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Biofuels in Brazil: debates and impacts

John Wilkinson and Selena Herrera

This article presents an analysis of the two major components of Brazil's biofuels initiatives – ethanol from sugarcane and biodiesel from a variety of raw material sources. With the crisis unleashed at the end of 2008, huge question marks hang over the timetable and the scope of future investments in the sector. Even prior to the current crisis the biofuels debate was suffering a sharp volte-face with earlier euphoria being replaced by sustained critiques from NGOs, social movements, influential representatives of the techno-bureaucracy, and global agrifood firms. As a result governments are currently reviewing their policies, further exacerbating the uncertainties surrounding biofuels. Brazil is already assuming a protagonist role in the promotion of biofuels and its biofuels programs occupy a central place both in global debates on this issue and in the eventual emergence of global biofuels markets.

Keywords: Brazil ethanol, biofuels, biodiesel, sugarcane

Introduction

Brazil is distinguished by the degree to which renewable resources participate in its energy matrix, accounting for almost half of total production. The table below compares Brazil's renewable/non-renewable mix with the global average. The breakdown of the different energy components shows that Brazil has an overall participation of renewable resources of some 44 percent against 14 percent globally (see Table 1). Of these, biomass accounts for 30 percent, compared with 11 percent globally. Sugarcane alone is responsible for some 15 percent of Brazil's total domestic energy supply.

At the same time, the total area dedicated to sugar cane production, some seven million hectares in 2006, roughly divided equally between sugar and ethanol, represents a small proportion of Brazil's total cultivable area, calculated at 340 million hectares. Ethanol production accounts for one percent of this total, or five percent of actually cultivated land, estimated at 63 million hectares.

From the 1980s, Brazil's agricultural research system adapted soy and other crops to the semi-tropical latitudes of its vast savannah interior, creating a new frontier of more than a hundred million hectares, which also includes large tracts of the northeast and now reaches into the Amazon region. This new frontier has transformed Brazil into the world's leading agricultural commodity exporter.[1] Soy at

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[1]For a general account of Brazil's position in the global agrofood system see Wilkinson (2009) and for a broader analysis of agrofood within a political economy perspective see McMichael (2009).

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Table 1. World and Brazilian energy matrix: comparison (%).

	World, 06/2003	Brazil, 12/2005
Petroleum	34.9	39.7
Coal	23.5	6.5
Natural Gas	21.1	8.7
Renewable Energy	11.4	29.1
Nuclear Energy	6.8	1.5
Hydrolectric	2.3	14.5

Source: DIEESE (2007).

22 million hectares and corn with 13 million hectares are currently responsible for seven and four times the area dedicated to ethanol production respectively. In addition, some 200 million hectares are classified as pasture land (MAPA 2008). The implications of these figures will be discussed in greater detail below but they are sufficient to suggest both that the food energy equation may be negotiable in Brazil and that this represents an exceptional situation when compared with many other countries in Latin America and especially when compared with Asia. Southern Africa, on the other hand, may offer similar conditions to Brazil but will need to negotiate key social and environmental obstacles (Richardson 2010).

Ethanol in Brazil

Ethanol production in Brazil has a long history going back to the 1920s. It emerged as a major factor in Brazil's energy strategy in the 1970s in the wake of the petroleum price hikes. The Pro-Alcohol Program was launched by the military government in 1975 with the aim of being able to substitute 20–25 percent of gasoline with anhydrous ethanol. The production of hydrous ethanol was then promoted for use in light vehicles especially adapted for alcohol. A highly regulated market was created to guarantee the adoption of ethanol, involving price controls, compulsory supply at gas stations, and a range of subsidies. By 1986 some 12 billion litres of ethanol were being produced and ethanol-run cars represented some 90 percent of new car sales. Although the incorporation of new lands was the principal response to increased demand, this period also saw important advances in research and engineering capacity involving seeds, agricultural practices, fermentation technology, equipment, and machinery. Since the 1970s overall productivity has increased by an average of four percent per year, lowering costs so that subsidies are no longer necessary. Brazilian ethanol is considered competitive with petroleum at US$30–35 a barrel (Andrietta *et al*. 2007).

With the reversion in petroleum prices from the mid-1980s, government commitment to the program waned and shifts in the relative attractiveness of sugar and ethanol prices led to crises in supply of the latter at the gas stations, undermining confidence in the ethanol car market. By the end of the 1990s ethanol-driven car production represented only one percent of total car production and the sugarcane sector increased its exports of sugar from one to ten million tons. In this decade, Brazil was led to import ethanol from the US to maintain the mixture in the gasoline (Furtado and Scandiffio 2007).

This situation changed abruptly in the first decade of the new millennium with the renewed increase in petroleum prices, greater levels of private sector coordination in the sugarcane sector, and the innovation of flex-fuel cars, which allowed the customer to make his/her choice not at the point of purchase but at the gas station depending on the evolution of relative prices. Flex-fuel car purchases exploded from 2003 and now account for over 70 percent of new car purchases. Ethanol production has expanded sharply from 15 billion litres in 2003 to 25 billion litres in 2008–09. The domestic market absorbs some 20 billion litres with the remainder being exported to the slowly emerging global commodity ethanol market.

Such growth prospects, combined with the pressures to respond to global warming, have unleashed an avalanche of investments that are beginning to transform the profile of the sector. Estimates vary depending on timetable adopted and source. The Brazilian government's Program for Accelerated Growth (PAC) calculates that some 77 new ethanol mills will come online through the end of 2010, involving investments of R$17.4 billion. Other estimates with a longer perspective, looking at the 2020s, put the figure at around US$33 billion.[2]

The sugarcane sector is still quite fragmented with some 350 mills, 230 dual purpose and over 100 exclusively for ethanol. Although the majority of mills are individually owned, the leading firms prior to the crisis of 2008–09 – Cosan, Crystalsev, Nova America – all had numerous plants and were already involved in processes of consolidation. An important initiative in this direction was the transformation of the Cooperative Coopersucar with 85 partners and 31 mills into a firm so that it could respond to the new competitive climate. Foreign investment has been traditionally low, with global players preferring minority associations. This situation began to change rapidly from 2003 with the acceleration of acquisitions and particularly greenfield investments. At the outset of the crisis some 40 firms controlled 50 percent of the sector's production and it was expected that this would be reduced to some six to eight within ten years with foreign participation reaching 50 percent (Wilkinson and Herrera 2008b). In the wake of the crisis many firms became insolvent and the rhythm of consolidation accelerated along with the participation of foreign capital, which by 2010 had already reached 20 percent.

Perhaps the most striking feature of planned investments has been the diversity of their sources. In the first place, prior to the crisis the leading players in the sector themselves invested heavily, launching themselves on the stock exchange and becoming involved in strategic investments related to the sector's expected expansion. A notable example here was Cosan, the sector's leading firm, buying up Exxon's gas station network. Another example was Crystalsev, the sector's then second leading firm, which in addition to developing a bioplastics operation with Dow Chemical was, as mentioned earlier, researching biodiesel from sugarcane in collaboration with Amyris. These incumbent leaders were, however, now faced with a more aggressive stance by the global traders, Dreyfuss, Tereos, Cargill, Bunge, and ADM, soon to be joined by the Singapore group, Noble. Brazil's transnationals, particularly those involved in countries with potential for ethanol production – the construction company Odebrecht and Petrobras – also began to invest heavily in the sector. Votorantim, Brazil's leading cement and cellulose firm, deserves special mention here since in addition to direct involvement in the sector it has, through its Biotechnology Investment Fund, been the main promoter of cutting edge research

[2]noticias.terra.com.br/. . ./0,,013139331-E18177,00.html

and innovation related to sugarcane in such firms as Alellyx and Canavialis (Gazeta Mercantil 2008). These latter, however, have now been sold to Monsanto, which has made a major turn to the sugarcane sector.

Of special note were the new actors entering the sector particularly in the form of global investment funds, often headed by Brazilian investors – BRENCO, Clean Energy Brazil, Adecoagro Infinite Bioenergy. Investors here included such diverse actors as Sun Microsystems, AOL, Merrill Lynch, Soros, and Goldman Sachs. These projects, ranging from hundreds of millions to various billions (US$), typically involved multiple greenfield investments on the new frontier with a view to becoming leading players in the sector. Governments, either directly or through their leading firms, also began negotiating a stake as they committed themselves to partial fuel substitution. China, in addition to its minority participation in Cosan, initiated negotiations on ambitious projects in the state of Bahia. India established a presence through its leading firms, Bajaj Hindustan and Reliance Industries. Japan, in its turn, entered into negotiations with Petrobras for the construction of a 1000km ethanol pipeline to secure its import requirements.

Brazil's Development Bank, the BNDES, has become a major financer and supporter of ethanol production. For the BNDES, the sugarcane complex occupies a strategic position in Brazilian development strategies since it is a sector where domestic competences have traditionally dominated all phases of the value chain from advanced genetic research to turnkey factories. As such it is thought to be a window of opportunity provided initially by natural resource competitiveness for assuming technological leadership in a globally dynamic sector.

The focus on greenfield site investment and also the nature of sugarcane production, which demands that processing occurs within 24 hours of harvesting, defined a new phase in foreign direct investment (FDI) involving also the purchase of land, which has now become identified as a strategic resource. While in the Brazilian case land for energy provides the principal motive this is not exclusively the case and increasingly land is becoming the object of FDI also for food. This would seem to be part of a more general global tendency as capital-rich but resource-poor countries look to large-scale land investment to secure their food and energy supplies, a tendency identified in Africa, Asia, and Central Europe.

These investment projects, however, were designed and negotiated before the 2008–09 crisis, which threatened a global slowdown, reversing the pressure on commodities and modifying the relative prices between biofuels and petroleum. While investments in the Brazilian case were very much premised on the expansion of the domestic market, this too began to suffer the effects of tighter credit, particularly important for the light vehicle market. Many domestic firms were hard hit by the crisis, which lead to an acceleration in acquisitions and consolidation to the advantage of transnationals, particularly the global traders. Global investment funds were also affected by the crisis, which put a temporary hold on green-field investments.

Brazilian ethanol and socio-environmental debates

In the same way that Brazil has become a protagonist in the promotion of ethanol as a global commodity it has also emerged as a key player in the global debates over the impact of ethanol on access to food, on the environment, and on issues relating to workers' rights. The sugarcane sector is represented by UNICA, the Union of the Sugar-Cane Industry, whose members account for some 60 percent of global

sugarcane production (UNICA 2005). This body, now headed by a leading academic proponent of modern agribusiness practices, Marcos Jank, has developed its own research competence and receives support from the agribusiness think-tank ICONE, the Institute of Trade Studies and International Negotiations. The sector has an important champion in the ex-Minister of Agriculture, Roberto Rodrigues, who chairs the committee for the transformation of ethanol into a global commodity, a powerful lobby for advancing the sugarcane ethanol strategy in the Americas, including the US market (Hollander, 2010, this issue). Key figures in the Brazilian academic community are vocal supporters of the ethanol program, such as the well-known physicist J. Goldemberg (2008). The Brazilian president has also made the ethanol program the centrepiece of his international diplomacy efforts.

Their vigorous proactive defence of the ethanol program in international fora has clearly had a major influence on the evolution of the global debate. While as we noted earlier there has been a swing from euphoria to widespread criticism, the international debate increasingly separates out the Brazilian ethanol program as a special case not to be confused with the US corn-based energy program or the EU support for biodiesel.[3] Successively, World Bank, Organization for Economic Co-operation and Development (OECD), and Food and Agriculture Organization (FAO) studies have exempted Brazil's ethanol program from the central critiques on biofuels in terms of economic efficiency, contribution to greenhouse gases, and impact on food prices. Important international non-governmental organisations (NGOs) have also either given their support to Brazil's program, as in the case of the World Wildlife (2008), or drawn attention to its distinctive features as in the recent Oxfam report (Oxfam International 2008).

What are the principal arguments put forward in defence of Brazilian ethanol? In the first place it is argued that sugarcane occupies a very small percentage of arable land in Brazil and only half of this is currently dedicated to ethanol. Total arable land is estimated at 340 million hectares, of which only 63 million are currently dedicated to crops (2006 harvest). Sugarcane for ethanol represents only one percent of total arable land and some five percent of land actually under crops. According to these calculations, some 77 million hectares are available for cultivation in addition to a large part of the land currently dedicated to pasture, some 200 million hectares.

Cattle-farming is rapidly increasing its productivity and also adopting the practice of confinement, both of which point to a greater availability of land. EMBRAPA, the Brazilian Enterprise for Agricultural Research, is currently promoting a mixed crop and cattle farming system for the savannah region, which, it is argued, would drastically reduce land use and increase sustainability.

In the light of these figures and tendencies, UNICA argues that Brazil could easily multiply its ethanol production without encroaching on sensitive ecosystems. Furthermore, unlike cattle farming sugarcane production is only viable close to sugar mills, making it easily identifiable and easily controllable. A mapping of the existing and projected sugar mill investments, based on those included within the Government's PAC program, would seem to confirm that they are situated far both from the Amazon and the Pantanal, Brazil's huge wetland region.

UNICA further argues that the increase in sugarcane production has been accompanied by an increase in both food crops and cattle production, transforming

[3]This argument has now become extremely fragile with the discussions in early 2010 on importing ethanol from the US to create stocks for the period between harvests (Veja 2010).

Brazil into the number one overall exporter of the different components of the animal protein complex. Sugarcane therefore, on this view, could not have been at the expense of overall food production and could not be judged responsible for increases in global food prices.

Many state governments in the northeastern region have vigorous programs for the promotion of ethanol production. These include the states of Bahia, Tocantins, Maranhão, and Piaui, involving cooperation and investment from China, Japan, the US and Germany. In Pará, Roraima, and Acre in the northern, Amazon region, there are currently very few mills but the region's governors, including the state of Amazonas, defend the production of sugarcane on what are known as 'degraded' lands – lands which have long been logged and transformed into pasture land and are now idle. In the Amazon region, it is argued, such lands amount to 90 million hectares. In addition, research programs are underway to develop sugarcane varieties adapted to these regions. There is similar pressure to allow mills to be established in the Pantanal region and here too distinctions are made between different types of land in the region. Considerations of the global market, however, led the federal government at the end of 2009 to propose a zoning law which excluded new sugarcane investments in the Amazon, the Pantanal, and the Bacia do Alto Paraguai.[4] In São Paulo concern with social and environmental measures is evident in the state legislation imposing mechanisation for sugarcane harvesting and the anticipation of the timetable for voluntary adoption by the major producer association UNICA. This has been motivated by the global context in which the sugarcane sector is now situated both from the perspective of investment and conditions of access to export markets. Given its magnitude, its transient nature, and the inhospitable working conditions repeatedly exposed by civil society organisations, manual harvesting is now being substituted by mechanisation. Each harvester is said to replace 100 cane-cutters.

This also has important environmental implications since manual harvesting requires prior burning of the sugarcane and serious pollution to the surrounding towns. Almost all new plants, particularly those in the new savannah regions, include provision for 100 percent mechanisation. In the state of São Paulo the timetable for mechanisation on levels lands, 2017, has been brought forward and it is estimated that 70 percent of the harvest will be mechanised by the end of 2010. Retraining schemes are being planned, but these will only cover a small proportion of the half million temporary workers in the sugarcane sector.

The working conditions of cane-cutters have been a major focus of conflicts within the sector and also of adverse attention from civil society organisations and the media. In recent years, these combined pressures would seem to have led to improved conditions particularly within the more organised segments of the industry. Studies show a decline in child labour, decreased use of labor with written contracts, real wage increases, increased benefits, and better schooling (Balsadi 2007). Nevertheless, on the key issue of workload this has not been the case since the same system of payment – by metre harvested – prevails even though agricultural productivity has vastly increased over the last 30 years. It is estimated that cane-cutters must now cut 10–12 tons a day, as opposed to three tons in the 1970s, and only young workers can endure the increased workload (Mendes 2007).

[4]www.agenciabrasil.gov.br/noticias

In the areas of new investment, such as Mato Grosso do Sul, there have been many denunciations of inhumane working conditions both in the case of migrant labour from the Brazilian northeast and local indigenous workers. The high-profile BRENCO, the Brazilian Renewable Energy Company, was charged by the public prosecutor in 2008 after inspections of its plants revealed unsafe working conditions, degrading living conditions, and use of informal recruiting systems without formal contracts. One hundred and forty contracts were rescinded and BRENCO had to commit itself to improving conditions in the plant and to providing public services for the neighbouring municipalities suffering from the influx of workers (Camargo 2008). In early 2010 the sector's leading firm, COSAN, was blacklisted by the Ministry of Justice for illegal labour conditions. As a result, the federal development bank, BNDES, suspended its credit and the firm's shares on the New York Stock Exchange fell by some five percent (Valor Econômico 08/01/2010).

Certification

Even though domestic growth will dominate the ethanol market in the medium term, Brazil's strategic goal is the creation of a global ethanol commodity market. This involves, as we shall see, the promotion of ethanol production in other developing countries. It also involves the negotiation of agreed standards. The initial focus here was on technical criteria but in the light of growing critiques of biofuel production the discussion on standards has expanded to include environmental and social criteria. Inmetro, the National Institute for Metrology, Norms and Industrial Quality, is in charge of the program, and pilot projects are now being tested on a regional sample of sugar-mills (INMETRO 2007). In addition to physico-chemical criteria relating to the quality of the sugarcane, respect for labour legislation and levels of greenhouse gas emissions are also included. It is hoped that certification will provide the passport to global market access. Private certification schemes are also being developed, such as that of the Swedish Biofuels & Chemicals, which uses Brazilian sugarcane and is Sweden's leading supplier of ethanol for heavy vehicles. A particularly unusual example is the socio-environmental certification scheme established between independent small-scale sugarcane suppliers and the Usina Della Coletta sugar mill in São Paulo State (Siqueira 2008). In addition to seeing certification as providing a privileged basis for access to export markets this sugar mill has committed itself to sharing any premium price eventually received. Small-scale independent sugarcane suppliers make up some 25–30 percent of the total harvest and the plan is to extend the certification scheme to other producers in this category.

The creation of a global ethanol market

It is clear to Brazilian biofuels interests that the creation of a global commodity market requires more than standards and qualification systems. It requires above all that a good number of other countries also become producers, allaying fears that one or two players may control the market. Brazil, however, as we have argued is a special case, and if it can be shown that the conflict between ethanol and food production is not a central issue in Brazil this by no means indicates that the Brazilian model can be exported. A study by the FAO/ECLA (2007) has argued that there is land available for viable biofuels programs in various Latin America

countries. It is similarly claimed that many African countries also would be able to support biofuels programs (Matthews 2008). Both of these options have become the object of foreign direct investment strategies by Brazilian firms and transnational firms based in Brazil. In the case of Latin America, it is above all the advantages provided by the Caribbean Free Trade Agreement (CAFTA) and the Caribbean Basin Initiative which provide a loophole through which Brazil can export ethanol to the US avoiding the import tax of US$0.54 per gallon imposed against Brazilian ethanol. Jamaica, El Salvador, and the Dominican Republic have all become the object of investments, which may involve little more than dehydrating ethanol exported from Brazil. Brazil has historic links in the lusophone African countries and has become an important investor in the context of postwar reconstruction. The advantage here is access to the European market within the framework of the Everything but Arms (EBA) agreement. Rather than creating a global market, these investment strategies are an expression of the transnationalisation of the Brazilian biofuels complex. The danger is that Brazil, in furthering its global interests, will provoke the environmental and food supply conflicts in these countries that it claims to be resolving in the very different conditions of Brazilian ethanol production (GRAIN 2007).

Second generation biofuels

While ethanol from sugarcane shows itself to be technically and economically superior to all other crops currently in use, it is widely thought that this advantage will be undermined once second-generation ligno-cellulose technology becomes commercially viable. Indeed, the criticisms of US corn-based ethanol are often thought to be partially deflected once the goal of a transition to non-food raw materials by 2015 is taken into account. We have already mentioned that the sugarcane sector is seen to be of strategic importance for Brazil in terms of wider development objectives, since in addition to strong traditional comparative advantages Brazil had established solid competences in all phases of the production chain. In particular, a strong national research network (RIDESA – Inter University Network for the Development of the Sugar-Alcohol Sector) ensured a steady supply of new, adapted crop varieties and improved agricultural practices for the expanding sugarcane sector. Brazil's biotechnology competence was confirmed with its contribution to genome research, which included sugarcane, and leading researchers from this network later developed advanced genetic research directed at the sugarcane sector through the start-ups financed by Votorantim's investment fund. In 2009, these start-ups were sold off to Monsanto, accelerating the transnationalisation of this crucial inputs sector.

While initiatives in other countries explore the potential of new non-food crops (grasses, waste products, woods), Brazil is advancing in research designed to exploit the potential of the whole sugarcane plant, including the bagasse (the waste product from sugar-cane processing) and the straw. It is probable, at this stage, therefore, that the centrality of the sugarcane complex will be confirmed in the context of second-generation biofuels. In such a situation we are likely to see a further expansion of sugarcane investments. With São Paulo state already at saturation point, these investments will increasingly be directed to regions where the attractiveness of income and employment opportunities often prove to be stronger than social and environmental concerns.

The Brazilian National Biodiesel Program (PNPB)

Brazil's biodiesel production is small (fifth place in the world) when compared to that of the European Union (EU), which is responsible for 65 percent of world production, some 8.75 billion litres per year from 276 plants, with close to 23.9 billion litres of installed production capacity in 2009 (EBB 2009).[5] By 2012, the EU market is scheduled to increase to 15–16 billion litres, and the 10 percent binding target established by Directive 2009/28 for renewable consumption in the transport sector will require the production of between 34 and 39 billion litres of biodiesel by 2020. The US produced 2.64 billion litres, in 2008, from 173 plants with a production capacity of 10.2 billion litres per year. Total production should increase to 8 billion litres by 2012 (BiodieselBr MAGAZINE 2009a, 2009b, NBB 2009). In Brazil, 63 plants have the National Petroleum Authority's (ANP) permission to operate and have a combined capacity of 12.8 billion litres per year. Since the statutory biodiesel mixture of five percent (B5) only creates a demand for 2.24 billion litres these figures suggest an ambitious export target in addition to further moves to expand the domestic market (through, for instance, a 20 percent mix for city bus fleets). For the moment, however, national production has only a small export potential and the focus is on supplying domestic biodiesel demand (Ewing 2008).

The Brazilian National Biodiesel Program (PNPB) was officially launched in December 2004, with the specific aim of using this opportunity to promote social inclusion. Whether intentional or not, this also served to deflect criticism from the ethanol program, based exclusively on the large sugar mills. A national two percent mandatory blending of diesel was imposed as of January 2008 to be increased to five percent by 2013 (Law n° 11,097/05). In July 2008, due to the pressure of the biodiesel industry, this share was raised to three percent; in July 2009, it increased to four percent, and in January 2010 to five percent (see Figure 1). According to the Program the preferred feedstock would vary according to region – palm oil in the north, castor oil in the northeast, soy and other oil crops in the remaining regions. Tax exemptions are offered to biodiesel producers who contract with family farmers for their feedstock. The Agrarian Development Ministry (MDA) offers a Social Fuel Certificate to those firms who comply with this requirement, enabling them to participate in the biodiesel auctions, which are currently the pre-condition for access to this market. Targets for family farm participation were established for each region – 10 percent in the north and the centre-west until the 2009–10 crop and 15 percent after the 2010–11 crop; 30 percent in the northeast, the south, and the southeast. The biodiesel company is obliged to offer technical assistance to the farmers and guarantee that it will buy their crop. State governments, for their part, have provided further support for the involvement of family farmers in the program.

While initially the Social Certificate was restricted to family farm production of palm and castor oil, the law now includes all raw materials coming from family farming. Nevertheless, official data, published for the first time by the government (the Ministry of the Mines and Energy – MME) in September 2008 and later by the National Petroleum Authority (ANP (2009)), have shown that the reality does not fit expectations. Castor oil has not been used by any industry since January 2008 and palm oil participation was less than one percent during that year. In spite of all the

[5]EU production capacity was estimated at 21 million tons in 2009. To calculate the conversion, a biodiesel density of 0.88 g/mL was employed (ORNL 2003).

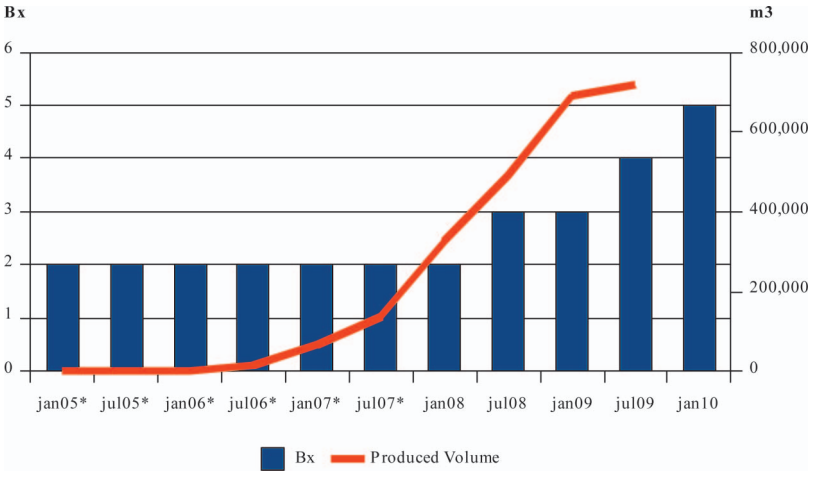

Figure 1. Percentage (Bx) of blended biodiesel compared to volume produced, 2005–2010. *Optional blending.

Program's explicit goals and practical efforts soy and animal fats dominate biodiesel production in Brazil (78 percent and 18 percent on average, respectively). According to Oilworld data (ABIOVE 2009), only soybean oil and animal fats have sufficient production scale and regional distribution to support biodiesel production in the short term until other vegetable oils come online. In addition to this failure to promote typical family farming products, the goals of social inclusion have also fallen short of the Program's targets. According to the national coordinator of the biodiesel program of the Agrarian Development Ministry (MDA), around 37,000 families were working in the biodiesel value chain in 2008 and the incorporation of family farmers into the program has ground to a halt, making it difficult to attain the initial goal of 200,000 families.

The biodiesel industry developed as a result of the regulation on obligatory blending, and the social inclusion of family farming is similarly dependent on the way this market has been regulated. To date, access to the market is by auction run by the National Petroleum Agency (ANP). Only firms with a Social Seal can participate and this is given by the Ministry of Agrarian Development (MDA) only if a firm commits itself to the regionally stipulated quota for family farm supplies of the raw material input. Only 30 of the more than 60 firms authorised to produce biofuels had the Social Seal in 2009. The end of the auction system, which has been extended but is seen as temporary, would open the market to firms without the Seal. According to the ANP (2009) a further 19 plants are in the process of authorisation and a further 13 have plans for expansion. The industry is already faced with a lack of adequate supplies from the small farming sector in the northeast and the north due to the low level of productivity and deeper structural problems related to access to land, tired soils, lack of resources and technical assistance, the effects of rural exodus on labour availability and indebtedness. In this context, greater demand would only accentuate problems of supply and increase sales from large-scale commercial farmers.

Greater controls over raw material inputs are being established both to ensure supplies and to position firms to profit from the possibilities of carbon credits as in

the case of Agrenco (CDM-PDD 2006). The profile of the new entrants suggests industrial capacity is going to be the deciding factor in the coming period. Whereas the original plants were in the 50 million litres/year range, the new plants have a capacity of 200–300 million litres. Acquisition and mergers involving firms such as Agrenco, Glencore, and Petrobras Biofuels are similarly creating greater capacity.

To face this challenge it is imperative that supplies from the family farm sector become more consolidated through the formation of cooperatives, which would allow greater access to resources and technical assistance, in addition to the possibility of generating added value through the development of primary processing capability, a demand articulated by family farm representative bodies such as the Agricultural Workers Federation of the State of São Paulo (Fetaesp) and the National Workers Federation for Family Farming (Fetraef).

Given the requirement to buy raw material from the family farming sector, firms are increasingly positioning themselves to operate both in the biodiesel and the oils markets more generally, thereby reducing the risks associated with price oscillations. Since the beginning of the program firms have bought castor oil from family farmers as demanded but have used other oils to produce biofuels. The castor oil has then been sold on the international markets. Petrobras Biofuels has similarly defined itself as a biofuels and oils firm operating in each market depending on relative prices and profitability. The family farming sector, therefore, is in a very vulnerable position, since its integration into biofuels depends exclusively on the persistence of current public policies.

The biodiesel program is often presented as a possible solution to the collapse of the traditional cotton-cattle-subsistence crop economy in the semi-arid northeast region, where cotton provided a cash crop for the small farm sector. Until May 2008, the government stimulated castor oil production in the northeast by making this the privileged crop for granting the Social Seal but this strategy failed in spite of the early opening of the Brazil Ecodiesel plant in 2005, the Petrobras plant in 2008, and the incentives provided by the state government. As Table 2 makes clear, for system I, castor oil revenue does not exceed the average *per capita* income received from social programs (IBGE 2006) on the basis of two hectares of planted area. In the case of a semi-commercial producer (system II), castor oil does begin to represent a solution. It has become clear that market style incentives on their own are insufficient and must give way to the systemic construction of a new agroindustrial production chain, where technical, organisational, logistical, and marketing features are equally decisive.

In addition to opposition of the biodiesel program based on a defence of alternative strategies for family farming in the Northeast, recent research (Carvalho *et al*. 2007) has called into question the capacity of the program to fundamentally change income and employment perspectives, given the low productivity and the reduced area available to family farming, as well as production systems often subordinated to whims of the large cattle ranches whose lands are rented. Currently, greater potential for response is being shown by the agrarian reform settlements, reinforcing the view that the agrarian structure remains a key barrier to the consolidation of viable family farm production systems in Brazil's semi-arid region (Wilkinson and Herrera 2008a).

In the northern region the raw material of choice is palm oil, the leading input globally for biodiesel and the only oil which has achieved the productivity target of

Table 2. Family farmer's income based on castor oil and bean productivities and the productive system, in Ceará state (northeast region).

System	Castor oil productivity	Production costs (R$/ha.year)	Bean productivity	Net revenue* (R$/ha.year)
System I	400 kg/ha	370	300 kg/ha	50–100
System II	750 kg/ha	493	600 kg/ha	436,40

*Without the state's grant of R$ 150/ ha (up to 3 ha) of castor oil crop for each family.
Note: System I is characterised by subsistence agriculture with little experience in oil crops, low levels of technology, and where sales are limited to the 'surplus'. To avoid subsidies, system I would have to produce at least 700 kg/ha with intercropping and have access to rural credit and to crop guarantee programs. The second system is composed of semi-commercial producers with some access to equipment and inputs and in receipt of PRONAF credit but they are not organised into associations or cooperatives and sales are irregular.
Source: Carvalho *et al*. (2007).

the National Agroenergy Plan fixed at five tons per hectare. This crop has the support of family farmers integrated into Agropalma's agroindustrial complex in the state of Pará and considerable hopes are placed in this crop, whether produced in the form of plantations or in contract relations with family farmers. A consortium between the mining company Vale and Biopalma, a Canadian firm, has been established to plant 60,000 hectares close to Belém in the state of Pará. Petrobras Biofuels, for its part, is studying the construction of a plant in Pará with a capacity for 115 million litres/year, which would come on line in 2011 with the raw material being supplied in part by family farming. A federal government inter-ministerial initiative aims to promote large-scale palm oil production on the so-called degraded lands, which would make Brazil self-sufficient in all sectors which use this input, not only biodiesel.

As a permanent crop, palm oil offers a greater guarantee of income for family farming. It is less labour-intensive and therefore compatible with the development of other activities, and in the first three to four years, palm oil can be inter-planted with food crops and a number of other commercial products, allowing for the generation of alternative income until the palm oil becomes productive. On the other hand, where controls are weak, palm oil plantations have been responsible for deforestation and the substitution of native plants for what is considered to be an exotic species. Socially, the expansion of palm plantations has been associated with the dislodging of family farmers pressured to sell their lands to medium- and large-scale firms. This has been particularly the case in the state of Pará where large investments such as that by Biopalma are currently underway (Valor Econômico 2009). The rural unions in the region have been campaigning to veto land purchases which involve forced sales by family farmers.

In the centre-west region, research has suggested that it is the more consolidated family farmer producing soybeans rather than the small farmer producing castor oil who is benefiting from the program (Ferreira 2008). Soybean production from family farming for the biodiesel market is directly related to the social seal awarded by the government. A clear example of this situation is the agreement between ADM, the agribusiness multinational, and some 500 small soybean producers from Mato Grosso do Sul. About a third of soy is produced in properties of 50 ha or under, mostly in the south, and it may be the case that this stratum participates in the supply of soy oil in Mato Grosso do Sul, the principal producer state in the

centre-west. The soy lobby in the biodiesel market, however, is clearly based on the large-scale producers, and if soy becomes the preferential raw material for biodiesel, it will be the large farmer and the dominant agribusiness channels which will certainly take over the program.

Biodiesel plants in Brazil and soybeans as the main oil seed

Brazil successfully distinguished itself from the 'bad ethanol' made from key food crops such as corn in the US or wheat in China and the EU.[6] With the failure of other alternatives, however, it now finds itself, in the case of biodiesel, relying on soy, the central feedstock of the animal protein market and, as edible oil, a strategic food resource, especially for poor urban families in developing countries. In a similar manner to US discourses, the argument is that for the moment soy is the only option although with time other inputs will become viable.

However, the explosion of demand for soy has since the 1980s promoted land concentration and threatened the position of family farming. In a comparison between the censuses of 1985 and 1996, an Embrapa study concluded that the number of properties producing soy had decreased by 42 percent (more than the national average of 16.3 percent), and the number of people working in soy production had declined by 44 percent (Repórter Brasil 2008).

The largest biodiesel companies and those that have closed the biggest deals in the auctions are the leading soybean agribusiness firms. This is the case of Agrenco, Granol, ADM, Caramuru (one of the largest domestic soy firms), and Oleoplan (a traditional industrial soy group). The leaders in the biodiesel market, Granol, Oleoplan, and ADM, were responsible for 17 percent, 12 percent, and 11 percent, respectively, of national production from soybeans during 2009. It is expected that soy will account for 90 percent of national biodiesel production (ANP 2009). Soy oil also dominates the global biodiesel market with 58 percent of world production. New investments in industrial plant, although in principle able to use a variety of raw materials, are concentrated in the soy producing areas. These investments include the world's largest biodiesel plant in the southern state of Paraná, which should come online in 2010 capable of processing 600,000 tons per year (Valor Econômico 2008c).

The Brazilian Forum of NGOs and Social Movements for the Environment and the Development (FBOMS) argued in a recent study that there is evidence that soybean expansion is leading to new areas of deforestation and is also dislocating cattle, which increases the pressure for further deforestation. Soybean production, however, is not the sole cause. Furthermore, futures scenarios indicate that soybean expansion responds to land and infrastructure availability. One of the consequences of the advance of the agricultural frontier into the north and centre-west regions is the concentration of land, income, and productive systems (mechanised monoculture in the soybean case), based on the economic resources, technology, and cultural models of migrant farmers from other regions of the country. This process provokes small producers to move on as a result of social conflicts or the sale of their land, leading to a further advance of the frontier and to increased deforestation. The agricultural frontier's advance into the Amazon region disrupts extraction and transforms the land into pasture and the peoples of the forest into rural workers (FBOMS 2009).

[6]But, as noted in footnote two, this success may be short-lived.

Between 1990 and 2005, the Brazilian beef herd increased by some 40 percent (from 147 to 207 million head [IBGE 2006]), transforming Brazil into the world's leading beef exporter (USDA 2006 in Barreto *et al*. 2008). Most of this increase, however, is occurring in the Amazon on the land from new forest clearances. In legal Amazonia the increase from 1985–2006 was some 44 percent. As a result almost 15 percent of the legal Amazon area (74.87 million hectares) was by then incorporated into farming, with 82 percent of this (61.6 million hectares) dedicated to pasture.[7] From 2000–2006, the state of Mato Grosso was the leading exporter and responsible for the greater part of beef exports from the Amazon (Barreto *et al*. 2008). At the same time, the area planted with soy in this state has increased 400 percent over the last decade. According to FBOMS (2009) the evidence suggests that soy has pushed cattle-raising into new areas, leading to a probable increase in deforestation. This can be adduced from the decline in the beef herd in the principal soy-producing municipalities and its increase in surrounding regions.[8] In addition to these social impacts, a growing number of NGOs (Imazon, Friends of the Earth, FASE, AS-PTA, etc.) have called attention to the increase in greenhouse gas emissions as a result of the conversion of native forests into pasture and then into soy. One estimation would put these emissions at 977 t CO_2/ha and 11.87 kg N_2O/ha as a result of deforestation in the state of Mato Grosso (Herrera 2009). If we consider a progressive increase in the admixture of biodiesel, reaching 20 percent (B20) in 2020, the demand for soy in Mato Grosso would lead to the emission of 23.37 million t CO2, corresponding to 9.7 percent of Brazil's target for reducing such emissions as a result of deforestation by 2020.

The Greenpeace campaign against Cargill's grain terminal in Santarém brought the world's attention to the presence of soy production in the Amazon. This has led to a moratorium agreed upon by leading traders and international NGOs on the marketing of soy produced on land in the Amazon region that has been cleared since 2006. This moratorium, due to have ended in 2008, was renewed, and production from the region now carries a certificate testifying to its environmental credentials. Just as state governors in the Amazon region have argued in favour of sugarcane, many defend the production of soy on what are known as degraded lands in this region, lands which have long been logged and which are calculated as being in the order of 90 million hectares. These lands are not included in the moratorium. EMBRAPA, Brazil's agricultural research institute, is promoting an Integrated Production System for this region which would combine crops and cattle-raising and relieve pressure for the opening up of new lands.

The biodiesel market implies a radical shift in the direction of the soy complex in Brazil, the implications of which are as yet unclear. Agribusiness analysis has argued that the soy complex needs an alternative to the vegetable oils markets and that Brazil has a chronic vegetable oil surplus (Zilio 2005). In this light, biodiesel becomes a key strategy for the soy sector as a whole and could lead to a sustained increase in production with a continuation of all the tensions which have accompanied its

[7]In the country as a whole, pasture land was the preferred terrain to expand for the sugarcane sector. From 2002–2006 approximately 90% of the new sugarcane area took place over pastures intended to milk and beef production (Novo *et al*., 2010, this volume).
[8]For a detailed analysis of the interaction between dairy, beef, and sugarcane sectors in Brazil, see Novo *et al*. (2010, this volume).

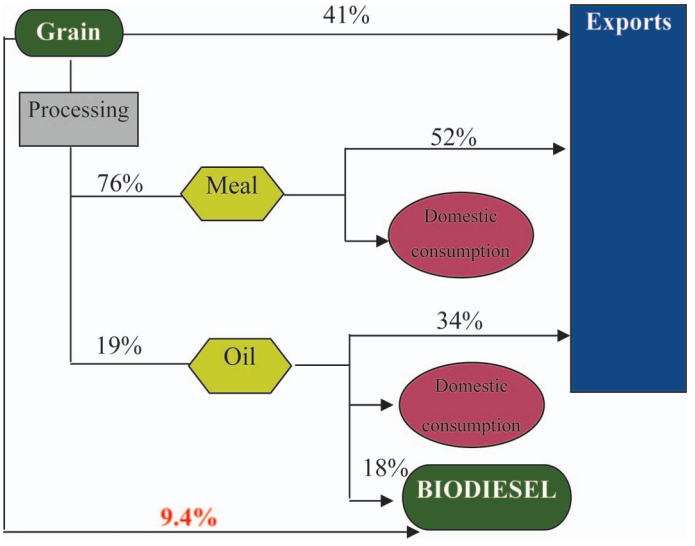

Figure 2. Distribution of Brazilian soybean production, based on 2008 data.
Source: Authors' elaboration on the basis of ABIOVE data site (www.abiove.com.br).

advance as large-scale monoculture up from the savannah regions of the centre-west into the Amazon (see Figure 2).

Biofuels and the agrarian structure

In the course of our discussion of each program we have pointed to a range of impacts of biofuels on the agrarian structure. Here we will present a brief reflection on the debates on this issue although it should be stated clearly from the outset that it is difficult to separate biofuels from the overall impacts of agribusiness expansion. Brazil has been notable for its combination of support for agribusiness and promotion of the family farm sector and agrarian reform. In spite of the undoubted importance of these latter policies, the overall predominance of agribusiness has been strengthened during the last period. From 1992–2003, 108 million hectares of new land were incorporated into farming and ranching and no less than 71.9 million hectares were occupied by large-scale farmers (Repórter Brasil 2008).

If we consider sugarcane and ethanol first, the expansion has been largely within the state of São Paulo itself and into the neighbouring states of Minas Gerais, Goiás, and Mato Grosso do Sul. In São Paulo the expansion has been at the expense of cattle and a range of other crops and is part of a national re-spatialisation of production. In the neighbouring states, the advance of sugarcane has provoked a competition with grains and the animal protein sector. A municipal law has been enacted in Rio Verde, Goias, the centre of white meat production on the new frontier, prohibiting the substitution of grains by sugarcane (Valor Econômico 2008a). In response to the advance of sugarcane, the São Paulo government enacted an economic and ecological zoning law to define the areas where the expansion of sugarcane could occur. A proposed national zoning law for sugarcane was presented by the federal government in late 2009. Doubts have been raised as to the effectiveness of such measures, although the Central Bank and the National

Development Bank (BNDES) are increasingly making credit conditional on conformity with environmental regulations (Valor Econômico 2008b).

In addition to the direct substitution of other activities, including food crops, sugarcane has sharply increased land prices, making many other farming options unviable. Increases in land prices and the search for new lands for sugarcane are also blocking the advance of agrarian reform initiatives. A considerable part of the expansion of sugarcane in São Paulo has been at the expense of cattle-raising, and the first decade of the new millennium has seen a huge shift in the geography of the cattle sector, with some 80 percent of the increase in the national herd between 1990–2006 occurring in the northern region of the country (Barreto *et al*. 2008). Sugarcane expansion is clearly only one factor in this enormous expansion of cattle production that has led Brazil to become the world's leading exporter and Brazilian firms to become the leading transnationals in this sector (Smeraldi and May 2008). Nevertheless, as we have seen above, prior to the crisis a large number of sugarcane investments had been planned for the north and the northeast, both by national and foreign capitals, and state governments in these regions conducted a strong lobby to attract sugarcane investments.

A novel feature of sugarcane investments has been the direct involvement of foreign capital in land purchases. Many of these new projects are vertically integrated from their conception, a factor facilitated by the choice of level lands with access to efficient infrastructure which will permit mechanisation, thereby drastically reducing the demand for labour and transforming the nature of labour demand, which will now be primarily for semi-skilled workers. Traditionally in the sugarcane sector a quota of sugarcane had to be supplied by small- and medium-size independent farmers and this may well be a demand which is taken up again to contest the concentration of this new model of sugarcane production.

Impacts on the agrarian structure can also be identified in the case of biodiesel. For the traditional crops we have seen how the efforts to promote cassava in the northeast have been frustrated by the pulverisation, the exiguous scales of production, and in many cases by the production controls involved in renting arrangements. In spite of the many agrarian settlements which have been promoted the overwhelming mass of small farmers in this region still require a redistribution of primary assets if they are to generate even a minimum income from agricultural activities. In the northern region the limits of incorporating small farmers into the production of palm oil has also been exposed. Only a very small number of families have been integrated, and although they are largely contented with the results, their integration was heavily subsidised and it is unlikely that this model will be generalised. In fact, the reverse has happened and new investments have been at the expense of small farmers who have been bought out and transformed into slum dwellers on the periphery of rapidly growing rural towns. These investments are large-scale plantation projects into which the newly urban dwellers are partially reincorporated as rural labourers. To date, however, the incentives for the expansion of palm oil have been more general market incentives rather than the consequence of the biodiesel program.

The main feature of the biodiesel program, as we have seen, has been its appropriation by the soy complex and particularly by its leading actors. In a similar fashion to cattle, the soy complex in Brazil has experienced extraordinary growth over the last decade, extending its production further into the centre-west, northern, and northeastern regions. This encroachment on the sensitive biomass of the

Amazon on the one hand and the Pantanal on the other has provoked an energetic response from a wide range of civil society coalitions, leading to moratoriums and negotiations for the certification of 'sustainable' soy (ABIOVE 2010). A peculiarity of the northern region which has made regulation particularly difficult is that a huge swathe of the territory is public land which has been occupied and effectively appropriated by private actors. It has been calculated that some 70 million hectares involving 300,000 properties are in this category, and the federal government has introduced legislation allowing for the legalisation of properties up to 1,500 hectares on the condition that the owners work and gain their income from the property and are not employed in the public sector. Civil society groups and small farmer associations have condemned this measure as legitimating land grabbing. The government argues that this is the only way control can be implemented effectively (Lourenço 2009). Agribusiness is also responding to the advance of the frontier into environmentally sensitive areas with pressure for modifications in legislation, as in the case of the Forestry Code. The strong rural lobby in the Federal Assembly has pressed for a relaxing of the measures limiting deforestation and protecting riverbanks. States such as Maranhão and Mato Grosso, which are included in the definition of the 'Legal Amazon', are pressing for exemption from the controls governing forest clearance. A campaign for a broad redefinition of land use is, therefore, underway, which if successful will put increasing pressure on smallholders in these regions either directly through expulsion or indirectly through the mechanism of increased land prices. Of particular importance here is the pressure to redefine indigenous lands and the informal encroachment on these lands often with the tacit support of public authorities.

Conclusions

Biofuels are now a key component of Brazil's agroindustry and their consolidation poses fundamental questions with regard to the environment and models of economic and social development. The advantages of scale have been largely accepted in the case of ethanol and the focus of critique has been the environment and working conditions. A number of initiatives have emerged integrating sugarcane ethanol into family farming systems with a view to local and regional consumption (Ramis 2008) and the potential for a new decentralised agroenergy/food system has been forcefully defended (Sachs 2007). Nevertheless, these have made little headway either in practice or in discourse. While localised conflicts over food displacement have been identified, it is argued that Brazil's exceptional availability of land and water in favorable climatic conditions permits the continued growth of both fuels and food. Exports have accompanied ethanol expansion and domestically food politics are seen primarily in terms of income and access.

Biodiesel promotion, on other hand, was initially designed as a regional development strategy whose priority was social inclusion. Local raw materials were to be used and priority given to the family farm sector as supplier and, where possible, as primary processor. Despite its innovative design and the commitment of considerable human and material resources, the structural weaknesses of the family farming sector have led its marginalisation within the program. Biodiesel has come to depend almost exclusively on soy and is increasingly integrated into the strategies of agribusiness. Given the complex interdependencies between the soybean, animal feed, and vegetable oil markets the long-term impact on food markets is as yet

unclear. Recent years however suggest that the volatility of supplies and prices will be exacerbated, pointing to the need for different policy instruments than have been used during the recent period.

Biodiesel developed as the antithesis of ethanol in almost all respects. The more recent tendency, however, has been towards convergence. Petrobras, the state petroleum company, in addition to its investments in processing and refining biodiesel, controls distribution. It is also a major investor in ethanol and has now set up a separate company responsible for its biofuels activities. Leading traders such as ADM are investing in both sectors. The use of ethanol for the production of biodiesel also favours convergence. The future, however, may see a more radical integration of biodiesel into a sugarcane-dominated biofuels sector if the research pointing to the possibility of producing biodiesel directly from sugarcane finds it to be economically feasible. Until such a time, biodiesel is likely to be increasingly integrated into the soy complex, although this is often claimed to be provisional depending on the development of alternative non-food feedstocks. While the current crisis will dampen demand in the coming period, medium- and long-term demographic tendencies point to the continued shift to an animal protein diet in developing countries, which is likely to maintain demand for soy. In this context, we will see a persistent advance of large-scale soy production in Brazil with all the attendant social and environmental tensions.

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