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Biodiesel for rural development

A sustainability assessment of the Brazilian biodiesel program

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Abstract:

This paper assesses the sustainability of the Brazilian National Biodiesel Production & Use Program (PNPB) by using the UN-Energy framework for sustainable bioenergy and looks at the program's performance in relation to its predetermined goals. A summative evaluation was conducted in the form of a goals-based evaluation. A variety of indicators were selected to assess the program's achievements in each of the goals. The program's performance was analyzed under the proposed sustainability framework. The conclusion is that the PNPB needs a different feedstock for biodiesel production as soy is unsuitable for the program both in terms of socio-economic and environmental sustainability. The conclusions drawn are presented as a formative evaluation, focusing on the performance of the program, its strengths and weaknesses and recommendations for improvements are given.

Keywords: Biodiesel, Brazil, PNPB, sustainability, family agriculture, rural development

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Table of Contents

List of Figures

List of Tables

1. Introduction

Eventhough traditional bioenergy[1] has been used for millennia it continues to be a contemporary topic. According to the Global Bioenergy Partnership (GBEP) bioenergy is a top priority in the international agenda because it is an issue related to global concerns such as energy security, climate change and poverty reduction.

In 2005, 78% of all the renewable energy produced came from bioenergy. This represents about 10% of the world's total primary energy supply (TPES) and provides heating and cooking energy for millions of people, especially in developing countries (Hunt, 2008).

Bioenergy use is growing both in developed and developing countries. In Brazil, the share of bioenergy in the energy matrix went from 26.6% (1728 PJ) in 1995 to 29.8% (2801 PJ) in 2005 (Hunt, 2008).

Figure 1:TPES from bioenergy in G8 countries (Hunt, 2008)

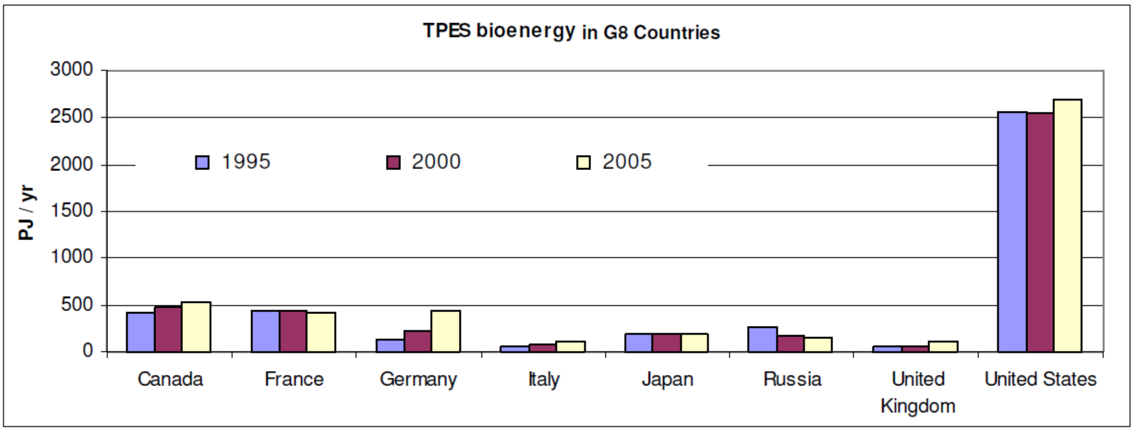
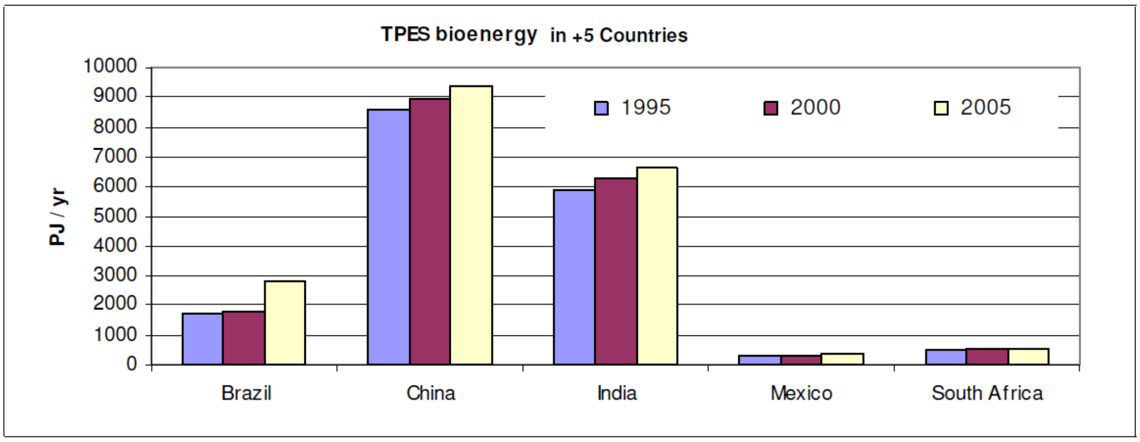


Figure 2: TPES from bioenergy in +5 countries (Hunt, 2008)



[1] Includes energy sources which can only deliver heat, such as fuel wood and charcoal (Hunt, 2008).

Liquid biofuels account for only 1.9% of total bioenergy (FAO, 2008), but their global production has doubled over the last five years and is expected to continue growing (UN Energy, 2007).
Brazil is a large ethanol producer and in 2004 the National Biodiesel Production & Use Program (PNPB in Portuguese) introduced biodiesel into the Brazilian energy matrix by establishing mandatory blending mandates of biodiesel into fossil diesel.

This paper has decided to focus in Brazil because of the country's potential leading role in the biofuels market.

1.1. Key drivers behind bioenergy development

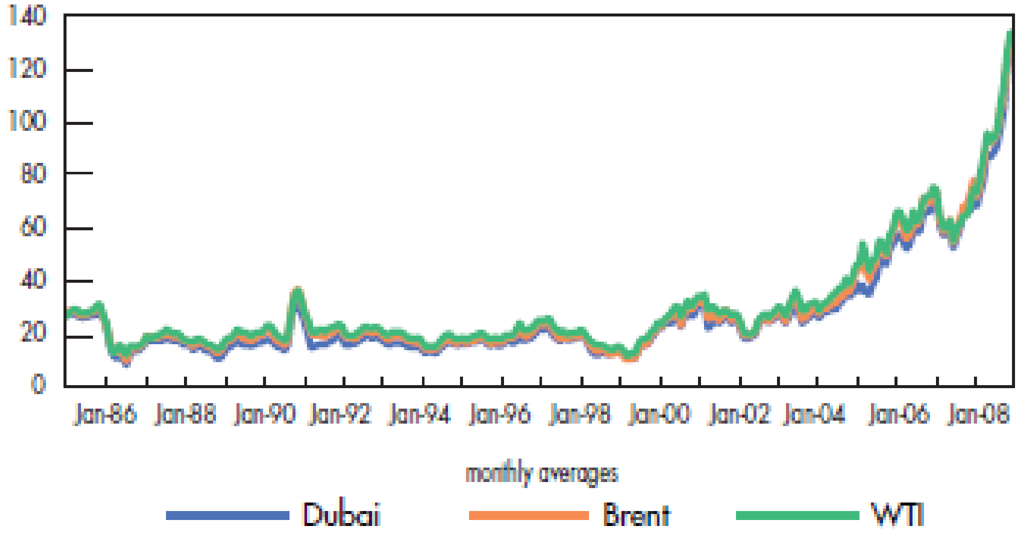
There are three drivers behind bioenergy growth: (1) the instability of oil prices and the shrinking of oil reserves; (2) the geopolitical issues associated with petroleum and (3) the concern about climate change (Sachs, 2005).

1.1.1. Oil reserves and market instability

Although there are arguments against the imminent "end of oil", there is also evidence that oil reserves are used up faster than they are discovered (Sachs, 2005). Regardless of the size of existing oil reserves, the instability of the oil market is one of the main drivers behind bioenergy development (UN Energy, 2007).

The first major Brazilian experience with biofuels (Pro-Alcool) was triggered by the rise of oil prices in the 1970's (Garcez, 2008). In the early 1980's, when oil prices hit another high, the Brazilian government rehearsed investments in biodiesel production (Garcez, 2008) but when prices went down the projects were abandoned (Oliveira & Ramalho, 2006, cited in Garcez, 2008). Biodiesel came back to the political agenda around 2002, when oil prices were again going up (Garcez, 2008).

Figure 3: Variations in crude oil prices in US dollars/barrel (IEA, 2008)



1.1.2. Energy dependence

Some countries spend six times more on fuel than on food and the unpredictability of oil markets has made fossil fuel dependence a risk most developing economies cannot cope with (FAO, 2008).

Although an exporter of gasoline and natural gas, Brazil is an importer of petroleum diesel (Rathmann, Santos, Padula, & Pla, 2005).

With a large natural resource base and the capability of producing and processing feedstock competitively, Brazil has great potential for the biofuels sector (FAO, 2008). By increasing biodiesel production the country can lower diesel imports and become more energy independent (Garcez, 2008).

1.1.3. GHG emissions

Biofuels may provide significant reductions in greenhouse gas (GHG) emissions (IEA/OECD, 2004). Biodiesel combustion emits 90% less hydrocarbons (HC) and between 75% and 90% less polycyclic aromatic hydrocarbons (PAHs) when compared to fossil diesel as well as significantly less particulates, carbon monoxide and sulfur (Demirbas, 2007). The one negative point is that emission rates for nitrogen oxides, however, are higher for biodiesel than for regular diesel (Demirbas, 2007).

Although this is one of the key drivers behind bioenergy development, the truth of the matter is that concerning climate change, biofuels can go either way. They may significantly reduce or increase emissions of GHG, depending on the land-use issue (Hunt, 2008). According to Hunt (2008) feedstock production (type and how it is produced) is the most relevant variable in assessing the sustainability of a certain biofuel.

Reductions in GHG emissions also depend on the fossil fuel energy balance, for although biomass fuels are potentially "carbon-neutral", that is rarely the case and over the entire lifecycle (production, processing and distribution) some biofuels may emit more carbon than they save (Hunt, 2008).

1.1.4. Fueling rural development

In the specific case of Brazil, as well as with some other developing countries, another motivation for biofuels are the potential roles the industry may play in rural development, through job creation, income generation and the provision of access to energy (Hunt, 2008).

The growing demand for biofuels brings an opportunity for rural populations in developing countries, most of which have suffered from declining agricultural commodity prices for decades (UN Energy, 2007).

Social inclusion and the fostering of family agriculture are two of the main directives of the PNPB (Carvalho, Vilela & Oliveira, 2007).Small farmers will only be able to take advantage of this opportunity when policies are put into practice enabling them to do so (FAO, 2008).

1.2. Is bioenergy the best answer?

It is easy to understand all the interest in bioenergy. After all "what could be more appealing than home-grown energy, essentially created by sun-and-water-fuelled photosynthesis, with new jobs and development opportunities to be tapped?" (UN Energy, 2007, p. 1).

But surely, things aren't that simple. Modern bioenergy brings opportunities but also risks (UN Energy, 2007). Important issues are at stake. Will biofuels have negative impacts on food security and the environment? Can they worsen climate change instead of helping reduce emissions? (UN Energy, 2007). Will they help promote rural development or broaden the gap between rich and poor?

In the best case scenario, the development of the biodiesel industry and the strengthening of the relationship between the energy and agriculture sectors will lead to higher production levels and prices and consequently higher gross domestic product (UN Energy, 2007). Biodiesel production may promote energy access, economic growth and food security (UN Energy, 2007). But it is also possible that the higher food prices will affect the poorest, those who already spend a large part of their income on food (UN Energy, 2007). Bioenergy can provide environmental gains or cause environmental damage (FAO, 2008).

So how do we make sure biofuels follow the right path and what would a sustainable biodiesel production program look like?

2. Objectives and scope

The objective of this paper is to assess the sustainability of the PNPB and the extent to which the program has been successful under each of its eight goals.

This thesis' research question (RQ), which has arisen from new developments in society is:

- Is the production of biodiesel in Brazil sustainable?

In order to answer this question a few other issues need to be addressed (rqs):

- What is sustainable bioenergy?
- What are the criteria needed to assess the sustainability of a biodiesel program?
- How does biodiesel production promote rural development?

One of the major flaws of this paper is addressing the PNPB at the national level, when regional specificities are of extreme importance for the development of a program like this one. This paper is an overall analysis of the PNPB in Brazil at the national level, but had I focused on a specific region the outcomes would have very likely been considerably different.

The long-term nature of many of the program's goals has been taken into account and the program's performance has been assessed in regards to what could have been achieved in these first few years and even more importantly, in relation to what the initial expectations were.

The main assumption is that the PNPB has focused on social aspects of sustainability, leaving environmental considerations behind. I believe different policies could allow for the program to avoid such a trade-off and this is the discussion for the remainder of this paper.

3. Methods and Materials

As the purpose of my research was to find out if the production of biodiesel in Brazil under the PNPB is sustainable, in order to accomplish a well rounded and holistic assessment of the PNPB, I have divided my analysis into two equally important parts. First, I will conduct a goal based analysis derived from the program objectives indicated by the PNPB. Secondly, I will make a deeper analysis of Goal 3 under the program objectives by conducting a sustainability assessment. All of the program objectives (and hence program characteristics) are important in determining whether the program is sustainable or not, but since Goal 3 summarizes most of these aspects it has been given special attention.

At first a summative evaluation was conducted in the form of a goals-based evaluation. Summative research aims at assessing the effectiveness of a program or policy and results in a generalization of the circumstances under which such interventions are effective (Patton, 1990 cited in Mikkelsen, 2005).

This evaluation was based on official documents by the PNPB and the ANP, which gave me the governmental point of view of the program as well as in a variety of published papers and reports by Brazilian academia about the PNPB, which were the source of a more critical analysis, covering diverse aspects of the program and addressing its strengths and weaknesses. This literature was the basis for reviewing the different aspects of the program and its performance under each of the goals, as a goals-based evaluation is used to examine the extent to which a program is meeting pre-determined goals and objectives (McNamara, 2008).

I looked at eight objectives and assessed the PNPB's performance in each one of them, using a number of indicators. Indicators here do not necessarily mean quantitative measurements or an attempt to operationalise sustainability (Bell & Morse, 2008). By indicators, I mean relevant information about the program in relation to its goals.

This goals-based evaluation was then followed by a sustainability assessment which is also the evaluation of Goal 3 under the program's directives. For the actual sustainability assessment I used reports published by international agencies such as FAO and IEA and peer reviewed articles from scientific journals, all dealing with the sustainability of biofuels in general or biodiesel in particular.

I also conducted a series of semi-structured interviews[2] where I focused was on how the interviewee understood the PNPB and on what they thought was important to explain (Bryman, 2004). The guiding question was whether or not they thought the PNPB was sustainable and why, but from there a conversation followed, in the lines of a very flexible interview.

For some of the questions raised throughout this process there were easily available quantitative answer, such as the number of family farmers involved in the program or Brazilian diesel import figures. But then there were issues of a different nature, much harder to assess. Whether or not the PNPB is promoting social inclusion, for instance. Knowing the number of jobs created doesn't necessarily answer this question. For these, a more qualitative approach was taken as I tried to elaborate on what has been achieved so far.

Even if I could have found hard data for all of my research, "in the end, any hard number must be translated to a qualitative statement anyway, in determining whether or not that indicator contributes to goal achievement" (Bossel, 1999, p. 24). This also brings about an "unavoidably subjective valuation" (Bossel, 1999, p. 24), which corroborates my constructionist ontological position (Bryman, 2004).

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[2] Interviews were conducted with Dr. Pierre Vilela, agronomist at the Federation of Agriculture and Livestock of Minas Gerais (FAEMG); Dr. Waldir Pascoal, regional coordinator at the Agency for Technical Assistance and Rural Research and Development in the state of Minas Gerais (EMATER-MG) and Prof. Antonio Marcio Buainain, who works with family agriculture and sustainable development at the University of Campinas (UNICAMP).

The conclusions drawn were then presented in a formative manner, focusing on the performance of the program, its strengths and weaknesses. Formative evaluations are conducted in order to improve an intervention and so recommendations for improvements are given (Patton 1990, cited in Mikkelsen, 2005).

4. Theoretical Framework

Answering my research question requires defining sustainability. And so this paper starts, like so many others before it, with the confusion surrounding the term and the discussion over its lack of a clear definition. Bell and Morse (2008) have put into words my exact thoughts on the matter, by writing that "almost every article, paper or book on sustainability bemoans the fact that the concept is broad and lacks a broad consensus; this is usually followed by the authors' own preferred definitions, which in turn add to the lack of consensus!" (Bell & Morse, 2008, p. 10).

Being in this position myself, and having to choose a definition for sustainable development to work with, I opted for a classic. In this paper, sustainable development is "development that meets the needs of current generations without compromising the ability of future generations to meet their needs and aspirations" (WCED 1987, cited in Bell & Morse, 2008).

Brundtland's famous definition, simplistic as it may seem, does provide me with all that I need, since I have chosen to work with the term sustainability not necessarily focusing on what it means, but rather paying attention to the context in which it is defined.

This research is an interpretative study which tries to understand the PNPB in the context of the Brazilian government's broader energy policies and also in the even larger context of global bioenergy development.

Following the hermeneutic rationality this paper analyzes the PNPB as a part and in its relation to the totality (Tesch, 1990 cited in Mikkelsen, 2005) – the PNPB is not an isolated event, it is a program for biodiesel production within a governmental strategy for the promotion of renewable energy and rural development.

The word 'sustainable' is found in several of the PNPB official documents. The purpose of the program is to implement the sustainable production and use of biodiesel, with special attention to social inclusion and regional development, through job (and income) creation (PNPB, 2009a). And the main directives of the PNPB, as announced by the Brazilian Government, are (PNPB, 2009a):

- To implement a sustainable program, promoting social inclusion;
- To guarantee competitive prices, quality and supply;
- To produce biodiesel from a variety of oil seeds, and in different regions.[3]

[3] Own translation of the original text from Portuguese into English.

The PNPB's clear focus is on rural development and the socio-economic aspects of sustainability seem to overpower environmental considerations (Garcez & Vianna, 2009).

That doesn't mean, however, that the program is unsustainable. It all depends on what kind of sustainability one is referring to. After all, "there is no such thing as a single unified philosophy of sustainable development; there is no sustainable development 'ism'" (Hopwood, Mellor & O'Brien, 2005, p.13).

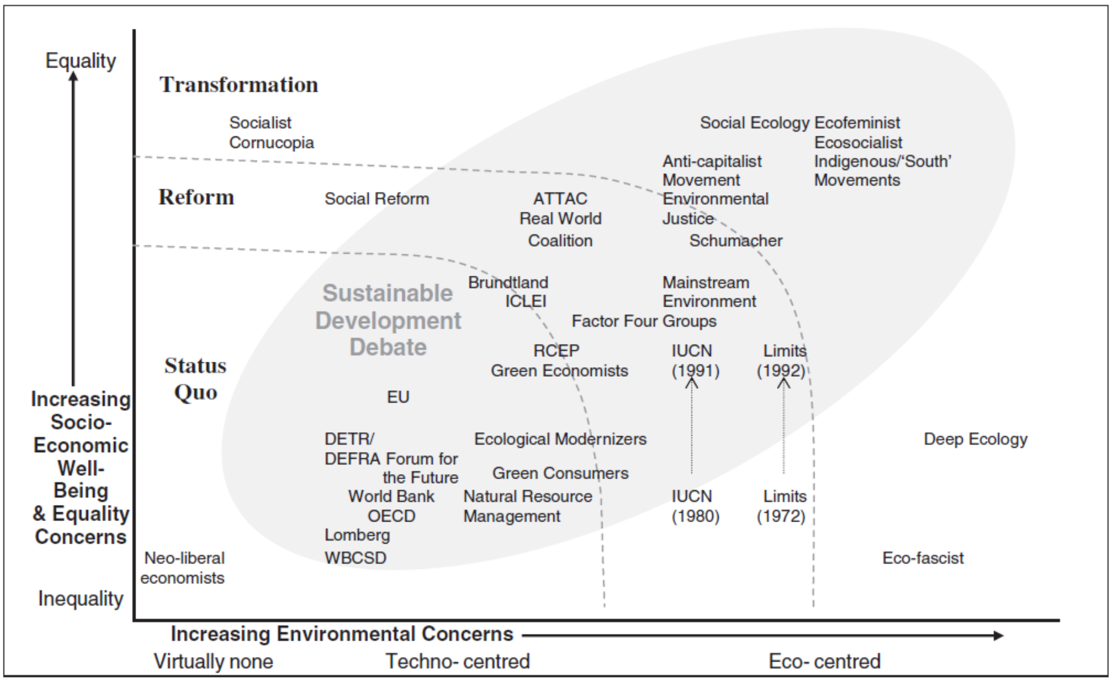
The flexibility of the term 'sustainability' can be argued to be one of the main causes behind its popularity (Bell & Morse, 2008). The concept is loose enough for it to be used by politicians and business leaders without requiring from them "any fundamental challenge to their present course" (Hopwood et al., 2005, p.14).

Hopwood, Mellor and O'Brien (2005) have suggested there are several degrees of sustainability within the sustainability concept itself. Under an interpretative epistemological position and taking from the philosophy of phenomenology (Bryman, 2004), I have tried to understand the PNPB as it makes sense for those involved with the program, although the policy documents are not precise in using the term sustainability.

Furthermore, this research draws on constructionist considerations according to which the researcher always presents a version of social reality, never the definitive picture (Bryman, 2004). This research is but one interpretation of the sustainability aspects of the PNPB. "The sustainability concept we adopt has consequences: our interpretation of the concept directs our focus to certain indicators at the neglect of others" (Bossel, 1999, p. 3).

The same Hopwood, Mellor and O'Brien (2005) have expanded on a classification system of environmental views (designed by O'Riordan, 1989) and by placing environmental and socio-economic views on two separate axes, the authors came up with the following mapping for views on sustainable development.

Figure 4: Mapping of different views on sustainable development (Hopwood et al., 2005)



The socio-economic axis refers to concepts such as human well-being, economic development and equality. The environment axis shows how important the environment is, in a range that goes from zero environmental concerns to deep ecology. Also in the map are three different views of the nature of the changes society has to face in order to achieve sustainable development: status quo, reform and transformation (Hopwood et al., 2005).

There are different ways of being sustainable, depending on what importance one grants each of the aspects which compose sustainability. By putting forth a program whose goal is the promotion of rural development through biodiesel production (meaning job and income generation), the Brazilian government has prioritized the vertical axis and is somewhere in between status quo and reform.

The PNPB prays on the trickle-down theory: economic growth will eventually benefit all (Dollar and Kraay, 2000, cited in Hopwood, 2005). Whether or not that is the case remains to be seen.

This research is a summative evaluation which focuses on the PNPB's goals in order to assess its effectiveness (Patton, 1990 cited in Mikkelsen, 2005). The desired result is a general evaluation of whether or not the program is working. But there is also a formative quality to it, since strengths and weaknesses of the program are discussed and recommendations for its improvement are made (Patton, 1990 cited in Mikkelsen, 2005).

In assessing if the PNPB is sustainable this paper looks into criteria proposed by UN-Energy framework for sustainable bioenergy (UN Energy, 2007) which would take the PNPB further along that horizontal environmental axis.

5. Background

5.1. Renewable energy in Brazil

Brazil has one of the cleanest energy matrixes in the world, where 45% of all energy consumed comes from renewable sources (Hunt, 2008). Hydroelectricity represents 14.5% of the total energy and Brazil is also the 4th largest user of energy from biomass, with 2000 PJ/yr (30.1% of the total energy) (Hunt, 2008).

5.2. The PNPB

The National Biodiesel Production & Use Program (PNPB in Portuguese) was created by the Brazilian Government in 2004 and set targets for biodiesel blending into petroleum diesel of 2% for the year 2008 and 5% for 2013. The PNPB was elaborated by 14 ministries and the Ministry of Mines and Energy (MME in Portuguese) is in charge of the program's operational management (Garcez, 2008).

Federal law n◦ 11.097, from January 13th 2005, introduced biodiesel in the Brazilian energy matrix and expanded the administrative competencies of the former National Petroleum Agency, now called National Agency of Petroleum, Natural Gas and Biofuels (ANP in Portuguese) (ANP, 2009a).

ANP is responsible for regulating and monitoring all activities related to the production, quality control, distribution and commercialization of biodiesel and of the diesel-biodiesel blend (BX) in Brazil (ANP, 2009a).

Resolution n◦ 2 by the National Energy Policy Council (CNPE in Portuguese), published in March 2008, increased the initial mandatory blend from 2% to 3%. Starting July 1st 2008, all diesel commercialized in Brazil had to be a B3 blend (a mixture of 3% biodiesel and 97% petroleum diesel) (ANP, 2009a)[4].

5.3. What is biodiesel and how is it made?

Biodiesel is a liquid biofuel derived from biomass, which can be used in compression-ignition engines and whose applicability is found mainly within transport (Demirbas, 2007). Biodiesel can be obtained from animal fats, residual oils and fats, fatty acids (from sewer) and vegetable oils (Kaltner, Azevedo, Campos & Mundim, 2005). This study has chosen to focus on the latter.

Vegetable oils are composed of three long chains of carbon which need to be separated in order to produce biodiesel. This is achieved through a process called transesterification (Carvalho et al., 2007). Within the transesterification process, there are two possible methods: the methyl and ethyl routes (Carvalho et al., 2007). In practical terms, both methods are used to separate the oil from the glycerin, a sub-product of biodiesel production.

[4] Several of the documents referenced in this paper were published before this resolution of March 8th and they still refer to a blend of 2%.

The methyl alcohol route uses methanol and has some advantages over the other route: it's a quicker and less complex process (Carvalho et al., 2007). It's also less expensive (Kaltner et al., 2005). The methyl route is the method most commonly used in The United States and in Europe (Carvalho et al., 2007).

Brazil has opted to promote the use of the ethyl route (ethanol), which gives the country a competitive advantage (P. Vilela, personal communication, 2009-02-10) but regulation is non-restrictive in terms of feedstock and production methods, so industries can choose the methyl route as well (Kaltner et al., 2005). The ethyl route has environmental advantages (Kaltner et al., 2005) since the ethyl catalyst is renewable (Carvalho et al., 2007).

Biodiesel can be blended with traditional diesel or burned in its pure form (Hunt, 2008). Its energy content is 8% lower than that of regular diesel but it has better ignition qualities and higher fuel density (Kaltner et al., 2005).

5.4. How does the PNPB work?

The PNPB has three main intervention instruments: the Social Fuel seal, differentiated tax regimes and specific financing options (Carvalho et al., 2007).

5.4.1. The Social Fuel seal

The Social Fuel seal, created on December 6th, 2004 by Presidential decree n◦ 5.297, is a regulatory instrument whose purpose is to promote social inclusion and foster the participation of small farmers in the biodiesel production and value chains (PNPB, 2009b). in order to operate, biodiesel industries must have this certification (Garcez & Vianna, 2009).

The certification is awarded by the Ministry of Agrarian Development (MDA in Portuguese), under three specific conditions: (1) biodiesel plants must purchase a specified minimum percentage of feedstock from family farmers, which varies depending on the location of the plant (see Table 1 for specific values); (2) the biodiesel industries must provide farmers with training and technical support and (3) industries must sign and honor legally binding contracts with small farmers and these contracts have to specify income levels and fulfill other criteria imposed by the MDA (Garcez & Vianna, 2009).

Table 1: Feedstock purchase specifications for the social seal (Carvalho et al., 2007)

Region where plant is located	Feedstock which needs to be bought from family agriculture (%)
Northeast and Semi-arid	50
South and Southeast	30
North and Center-West	10

5.4.2. Differentiated tax regimes

The differentiated tax regime for biodiesel was introduced by Presidential decree n◦ 5.457 of June 6th, 2005 which modified the previously mentioned decree. In order to encourage biodiesel production the Government has set reductions in the PIS/PASEP and COFINS, and full exemption of the CIDE; all these three are federal taxes (Garcez & Vianna, 2009).

Tax reductions depend on the industry location, feedstock used and whether or not it came from family agriculture. There's total exemption of federal taxes for biodiesel produced from castor or palm in the less developed regions of Brazil and 67,9% reduction in taxes for biodiesel produced anywhere in the country with whatever feedstock, provided it came from family agriculture (Carvalho et al., 2007).

5.4.3. Financing options

The biodiesel industry has three lines of credit designed specifically for this purpose. They are[5]: the Program for Financial Support of Biodiesel Investments, available through the Brazilian Development Bank; the BB Program for Support of Production and Use of Biodiesel, available through Banco do Brasil and the Pronaf Biodiesel[6] (Carvalho et al., 2007). Conditions and budgets vary but financing is available for all phases of biodiesel production (Carvalho et al., 2007).

5.4.4. Biodiesel auctions

The ANP regulates the production of biodiesel through a system of public auctions (ANP, 2009a). The auctions begin with the announcement of the amount of biodiesel the ANP wants (Garcez & Vianna, 2009).

The day the auction is to be held the ANP sets a maximum price. Producers can then place up to three bids in which they must include the amount of biodiesel they are willing to produce and the location of the plant. The companies which offer to produce biodiesel for the smaller cost win (Garcez & Vianna, 2009). There have been 13 auctions to date[7]; the last one took place on February 27th this year. The 14th auction is scheduled for May 26th (ANP, 2009b).

6. The Goals of the PNPB

The PNPB has eight goals, stated in the policy documents as the program's directives and overall objectives (PNPB, 2009a).

1. To have a B5 biodiesel-diesel blend (5% biodiesel, 95% petroleum diesel) by 2013;

2. To reduce diesel imports;

3. To implement a sustainable program;

[5] Own translation of the original text from Portuguese into English.
[6] Pronaf is the National Program for Family Agriculture.
[7] As of May 15th, 2009.

4. To promote social inclusion (through the fostering of family agriculture participation);
5. To promote regional development (through job and income creation);
6. To guarantee competitive prices;
7. To guarantee biodiesel quality and supply;
8. To produce biodiesel from a variety of oil seeds;

Information about the program's performance under each one of these eight objectives was gathered and an overall program evaluation is presented below.

6.1. Goal 1: B5 biodiesel-diesel blend by 2013

I assume achieving Goal 1 depends on the existence of production capacity (infrastructure) and feedstock. Feedstock implications in land use are also analyzed.

6.1.1. Infrastructure and production capacity

The mandatory minimum blending percentages guarantee a demand for biodiesel in the internal market. The B2 blend created a firm market of at least 800 million liters/year (PNPB, 2009b) and this demand will increase to 2.4 billion liters/year with the B5 blend starting in 2013 (Carvalho et al., 2007).

According to the ANP (ANP, 2009a) these are the numbers for total biodiesel[8] production in Brazil, from 2005 until 2008:

Table 2: Brazilian biodiesel production ANP (ANP, 2009a)

2005	2006	2007	2008
736 m^3	69.002 m^3	404.329 m^3	1.167.099 m^3

Currently, there are 65 authorized biodiesel plants in Brazil, with a total estimated authorized capacity of 11.383,83 m^3/day (ANP, 2009c)[9]. As of March 2009, 8 new plants were in the process of obtaining necessary documentation to start operations and 4 of the already operating plants were undergoing expansion of infrastructure capacity (ANP, 2009c).

But it takes more than physical infrastructure to produce biodiesel. In order to meet the targets set by the program there needs to be enough feedstock and also land in which to grow fuel crops.

[8] Considering B100 (100% biodiesel).

[9] According to ANP these numbers refer to a 360-day operation cycle per year and take into consideration all the necessary environmental restrictions (ANP, 2009c).

6.1.2. Availability of feedstock

Brazil is a major producer of vegetable oils and animal fats, with a total of 6 million tons of oil in 2007, representing 6.3% of the world's production (OECD/FAO, 2008).

Table 3: Production of oilseeds in Brazil (thousand metric tons) (Barros, 2007a)

Oil Seed	2002/03	2003/04	2004/05	2005/06	2006/07
Soybeans	52.017.5	49.792.7	52.304.6	55.027.1	58.421.5
Cottonseed	2.212.3	3.408.6	3.397.0	2.723.6	3.910.2
Peanuts	174.9	217.3	301.6	267.7	226.8
Castor bean	86.3	107.3	209.8	103.9	106.1
Sunflower	56.4	85.8	68.1	93.6	105.9
Total	54.547.4	53.611.7	56.281.1	58.215.9	62.700.5

According to the table above in 2006/07 Brazil produced over 62 million tons of oil seeds. The problem is, most of this production is already taken up by the food, pharmaceutical and chemical industries and therein lies one of the greatest challenges for the biodiesel industry: the competition with other production chains, some of which pay a lot more for the oil (Carvalho et al., 2007).

Hence the Brazilian Association of Vegetable Oil Industries (ABIOVE in Portuguese) conducted a study in order to find out what the increase in the production of oil seeds needs to be in order for biodiesel not to compete with current uses of vegetable oil (Nappo, 2006). The study divided Brazil in three regions[10]: North, Northeast and Center-South and considered these regions' participation in national diesel consumption in 2004 as the basis for its calculations. Diesel consumption for regions North, Northeast and Center-South was of 9%, 14% and 77% respectively (Nappo, 2006). The study then looked at a biodiesel production of 1 billion liters per year, and what every region would have to produce in terms of vegetable oil so as to supply its own demand.

Table 4: Required land use increase for different oil crops and regions (Nappo, 2006)

Region	Type of oil seed	Biodiesel demand[11] 000 m^3	Total oil production[12] 000 m^3	Needed increase %
North	Palm and soya	90	317	28%
Northeast	Castor, cotton, soya	140	567	25%
Center-South	Soya, cotton, peanut, sunflower	770	6.063	13%

[10] Regions in the study are comprised of the following states:
North: AC, AM, RR, RO, PA, AP
Northeast: TO, MA, PI, CE, RN, PB, PE, AL, SE, BA
Center-South: MT, MS, GO, DF, MG, ES, SP, RJ, PR, SC, RS

[11] For a B2 blend

[12] Average for years 2003/04, 2004/05 and 2005/06

So in order for the totality of the vegetable oil that goes into biodiesel production to be "extra" (not already incorporated by any other industrial chain), oil production in Brazil needs to be increased in 66%. And these oil crops have to come from somewhere.

6.1.3. Land use for oil crops

The National Company of Food Supply (CONAB in Portuguese) estimates the total grain planted area in Brazil to be of 47.6 million hectares for the harvest 2008/09, which represents an increase of 0.4% (or 190.000 ha) from last year's figure (CONAB, 2009). In 2006/07, the main oil crops (soybeans, cottonseed, peanuts, castor beans and sunflower) occupied over 22 million ha of agricultural land (Barros, 2007a).

The numbers which show the necessary increase in production are quite demanding, especially for the North and Northeast regions. However, Brazil has great potential for agricultural expansion, both through improved productivity and in increasing agricultural land area (Kaltner et al., 2005). Having said that, it is necessary to point out that arriving at exact numbers for Brazil's agricultural frontier is a rather complicated task; figures vary greatly.

The table below shows a potential for expansion of over 76 million ha (Barros, 2007b) whereas government sources have claimed that figure to be of 150 million ha (PNPB, 2009b).

Table 5: Agricultural Land in Brazil in 2006 (Barros, 2007b)

	Million hectares	% of total agricultural land
Total Brazil	849.900	n/a
Total Agricultural Land	339.900	100%
Cultivated land (all crops)	63.100	18.6%
Pastures	199.900	58.8%
Available Land	76.900	22.6%

Achieving the 66% increase in oil crop production seems feasible provided Brazil can at least double its current agricultural land area. Furthermore, improvements in agricultural productivity can free land for energy crop production (Smeets, Junginger, Faaij, Walter, & Dolzan, 2006) and Brazilian pasture lands have very low densities when compared to those of developed countries (Smeets et al., 2006).

6.1.4. Scenarios for different oleaginous

A study published in 2007 (Silva, Melo, & Esperancini, 2007) estimated the amount of land needed to meet biodiesel production targets as set by the PNPB. The authors looked at national diesel consumption over a 12 year-period and found an average annual growth rate of 3,28%, which was used to project the fuel consumption until the year 2015 (Silva et al., 2007). Based on these figures and on the blending targets set by the PNPB (2% until 2012, 5% from 2013 on) they then estimated the biodiesel demand from 2006 until 2015. The results are shown on Table 5:

Table 6: Predicted biodiesel demand (thousand liters) (Silva et al., 2007)

Year	Petroleum diesel consumption	Biodiesel demand
2006	43.477.550	869.551
2007	44.801.639	896.033
2008	46.630.028	932.600
2009	48.050.124	961.002
2010	49.513.468	990.269
2011	51.021.378	1.020.428
2012	52.575.210	1.051.504
2013	54.720.845	2.736.042
2014	56.387.343	2.819.367
2015	58.104.593	2.905.230

In addressing land use, the authors looked at four distinct scenarios: (1) the amount of land needed to produce biodiesel if all demand was to be met by soybeans alone; (2) the amount of land needed to produce biodiesel if all demand was to be met by castor seeds alone; (3) the amount of land needed to produce biodiesel if soybeans were to meet only 25% of the total biodiesel demand and (4) the amount of land needed to produce biodiesel if castor seeds were to meet only 25% of the total biodiesel demand (Silva et al., 2007).

To calculate the land area taken by biodiesel crops in each of the previously described scenarios the authors worked with the following figures: 2.524kg/ha for soy productivity and 672kg/ha for castor seeds. 20% oil content in seed for soy and 47% for castor (Silva et al., 2007). The findings are presented on the following table:

Table 7: Land area needed to supply biodiesel demand (Silva et al., 2007)

Year	Biodiesel demand (1000 L)	Area soy 100% (ha)	Area castor 100% (ha)	Area soy 25% (ha)	Area castor 25% (ha)
2006	869.551	1.524.394	2.436.405	381.099	609.101
2007	896.033	1.570.819	2.510.605	392.705	627.651
2008	932.600	1.634.925	2.613.064	408.731	653.266
2009	961.002	1.684.716	2.692.644	421.179	673.161
2010	990.269	1.736.023	2.774.647	434.006	693.662
2011	1.020.428	1.788.893	2.859.148	447.223	714.787
2012	1.051.504	1.843.373	2.946.222	460.843	736.555
2013	2.736.042	4.796.506	7.666.148	1.199.127	1.916.537
2014	2.819.367	4.942.582	7.899.617	1.235.645	1.974.904
2015	2.905.230	5.093.106	8.140.197	1.273.276	2.035.049

A biodiesel demand of almost 3 billion liters could be met by 5 million ha of soy or 8 million ha of castor seeds, which have a higher oil content but lower productivity. But these numbers don’t address regional production and the diversification of oil seeds, which are strong points of the PNPB.

Another study by the Brazilian Agricultural Research Corporation (EMBRAPA in Portuguese) (EMBRAPA, 2005, cited in Kaltner et al., 2005) considered a total national diesel consumption of 36 billion liters and calculated the land needed to produce biodiesel for B2, B5 and B100. The study took into consideration different oleaginous for different regions and also the land needed to plant sugarcane in order to produce the ethanol for the transesterification process.

Table 8: Area for biodiesel B2, B5 and B100 (Kaltner et al., 2005)

Biodiesel blend	Total area (ha)
B2	1.285.000
B5	3.212.000
B100	65.448.800

Land use expansion requirements to supply a B5 biodiesel blend seem feasible in all of the above scenarios, but this last study is the only one which takes into consideration what the PNPB set out to do: produce biodiesel from different oilseeds in different regions.

6.1.5. The Brazilian Cerrado

Numbers about the Brazilian potential and needs for the expansion of agricultural land vary greatly and an even more debated point is where in the country this expansion should take place. The Brazilian Cerrado is often quoted as a viable alternative. The Cerrado, a woodland-savannah which is the second-largest Brazilian biome occupying 204 million hectares (21% of the country's territory) (CI, 2009a), is home to some five thousand endemic species (CI, 2009a) and has been rated a "biodiversity hotspot" by Conservation International (CI) (CI, 2009b).

It may not come as a surprise, but environmental NGOs and Government agencies paint the biome in central Brazil with very different colors. Conservational International has ranked the Cerrado as one of the most threatened biomes in the world claiming only 20% of native vegetation remain (CI, 2009b). The NGO says that deforestation rates are of 1.5% (or 3 million hectares) per year and predicts the Cerrado may disappear before 2030 (CI, 2009b).

According to the World Wildlife Foundation (WWF) the savannah-like Cerrado, unlike the rainforest, can be directly converted into soy plantations and millions of hectares of native vegetation have given way to soy plantations in the past decades (Fritsche, Hünecke, Hermann, Schulze & Wiegmann, 2006).

The WWF Report does say, however, that the expansion of soy, at least at present, is mainly driven by exports to industrialized countries, where it is used as animal feed. But the potential impacts of biodiesel in the region need to be addressed (Fritsche et al., 2006).

EMBRAPA describes an extremely different scenario. With a total area of 204 million hectares, 137 million of which are suitable for agriculture, the Cerrado is prime land for agricultural expansion. Of the 137 million hectares only 12 million are currently in use (2 million ha of forests and perennial crops and 10 million ha of plantations). There is also 35 million ha currently used for cattle grazing which have to be subtracted. That still leaves an agricultural frontier of 90 million ha (Crestana, 2005).

6.1.6. Conclusions Goal 1

A B5 biodiesel-diesel blend by 2013 seems easily achievable in terms of infrastructure because the current production capacity of the 65 operating plants suffices to produce enough biodiesel for this stated demand.

Brazil is a major producer of vegetable oils but if biodiesel production is not to compete with other industries for feedstock, there needs to be a great increase in production. That results in the need to expand agricultural land. The amount of land required depends on the seed type, its productivity and its oil content. The studies presented came up with different scenarios, all feasible because of the great agricultural frontier Brazil still has to offer.

The expansion of agricultural land in order to increase feedstock production (and achieve Goal 1) may, however, have negative impacts in the Brazilian Cerrado, the country's second largest biome, which lies next door to the largest soy producing region.

6.2. Goal 2: Reduce diesel imports

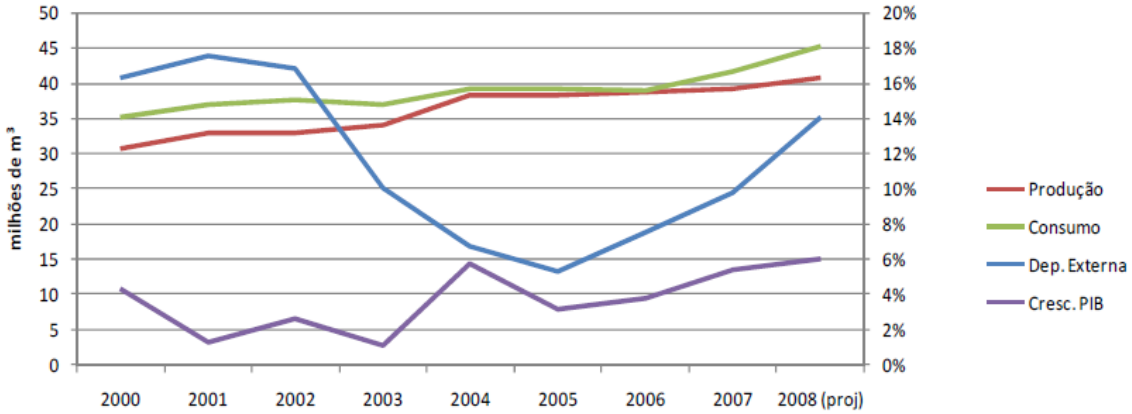
In addressing Goal 2 it is necessary to know how much petroleum diesel is consumed in Brazil, how much of it is imported and whether or not this figure has gone down since the introduction of the PNPB. I understand a reduction in diesel imports as the reduction in the total amount of diesel imported into the country.

6.2.1. Diesel imports

Petroleum diesel is the main transport fuel in Brazil, representing 57.7% of the total fuel consumption at 38.2 billion liters per year, 10% of which are imported (Carvalho et al., 2007). Savings with the reduction of diesel imports can add up to US$ 160 million in a single year, with the B2 blend (PNPB, 2009b) and ANP estimates that as the biodiesel content in the blend increases, these annual savings can reach US$400 million (Rathmann et al., 2005).

But according to the ANP diesel imports have gone up since the introduction of the PNPB and are predicted to continue increasing (ANP, 2008). The figure below shows diesel production (red), consumption (green), external dependency (blue) in millions of m^3 and GDP growth (purple):

Figure 5: Diesel numbers in Brazil (ANP, 2008)



The imported value in reference to the total consumption went from 5.3% in 2005 to 14.1% in 2007 (ANP, 2008). The ANP says the increase in dependence of external diesel has been caused by the sustained growth of diesel demand since 2004, which is directly linked GDP growth in Brazil.

6.2.2. Conclusions Goal 2

The continuous dependence on imported diesel doesn't necessarily mean a failure of the PNPB, since the goal to reduce diesel imports should be addressed in the long-term and also because economic growth is the main driver behind the increase in diesel consumption (P. Vilela, personal communication, 2009-02-10). However, it should be pointed out that the capacity of diesel refineries in the country is saturated (and no investments have been made for quite some time) and that Brazil has an inefficient transport matrix, which relies mainly on road transport in detriment or railways and waterways (P. Vilela, personal communication, 2009-02-10).

Even if the PNPB meets its production targets, the reduction in diesel imports will only be possible if the above issues, which are external to the program, are addressed.

6.3. Goal 3: Sustainable program

Goal 3 couldn't really be analyzed as the other goals and its evaluation has been done in the form of the sustainability assessment presented later in this paper. A "sustainable program" is a reasonably vague definition. The sustainability framework I have chosen to analyze the PNPB with is not necessarily that which the policy makers had in mind at the time of the program's elaboration. Having said that, it is also true the UN Energy sustainability framework is simple and addresses very basic sustainability criteria, which I understand should be met by any bioenergy initiative as the very minimum sustainability requirements.

6.4. Goal 4: Social inclusion

In order to evaluate the PNPB in relation to Goal 4 this paper looks at the initial prospects for family agriculture participation and the number of small farmers currently involved with the program. I understand Goal 4 as the involvement of family farmers in the PNPB.

6.4.1. Initial estimates

The participation of family agriculture in the production and value chains of biodiesel production is one of the main pillars of the PNPB (Carvalho et al., 2007).

In accordance to Law n◦ 11.326 of July 24th 2006, is it considered a family farmer the agricultural producer who (1) owns a piece of land not larger than 4 *modulos fiscais*[13] (2) uses mostly family working force in the economic activities of his/her farm, (3) has most of his/her income from economic activities in the farm and (4) manages the farm with his/her family (Carvalho et al., 2007). Family agriculture in Brazil is extremely diversified in its produce and its production techniques (Potengy, Carvalho & Kato, 2007).

Initial estimates from the MDA in 2005 mentioned 250.000 families employed by the program (Rathmann et al., 2005). Oxfam quotes government statistics in saying that in 2007 there were 200.000 farmers involved with the PNPB, with a forecast of 350.000 farmers for the B5 blend (Bailey, 2008).

In August 2006, the MDA released a report in which 40.000 family farmers were producing oil seeds for biodiesel (most of them in the Northeast) and that this number was expected to rise to 205.000 until 2007 (MDA, 2006, cited in Garcez, 2008). The following year (in March 2007) the MDA published another report and this time 63.481 farmers were working with the PNPB, about a third of the projected figure (MDA, 2007, cited in Garcez, 2008).

6.4.2. Family agriculture and the PNPB

The participation of family agriculture is way below that which was advertised in the inauguration of the program by government sources, and that is a very critical point for the PNPB. One of the explanations for this is that soybean oil is currently used in the production of 73,68% of the biodiesel in Brazil (ANP, 2009c). Soy crops are cultivated in highly mechanized large-scale monocultures which employs ten times less than castor (Silva et al., 2007). Another explanation is that family farmers were never prepared to join in the biodiesel wave (A. Buainain, personal communication, 2008-09-19).

Although the industry sector has responded well to government incentives and blending targets, the share of the agricultural sector which is represented by the small farmers in Brazil hasn't followed up with the same strength. Family agriculture was invited into the PNPB but no structural adjustments were made in order to

[13] *Modulo fiscal* is a measurement unit expressed in hectares, established on a municipal basis, considering the following: predominant agricultural crops in the municipality, income obtained from such cultivation, other cultivation that is significant for income and the concept of family agriculture (A. Buainain, personal communication, 2008-10-11).

accommodate this historically fragile segment of Brazilian society (A. Buainain, personal communication, 2008-08-12).

Family farmers have had technical problems in turning their production which was until recently almost purely extractivist into an organized cultivation which can meet contract demands and deadlines (A. Buainain, personal communication, 2008-08-12). Specialized production of oil seeds is not the best option for family agriculture in the Brazilian semi-arid (Potengy et al., 2007). Oleaginous seeds need to be planted in relatively large areas and even at their highest productivity levels they are still not very profitable per hectare (Potengy et al., 2007).

The competitiveness in the oil seeds market requires constant efforts in increasing productivity and that leads creates the need for technological innovations and focused production, which doesn't suit family farming and subsistence agriculture (Potengy et al., 2007).

In spite of all these problems, it should be noted that it is the first time a government policy has put so much emphasis in enabling the participation of family agriculture in an industry where small farmers would not be competitive otherwise (Potengy et al., 2007).

6.4.3. Conclusions Goal 4

Although advertised as one of the main pillars of the program, the integration of small farmers into the PNPB has encountered many difficulties. The participation of family agriculture is way below initial estimates and not growing in accordance to the expectations.

One of the main reasons for that is the clear dominance of soy, an oil seed usually cultivated in large extensions of land under highly mechanized agriculture. Participation of family agriculture depends on the stimulation of other crops such as castor and palm, which can be grown as complementary to the subsistence agriculture already in place.

The potential for job creation and involvement of small farmers in the PNPB are directly linked to the location of the plants and the choice of feedstock for biodiesel production, and are analyzed under Goals 5 and 8, respectively.

6.5. Goal 5: Regional development

Regional development depends on the location of the biodiesel plants, the number of jobs they create and the resulting income. The achievement of Goal 5 requires biodiesel plants to be spread all over the country, especially in the semi-arid regions in the North and northeast of Brazil.

6.5.1. Geographical distribution of biodiesel plants in Brazil

The PNPB has always had as one of its central objectives the aim to renew the country's energy matrix while addressing social inclusion and the reduction of regional disparities (Potengy et al., 2007).

The following table presents the distribution of authorized biodiesel plants and production capacity per state.

Table 9: Authorized biodiesel plants and production capacity per state (ANP, 2009c)

State	Number of Plants	Total production capacity (m^3/day)
BA	3	852
CE	3	519,4
GO	4	1416,7
MA	1	360
MG	6	265,4
MS	1	30
MT	23	3014,42
PA	2	115
PI	1	270
PR	3	190
RJ	1	60
RO	2	62
RS	4	1891,67
SP	9	2010,24
TO	2	387
TOTAL	65	11.383,38

Of the 65 existing plants in the country, 23 are located in the state of Mato Grosso do Sul, Brazil's main producer of soya (Schlesinger, 2008). Only 14 plants are located in the North and Northeast, Brazil's least developed regions and the main focus of the PNPB.

Furthermore, biodiesel production in the North and Northeast is controlled by a few companies, whereas in the other regions, there are more companies and 60% of the farms involved with biodiesel can be considered small properties (Soares, Pavan, Barufi, Bermann & Parente, 2007). This shows the strong dominance of a few large producers, which goes against the goal of social inclusion and puts the social sustainability of the PNPB in check (Garcez, 2008).

6.5.2. Jobs

The job creation potential is directly linked to the choice of feedstock. The same study that estimated land demands for biodiesel production (Goal 1) also calculated the potential for job creation of the same 4 scenarios previously described (Silva et al., 2007).

Table 10: Potential job creation with soy and castor biodiesel (Silva et al., 2007).

Year	Biodiesel demand (1000 L)	Jobs soya 100% (ha)	Jobs castor 100% (ha)	Jobs soya 25% (ha)	Jobs castor 25% (ha)
2006	869.551	15.244	243.641	3.811	60.910
2007	896.033	15.708	251.060	3.927	62.765
2008	932.600	16.349	261.306	4.087	65.327
2009	961.002	16.847	269.264	4.212	67.316

2010	990.269	17.360	277.465	4.340	69.366
2011	1.020.428	17.889	285.915	4.472	71.479
2012	1.051.504	18.434	294.622	4.608	73.656
2013	2.736.042	47.965	766.615	11.991	191.654
2014	2.819.367	49.429	789.962	12.356	197.490
2015	2.905.230	50.931	814.020	12.733	203. 505

According to this study, cultivation of castor employs 10 workers per 100 ha, whereas soya employs one worker for the same area (Silva et al., 2007). If the entire biodiesel demand was to be supplied by castor seeds, some 800 thousand jobs would be created (in comparison to 50 thousand jobs for soya).

Using castor as a feedstock for biodiesel production has its pros and cons (compared to soy it has lower yields and hence requires more land), and it all depends on what the PNPB chooses to prioritize. "Models of production which maximize employment opportunities for rural populations may not be the most efficient from an export perspective, but may offer greater benefits for rural communities" (Bailey, 2008, p. 29).

6.5.3. Income generation and job quality

Maybe more relevant than asking how many jobs is asking what type of jobs, where they are and for whom. It should be noted that when talking about job creation, the quality of the jobs is usually left aside. The majority of jobs in family agriculture are of low income (Kaltner et al., 2005).

In order to have family farmers participate and profit in biodiesel production and not only as mere raw material suppliers it is necessary to do a lot more than just distribute seeds and set minimum prices (Kaltner et al., 2005). Producers have to be able to organize themselves in cooperatives and have access to proper credit (Kaltner et al., 2005).

But the PNPB can only do so much. In Brazil increases in GDP do not mean the lessening of social disparities and the country is in great need for land use reform (Kaltner et al., 2005). Unless these issues are also addressed the potential the PNPB has to promote social inclusion and rural development is very limited.

6.5.4. Conclusions Goal 5

As with the participation of family agriculture, the numbers for jobs created through the PNPB are well below the initial estimates. The jobs created are usually of low income and unless policies are put into place so that farmers may truly benefit from the industrial gains in the production chain, they will act as mere feedstock suppliers.

Biodiesel plants are concentrated in the center-south of the country, the soy producing region, away from the semi-arid region the program was supposed to be benefiting. The potential for job creation is directly linked to choice of feedstock and is further analyzed under Goal 8.

6.6. Goal 6: Competitive prices

Bioenergy is currently not competitive without subsidies, especially given that fossil fuels are themselves subsidized (Hunt, 2008). The only exception is Brazilian sugar cane ethanol (Hunt, 2008). Brazilian biodiesel is another story. I have addressed competitive prices of biodiesel in relatin to petroleum diesel in the Brazilian market.

6.6.1. Production costs

The costs of producing biodiesel are much lower in tropical countries with low land and labor costs such as Brazil if compared to developed countries (IEA/OECD, 2004). But still, price of biodiesel is higher than that of conventional diesel (Kaltner et al., 2005).

Table 11: Biodiesel and diesel costs in 2004 (euros per energy-equivalent liter) (Hunt, 2008)

	Biodiesel	Diesel w/ tax	Diesel w/o tax
United States	0.50 (soy)	0.47	0.31
Europe	0.56 (rapeseed)	1.06	0.33
Brazil	0.52 (soy)	0.40	0.32

At present, the economic viability of biofuels in most countries can only be achieved through subsidies (FAO, 2008). The competitiveness of biodiesel as a substitute of petroleum diesel depends mostly on the production cost of the oleaginous plant used, since that usually refers to 80% of the fuel's final cost (Kaltner et al., 2005).

A study by the Brazilian Center of Infrastructure (CBIE in Portuguese) found that in comparison to petroleum diesel, biodiesel produced from castor seeds is 50% more expensive whereas biodiesel from soy is 10% more expensive (Kaltner et al., 2005). At present soy is the only economically viable alternative for biodiesel in Brazil (P. Vilela, personal communication, 2009-02-10).

6.6.2. Non-market benefits

One of the problems with pricing biodiesel is that although production costs are easily quantifiable, the benefits aren't (IEA/OECD, 2004).

Benefits such as improved energy security and reduced pollutant emissions are not adequately reflected in the market price of biodiesel (IEA/OECD, 2004), although taking such gains into account is fundamental for understanding the sustainability of biofuels (Garcez, 2008). It is precisely the recognition of these non-market benefits that will make biodiesel less "expensive" as they are often the drivers behind biofuels development (IEA/OECD, 2004). If these externalities are considered, if gains with CO2 emissions' reductions, energy security and rural development are accounted for, biodiesel may become competitive (Ryan, 2006, cited in Garcez, 2008).
This highlights the need for subsidies. But it has to be noted that although subsidies may be necessary in the initial stages of the industry's development, they ought to be planned to be temporary (UN Energy, 2007). "Economic sustainability implies that the total costs to society, including financial costs, environmental and social costs, should be

outweighed by the benefits" (Hunt, 2008, p. 40). If the PNPB wishes to promote rural development through the fostering of family agriculture in the program, subsidies are necessary to ensure that crops such as castor are competitive and that there is room in the market for small farmers (P. Vilela, personal communication, 2009-02-10).

It also remains to be seen if the social seal will be economically advantageous for the biodiesel industry in the long-term. Will the tax incentives compensate for the higher cost of feedstock if soy continues to lead the market?

It is also important to assess whether or not the promotion of biodiesel is an economically viable way of reducing GHG emissions (IEA/OECD, 2004) for Brazil. There is growing evidence that biofuel development is neither a safe nor a cost-effective way of doing so (Bailey, 2008).

6.6.3. Conclusions Goal 6

The only economically viable alternative at present for the production of biodiesel in Brazil is soy. But in addressing biodiesel costs, externalities should be considered, in which case soy would no longer be a suitable option.

Furthermore, if the PNPB really wishes to promote regional development and the fostering of family agriculture, soy cannot be the feedstock of choice, in spite of its economically viability.

More subsidies are needed so that castor, palm and other oleaginous can enter the market. The tax reductions offered through the social seal might not be enough for companies to purchase from small farmers, if soy is more competitive. Government policies are needed to direct the industry towards feedstock diversification, which is further analyzed under Goal 8.

6.7. Goal 7: Quality and supply

In order to guarantee the quality of the biodiesel produced and commercialized in the country the ANP needs a set of specifications and a mechanism for quality control. As supply I understand the logistics involving transport and storage of biodiesel, from production units to demand centers.

6.7.1. Quality and Supply

The ANP is in charge of ensuring quality control of the biodiesel production (ANP, 2009a). Specifications are similar to those in the European and American markets. Laboratories across the country can apply to be certified by the ANP for quality control and industries should submit monthly quality repots (ANP, 2009a).

The PNPB is non-restrictive in terms of technological routes and industries can use either methanol or ethanol for biodiesel production. At present all biodiesel production is for the internal market, but if it were to be exported in the future, quality specifications may have to be revised since the European market does not accept biodiesel produced through the methyl route.

Only recently there have been investments in the integration of productive systems and Brazil has not yet “disseminated the technological skills needed to the extent of the proposed program in the equipment industry” (Kaltner et al., 2005, p. 52). ANP specifications are costly for small plants and tend to favor larger production capacities (Kaltner et al., 2005).

Since biodiesel can be used in conventional unmodified engines, there was no need for alterations in the vehicle fleet (Carvalho et al., 2007) and With the introduction of the PNPB, all the petrol stations in Brazil which commercialize diesel started also selling biodiesel (ANP, 2009).

Unlike ethanol, which needs special infrastructure, biodiesel can be stored and transported like petroleum diesel (IEA/OECD, 2004) and its biodegradability and higher flash point make it safer to transport than its fossil counterpart (Demirbas, 2007). Biodiesel is non-toxic and it requires no additional safety measures for transport or storage (IEA/OECD, 2004).

Although it may use the same supply infrastructure already in place for diesel, there are significant costs in transporting biodiesel from production facilities to storage terminals and then also the storage costs (IEA/OECD, 2004). One of the challenges the PNPB must face in dealing with regional development and the scattering of biodiesel production units is that low production levels can increase these costs considerably (IEA/OECD, 2004).

In addition, in spite of the program’s focus for production being regions north and northeast, most of the demand for fuel is concentrated in the centre-south and southeast of Brazil.

6.7.2. Conclusions Goal 7

In favouring the national production of ethanol and prioritizing the ethyl route over the methyl route used in both Europe and the USA, the PNPB has made Brazilian biodiesel unsuitable for export, at least according to current specifications.

The PNPB is not directed at the external market but in the future, were biodiesel production to keep growing, regulation and quality control methods might have to be revised.

Infrastructure for biodiesel is the same as the one already in use by petroleum diesel, and no investments were needed in this area. If anything, biodiesel is safer to handle and transport. But the PNPB aims at spreading biodiesel production throughout the country and industries with small production capacity may face high additional costs. It may be in the interest of regional development to subsidize these companies, depending on their location and feedstock choice.

6.8. Goal 8: Diversification of feedstock

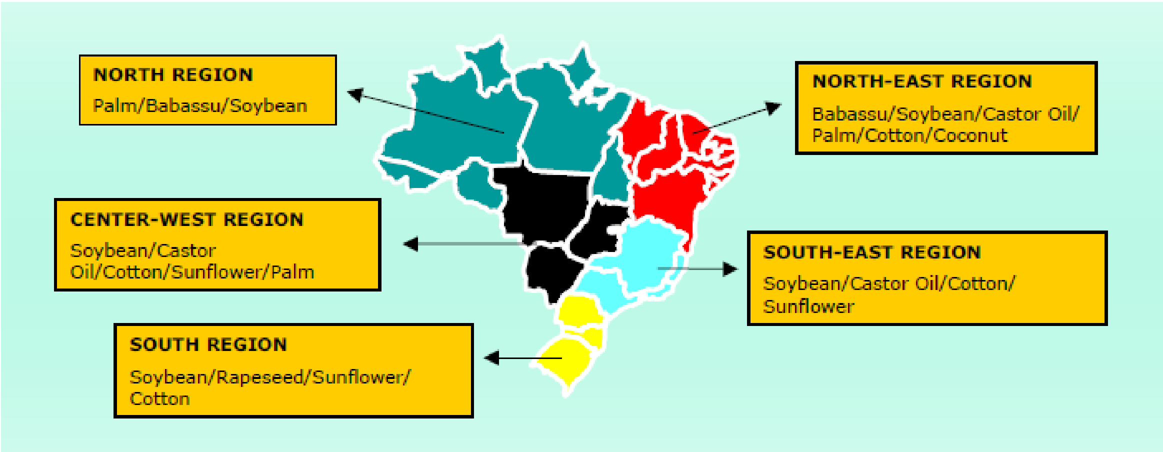
By diversification of feedstock I understand the incorporation of a variety of oleaginous seeds by the biodiesel industry.

6.8.1. Potential feedstock for biodiesel production

The diversification of feedstock is one of the three directives of the PNPB (PNPB, 2009a) and many of the previously addressed goals are directly linked to what type of oil seed is used and where.

There are several oleaginous seeds that can be used by family agriculture in different regions (Sluszz & Machado, 2006, cited in Garcez, 2008).

Figure 6: Potential feedstock for biodiesel (Kaltner et al., 2005)



Over one hundred plant species have been identified as potential feedstock for biodiesel in Brazil (Kaltner et al., 2005). However, most of them are palm trees which grow on wild groves and little or no information is available about their possibilities as commercial crops (Kaltner et al., 2005).

Normally these grow in wild and/or protected areas and that entails difficulties and environmental concerns over their exploration (Kaltner et al. 2005). Furthermore, the potential for biodiesel production from these native plants is limited and the idea of high yields is a misconception; fertilizers would be necessary to allow for continuous exploitation and in some cases even extractivism may cause significant reductions in productivity (Kaltner et al., 2005).

Despite all these difficulties, further research on the applicability of these native species is recommended (Kaltner et al., 2005) as crude vegetable oils are an important energy source for isolated communities, for electricity and transport (Kaltner et al., 2005). Some straight vegetable oils can be used in diesel engines with little or no modifications, which makes them a good alternative for small farmers, since the costs of adapting the engines and injections systems are much lower than those of processing oil into biodiesel, regardless of the production scale (Kaltner et al., 2005).

With subsidies, oil from native species could be produced in some carefully selected locations and its application would have great impact in isolated rural communities throughout the country (Kaltner et al., 2005).

Not considering wild grove plants, there's a smaller but still significant number of oleaginous which are more "well-known". Their viability as biodiesel feedstock depends on oil content, productivity, efficiency in oil extraction and energy balance.

6.8.2. Productivity

The difference in production yields amongst the different seeds is a determining factor in selecting sustainable biodiesel feedstock (Kaltner et al., 2005). Productivity is directly linked to land use requirements and economic viability (Carvalho et al., 2007).

Table 12: Productivity of main oil seeds (Kaltner et al., 2005)

Seed	Productivity (kg/ha/year)
Palm	3500 to 5000
Soy	400 to 600
Coconut	2000 to 3000
Babacu	400 to 800
Rapeseed	500 to 900
Sunflower	600 to 1000
Peanut	600 to 800
Castor	600 to 750

The higher yields are palm and coconut, none of which has been give a lot of attention by the PNPB.

6.8.3. Oil content and efficiency in oil extraction

Alongside productivity, the oil content of the seed and how much of this oil can actually be extracted will give competitive advantages to some crops over the others.

Souza (2004) has defended the diversification of crops and the feasibility of other alternatives for biodiesel feedstock other than soya. The following table shows the efficiency of oil extraction for different seeds. The capacity refers to an industry in the state of Rondonia, where the study took place[14].

Table 13: Oil content and efficiency in oil extraction (Souza, 2004)

Seed	Capacity	Oil in seed	Efficiency of	Oil produced

[14] No other clarifications of the term "capacity" were given in the study.

	(kg/h)	(%)	extraction (%)			
				% in weight	kg/h	L/h
Soya	76	18	66	12	9,0	9,8
Peanut	30	35	83	29	8,7	9,5
Sunflower	60	35	83	29	17,4	18,2
Castor	40	40	75	30	12,0	13,1
Sesame	60	60	75	45	27,0	29,4
Cotton	30	16	69	11	3,3	3,6
Babacu	50	60	75	45	22,5	24,6
Cocoa	50	40	85	34	17,0	18,5

Soya has one of the lowest seed oil contents and also one of the lowest extraction efficiency rates. It is one of the least suitable feedstock options, despite its dominance of the market.

6.8.4. Energy balance

Energy balances for biodiesel depend on the technology used in the agricultural and processing stages of production (Janulis, 2004).

Table 14: Energy balances for various seeds (Kaltner et al., 2005)

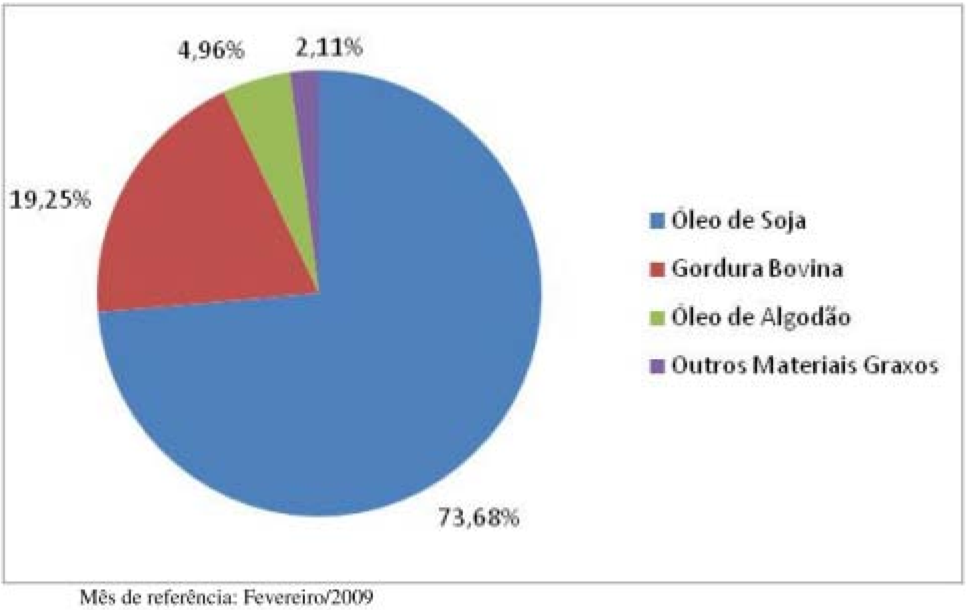
Oilseed	Energy balance
Soy	1,43 – 3,4
Sunflower	0,76
Palm	5,6 – 9,6
Castor	2,1 – 2,9
Macauba	4,2

Palm and castor are the most viable alternatives in terms of energetic sustainability but they are also the feedstock for which there is less infra-structure and technical support (Roman, 2007, cited in Garcez, 2008).

6.8.5. Soy biodiesel

Despite all the feedstock possibilities discussed above, over 70% of the biodiesel produced in Brazil comes from soy oil (ANP, 2009c).

Figure 7: Feedstock used for Biodiesel production in February 2009 (ANP, 2009c)



Unlike the sustainable family farming the PNPB wishes to promote, soy farming is large-scale and highly mechanized, with 4% of the farms occupying 60% of the cultivated land (Fritsche et al., 2006). Large scale monocultures lead to a loss in biodiversity and demand the use of pesticides, which may contaminate soil and water (Wehrman et al., 2006, cited in Garcez, 2008).

As previously addressed, the number of jobs created with soy plantations doesn't even compare to the number of jobs in a labor intensive crop such as castor or palm (see Goal 5). Soy production and processing is dominated by a small group of companies, mostly multinationals (Wehrman et al., 2006, cited in Garcez, 2008).

It is often said that soy is the only crop that can meet biodiesel demands in Brazil today (P. Vilela, personal communication, 2009-02-10) and that may well be the case. This does, however, compromise the sustainability of the PNPB and almost all of its objectives. "The fact that soybean is the sole organized chain does not justify their utilization in the implementation of a program whose legislation has strong social scope" (Kaltner et al., 2005, p. 75).

6.8.6. Conclusions Goal 8

There is a variety of seeds with potential as feedstock for biodiesel. There are restrictions on many of them (technical and economic) but there are also many options which could be explored by the PNPB. Castor and palm are two of the most popular alternatives, but there are other oleaginous with high oil content and productivity, which could be produced by family agriculture in the semi-arid regions.

In practice, however, soy beans, with an already established industry, have been dominating the market. The only advantage soy has over the other options is economic viability. But if non-market benefits, such as rural development, which is in fact one of the main objectives of the PNPB, are taken into account, then soy is no longer a suitable option.

The diversification of feedstock is one of the key points in the PNPB's sustainability and policies are needed to make it happen.

7. Sustainability assessment of the PNPB (Goal 3)

The UN-Energy framework for sustainable bioenergy presents nine key sustainability issues (UN Energy, 2007, p. 2):

1. The ability of modern bioenergy to provide energy services for the poor;
2. Implications for agro-industrial development and job creation;
3. Health and gender implications;
4. Implications for the structure of agriculture;
5. Implications for food security;
6. Implications for government budget;
7. Implications for trade, foreign exchange balances, and energy security;
8. Impacts on biodiversity and natural resource management; and
9. Implications for climate change.

Considering the all the information gathered through the goal-based evaluation in the previous section I have used this framework to assess the sustainability of the PNPB.

For this section it has been assumed that within the PNPB:
- Whenever feedstock is mentioned, it means soy;
- Biodiesel production is concentrated in the centre-south of Brazil;
- Expansion of feedstock production for biodiesel will have negative impacts on the Cerrado;
- Biodiesel production is meant for the internal market only.

The framework used in this paper concerns all bioenergy and some of the criteria is unsuitable for biodiesel (as a transport fuel). In such instances, the evaluation has been not applicable (n/a).

The analysis made through the goals-based evaluation has already assessed the sustainability criteria below. The following tables are a summary of goals-based evaluation analyzed under the sustainability framework. The program was simply evaluated as compliant (yes), compliant to some degree (yes/no) or incompliant (no).

Table 15: Issue 1 - Ability of biodiesel to provide energy services for the poor

1. Bioediesel must be physically available	**yes**

2. Biodiesel must be accessible (both in terms of location of supply and demand and in purchasing power versus cost):	**yes**
3. Biodiesel cannot compete with present use of biomass resources	**yes/no**
4. Biodiesel must be reliable	**yes**
5. There has to be local maintenance and monitoring capacity	**yes/no**
6. Technologies needed to make use of these resources must be available:	**yes/no**
7. Financing opportunities must be available	**yes**

Table 16: Issue 2 - Implications for agro-industrial development and job creation

1. Biodiesel production must take place at an appropriate scale	**no**
2. Biodiesel production should create jobs	**yes/no**
3. Biodiesel production must lead to income generation:	**yes/no**
4. Infra-structure investments have to be worthwhile	**yes**
5. Quality must be assured	**yes**
6. Biodiesel production must happen at an appropriate location	**no**
7. There have to be distribution channels	**yes**

Issue 3 – Health and gender implications

All the criteria listed in the framework refer to household use of bioenergy and is not suitable for the evaluation of the PNPB, which only works with biodiesel as a transport fuel. Since this paper has not addressed the use of straight vegetable oil I have rendered this issue to be outside of my analysis' scope.

Table 17: Issue 4 - Implications for the structure of agriculture

1. Feedstock must be economically viable	**yes**
2. Feedstock must have high yields per hectare	**no**
3. Feedstock must need low input requirements	**no**
4. Feedstock must not have competing uses	**yes/no**
5. Feedstock must be energy efficient	**no**
6. Biodiesel must promote ownership of land	**no**

Table 18: Issue 5 – Implications for food security

1. Biodiesel should not affect food security availability	**no**
2. Biodiesel should not affect food security access	**yes/no**
3. Biodiesel should not affect food security stability	**no**
4. Biodiesel should not affect food security utilization	**yes**
5. Biodiesel should enhance agricultural productivity and sustainability	**no**

Table 19: Issue 6 – Implications for government budget

1. Biodiesel must bring social returns	**yes/no**
2. Biodiesel production must be an efficient and economically viable way of promoting rural development	**yes/no**
3. Biodiesel production must be an efficient and economically viable way of reducing GHG emissions	**no**
4. Biodiesel subsidies must be temporary	**no**

Table 20: Issue 7 – Implications for trade, foreign exchange balances and energy security

1. Biodiesel must help reduce energy dependence	**yes**
2. Biodiesel must help reduce government spending on imported fuels	**yes**
3. Biodiesel trade should lower production costs:	**n/a**

Table 21: Issue 8 – Impacts on biodiversity and natural resource management

1. Biodiesel must reduce GHG emissions	**yes/no**
2. Biodiesel must reduce environmental load relative to conventional agriculture	**no**
3. Biodiesel production must not affect virgin land and land with high conservation value	**no**
4. Biodiesel must not have negative impacts on habitat and biodiversity	**no**
5. Biodiesel must not have negative impacts on water quality and availability	**no**
6. Biodiesel must not have negative impacts on soil quality	**no**
7. Biodiesel must not have negative impacts on air quality	**yes/no**
8. Biodiesel must not have negative impacts on carbon content of soils	**no**
9. Biodiesel must not have negative impacts on forest carbon stocks	**yes**

Table 22: Issue 9 – Implications for Climate Change

1. Biodiesel must help reduce GHG emissions	**yes/no**
2. Biodiesel must be a cost-effective way of reducing GHG emissions	**no**

8. Results

The table below shows the results of the sustainability assessment. Issue 3 has not been included in the table and "X" marks non-existing criteria. The color green refers to environmental criteria; yellow refers to socio-economic criteria.

Although I realize socio-economic and environmental aspects of sustainability are strongly interrelated and to a great extent dependent on each other, I have chosen to classify criteria as belonging to one group or the other based on where I believe their impacts are more relevant, just so as to facilitate the following discussion.

Table 23: Results of the sustainability assessment of the PNPB

Criteria	Issue 1	Issue 2	Issue 4	Issue 5	Issue 6	Issue 7	Issue 8	Issue 9
1	yes	no	yes	no	yes/no	yes	yes/no	yes/no
2	yes	yes/no	no	yes/no	yes/no	yes	no	no
3	yes/no	yes/no	no	no	no	n/a	no	X
4	yes	yes	yes/no	yes	no	X	no	X
5	yes/no	yes	no	no	X	X	no	X
6	yes/no	no	no	X	X	X	no	X
7	yes	yes	X	X	X	X	yes/no	X
8	X	X	X	X	X	X	no	X
9	X	X	X	X	X	X	yes	X

The PNPB fulfills (only "yes" were considered) 10 out of 26 (38,46%) socio-economic criteria and 2 out of 17 (11,76%) environmental criteria.

For comparison, and as subject for further discussion, I have analyzed the PNPB using castor seeds as feedstock under the same sustainability framework.

Table 24: Sustainability assessment with castor as feedstock

Criteria	Issue 1	Issue 2	Issue 4	Issue 5	Issue 6	Issue 7	Issue 8	Issue 9
1	yes	yes	no	yes/no	yes	yes	yes/no	yes/no
2	no	yes	yes	yes/no	yes	yes	yes	no
3	yes/no	yes/no	yes	no	no	n/a	yes	X
4	yes	yes	yes/no	yes	no	X	yes	X
5	yes/no	yes	yes	yes	X	X	yes	X
6	yes/no	yes	yes	X	X	X	yes	X
7	yes	yes	X	X	X	X	yes/no	X
8	X	X	X	X	X	X	yes	X
9	X	X	X	X	X	X	yes	X

Castor fulfils 14 out of 26 socio-economic criteria (53,84%) and 12 out of 17 environmental criteria (70,58%).

9. Discussion

The initial hypothesis of this paper was that the PNPB had prioritized socio-economic sustainability over environmental concerns but according to this assessment, by using soy as feedstock, the PNPB is unsustainable even in regards to the social aspects which were supposed to be the program's strong points.

Issue 8, which specifically addresses environmental criteria, is where the difference between soya and castor is more easily noted.

Issue 1, which deals with the ability of bioenergy to provide energy services to the poor is where the PNPB performed better, but the criteria deals mostly with accessibility and reliability of biodiesel, not its actual social impact.

Employment generation, the participation of family agriculture, regional development, small-scale production… All of these objectives are neglected under the current policies, which have allowed the dominance of soy in biodiesel production. The entire soy agricultural system, as shown in this paper, is incoherent with goals of rural development and sustainability. Soy means large-scale, highly mechanized, monoculture production, with high input requirements.

Furthermore, soy production is located mainly in the center-south of Brazil, which has two negative implications for the PNPB: firstly, it directs biodiesel production away from the north and northeast regions which are the focus of the program; secondly, it puts a lot of pressure on the Cerrado, under the constant threat of agricultural expansion.

The dominance of the soy industry in biodiesel production is of course explainable. Brazil is one of the largest soy producers in the world and the industry is large and well established. The mandatory blending mandates set by the PNPB have been said to be ambitious, and in spite of that, soy farmers rose up to the challenge. It was clearly easier for them to supply the newly created demand for oilseeds than for small farmers scattered around the northern portion of the country who had been living out of subsistence agriculture and who were, to a great extent, unaware of the biodiesel talks taking place in Brasilia, thousands of kilometers away.

The soy industry reacted well to the program, meeting the blending targets and keeping production costs reasonable. But economic viability has been achieved at the cost of almost all the other program goals. Soybeans have low oil content and low energy efficiency; in short, soybeans are unsuitable for biodiesel production.

Had there been no alternative feedstock, maybe the PNPB could have argued that soy is better than nothing. But that is definitely not the case. There are over a hundred oleaginous seeds with potential for biodiesel production, and although the great majority of these cannot be commercially explored at present, there are a few options which can. Castor seeds and palm are two of the greatest candidates in this front.

In purely quantitative terms (in relation to the tables above) castor is over 6 times more environmentally sustainable than soy. A simplistic evaluation but one that gives an idea of the difference another feedstock choice would have in the program. The problems which are intrinsic to bioenergy development, such as competition for resources (mainly water and land) and influences on food prices, would remain and the program would lose a lot of its economic viability, but it would gain in almost all other aspects.

In a program whose focus is social development, economic sustainability alone should not be a synonym of viability. Although soy may present an economic comparative advantage now, in the long-term, given that the main directive of the PNPB is the promotion of rural development, it will prove to be a bad idea.

So the question here is how to get away from soy and promote the diversification of feedstock which is one of the main directives of the program and which represents a key aspect of its sustainability. Diversification of feedstock goes hand in hand with the participation of family agriculture, another point where the PNPB has been unsuccessful. How can these issues be addressed in order to improve the PNPB in its role as tool for sustainable rural development?

The social seal was meant to guarantee the participation of small farmers in the biodiesel industry and consequently the diversification of feedstock, since these producers are seldom in the soy business. The seal hasn't been working quite well, however. As a matter of fact, it might be working to the best of its ability, but the way it was set up really limits its potential.

Industries need to obtain the social seal in order to operate, and so they will purchase a certain amount of feedstock from family agriculture, depending on where they are located. The problem is that feedstock from small producers costs more than soy from big agricultural corporations and the tax reductions offered through the certification do not compensate for this extra cost. Industries buy the minimum quota required by the program, but have no reason to buy any more than that from family farmers. The social seal does very little of a good thing.

In order to increase the participation of small farmers in the program, the PNPB could set higher minimum quotas, creating a higher demand for feedstock from family agriculture. In this scenario, the biodiesel industry would have to handle the extra costs of a more sustainable practice. The danger then is that companies will decide to produce soy biodiesel for export and ignore the social seal altogether.

Another alternative is for the government to directly subsidize family agriculture in Brazil. In one of my interviews it came up that the word "subsidy" is almost taboo in Brazilian agriculture. But agriculture is subsidized in many countries. Bioenergy is subsidized in many countries. To complicate matters further, fossil fuels are subsidized in many countries, including in Brazil. So why shouldn't a biodiesel program whose focus is social inclusion and rural development offer subsidies to family agriculture?

Small farmers cannot compete with the large soy monoculture farms and they need to be helped into the market. Subsidies are the price the government has to pay in order for the PNPB to work. The introduction of a new energy source in a country's energy matrix cannot be left to the private sector. Nevertheless, it is fundamental to stress that subsidies, if well managed, should be temporary, provided research and development and increased production can lower costs of palm and castor biodiesel, amongst others.

Most of the problems this paper has discussed aren't wrong doings of the program itself, but rather a consequence of it having soy as its main feedstock. The program does have a very strong social focus and biodiesel production has the potential to bring about development in the Brazilian semi-arid.

There will still be problems with castor or any other feedstock and the PNPB can only do so much. Brazil has serious social inequality and income distribution issues and the country is in great need of a land use reform. But the PNPB can be successful as a program if policies are put into practice so as to ensure more participation of family agriculture and the diversification of feedstock for biodiesel.

10. Conclusions

The aim of this study was to assess the sustainability of the PNPB. The analysis was divided in a goals-based evaluation and a sustainability assessment. The goals-based evaluation showed that in relation to the objectives of promoting social inclusion and the diversification of feedstock the PNPB's performance is below initial expectations. The sustainability assessment of the program has made it clear that soybeans are an unsuitable feedstock for biodiesel production both in socio-economic and environmental terms, in spite of their economic viability. With a different feedstock, such as castor seeds or palm, the PNPB can be more sustainable in all aspects. In order for the PNPB to achieve all of its goals direct subsidies for family agriculture are needed in order to ensure their participation in the biodiesel industry and reinforce policies for the diversification of feedstock.

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