the food production (40%) in Brazil are not only facing the risk of being squeezed out of the biodiesel production process but also expulsion from rural areas due to the increase of monocultures conditions for future biodiesel feedstock expansion.

In Brazil, mamona (Castor beans) grows as a bushy plant. As a tropical and subtropical plant, it finds excellent growing conditions in Brazil. It is as well adapted crop for the semi-arid regions of the Northeast.

Jatropha is not as well-known a biodiesel feedstock as is palm oil or soy oil. Jatropha is a perennial, yielding oil seed for decades after planting. The tree can grow without irrigation in arid conditions where many other biodiesel candidates such as corn and sugar cane could never thrive. Another useful feature of Jatropha is its oil yield the yield is significantly higher than the yields of many other candidates

5 Case studies of the biodiesel programme, based on experiences in northeast Brazil

5.1 Theory and practice of biodiesel based on castor oil: technical and economic feasibility, risks

Wanting to further promote production and use of biodiesel, the government of Brazil created the National Biodiesel Production Program (PNPB) in 2004. The program was established to reduce petroleum-import dependency, pollutant emissions and health-related costs—and to generate jobs and alleviate regional income disparities. This program was aimed to add biodiesel in the Brazilian energy matrix by blending 2% of biodiesel (B2) until 2008 when B2 will become compulsory nationwide and 5% (B5) until 2013.

In addition, a federal law enacted in Brazil on Jan. 13, 2005, established a mandate for the ANP to be responsible for regulating and controlling the Brazilian biodiesel market. The government wants to promote social inclusion through the program which three main objectives are: (1) the production of biodiesel from different oil seeds from the diverse regions of the country; (2) the promotion of social inclusion through job creation; and (3) the support of a new source of oil supply with competitive prices and appropriate quality.

For that reason, the government created a social certificate, a tax reduction to induce companies to employ families in the production of the biodiesel raw materials. Furthermore, the government has stipulated minimum quantities of raw materials that

must be produced from family agriculture project and big properties or conventional agriculture model.

The Brazilian Biodiesel program intends to produce biodiesel from different oil materials, mainly the soy oil with 90% of the production for vegetable oil; the palm oil because of its large productivity; and, the castor oil because of its resistance to dry soils that are an important characteristic for the northeast region of the country (Plano Nacional de Agroenergia 2005). Thus, allowing the implantation of the biodiesel production plants in the regions where these cultures are produced. This distribution is important because it ensures that each region will use their local resources in the biodiesel production.

The National Plan of Agroenergy, of 2005, emphasised that the north region of Brazil would be responsible for 10% of the total production of biodiesel having as its main feedstock the palm oil. The Northeast region would be responsible for 15% of the production using the castor oil a plant that can promote social inclusion. In the centre-south regions the main raw material would be soy oil associated with other different sources such as animal grass, sunflower, and canola

Because of the availability of ethanol in Brazil, the technological process of the biodiesel production occurs mainly through the vegetable oil transesterification with sugarcane ethanol.

The Brazilian Vehicle Manufacturers Association (ANFAVEA) has committed itself to upholding diesel engine warranties for B2 use within ANP's specifications. Fuel, engine and emissions tests for a maximum biodiesel blend are in progress under the coordination of the Science and Technology Ministry (MCT).

5.2 The Social Fuel Seal

The Social Fuel Seal is a certificate issued to biodiesel producers that purchase raw materials from family farmers within minimum limits that vary according to the region. The Ministry of Agrarian Development (MDA) issues the Social Fuel Seal to biodiesel producers authorized by the Brazilian legislation to produce and sell this new fuel provided that they meet the following requirements:

a) To purchase minimum percentages of raw materials from family farmers, 10% from regions North and Mid-West; 30% from the South and Southeast and 50% from the Northeast and the Semi-Arid Region; and

b) To enter into contracts with family farmers establishing deadlines and conditions of delivery of the raw material and the respective prices, and to provide them with technical assistance.

Companies holding the Social Fuel Seal may benefit from a partial or total reduction of federal taxes, as defined by the biodiesel tax legislation. They may also participate in purchase auctions for this new fuel and use this certificate to identify the origin/brand name of biodiesel

To guarantee a market for that production, the government required in late 2005 that blending of all “Social Fuel Seal” biodiesel would be compulsory up to a limit of 2 percent of all diesel, as of January 2006. That rule further mandates the purchasing of that biodiesel through public auctions coordinated by ANP.

5.3 The ANP biodiesel auctions

In order to stimulate the companies that adopted the family model of production, the first four auctions were opened only for the companies that had a social certificate or had initiated the certification in Ministry of the Agrarian Development (MDA).

The auction format permits lower prices paid for the product. The undercharges in the auctions were 2.53 % and 8.29% for the second and fourth auctions respectively.

The ANP agency has carried out four auctions with a negotiation volume of 840 liters of biofuel benefiting around 205 thousand small farmers. The oil state owner – Petrobrás - 93% bought the major part of this fuel and the rest to other company that is partly own by Petrobras. These companies sell the biodiesel to distributors, like they sell the fossil diesel, where the blend is prepared. There are more than 2000 filling stations that supply B2 throughout the country (Petrobras 2007).

In these auction a total of 23 companies were chosen as biodiesel suppliers. 8 out of those companies where located in the northeast region and use castor oil as feedstock. This is important because, mamona production in the northeast is the special focus of the social inclusion strategy of the PNB (ANP, 2006).

The most important quantity comes from the northeast region, 316,000 m3, while 97,200m3 are from the north. These two regions are where the program wants to promote a consistent focus on social inclusion. Even though, thirty eight percent of the total volume comes from the northeast region, it was supplied from a unique company, Brasil Ecodiesel. This fact is not desirable, because it demonstrates a market concentration. The north region and the northeast have their markets controlled only by two companies – “Agropalma and Brasil Ecodiesel” which produced almost 60% of all the biodiesel production negotiated in the first auctions.

In order to encourage the production of biofuels and to promote social inclusion, the Brazilian government has put federal tax exemptions and incentives in place, according to the nature of the raw material, size of producer and region of production.

5.4 Experiences of smallholder producers and cooperatives

5.4.1 4.2.1 Family Agriculture and contract

The family agriculture production framework consists in an association among a biodiesel producer company, a raw-material family producer(s) and the regional public power or the federal authorities. The company offers technical assistance to the local families for the tillage, and a guarantee that the production will be bought by the company. The families use their properties to cultivate the oilseeds and borrow money for financial costs. The regional authorities provide financial assistances with low

interest taxes (Soares et al. 2006). The families and the companies must negotiate a contract for this commercial agreement.

Another point is the way the contracts are being negotiated: They are agreed upon between the families and companies and these terms oblige the feedstock producers to sell their production to only one company. The production price is tied to the international costs of the oilseeds. This leaves the families unprotected against international price variation. So, the families are very dependent on the companies that buy their products.

5.4.2 The role of the social organisations and trade unions.

There are 11 cooperatives having company contracts with social fuel stamps. In Bahia, the system Contag effectively developed a strategy paper in order to assess its role as intermediary in any negotiation between the companies and the families. The union is already preparing its federation members and syndicate to take over the secondary chain of the production process.

The organisations Fetraf, MPA and MST have adopted an action strategy for forthcoming negotiations with Petrobras in its future biodiesel units in the northeast states of Bahia and Ceara.

5.4.3 Finance and credit institution

The small holders, cooperatives and the biodiesel producers have access to a subsidized credit line created by the MDA to encouraged biodiesel production:

- “Pronaf Biodiesel” provides financing for primary crop producers with interest rates between 1 percent and 7.25 percent
- “Pronaf Agribusiness” provides financing for machinery, and crushing and refining equipment
- “Pronaf Infrastructure” provides support for infrastructure development

These are funding lines with reduced financial charges and longer grace and amortization periods for the entire biodiesel value chain, encompassing investments in equipment and industrial plants and loans for the planting of raw material for the production of biodiesel.

Official banks grant these loans with funds from the National Bank of Economic and Social Development (BNDES), from the National Program for the Strengthening of Family Farming (Pronaf) and from other sources.

Given the economic attractiveness of the production of biodiesel, other credit institutions are funding or planning to fund links of the biodiesel value chain, such as Banco do Brasil, with the BB-Biodiesel line of credit, and other national bank Banco do Nordeste in the case of the region Northeast and foreign private banks.

- Currently the BNDES approved R$ 89 millions for a project with a total capacity of 300 million liters biodiesel a year (36% of the B2 installation capacity).
- The Banco do Brasil approved 8 projects with a total value of R$ 117 millions.

- In Piaui, Pronaf is financing with R$ 13.5 millions a project of 24.000 ha mamona plantation that will support about 8.000 small families with small plot (3ha). That will increase their income of 20%.
- The Banco do Nordeste is going to finance for the next harvest more than 50 thousand family agriculture producers in the semi-arid regions of the northeast.

The banks objective is to supply 100% of the demand of Pronaf credit exclusively aimed at biodiesel production.

5.5 Required inputs: capital/technology and labour (incl. skills and seasonal distribution)

To produce and sell biodiesel in Brazil, authorization from ANP and full compliance with a set of legal and normative regulation issued specially for the PNB are required.

Companies willing to receive the tax benefits associated to social inclusion and to regional development (generation of jobs and income for family farmers, particularly in the most poor regions of the Country), must additionally obtain the Social Fuel Stamp.

5.6 Net employment and income effects when compared with other land-uses or uses of working time

The biodiesel program does not have enough reliable data to assess the income effects of the program, as the second harvest is still underway. According to Janio da Rosa (2007), the program has only started effectively in 2006, and that is not enough time to conduct a quantitative assessment.

But there are some trends that could be observed in the case of mamona in the Northeast: The smallholder's annual income went up from R$ 1.060 to R$ 3.000 and its indebtedness could be lessen through his access to certified high yield seeds from Embrapa combined with a new special Pronaf credit.

5.7 Theoretical and actual contribution to poverty reduction

From a social perspective, the Brazilian government is willing to create jobs for the household engaged in agricultural activities model. The number of jobs that will be created is uncertain. The Brazilian Ministry of Mines and Energy ("Ministério de Minas e Energia" - MME) estimated that in 2006, 210.000 jobs were created for families engaged in the biodiesel production (Agência Brasil, 2006).

Next year, Petrobras is planning to produce biodiesel with family agriculture. It is expected that its future three plants in the northeast will result in the social inclusion of around 75.000 families in the region (Petrobras, 2007).

5.8 Contribution to local development

Some social movements and Non Governmental Organizations (NGO) had criticized the family agriculture projects because for them the social approach adopted by the government is not adequate to promote rural development in some regions.

According to FETAPI (2007) the family production framework does not permit to the families engaged in raw-material production to negotiate good contracts to sell their products.

Some authors such as Soares et al (2006) mentioned the discrepancy between the government present job creation perspective for the biodiesel and the real number: while the official numbers demonstrated that the number of families employed were 200,000, independent study pointed out that in fact, the number was closer to 60,000 families for the B5 blend.

There is currently a big controversy about the impact of the biodiesel program on its contribution to local development. This case has been highlighted by the conflict surrounding the project Brasil Ecodiesel at the experimental model farm Fazenda Santa Clara in the municipality of Canto de Buriti in Piaui.

Brasil Ecodiesel initially created a small municipality where 300 families of mamona farmers settled.

In a contract with the company, they were each given 18 ha of plots on which they could cultivate mamona for the company biodiesel production plant in the region. This project of integrated production was supposed to be a model of local development in the region. For some reasons things went wrong and the families were disappointed and were complaining about lack of food and breach of contact from the company side. A huge social unrest followed, and the problem could not be sold. Following this case numbers of social organizations and trade unions were putting into question the social aspect of the PNB.

Piaui State has more than 25.1 million hectares of arable land. Its occupation with permanent farming is only 4.61% meaning that there is enough land available for the intensification of oleaginous plants cultivation for biodiesel production. Piaui is the second largest mamona producer in the northeast region, with a cultivated area of 11.1 thousand hectares. The state has made important infrastructure investment to facilitate biodiesel production in Santa Clara, situated in the municipality of Canto do Buriti, near the city of Floriano, where BrasilEcodiesel operate the first biggest plant of it kind in the country.

The initiation of the Projeto de desenvolvimiento Sustentavel do Agronegocio da mamona no semi-arido estado do Piaui in 2004, is considered by the state government to be a milestone in the development of the region. The project was implemented under the supervision of Sebrae, the Brazilian Service of Support for Micro and Small Enterprises in Piaui, in partnership with 17 public and private institutions, and also involves the federal, state and municipal government.

According to Jose Wellington (2007), Sebrae general consultant and project manager, the project was mainly created with the objective to integrate the family agriculture in a new production process, in order to reduce rural migration.

The project, with an investment volume of R$ 15 million, involved 5000 small producers in 33 municipalities aims at cultivating 16 millions hectares of mamona. The objective is to double the cultivated area for the 2007/2008 harvest (Sebrae 2007).

Janio Luis da Rosa (2007), coordinator general for biofuels at the Ministry of Agrarian Development (MDA), said that biodiesel is definitely a growing industry for Brazil and that he expects the production to rise to 800 million litres annually in three years. There is a potential market for other forty biodiesel plants around the country like the one going into operation in Floriano, he added.

In his view, the cultivation of mamona, together with the production of biodiesel fuel, will generate nearly R$500 million in additional income for 200,000 thousand families of small farmers in the semi-arid northeast region and this would amount to R$200 per month for each family - more than triple the average payment of R$63 currently distributed by the Bolsa Familia program.

The Bahia region is responsible for 90% of the Brazil mamona production (IBGE 2007), due to historical knowledge and traditional cultivation of that crop. In the words of Luiz Barata (2007), cooperative leader and biodiesel specialist in Bahia State, the family agriculture in Bahia, thanks to cooperatives establishment and farmer's empowerment, is already to be found in the second chain of the biodiesel production, and is in a better position for financial and social negotiation with the biodiesel producer companies (Coopaf 2007).

Luiz Barata pointed out that, on one hand, the increased demand for mamona for biodiesel production has brought negative ecological consequences (soil and water quality, biodiversity) in the region but on the other hand, the productive intensification has a positive effect on local job opportunities, job generation and farmers' empowerment.

Also according to him, the potential competition between mamona and food production, thanks to the Embrapa's developed and applied concept of intercropping mamona with caupi beans (Vigna unguiculata L.) to secure food production, is well managed in both regions of Bahia and Piaui.

With the initiation of the PNPB, the state of Pernambuco expected that it would be one of the biggest mamona producers in the northeast region. Although this is sugarcane country, in 2006, according to Ingo Melcher of the GTZ (2007), 4,232 hectares of mamona has been planted in Pernambuco and the level of production reached 1.2 million tons. For 2008, the cultivated area is expected to rise to 100 million hectares. Furthermore, the implementation in Caetés of a new biodiesel plant with a capacity to produce 2000 liters of biodiesel is expected to boost mamona production, job creation and income generation in the region.

It should be emphasized that in general, the current productive intensification is positive and on the long term, income generation and diversification, land value improvement will have beneficial results on poverty alleviation in the Brazilian Northeast regions.

6 Conclusions and recommendation

The PNPB has basically three objectives: to reduce Brazil dependence on imported diesel, to decrease the emission of greenhouse gases and to keep the rural population from moving to urban areas. The Federal Law n° 11.097 which established the mandatory blending of 2% biodiesel into commercial diesel used within the national territory by 2008, created the expectation that biodiesel will promote the integration of industry, family agriculture and poverty reduction actions, and will set a new energy standard: sustainable, environmentally responsible and economically dynamic.

The main government priority is to promote social inclusion, by including family agriculture as partner to biodiesel producers. As there is still uncertainty regarding fiscal and financial federal subsidies, it is not sure that familiar agriculture will be able to compete with agribusiness to ensure the supply of raw materials.

Probably, the government should, beyond subsidies, provide technical and social assistance to family agricultures in order to organize their business and prepare them to be competitive against larger biodiesel feedstock suppliers.

It can be concluded that the possibilities for success of the Brazilian biodiesel program are based on the following key elements:

- The availability of feedstock production, with exploitation of conventional cultures and use of oleaginous plants for biodiesel production;
- the will and political decision to invest in alternative fuels, by means of specific programs and projects;
- the development of scientific research directed toward the subject; and
- practical experiences in adding value to the products and better integration of the producers into the biodiesel product chain.

The debate about the real potential of the program is ongoing, and different views are emerging. What is certain is that the sustainability of the biodiesel program, despite the overwhelming upbeat position of the policy makers, is not straightforward. The program is still in a trial and error phase, and there is a need to thoroughly identify the sustainable development opportunities related to it and how to maximize them, to identify the potential or real threats and risks linked with the expansion, and the trade-offs and problems involved in order to minimizing them.

Despite the potential in Brazil for oleaginous cultivation for biodiesel production, there are challenges ahead for setting up and consolidating a wide program of biodiesel use. The challenge is to produce biodiesel that has the specifications required by the National Petroleum Agency (ANP) and international agencies, based on feedstock that decouple from the food market and produce biodiesel with a mixture of non-edible oil sources, like mamona, jatropha and babassu.

The main challenges and considerations are to be found in the technological, agronomic and infrastructure areas.

From the agronomic perspectives, the following challenges have to be addressed:

- The planning and execution of the ecologically sustainable agricultural zoning of oleaginous cultivation as foreseen by the MDA has to be mainstreamed
- Supply guarantees for the producers
- Financial support to increase cultivation are and efficiency
- Intensify genetic improvement and introduction of new feedstock such as jatropha

This would suggest that a “feedstock approach”, as defined by Duffey (2007), should be taken. According to that approach, since the range of sustainable development impacts and the different policy goals associated with biofuels are known, it is necessary to identify the type of energy crops that fulfil a given policy goal with the least negative impacts on sustainable development.

Substantial information is already available on the key environmental and social impacts associated with the cultivation of various oleaginous. The information about the linkages between energy crops and food security and the impacts along the value chain is needed.

There are regional differences exist on the path to sustainability. While comparing the experience from Piaui, Pernambuco and Bahia, the patterns that emerged from the expected pressure on oil demand that will consequently translated to the increases in mamona cultivated area, are pretty much alike in the two regions of Bahia and Piaui.

However, given to the very low technological level of agricultural practices in Piaui state, only minor effects on the use of inputs and resource are expected. Although some positive effects on the feedstock production, thanks to Embrapa new high yield seeds, are likely and the substitution of fossil energy used to break the fruits and transport the beans, by biodiesel in the context of the production chain reflects positively, Piaui needs more time and technological assistance in order to reach the high level production standard as seen in Bahia.

The case of Pernambuco is different, since this state has no cultural knowledge in mamona cultivation; it needs more technical assistance than the two others. Therefore, it is necessary to invest in farmer education, agricultural extension and empowerment in order to create a viable mamona production sector.

Regarding social aspects, widespread scepticism exists about its social sustainability from a broad range of Brazilian social organisations, trade unions, farmer associations and NGOs which view the program as a political tool used by the current government to give the impression that they are undertaking something to solve the problem of hunger and poverty in that area of Brazil for political gain.

The most formulated complaints from farmers about the program are the insufficiency of technical assistance in agricultural extension services and the host of broken promises they are confronted with, giving way to a general disillusion and passivity.

This situation has to be addressed effectively if the program has to succeed in the integration of family agriculture.

For the success of the program, however, it is necessary to fulfil the social fuel seal requirements, which guarantee the participation of family agriculture in the feedstock supply, and also that the regulating federal authority imposes effective limits to those who want to take exclusive advantage of the program.

In conclusion, the Brazilian biodiesel program is an important example for innovative instruments to include social and environmental considerations into (bio)energy and regional development policies.

Given the relatively short time of its practical implementation, our review resulted in a preliminary positive picture: Brazil seems to be on the way to demonstrate a successful approach for sustainable biofuel supply. Still, more evidence is needed on the practical viability of the program to deliver on its positive social impacts, and on its potential to be mainstreamed and replicated in other areas.

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Appendix: Ethanol in Brazil

Although the Brazilian energy system with a 44% shore of renewable sources is relatively clean compared to most other countries, the energy policy of Brazil takes into account environmental concerns associated with global climate change, and aims to diversify the national energy matrix. The Brazilian biofuel policy is mainly focused on the development and optimization of the bioethanol and biodiesel production sector.

The main objectives of Brazil's biofuels policy include increasing biofuels production and consumption, and promoting a global biofuels market to competitively export increasing shares of its domestic ethanol production..

The Brazilian Ethanol Sector

The Brazilian sugar and alcohol industry is the most competitive in the world, match by high productivity, better yields and low costs. The catalyst responsible for such development has been the growth the industry experienced over the last 30 years, spurred on by increase in ethanol production, followed later by sugar production and, more recently, focuses on maximizing the use of sugarcane.

Over this period, combination of experience and accumulation of new knowledge has been successfully applied to improving not only productivity on, but also innovations in the development of new equipment and process or systems as well as the establishment of optimised plants (Oliverio 2006)

Brazil is responsible for 45% of the world’s fuel alcohol. The sugarcane crop permitted a national production of alcohol of 14.5 billion liters in 2005 – of which more than 2 billion of liters were destined for exportation.

The area used for sugarcane plantations covers about 6.2 million hectares, a figure representing 1.7% of total arable land in the country, or 18.3% of the land currently used for annual crop production (IBGE 2005).

The regions witb the greatest areas for plantations are in the subtropical zones of the Mid-South and in the Atlantic tropical areas of the Northeast of Brazil. Nevertheless, the traditional producer groups of the Northeast have re-directed their investments to the Mid-South. They installed new processing units or incremented the plantation areas. The South-east region, specifically the state of Sao Paulo, is responsible for a constant growth of the production and yields 89% of the volume of sugarcane, 89% of the alcohol and 90% of the sugar produced (IEL 2006).

Paraná, in the South, and Alagoas in the Northeast are among the main producer states that produces approximately 20% of the national total.

The production of sugar and alcohol is expanding and the estimate for the 2006/7 harvests is approx. 470 million tons, i.e. an increase of 9% over last year, mainly due to an 5.4% increase of planted area and a gain of 3.4% of productivity in this period (CONAB 2006).

Sugar and alcohol production system

The most important and immediate raw material for sugar and ethanol production today in Brazil is based on the same feedstock: sugarcane (*Saccharum officianale*).

Sugarcane offers various advantages such as the existence of a sugar industry, a domestic agricultural and industrial technology. It is a semi-perennial crop which cultivation is based on a “ratoon”-system. The energy balance is in most of the cases positive and its by-product molasses can be used for producing alcohol.

Sugarcane has a higher than average photosynthetic efficiency and contains high amounts of sucrose (Herzog 2006). Sucrose is the most important feedstock in the industrial process of bioethanol production that is fermentation. The production process has two complete different aspects, sugar production by cultivating cane and industrial ethanol processing.

Sugarcane cultivation

Sugarcane cultivation in Brazil is based on a ratoon-system, i.e. after the first cut, the same plant is cut several times on a yearly basis. Prior to planting in the first year, the soil is intensively prepared by e.g., harrowing and application of mineral fertilizers.

After this, seeds are distributed and the furrows are closed and fertilizers and herbicides are applied again.

The plants are furrowed and treated with artificial fertilizers or “filter cake” once or twice again during cultivation in the first year. After 12-18 months, the cane is ready for the first cut.

Sugarcane harvest

The Brazilian climatic conditions allow two harvesting possibilities: in the Northeast the harvests are from October to March, while in the Southeast, the South and the Mid-west, from April to August. Therefore, Brazil is able to produce sugar and alcohol all year long. The burning down of the cane in order to simplify manual harvesting is a common practice. Mechanical harvesting is applied by approximately 25% of the cane in SP compared to the wholly manual work in the Northeast.

The planting occurs primarily on land surrounding 340 sugar mills and alcohol distilleries (MAPA 2006) and more than 320 plants are capable of producing either ethanol or sugar. There are approximately 60,000 independent suppliers with properties smaller than 150 hectares each which contributing with 27% of the total national production.

The 13,110 suppliers from the state of Sao Paulo produces 67% of all the independent producers followed by the producers in Pernambuco who contribute 8.4% of the production and 3.3% of the national production (ORPLANA 2006).

The industrial process of ethanol production

The production and processing of sugar cane are exclusively in the hands of the private sector. In Brazil the sugarcane sector has the smallest cost of production in the

world for sugar and for alcohol and is appearing as a highly competitive country in the international market (Goncalves 2005).

Almost half of the sugar cane production is transformed into ethanol. One of the advantages of sugarcane consists in a well establish crop in terms of cultivation, breeding, harvesting and processing. Currently exclusive fermentation of sugarcane juice is no longer carried out in industrial units. When Proalcool was first introduced, many units fermented only juice. Currently, none of those units ferment exclusively natural cane juice, and the once named autonomous distilleries have turned into sugar mills. According to Rodrigues et al (2007) these producers call themselves independent, but in reality are involved in some degree of integration and form of dependence to the mills and distilleries. They are the exclusive supplier of the agro industrial complex.

The fermentation process now comprises the sucrose crystallisation by-product that is molasses. The excess bagasse largely covers the plant energy needs and allows the Brazilian bioethanol production cost to be competitive. Ethanol from sugarcane is nowadays used in Brazil in two ways:

- Anhydrous alcohol as a gasoline additive for various types of vehicles (about 60% of the total) and
- Hydrated alcohol as the sole fuel in dedicated vehicles (40%).

A total of over 19 million vehicles are running today in the country, from which more than 16 millions are gasohol and 3 millions are pure ethanol driven cars (Klebin 2006).

Impacts on Agriculture and land use

The monoculture of sugarcane leads to an increasing concentration of lands in the hands of the sugar mill owners. Soil erosion from sugarcane cultivation is partly due to inappropriate cultivation techniques; still, as a perennial crop, it causes lower erosion than e.g. soybean production. Furthermore, contour ploughs, terracing and strip cropping in rotation (i.e. planting and harvesting in alternating strips on slopes) can reduce the level of erosion, but they are not able to prevent it (Kutcher et al. 2000). The use of chemicals could result in substantial soil loss, followed by seepage of agrochemicals contaminating surface water. In the Northeast, substantial reductions in agricultural yield are to be seen on sloping sites owing to soil degradation.

The Comissao Pastoral de Tierra (2007), a church based organization, affirms that the agricultural expansion has affected the Mata Atlântica ecosystem most of all (Atlantic coastal rainforest). With its 6,000 endemic plant forms, 160 species of mammal and 253 species of amphibian, this ecosystem is classed as one of the most biologically diverse on earth. Today, only about 90,400 km2 or approximately 7% of the area remains.

The deforestation is not only advancing as a result of expanding cultivation areas, but among other things through the use of fuel wood as an additional means of fuelling boilers in the sugar industry at the start of the harvesting season (bagasse is still too damp for burning at this point).

In the Northeast, the sugarcane expansion is one of the main reasons why the flood plains, rivers and mangrove forests have silted up and has also triggered the death of the coral reefs in coastal proximity (CPT 2007).

Food security issues

As it is currently developing, the Brazilian ethanol industry represents a direct challenge to food sovereignty and agrarian reform. Ethanol exports to sustain the enormous consumption levels of industrialized countries will not lead the Brazilian countryside out of poverty, or help attain food sovereignty for its citizens, since the further expansion of the ethanol feedstock will be at the expense of agriculture land.

As more land is planted with sugarcane, and control of the industry becomes more concentrated, rural poverty increases. According to Melo (2007), monoculture has created a huge dependency on the sugarcane economy in the region of Pernambuco, and impedes the creation of other forms of work and income. In all cultivation areas, expansion is in the large landowners' favor and led to the ousting of small family-run farms with traditional, more appropriate cultivation systems (CPT 2007).

Labor and social issues

Brazilian ethanol is produced from sugarcane, which has always been a primary agricultural commodity for the country. Because ethanol relies on sugarcane as feedstock, the industry is linked to the social and economic dynamics in rural areas that have developed from sugarcane production since the colonial era, most importantly labor exploitation and concentration of land ownership.

The sector's development has been linked to a poor social record, social exclusion and exploitation of rural workers to the present day. Brazil has the lowest cost of production in the world not only because of the industry's experiences with high-yielding varieties of sucarcane, but also because of dependence on labor exploitation, , and its refusal to implement environmental regulations.

As a result, social problems, such as hunger, child labor, social isolation, loss of social identity, and human-rights violations (evictions, expropriations) continue to exist to the present day (CPT 2007).

"*Rural poverty has always been intrinsically related to the economy of sugarcane. Even in the 1970s, when Pernambuco was the largest national producer of sugarcane, the levels of poverty were amongst the highest in the world."* (Marluce Melo, CPT Recife Pernambuco, 2007)

"The problems with sugarcane's production today are very similar to the problems it generated hundreds of years ago," (Maria Luisa Mendoça, Director of the Sao Paulo-based NGO Rede Social, interview 2007).

Brazilian biofuels policy framework: national, regional and local policies

Until recently, Brazil was the world's largest producer and consumer of fuel alcohol and is the global leader in the use of renewable transport fuels. Brazil's National Alcohol Program (ProAlcool) was the largest fossil fuel substitution program in the

world automotive market. It is considered a global example of excellence and its success is the result of a concerted 30-year government effort to promote an alternative fuel policy.

The public biofuel policy is based on the government intervention in three different forms:

(1) Tax exemptions in the production chain,

(2) compulsory blend/mandated use,

(3) subsidies for producers and blenders and

(4) import protection from lower-cost suppliers.

In 2006, Brazil officially achieved "energy independence" Much of its energy independence stems from a successful ethanol program, which has replaced about 40 percent of gasoline use in the country.

The National Alcohol Program (ProAlcool)

Brazil was a leader in ethanol production and use even prior to its National Alcohol Program (ProAlcool), which was launched in 1975. The program was established as a response to high crude oil prices and declining sugar prices, and as a way for Brazil to reduce its dependence on foreign oil and to find alternative markets for sugar. Under ProAlcool, ethanol production was encouraged through credit guarantees, low interest loans for construction of new plants, storage credit to millers, and subsidies to ethanol producers.

Ethanol prices were set at favorable levels relative to gasoline. The government also imposed mandates on blending ratios of ethanol with gasoline and provided incentives to promote ethanol cars, which run solely on hydrous ethanol. As a result, Brazil experienced a draconian increase in ethanol production by the end of the 1970s. Although the program lost support in the mid -1980s with falling world oil prices, and severe economic difficulties, recent interest in ethanol as an alternative fuel has revived the industry in the country

The industry was deregulated in 1999, but the Brazilian government continues to provide support to ethanol production through imposition of a blending ratio of anhydrous ethanol with gasoline of 20 and 25 percent in transport fuel, a lower excise tax for ethanol than for gasoline, and through the use of strategic reserve. Imports of ethanol into Brazil are subject to high duty.

The ProAlcool program left a long-term legacy of a dedicated ethanol-handling infrastructure, an ethanol-powered automotive fleet and continued production of both gasoline- and ethanol-fueled automobiles.

The current resurgence of ethanol in the fuels matrix is due to a private-sector commitment to take advantage of ethanol's availability. The development of the Flex Fuel Vehicles (FFV) and its production allowed consumers to freely choose between gasoline or/and ethanol. Following the FFV’s launch in 2003, sales rocketed and more

than 76 percent of light vehicle sales by the end of 2006 were Flex models (MME, 2007).

The government policy still does have a significant influence on market dynamics even if the current ethanol demand growth is market forces driven. It supports for ethanol consumption include both an ethanol-use mandate and significant tax credits.

The government incentives measures included:

- Prices guarantee for ethanol fuel (maximum 65% of gasoline price)
- 5% tax reduction for alcohol fuelled vehicles,
- Loan subsidies for ethanol producers to improve capacity,
- Compulsory sales of ethanol at fuel stations and

Not only the Government controls the fuel stocks to guarantee supply and price but also imposes duty on ethanol import.

Brazil's first ethanol-use mandate in 1977 required a 4.5 percent mixture of ethanol to petrol. Since that time, the mix of ethanol in gasoline has risen as high as 25 percent. Current legislation requires an ethanol content of between 20 and 25 percent, with the executive branch having the flexibility to adjust levels within that band (ANP, 2006).

The FFV's introduction, its increasing popularity and number, provides a ready market for ethanol. Tax breaks for ethanol consumption provide a significant support to ethanol producers and distributors.

Tax incentives play an especially important role in supporting ethanol consumption. The government provided, under federal tax, preferential treatment for ethanol consumption programs and also State tax regimes is very ethanol friendly, giving ethanol consumption a greater boost.

Outlook in the bioethanol sector

Brazil is expected to continue as the global leader in biofuels production and export.

Although the internal market will still account for the largest part of production, exports will rise sharply. Demand perspectives on the international market are boosting the expansion of the Brazilian biofuel sector. This demand is being fuelled by the different conjectural factors in the world energy context such as: World-growing demand, climate change reality and more rigorous environmental concerns, geopolitical instability and conflict at important energy supplier countries, high prices for fossil energy and shift to renewable energy sources.

This will result to a global increase in ethanol demand and an increase of the biofuel international trade flow between producers and consumers.

The Brazilian Government is preparing for bioethanol's global role. According to Brazil's Trade Minister Luiz Furlan (2007), *"we are also expanding the cultivation of sugarcane to meet the increasing domestic and foreign demand for bioethanol. By 2013 Brazil is expecting to need to increase cultivation by 3 million hectares from the*

5.7 million currently used for sugarcane. Brazil does have the potential for increasing sugarcane cultivation since there remain vast tracts, up to 90 million hectares, of unused agricultural lands."

The Brazilian ethanol industry has expanded significantly, adding 19 sugar and ethanol mills in 2006 with a cane-crushing capacity of 13.3 million tons (Elobeid et al. 2007). Fourteen more mills are under construction, and five mills are undergoing expansions. It is expected that 89 new mills will have to be built in the next few years to meet the ethanol rising demand.

In 2006, the country exported about 19% of the total 16 billion liters it produced, providing 70% of the world's ethanol exports (IBGE 2007)

According to the Sao Paulo Sugar and Bioethanol Institute, the value of Brazil's bioethanol exports are expected to jump from US$ 1 billion a year to US$ 8 billion by 2007.

A partnership between the Ministry of Science and Technology and the University of Campinas in Sao Paulo is currently conducting a study to plan Brazil's ethanol exports as a substitute for 10% of the global use of gasoline in 20 years.

If this plan is successful, the country's ethanol exports will total 20 billion liters by 2025, an increase of almost 67%. The geographic area planted with sugarcane will increase from 3 million to 30 million hectares.

To support major production and trade, The Brazilian Government authorities, Petrobras, and private stakeholders are increasing their investments in infrastructure construction of pipelines, railways and port facilities to meet the rising demand and further reduce production and logistical costs.

The current logistical infrastructure for the bioethanol export could handle supplies up to 2.5 billion liters a year. With the recent negotiation of additional export contracts, Petrobras will make additional investments to expand the logistical capacity to supply up to 9 billion liters and construct fuel pipelines to add another 3 billion-liter export capacity. By 2010 Brazil will have an export capacity of 12 billion liters/year (Petrobras 2007).

Concentration in the industry

As it grows, the sugar-ethanol industry has undergone a process of increasing concentration and vertical integration, as large corporations invest in land and production.

In the past, control of the industry was dispersed among smaller businesses, individual owners who controlled both cultivation and milling owned sugar mills. Today Brazil has 72,000 sugar producers, and the ten largest producers still control less than 30% of production and the current trend is toward concentration, with a large number of mergers and acquisitions

Many of the larger companies that are buying out the smaller companies are multinational agribusiness corporations. The participation by foreign capital in the production of sugar and ethanol is currently 4.5%, and this number is going to grow.

Recently many foreign groups are looking to invest in this industry in Brazil, due to one of the lowest costs of production in the world.

Sugarcane seems to be following the same pattern of foreign investment and concentration as that of soybeans. Today almost all soybean production in Brazil is controlled by a handful of multinational agribusinesses.

Many of the corporations that control soybeans are now investing in the ethanol industry. Among the multinational agribusinesses investing in the industry are: Louis Dreyfus Commodities and Tereos, both based in France, as well as U.S.-based Cargill.

The Louis Dreyfus is one of the three largest sugar traders in the world, and owns three Brazilian sugar mills with a fourth mill currently under construction in Mato Grosso do Sul. The company produces 450,000 tons of sugar and 150,000 cubic meters of ethanol annually.

Cargill, in addition to being Brazil's largest soybean exporter and second-largest processor, is the largest operator of sugar, both in terms of Brazilian sugar production and export sales, as well as global sugar trading

The ethanol production sector presents huge opportunities for job creation and environmental benefits, but if biofuel is to play a major role in sustainable development in Brazil, improving the quality of employment should be a major task. Rural workers in the sugarcane sector should receive the same kind of social rights received by urban workers, such as acceptable health and safety conditions, social security, salaries above specified minimum levels, vacations and profit bonuses.