ELLA
Evidence and lessons from Latin America

Energy insecurity in the 1970s led the Brazilian government to drive forward the development of the world's strongest national biofuels industry. So just how has Brazil become the world's largest producer of sugarcane ethanol and what lessons can the country's experience provide for other regions?

THE STORY OF BRAZIL'S ETHANOL PROGRAMME

SUMMARY

Launched in 1975, Brazil's ethanol programme, *Próalcool*, has propelled the country towards being the world's number one producer, user and exporter of sugarcane ethanol. *Próalcool* not only reduced national dependence on imported energy, it also bolstered the economy, created jobs and diversified the country's renewable energy portfolio. Many countries in Africa and Asia are dependent on imported energy and could consider cultivating fuel crops by learning from the Brazilian experience. The development of ethanol in Brazil was not flawless, however, and as such, other nations wishing to develop a biofuels market can avoid making the same mistakes by understanding the specific challenges and impacts of ethanol production in Brazil. This Guide begins by describing the main phases of ethanol production in Brazil, including an analysis of key government initiatives and some of the most important benefits to date. The following section then presents the social, economic and environmental impacts of biofuel production in Brazil, before discussing the prospects of second generation ethanol, a more environmentally-friendly biofuel. Finally, the Guide describes the main enabling factors behind ethanol production in Brazil and summarises key policy and practice lessons. Links to further reading and key organisations are also provided to guide readers to additional information.

COMMON PROBLEM: HOW TO ACHIEVE ENERGY SECURITY?

Many developing countries are dependent on imported oil. Energy powers economic development, and thus when supply is threatened or prices become prohibitively high, the functioning and growth of the economy can be directly affected. The main impacts on the economy are reflected in imbalances between internal and external accounts, rising inflation and unemployment and falling Gross Domestic Product (GDP). Until the 1980s Brazil found itself in this very position, with approximately 80%

KEY LESSONS LEARNED

The biggest biofuels programme in the world, Brazil's *Próalcool*, has had important successes including reducing dependence on oil imports, decreasing GHG emissions and creating jobs.

Government policies and incentives have been fundamental to stimulating and maintaining competitive ethanol production.

Negative environmental and social impacts of ethanol production must be tackled with innovative planning tools and strong enforcement measures.

Second generation ethanol offers the potential for significantly increasing productivity without the need for expanding cultivation, and may therefore be considered a more sustainable fuel option.

of oil consumed in the country coming from abroad.[1] With the oil crisis of 1973, the country dedicated itself to developing an ambitious biofuels programme, which improved energy security, stimulated the economy, and had the additional benefit of reducing greenhouse gases (GHG). Another major advantage of ethanol is that this fuel is compatible with existing technology, and can be stored, distributed and used in a very similar way to petrol.

Other developing countries with available land and suitable climatic conditions have the basic requirements with which to reduce energy insecurity and become better prepared to face future challenges. In these countries, investments in the production of renewable fuels can produce numerous additional advantages for the national economy, such as those mentioned for Brazil.

This Guide is the result of extensive research on the history of Brazilian ethanol. Data has been sourced from academic papers and reports from international institutions such as the International Energy Agency and the World Bank. In addition, data and charts have been sourced from the Brazilian government and private institutions such as the Energy Research Company (*Empresa de Pesquisa Energética* - EPE), the Ministry of Agriculture, Livestock and Food Supply (*Ministério da Agricultura, Pecuária e Abastecimento* - MAPA) and renowned biofuel journals.

THE BRAZILIAN ETHANOL EXPERIENCE – AN OVERVIEW

Forty years after the national ethanol programme was first implemented, Brazil is now known and respected worldwide for its success in producing and using ethanol, a renewable and versatile fuel. Today, Brazil is the largest producer and user of ethanol from sugarcane and is the biggest ethanol exporter in the world. As well as reducing petrol imports, this biofuel provides several benefits to the country, such as job and income creation, energy security, a cleaner energy profile and reduced GHG emissions. However, ethanol production in Brazil has also encountered some significant problems. Over the last five years, for example, ethanol production has become less competitive and, as a result, prices have risen and users are choosing to fill up with gasoline instead. In response, ethanol producers are calling on the federal government for tax breaks and financial aid to help restore the competitiveness of ethanol once again. The history, current situation and future of ethanol production in Brazil are described in the sections that follow.

Ethanol's Rise

In the face of rising international oil prices and the 1970s oil crisis, the government of Brazil organised a working group consisting of representatives from research institutions, the automobile industry, sugar refineries and ethanol distilleries,. This working group was responsible for creating a programme to leverage production and use of ethanol as a fuel with the principal objective of ensuring national energy security.

The result was the National Ethanol Programme (*Programa Nacional do Álcool – Proálcool*) which was launched in 1975.[2] *Proálcool* aimed to expand the production of ethanol from sugarcane, with the specific purpose of mixing it with gasoline as an alternative energy source to oil. Through the programme, the government provided subsidies, incentives and tax breaks in order to reduce the costs of production and increase the competitiveness of ethanol.

The programme was also intended to reduce income disparities within the country, expand production of capital goods and create jobs. For detailed information about public policies, government incentives to boost ethanol production and market reactions see the ELLA Brief: Government Intervention to Strengthen the Ethanol Sector: Lessons from Brazil.

Through this programme, Brazil was able to replace part of the national fuel quota derived from petroleum. Moreover, *Proálcool* strengthened the sugarcane sector by reactivating sugar for ethanol production in unused mills and distilleries. The national oil company, Petrobras, played an important role in the creation and consolidation of the infrastructure

[1] Brazilian Energy Research Company (Empresa de Pesquisa Energética – EPE). 2011. *Brazil Energy Balance 2012*. EPE, Rio de Janeiro.
[2] Decree number 76,593 of 14th November 1975.
[3] Biodieselbr. 2011. *PróAlcool – Programa Brasileiro de Álcool (PróAlcool - The Brazilian Ethanol Programme)*. Biodieselb, Online publication.

required for the *Proálcool* programme and for several years was in charge of buying, mixing and distributing ethanol country-wide.

Proálcool also helped to drive forward significant technological advances for both growing and processing sugarcane. One of the programme's major successes was the promotion of sectoral synergies whereby the technical expertise of major industries and research institutions were combined with support from government agencies in several key areas including technology, industrial policy, energy planning and agriculture.

A Second International Crisis and the Second Phase of *Próalcool*

After another international oil crisis during the 1970s, the Brazilian government decided to shift the focus of the second phase of the *Próalcool* programme from the production of ethanol as an additive (anhydrous ethanol), to a complete fuel (hydrous ethanol) for direct use in cars with appropriate engines. In 1979, the first commercial neat ethanol-powered car was launched in Brazil.

During the 1980s, most of the vehicles sold in the country were ethanol-fuelled models. In 1986, a record 700,000 ethanol-powered vehicles were licensed and ethanol production reached 12.3 billion litres, three times higher than in 1976.[3]

The Decadence of the Ethanol Industry

Reductions in international oil prices and increases in sugar prices in the international market at the end of the 1980s drove producers to redirect production away from ethanol. This led to severe shortages in ethanol supply between 1989 and 1990, with many people unable to buy fuel for their cars.

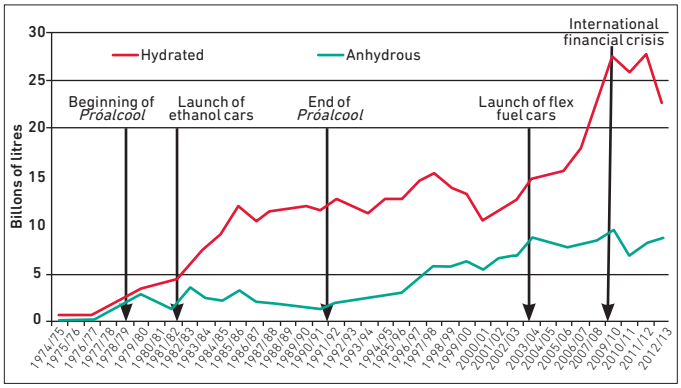
This crisis affected the credibility of *Proálcool*, as did subsequent reductions in government incentives for ethanol production, which pushed prices up even further. The result was a significant decrease in demand and, consequently, in the sales of cars powered by this fuel. Finally, the *Proálcool* programme was terminated in 1990.

A New Ethanol Era: The Advent of Flex Fuel Technology

In 2003, driven by energy security and global warming issues, the government of Brazil encouraged the development of flex fuel (FFV) technology which enables engines to run on any mix of ethanol or gasoline. Widely accepted by consumers, these vehicles boosted ethanol consumption in the domestic market, opening a new horizon for the expansion of the ethanol industry in Brazil. For more details on the flex fuel technology and its impact on the ethanol market see the ELLA Brief: Government Interventions to Strengthen the Ethanol Sector: Lessons from Brazil.

Since then, the purchase of FFVs increased at a dramatic pace. The share of FFVs in the total light vehicle market was 4.7% in 2003 and by 2011 83.1% of new cars sold in Brazil used flex fuel technology. As such, ethanol production grew from 11.5 billion litres in 2003 to its highest value to date of 28 billion litres in 2009.[4] Figure 1 below illustrates the growth of ethanol production in Brazil between 1975 and 2012.

Figure 1: Hydrated and Anhydrous Ethanol Supply in Brazil (billion litres)[5]



Source: Own elaboration adapted from Ministry of Agriculture, Livestock and Food Supply (*Ministério da Agricultura, Pecuária e Abastecimento* – MAPA). 2012. *Anuário Estatístico de Agroenergia – 2012* (Statistical Yearbook of Agrienergy – 2012). MAPA, Brazilia.

In May 2013, the Brazilian government announced the country's most recent public policy aimed at providing incentives to increase the competitiveness of ethanol production once again. The policy includes:

- Targets to increase anhydrous ethanol blend in gasoline from 20% to 25%[6]

[4] Energy Research Company (Empresa de Pesquisa Energética - EPE). 2012. *Análise de Conjuntura Econômica dos Biocombustíveis 2011 (Analysis of Economic Situation of Biofuels 2011)*. EPE, Rio de Janeiro.
[5] Hydrous ethanol is the liquid fuel generated from ethanol. It can be used as fuel in pure ethanol driven engines or in Flex Fuel Vehicles (FFVs). Anhydrous ethanol is the pure ethanol made through the process of dehydrating the hydrous ethanol. It is used as an additive to be blended with pure gasoline.
[6] Once anhydrous ethanol is more profitable than hydrated, the bigger the blend of anhydrous ethanol in gasoline and the higher the profits for the producers.

- Tax relief on ethanol to reduce production costs by up to US$0.05 per litre
- A reduction in the annual interest rate of credits for sugarcane production from 9.5% to 5.5%
- A cut in the annual interest rate for investments in ethanol storage from 10% to 7.7%

Although these measures are expected to reduce production costs, producers are not yet fully satisfied. They say these are short term policies that are insufficient to reduce ethanol prices at the pumps or stimulate new investments. Thus, for the time being, there is considerable uncertainty about the future of the ethanol market in Brazil.

The development of the ethanol sector is summarised in Table 1 below.

Table 1: Important Phases in the History of Brazilian Ethanol

Phase 1: 1975-1978	- *Proálcool* programme initiated - Ethanol and gasoline mixing begins with the so-called E20 blend (1 part ethanol to 4 parts gasoline) - Expansion of distilleries - Production of E20-powered cars by the automobile industry
Phase 2: 1979-1985	- Hydrous ethanol production initiated under *Proálcool* - Cars powered exclusively by hydrated ethanol launched on the Brazilian market
Phase 3: 1985-1990	- Hydrated ethanol consumption increases due to a significant increase in ethanol-driven vehicles. - Rises in international sugar prices and the end of ethanol subsidies
Phase 4: 1988-2001	- Deregulation of the sugar and ethanol sector marks the end of the government's direct intervention
Phase 5: 2002-2009	- Increasing oil prices - Global concern for GHG emissions - Development of flex fuel engines - Renewed expansion of ethanol production
Phase 6: 2008-2013	- International financial crisis and reduction in investments - New government incentives attempt to improve competitiveness of ethanol, but an uncertain future lies ahead

Source: Author's own elaboration based on Center for Strategic Studies and Management in Science, Technology and Innovation (CGEE). 2009. *Bioetanol Combustível: uma Oportunidade Para o Brasil (Bioethanol Fuel: An Opportunity for Brazil)*. CGEE, Brasília.

Due to these developments, Brazil has become a global benchmark for sugarcane-based ethanol production. Today the country is the world's biggest producer, consumer and exporter of sugarcane ethanol. In 2011, Brazilian ethanol exports reached two billion litres, with principle markets in the United States, the European Union and Japan.[7]

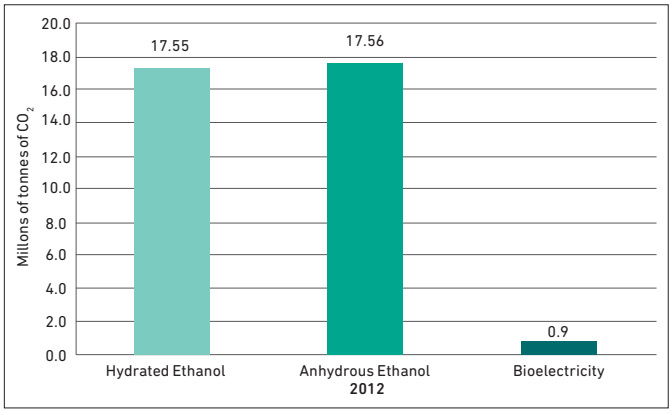
BENEFITS OF ETHANOL

Since 2003, the Brazilian government has shown a growing interest in maintaining and reactivating *Proálcool* as a key strategy to meet commitments under the Framework Convention of the United Nations on Climate Change and to drive transition towards a more sustainable development pathway. Indeed, since the implementation of *Proálcool*, ethanol production has yielded several important benefits for the country.

Reduces GHG emissions

Sugarcane ethanol is considered a renewable fuel because it requires only a small amount of fossil fuel for production.[8] Because of high yields in sugarcane production and high efficiency in biofuel conversion processes, the utilisation of sugarcane-based bioethanol significantly reduces GHG emissions when compared with the use of fossil fuels (gasoline) in cars with similar characteristics. Recently, the United States Environmental Protection Agency (EPA) issued a statement classifying sugarcane ethanol as an advanced biofuel as its use as a fuel results in a 61% reduction in CO_2 emissions compared to gasoline.[9] This is because the CO_2 released from the burning of ethanol in vehicles was absorbed via photosynthesis by the sugarcane plants as they grew. Furthermore, when compared to ethanol produced from other feedstocks, sugarcane ethanol demonstrates a very favourable GHG emissions balance. The use of ethanol has made significant contributions to reducing GHG emissions in Brazil. In 2012, for instance, the use of ethanol as carburant fuel in Brazil instead of gasoline avoided the release of 35 million tonnes of CO_2 (Figure 3).

Figure 3: CO_2 Emissions Avoided in 2012 (million tonnes)



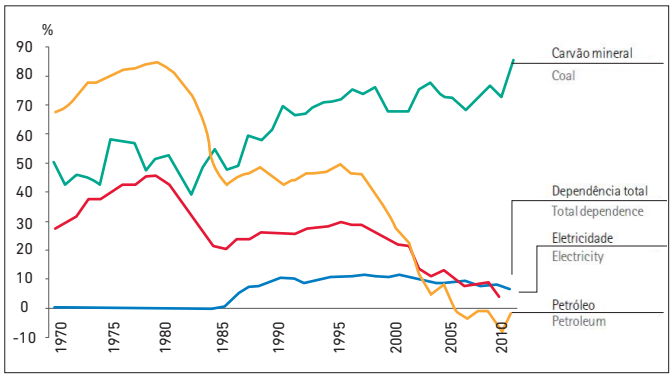
Source: Energy Research Company 2013, see n4 above.

[7] Brazilian Energy Research Company (Empresa de Pesquisa Energética – EPE). 2010. *Plano Decenal de Expansão de Energia (Brazilian Ten Year Energy Plan)*. EPE, Rio de Janeiro.
[8] Goldemberg, J., Coelho, S., Guardabassi, P. 2008. The Sustainability of Ethanol Production from Sugarcane In: *Energy Policy* 36 2086-2097.
[9] Environmental Protection Agency. 2010. Part II - Regulation of Fuels and Fuel Additives. Changes to Renewable Fuel Standard: Final Rule. In: *Federal Register* 75 (58).

Strengthens energy security

Since Brazil is not self-sufficient in producing adequate gasoline to meet domestic demand, it is very important to complement and diversify the transportation energy mix with national sources. The bigger the share of a domestically sourced fuel (in this case ethanol) in the energy matrix, the less reliant the country is on fuel imports and the more resistant it is to external shocks. Figure 4 shows that Brazil reduced its external fuel dependence at the same time as launching the second phase of *Proálcool*. This becomes clearer when compared to Figure 1 above. Brazilian dependence on imported oil (yellow line in Figure 4) decreases substantially when hydrated ethanol production (red line in Figure 1) increases considerably.

Figure 4: Brazilian Dependence on Energy Imports



Source: Energy Research Company (Empresa de Pesquisa Energética - EPE). 2012. *Balanço Energético Nacional 2012 (Brazilian Energy Balance 2012)*. EPE, Rio de Janeiro.

Besides reducing vulnerability to oil price volatility, producing and using ethanol also results in foreign exchange savings from buying gasoline or petrol.

Boosts GDP and generates employment

The ethanol economy boosts several sectors linked to this biofuel, such as capital goods for mill construction, investments in development and innovation and the entire agro-industrial market chain for ethanol production. According to the Brazilian Sugarcane Journal (*Jornal da Cana*)[10], sugarcane production for sugar ethanol and bioelectricity was worth US$60 billion between 2010 and 2011, approximately 1.6% of national GDP. In the same period, investments in sugarcane production reached US$4.7 billion and generated 4.5 million jobs (directly and indirectly). Furthermore, the sugarcane industry encompassed 72,000 independent producers, generated US$12.5 million in exports and paid US$7.5 million in taxes.

CONTENTIOUS ISSUES IN ETHANOL EXPANSION

Despite being renewable and clean compared to fossil fuels, sugarcane ethanol can generate several negative impacts throughout its lifecycle. These include environmental impacts from the use of land (leading to deforestation and degradation), competition with food crops, air pollution and health risks from harvesting and processing techniques, and poor working conditions. This section explores each of these in turn.

Environmental impacts

One of the biggest threats posed by the expansion of agricultural land to cultivate crops is the irreversible conversion of virgin ecosystems. Deforestation, for example, can cause the extinction of species and their habitats, as well as the loss of ecosystem functions such as production of biomass and conservation of genetic diversity. Wide-scale destruction of forests can also affect the hydrological cycle and the local climate, leading to reductions in regional precipitation and increases in regional temperatures. In general, the impacts of sugarcane expansion in areas previously used for other productive purposes (i.e. land-use change) are lower than the impacts of planting in virgin areas, especially forests.

Unfortunately, due to a lack of enforcement of national laws aimed at preserving native vegetation, the expansion of farmland for sugarcane production over recent decades has led to wide-scale deforestation in Brazil. Land currently used for sugarcane plantations is mainly located in areas that were once occupied by the Atlantic Forest. Today, less than 13% of the original forest remains intact and this is now protected by law.[11]

The ELLA Brief: Sugarcane Agro-Ecological Zoning: Greening the Expansion of Ethanol provides a review of the environmental impacts associated with the expansion of sugarcane for ethanol production in Brazil.[12] The Brief also provides an overview of government policies to control the expansion of sugarcane production in Brazil, including the

[10] Jornal da Cana. 2012. Números do Setor Sucroenergético (Numbers From the Sugarcane Industry). *Jornal da Cana*. Online Publication.
[11] SOS Atlantic Forest. (No date). A Mata Atlântica (The Atlantic Forest). *SOS Atlantic Forest*. Online publication.
[12] With the introduction of flex fuel vehicles that can be filled up with gasoline, ethanol or a combination of both, land expansion for ethanol production in Brazil has been considerable since 2005.

creation and application of the National Agro-Ecological Zoning of Sugarcane (*ZAE Cana*). *ZAE Cana* is a policy instrument used by the government to plan the sustainable expansion of sugarcane production according to specific criteria such as potential output and irrigation requirements. To avoid and reduce environmental harm, certain areas that are considered environmentally fragile have been excluded from the zoning, meaning that sugarcane crops are now strictly forbidden there.[13]

Aside from deforestation, other environmental impacts of sugarcane cultivation, harvesting and processing include soil degradation, biodiversity loss, intense water use, water contamination, atmospheric emissions and massive waste generation. When the *Próalcool* programme began, environmental institutions, legislation and public management linked to biofuels were all weak, and thus were unable to stop significant environmental harm from being caused. Over recent years, efforts have been made to reduce environmental impacts due to greater ecological concern and the design of a specific framework for biofuels and the environment. For more details, see the ELLA Brief: Brazil's Efforts to Mitigate the Environmental Impacts of Ethanol Production.[14]

Another major environmental concern is related to the practice of pre-harvest burning, which involves burning the spikey voluminous leaves of the sugarcane plant in order to speed up manual harvesting and reduce injuries suffered by cutters. More information on this can be found in the ELLA Brief: From Manual to Mechanical Harvesting: Reducing Environmental Impacts and Increasing Cogeneration Potential. Through the government's Green Protocol, this technique is gradually being replaced with mechanised harvesting, which is good news for the environment but will inevitably result in job losses for labourers.

Impacts on the workforce

Many people are economically dependent on the sugarcane industry,[15] with the majority of employment opportunities being low-income, seasonal positions associated with manual harvesting. This kind of manual work generally consists of 8 to 12 hours of cutting and carrying sugarcane stalks, while inhaling dust and smoke from the burned residue. To cut ten tonnes and earn US$20 per day, it is necessary to walk approximately five kilometres and make around 67,000 movements with a machete. At such a pace, the average cutter earns an average of US$2 per tonne of sugarcane collected.[17]

In addition, basic working conditions such as clean water, toilets and food storage facilities are usually lacking in sugarcane fields.[18] Due to the seasonal nature of the work, many of the workers are migrants who have no alternative but to reside in inadequate lodgings during the harvest season.[19]

As previously mentioned, pre-harvest burning is slowly being eradicated with the adoption of mechanised harvesting techniques and this is increasing unemployment among manual labourers. On average, one mechanical harvester replaces 100 workers,[20] and as such thousands of unskilled workers have lost their jobs over recent years.[21]

At the same time, the threat of unemployment leads to the acceptance of poor working conditions, including long working hours, a lack of protective equipment, inadequate meals, unsafe transportation, high exposure to soot and dust, risk from pesticide poisoning and the development of repetitive-strain injuries.[22]

To reduce problems related to working conditions, the Brazilian government ratified the International Labour Organization's recommendations which forbid the most precarious forms of labour (including child labour) and set minimum standards

[13] The Amazon Pantanal and Upper Paraguay River Basin are the two areas designated as off-limits for ethanol crops.
[14] This Brief also provides information on specific policies for reducing environmental impacts, such as Sugarcane Agro-Ecological Zoning, the Green Protocol, water fees and licensing requirements, among others.
[15] Jornal da Cana 2012, see n11 above.
[16] Rodrigues, A. 2006. *O Corte: Como Vivem e Morrem os Migrantes nos Canaviais de São Paulo (The Cut: How Migrants Live and Die in São Paulo's Plantations)*. Instituto Superior de Ciencias Aplicadas, Limeira.
[17] De Oliveira, C. 2013. Cortadores de Cana a Doecem e Morrem por Conta de Pagamento por Produção (Sugarcane Cutters Get Sick and Die on Account of Payment for Production). *Revista Forum*, Online publication.
[18] Martinelli, L. and Filoso, S. 2008. Expansion of Sugarcane Ethanol Production in Brazil: Environmental and Social Challenges. In: *Ecological Applications* 18 (4) 885-898.
[19] Costa, C., and Neves, C. S. 2005. *Super Exploracão do Trabalho na Lavoura de Cana-de-Acúcar (Over Exploitation of Cane Sugar Crop Labourers)*. In: Rodriguez, M. E. (Ed.). *Relatorias Nacionais em Direitos Humanos Econômicos, Sociais, Culturais e Ambientais. Informe 2005 (National Rapporteurs on Economic, Social, Cultural and Environmental Affairs. 2005 Report)*. Plataforma DhESCA, Rio de Janeiro.
[20] Guilhoto *et al.* 2001. *Emprego e Mecanização na Colheita da Cana de Açúcar: Diferenças Regionais (Employment and Mechanisation in the Sugarcane Harvest: Regional Differences)*. Unpublished manuscript.
[21] Correio do Brasil. 2011. Desempregados pela Mecanização, Ex-cortadores de Cana Ingressam em Luta pela Terra (Unemployed by Mechanisation. Former Cane Cutters Join in the Struggle for Land) *Correio do Brasil*, Online publication.
[22] Smeets, E. *et al.* 2008. The Sustainability of Brazilian Ethanol: An Assessment of the Possibilities of Certified Production. In: *Biomass and Bioenergy* 32(8) 781-813.

for physically demanding jobs. The Brazilian government has also intensified inspections of working conditions in sugarcane production through the Special Mobile Inspection Group of the Ministry of Labour and Employment. However, inspections are still not of adequate standard and violations of workers' rights continue to be reported.[23]

Every year several mills are prosecuted because of evidence of bad treatment of workers. At least 60 of the 169 mills certified by the government as "committed companies" are currently responding to reports of irregularities related to labour issues.[24] The "committed companies" certification is a government initiative to improve working conditions in manual cultivation of sugarcane and represents an effort to promote the sale of Brazilian ethanol abroad as a sustainable and socially responsible product. The certification is granted based on best practices identified by a tripartite commission, which includes producers, workers and the government.

The debate about competition between food and fuel

The expansion of production of feedstock for energy purposes may represent a change in the use of land traditionally set aside for food production. Many farmers are tempted into switching to energy crops in order to make higher profits, however this can have a negative effect on food supply.[25] And in fact this raises a global dilemma - the need to feed the world's population versus a growing energy demand that can partially be met by using land to produce fuel rather than food crops. It is clear, therefore, that two important factors that can determine the impacts of sugarcane production on local and global food security are the choice of feedstock and the nature of public policies.

Recent studies have found that the emergence of agro-energy has altered land use dynamics, albeit not yet significantly, with a shift of areas traditionally used to grow foods over to crops to produce biofuels.[26] This has contributed to raising food prices by between 15% and 75%.[27] In an important sugarcane growing area in western São Paolo, Brazil, the doubling in land prices between 2002 and 2005 suggests an indirect impact on food prices.[28] Brazilian sugarcane ethanol has not contributed directly to rises in prices of agricultural commodities, however, because while energy demand grew, sugarcane production increased fast enough to meet the demand for both sugar and ethanol.[29]

Although indirect impacts of sugarcane production on food supply do exist in Brazil and are important, they are still small in magnitude. Also, the structure of Brazilian mills is flexible enough to produce both sugar and ethanol. Even when the price of ethanol rises, the mills allocate a maximum of 60% of sugarcane to ethanol production. So, in Brazil, producing ethanol does not mean making a choice between biofuel and food. Thus, Brazil finds itself at an advantage in comparison to other countries such as the USA, where the corn used to produce ethanol is unfit for human consumption.

SECOND GENERATION ETHANOL: PERSPECTIVES ON A MORE SUSTAINABLE BIOFUEL

Due to the exhaustion in productivity of traditional sugarcane plantations, increasing biofuel production implicitly requires increasing land use. As previously mentioned, this can potentially result in greater pressure on virgin forest cover and inflation in food prices. In an attempt to avoid these negative impacts while at the same time meet targets for substituting oil derivatives and for reducing GHG emissions, the Brazilian government boosted the development of an advanced, more efficient type of ethanol; the so-called second generation ethanol.

Second Generation Ethanol

Second generation biofuels are produced from residual non-food parts of crops, such as stems, leaves and husks, as well as other crops that are not used for food purposes, such as switchgrass, Jatropha and Miscanthus, and cereals that bear little grain. Industry waste such as wood chips, skins and pulp from fruit pressing and other organic waste can

[23] Goldemberg J., Coelho S., Guardabassi P. 2008. The Sustainability of Ethanol Production from Sugarcane In: *Energy Policy* 36 2086-2097.
[24] Rodrigues, L. 2012. Compromisso para Gringo Ver (Fake Commitment). *O Globo Economica*, Online Publication.
[25] Johansson, D., Azar, C. 2007. A Scenario Based Analysis of Land Competition Between Food and Bioenergy Production in the US. In: *Climate Change* 82 267-291.
[26] Rathmann, R., Szklo, A., Schaeffer R. 2010. Land Use Competition for Production of Food and Liquid Biofuels: An Analysis of the Arguments in the Current Debate. In: *Renewable Energy* 35 (1) 14 -22.
Oberling, D. 2008. *Avaliação Ambiental Estratégica da Expansão de Etanol no Brasil: Uma Proposta Metodológica e sua Aplicação Preliminar (Strategic Environmental Assessment of the Ethanol Expansion in Brazil: A Methodological Proposal and its Preliminary Application)* MSc dissertation. Federal University of Rio de Janeiro, Rio de Janiero.
[27] Sims, R. E. H. *et al.* 2009. An Overview of Second Generation Biofuel Technologies. In: *Bioresource Technology* 101 (2010) 1570 -1580.
Mitchell, D. 2008. *A Note on Rising Food Prices*. World Bank, Washington, DC.
[28] Smeets *et al.* 2008, see n22 above.
[29] Mitchell 2008, see n27 above.

also be used.[30] Since they can be generated from virtually any biomass, second generation biofuels offer important advantages, such as:

- Low input costs
- Mass availability
- The possibility of using marginal land without threatening food production
- Increases in agricultural productivity
- Reduction of waste
- Lower GHG emissions

Second generation ethanol is therefore expected to improve the overall sustainability of ethanol production given the additional benefits it can provide.

Although technology for second generation ethanol already exists and the inputs are relatively cheap, industrial processes are still incipient and thus prohibitively expensive. Through a joint plan with the Brazilian Development Bank (*Banco Nacional de Desenvolvimento Econômico e Social* – BNDES) and the Brazilian Financing Agency for Studies and Projects (*Financiadora de Estudos e Projetos* – FINEP), the Brazilian government has developed initiatives to reduce costs and increase the competitiveness of advanced ethanol. The most import initiative, known as Support for Technological Innovation and Industrial Sugarcane Sectors Sucroquímico (PAISS), was launched in 2011. It provides US$1 billion for the development of production and trading of new technologies for industrial processing of biomass derived from sugarcane to produce second generation ethanol.

Despite this potential, if second generation ethanol becomes competitive in Brazil, it is likely it will raise issues about the trade-off between using sugarcane bagasse as feedstock for advanced ethanol or for cogeneration. As described in the ELLA Brief: From Manual to Mechanical Harvesting: Reducing Environmental Impacts and Increasing Cogeneration Potential, using bagasse for cogeneration is strategic for Brazil because it can complement shortfalls in hydroelectricity supply, since sugarcane harvesting takes place during Brazil's central-southern region's dry season. Consequently, the decision about whether to use bagasse as feedstock for ethanol or for cogeneration will not only depend on a cost-benefits analysis, but will also have to consider national energy supply.

[30] International Energy Agency (IEA). 2008. *From 1st to 2nd Generation Biofuel Technologies: An Overview of Current Industry and RD&D Activities*. IEA, Paris. Kristoufeka, L., Jandaa, K., Zilbermane, D. 2012. *Relationship Between Prices of Food, Fuel and Biofuel*. Paper prepared for presentation at the 131st EAAE Seminar 'Innovation for Agricultural Competitiveness and Sustainability of Rural Areas', Prague, Czech Republic, September 2012.

CONTEXTUAL FACTORS

ENABLING THE INCEPTION OF THE BIGGEST ETHANOL PROGRAMME IN THE WORLD

Although *Proálcool* was launched during a military regime, it was well accepted by civil society and the private sector since it was expected to increase the Brazilian GDP through job generation, agribusiness strengthening and foreign currency exchange. Since the mid-1970s, the Brazilian government has provided significant backing to improve ethanol competitiveness through favourable pricing policies and financial incentives. Likewise, partnerships between research centres and universities for technology development and transfer have helped to improve the efficiency of ethanol production processes. The national oil company, Petrobras, facilitated the mixture, distribution and sale of ethanol, and was also fundamental to building the logistics network.

The growth in sugarcane and ethanol production raised concerns within the government and civil society about the environmental impacts. Many years after the inception of the *Proálcool* programme, international and domestic institutions began to pressure the Brazilian government to develop and implement policies to mitigate these problems and ensure a more sustainable pathway for future biofuel production. The government's response included mandatory environmental assessments for ethanol licensing, an agreement to phase out the practice of pre-harvest burning and an agro-ecological policy tool for planning and delineating the expansion of sugarcane. Public-private partnerships have also supported the adoption of environmentally friendly practices in ethanol production.

Similarly, the negative impacts related to land use expansion for first generation ethanol have boosted investments in research and development for second generation biofuels from sugarcane which appear to hold considerable promise.

CONCLUSION

Large-scale consumption of ethanol has turned Brazil into a world benchmark in low carbon technology for transport and has enabled the country to save millions of tonnes of GHG emissions by replacing gasoline with a renewable fuel. The Brazilian model for ethanol production has not only improved national energy security and reduced external debts, it is also providing an important source of employment and GDP.

Despite these benefits, it must be acknowledged that ethanol production in Brazil continues to have serious social and environmental impacts that have not yet been adequately addressed by government policy or the private sector.

Furthermore, the ethanol sector has managed to survive thanks in large part to government incentives. Due to many external and internal factors, the private sector has never been able to maintain sustainable levels of production and this represents a serious risk to long-term energy security.

Today, public expenditure on biofuels and environmental management are two key issues being flagged by civil society and international institutions, and require urgent measures in order for the ethanol market to keep on growing in a sustainable manner.

KEY POLICY AND PRACTICE LESSONS

The Brazilian experience of ethanol production provides several important lessons about what to do and what to avoid when creating and strengthening a biofuels industry.

1. The Brazilian biofuels programme, *Próalcool*, boosted ethanol production on a large scale, reducing Brazilian dependence on oil imports, reducing energy insecurity and economic constraints as well as increasing the share of renewables in the energy matrix.

2. The government was, and still is, the main actor behind the success of ethanol in Brazil. Through key measures including mandatory blending policies, financial incentives aimed at increasing the competitiveness of ethanol, and partnerships with the private and research sectors, the Brazilian government created and consolidated the biggest sugarcane ethanol market in the world.

3. Producing ethanol has generated a wide range of negative environmental impacts in Brazil. Civil society pressure and government response through a wide array of public policies has succeeded in reducing negative impacts from harvesting and production. However, further measures are required in order to mitigate and reduce future impacts likely to arise from increasing global demand.

4. Sugarcane agro-ecological zoning is an important policy tool for planning sugarcane expansion and protecting the environment. This tool was developed 30 years after the beginning of the *Proálcool* programme. Had this been done earlier, it would have protected large areas of native forests from deforestation and degradation.

5. Replacing gasoline with ethanol reduces GHG emissions, both through the absorption of CO_2 during sugarcane plant photosynthesis and through the reduction of CO_2 emissions from ethanol-powered engines.

6. The launch of flex fuel vehicles, which can be fuelled with any mix of ethanol or gasoline, GHG emissions from Brazilian vehicles have been reduced significantly. However, consumers have shown themselves to be very sensitive to price changes. As ethanol loses competitiveness and becomes more expensive, consumers shift to gasoline, regardless of the environmental disadvantages.

7. Despite lowering GHG emissions, ethanol production has negative social and economic impacts. Low wages, bad work conditions and child labour are among the main problems created by the sugarcane industry in Brazil and should be urgently addressed with adequate policy and enforcement measures.

8. Second generation ethanol has the potential to significantly increase sugarcane productivity without the need for expanding cultivation areas. Second generation biofuels therefore show the potential for avoiding many of negative environmental impacts observed in the production of traditional ethanol, and thus may be considered a more sustainable fuel option.

KNOWLEDGE PARTNERS

Below is a sample of some of the most influential organisations researching and working on biofuel production and consumption and its impacts in Brazil and worldwide. For additional information about these and other organisations, read the ELLA Spotlight on Organisations: Brazil's Ethanol Programme.

The Brazilian Reference Centre on Biomass (CENBIO/IEE/USP) was established with the main goal of conducting research and disseminating scientific, technological and economic information on the use of biomass as an efficient energy source in Brazil. To achieve this, CENBIO has focused on developing studies and projects on biomass, as well as promoting exchange between Brazilian and foreign institutions on the economic, social and environmental impacts of biomass technology. The centre also publishes the Brazilian Journal of Bioenergy and many of its publications are available in English.

The Brazilian Bioethanol Science and Technology Laboratory (CTBE) is a national laboratory that contributes to developing sustainable production of Brazilian ethanol from sugarcane by investing in scientific research and technological innovation. Studies cover the sugarcane lifecycle and focus on industrial technologies for improving feedstock and conversion. The CTBE partners with other research organisations working in related areas through a network of associated laboratories in universities and research institutes.

The Industry Association for Energy Cogeneration (COGEN) is a not-for-profit and independent civil society group established in 2003 to encourage energy cogeneration projects and diversification of the Brazilian energy matrix through more efficient, cleaner and cheaper energy options. COGEN aims to create an appropriate environment to enable an increase in the supply of bioelectricity to the regulated market and the free market. The association conducts studies on alternative access and connection to the grid, seeking to rationalise costs, and focuses on creating and refining mechanisms to promote and trade bioelectricity.

The Biofuel Watch Centre is a programme run by the organisation *Repórter Brasil*, whose mission is to raise awareness of the social and environmental impacts of crops used to produce biofuels in Brazil. The Biofuel Watch Centre works to create mechanisms to strengthen the capacity of the government and civil society to control and supervise damage caused by biofuel production.

The Renewable Energy Policy Network for the 21st Century (REN 21) is a global multi-stakeholder network that convenes international leaders from the public, private and civil society sectors with the aim of increasing the share of renewable energy in the world energy matrix. REN 21 provides policy-relevant information and research-based analysis on renewable energy driven by concerns for climate change, energy security and poverty alleviation. To achieve its objectives, REN 21 encourages action in three key areas: policy, advocacy and exchange. Through reports and interactive maps, REN 21 provides important information about ethanol in Brazil, as well as in countries across Africa and Asia.

RECOMMENDED READING

The following is a selection of some of the key publications related to Brazil's ethanol programme. For more information about these and other publications, see the ELLA Spotlight on Publications.

Almeida, M. 2012. *Analysing the Brazilian Sugarcane Agro-ecological Zoning: Is this Government Policy Capable of Avoiding Adverse Effects from Land-use Change?* MSc dissertation, Victoria University of Wellington.

Carvalho, L.C.C. 2007. Ethanol: A Brazilian Successful Story. In: WROBEL, P. (ed). *Clean Energy: The Brazilian Ethanol Experience*. London, UK.

Hofsetz, K., Silva, M. 2012. Brazilian Sugarcane Bagasse: Energy and Non-energy Consumption. In: *Biomass and Bioenergy* 46 564-573.

National Development Bank (BNDES) and Centre for Strategic Studies and Management in Science, Technology and Innovation (CGEE). 2008. *Sugarcane-Based Bio-ethanol: Energy for Sustainable Development*. BNDES, Rio de Janeiro.

Padula, A. *et al*. 2011. *Sustainability, Certification and Internationalisation of Brazilian Ethanol*. Paper presented at the International Food and Agribusiness Management Association (IFAMA) 2011 Annual World Symposium, 20-21 June 2011, Frankfurt.

Rathmann, R., Szklo, A., Schaeffer, R. 2010. Land Use Competition for Production of Food and Liquid Biofuels: An Analysis of the Arguments in the Current Debate. In: *Renewable Energy* 35 (1) 14-22.

Schaffel, S., La Rovere, E. 2010. The Quest for Eco-social Efficiency in Biofuel Production In Brazil. In: *Journal of Cleaner Production* 18 1663-1670.

LEARN MORE FROM THE ELLA BRIEFS

These four ELLA Briefs provide analysis of some the most important issues related to Brazil's ethanol programme.

From Manual to Mechanical Harvesting: Reducing Environmental Impacts and Increasing Cogeneration Potential

Mechanisation of sugarcane harvesting in Brazil has been shown to decrease environmental impacts and waste, while also increasing efficiency, energy cogeneration and thus sector profits and national energy security. Learning from Brazil's years of trial-and-error, other countries could build an ethanol production system with these benefits.

Brazil's Efforts to Mitigate the Environmental Impacts of Ethanol Production

As the sustainability of ethanol production continues to be a hot question, Brazilian attempts to improve an environmentally inefficient production process could provide pointers for those dealing with similar challenges in other countries.

Government Intervention to Strengthen the Ethanol Sector: Lessons from Brazil

The scale of Brazil's ethanol production, demand and competitiveness is largely attributable to government initiatives. The varying levels of success of such initiatives can provide interesting lessons for other countries.

Sugarcane Agro-ecological Zoning: Greening the Expansion of Ethanol

As ethanol production becomes increasingly lucrative, how can nations ensure that expansion is environmentally sustainable? Brazil's experiment with sugarcane agro-ecological zoning may provide some answers.

CONTACT SSN

To learn more about Brazil's experience with agro-ecological zoning in the ethanol industry, contact the author, Pedro Ninô de Carvalho, Researcher at the Environmental Sciences Laboratory (LIMA) of the Federal University of Rio de Janeiro, at pnino22@ppe.ufrj.br.

FIND OUT MORE FROM ELLA

To learn more about Brazil's experience with ethanol, read the rest of the ELLA knowledge materials on this theme. To learn more about other ELLA development issues, browse other ELLA Themes.

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