Biofuels production, trade and sustainable development

Annie Dufey and Maryanne Grieg-Gran (editors)

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Glossary

Bagasse – Used as a biofuel. Bagasse is the fibrous residue remaining after crushing sugarcane or sorghum stalks.

Biodiesel –Vegetable or animal based diesel fuel. It is a form of renewable energy.

Bioethanol – Produced from agricultural feedstocks by the sugar fermentation process. It is a form of renewable energy.

Cellulosic biothanol – Biofuel produced from non-edible parts of plants, wood or grasses.

Denatured alcohol – also known as methylated spirits. It is mainly used as a household solvent and as a fuel for many different industrial uses. It is undrinkable.

Diesel No.2 – Diesel road fuel.

ETBE – Ethyl tert-butyl ether is a gasoline additive used to raise the octane number of gasoline. It is far less polluting that MTBE.

Ethanol – Also known as ethyl alcohol. Involves the fermentation of sugar from non-renewable sources.

Fischer-Tropsch process – a process that converts gas to liquids. It produces a petroleum substitute.

Gasoline (US term) – Petroleum-derived liquid used mainly as road fuel.

Glycerol – A byproduct of biodiesel.

Hydrous bioethanol versus anhydrous bioethanol – Anhydrous alcohol is purer than hydrous bioethanoal and is free from water. This ethanol may be used in fuel blends. Hydrous alcohol contains water.

MTBE – Methyl tert-butyl ether is a gasoline additive used to raise the octane number of gasoline although it is major pollutant and is banned in many places.

Petrol (UK term) – Petroleum-derived liquid used mainly as road fuel.

Ratoon – Stubble crop.

Syngas/synfuel – Synthetic liquid fuel that can be made from biomass.

The various mixes, e.g. B2, B5, E8, E10, E20, E25, E85 – B means biodiesel, E means bioethanol and the number represents the percentage of the relevant biofuel within the mix. It may also be referred to in a ratio form e.g 10:90 ratio is E10 fuel.

Vinasse – byproduct of sugar fermentation process.

Chapter 1

Introduction

The last five years have seen the emergence and growth of the biofuel sector and its growth into a global industry. Indeed, global biofuel production in 2007 was estimated to be over 54 billion litres, (calculated from REN 2007), accounting for 1 per cent of the fuel in the transport sector (IEA 2008). Many countries, low-, middle-income and rich, have implemented ambitious targets and policies to promote significant biofuel industries. In industrialised countries, the main driver of biofuel growth has been the concern to reduce greenhouse gas (GHG) emissions. In contrast, low- and middle-income countries have seen biofuels as a way of addressing a number of goals including greater energy security, promotion of exports and rural development. Liquid biofuels can be produced from a wide range of agricultural and forest products that often are an important part of the agricultural sector in low- and middle-income countries. Sugar and cereal crops such as sugarcane and maize are important for bioethanol while oilseeds crops such as soya, palm oil and coconut are the feedstocks for biodiesel (see Box 1). Biofuels therefore appear to present attractive opportunities for low- and middle-income countries. According to the Food and Agriculture Organization's (FAO) State of Food and Agriculture Report 2008, feedstocks for liquid biofuels are the largest source of new demand for agricultural products and will have a significant effect on markets in the next decade and beyond.

Yet this rapid growth in biofuel production has not been without controversy as concerns have been raised by a wide range of stakeholders (environmental non-governmental organisations (NGOs), indigenous peoples' groups, and community development organisations) about the environmental and social impacts of biofuel production. As with other agricultural commodities produced on a large scale, biofuels are associated with the environmental problems of intensive agriculture, high use of water, pollution impacts of agrochemical use, soil erosion and biodiversity loss. In particular, the expansion of palm oil and soy to meet biofuel demand has been singled out as a major driver of deforestation in Asia and Latin America. Some studies have questioned the climate change mitigation benefits of biofuels given the energy requirements for feedstock cultivation and processing.

From a social point of view, the impact of biofuel expansion on food prices and its effects on food security has been particularly controversial. A number of studies have examined the impact of biofuel production on food prices, producing estimates ranging from as little as 3 per cent to as much as 75 per cent, but with a median range of 30-40 per cent for maize and somewhat less for other basic commodities (FAO 2009). There are also concerns that rapid expansion of commercial biofuel production in contexts of unclear land tenure will lead to displacement of the poor from the land on which they depend. Evidence that this is happening in some areas is given in Cotula *et al.* (2008) although promising approaches to prevent such effects are also identified.

From an economic perspective, concerns have been raised about the cost-effectiveness of some biofuel support policies (OECD 2008). As a consequence, enthusiasm for biofuels amongst policymakers has waned, and some countries have drawn back from ambitious biofuel development. In the midst of this backlash against biofuels it is easy to conclude that they are high risk and that the best option for low- and middle-income countries is to avoid them altogether. But the reality is more complex. There are social and environmental risks associated with biofuels but, as FAO (2009) points out, there are also considerable advantages for low- and middle-income countries to nurture and expand their biofuel industries. Indeed IEA Bioenergy (2008) concludes these potential drawbacks do not necessarily rule out biofuels as an option, as long as they can be produced in a way that decreases poverty and does not have a negative effect on biodiversity.

It is also unlikely that low- and middle-income countries can achieve all the policy goals identified to the same degree for a biofuel strategy, so choices have to be made. Much depends on the type of feedstock, the context and, perhaps most important, the policy framework that producing and consuming countries put in place. It is therefore important to avoid generalisations and to examine each case on its merits, taking account of the site-specific factors.

This book presents case studies from Pakistan, Costa Rica, South Africa and Ecuador that give a low- and middle-income country perspective on the potential for biofuel development. The focus is on the transport sector as this is the main use of liquid biofuels but co-benefit possibilities for use in domestic lighting, cooking and heating are noted. Each case study, prepared by experts from each of the four countries, examines the potential for developing the biofuel sector in the national context, explores the trade-offs for economic development and the sustainable development implications. These countries were chosen because they all are significant producers of one or more of the main feedstock crops for bioethanol or biodiesel, and because they are small or medium size. Their current level of biofuel development is small or incipient and their governments are currently faced with the task of developing an appropriate enabling policy framework. By focusing on particular feedstocks in particular contexts, the case studies demonstrate the complexities in predicting the range of impacts and designing policies to guide and promote biofuel development.

Box 1: Bioethanol and biodiesel

Bioethanol: Alcohol produced by fermenting and then distilling sugars from sugar-rich plants (e.g. sugarcane, maize, sugar beet, cassava, wheat and sorghum). The alcohol is then purified to remove water. Both anhydrous bioethanol (less than 1 per cent water) and hydrous bioethanol (1–5 per cent water) can be used in a pure form as fuel, but they are usually blended with petrol before use. Blends of 5–10 per cent of bioethanol in gasoline (named E5 and E10 respectively) do not require any modification to the vehicle engine either. Work is now underway to develop a 'second generation' of bioethanol, based on cellulose. This technology will allow almost any plant biomass to be used as feedstock, including forestry products (e.g. short rotation coppices), sawmill wastes, crop residues (e.g. stalks, leaves and husks), energy grasses (e.g. switch grass) and macro algae, as well as industrial and domestic wastes. The most promising second generation technology for bioethanol is enzymatic hydrolysis (Dufey *et al.* 2007).

Biodiesel: Produced from the reaction of vegetable oil with alcohol in the presence of a catalyst to yield mono-alkyl esters and glycerine, which is then removed. The oil comes from oily crops or trees (e.g. rapeseed, sunflower, soya, palm, coconut or jatropha), but also from animal fats, tallow, and waste cooking oil. Some types of biodiesel can be used unblended or in high-proportion blends if vehicle engines are modified. A blend of 5 per cent biodiesel in regular diesel is denominated as B5.

Chapter 2 by Shaheen Rafi Khan, Moeed Yusuf, Selina Adam Khan and Reza Abbasy focuses on sugarcane bioethanol in Pakistan. It provides a preliminary assessment of the production potential of energy crops in Pakistan and the foreign exchange benefits in terms of savings from reduced fossil fuel imports and earnings potential from biofuel exports. It then analyses the sustainable development implications of increased biofuel production and trade. The chapter concludes by proposing anticipatory policy measures to help maximise sustainable development opportunities at minimum risk. It also identifies research gaps.

Chapter 3 by Carlos Murillo looks at Costa Rica. The chapter analyses the country's experience with sugarcane bioethanol production since the 1980s, highlighting the constraints encountered and drawing out the main lessons learned. It also analyses the implications for sustainable development of an increase in bioethanol in view of current supply capacity issues related to production costs, trade trends and supply, as well as the implications arising from meeting future demand. The author concludes with the identification of some institutional challenges that will need to be addressed if biofuel production and distribution are to develop on a sustainable basis.

Chapter 4 by Anthon Cartwright examines the case of South Africa, which unlike the other three countries does not yet have significant biofuel production or trade. The study focuses on sugarcane and maize, which are the most likely feedstocks, examining the potential for bioethanol trade to and from South Africa to contribute to sustainable development. The author explores South Africa's processing capacity, potential to export bioethanol in terms of trade policies, ability to comply with international bioethanol standards and the macro-economic, environmental and social impacts of bioethanol exports from South Africa. A key question arising from the chapter is whether or not South Africa can rise to the economic governance challenge of ensuring that an export-oriented bioethanol industry can deliver on its sustainable development potential.

Chapter 5, by Maria Amparo Albán and Helena Cárdenas, explores the case of palm oil biodiesel in Ecuador where the palm oil sector – one of the fastest growing industries in the country – has taken the lead in producing biodiesel for export. Biodiesel production is still not very high, but shows potential for the development of a whole new industrial sector. The chapter explores how international and national policies on biodiesel trade are affecting the development of the sector. It surveys the key economic, environmental and social issues associated with palm oil biodiesel and concludes with policy recommendations to foster sustainable practice.

Finally, Chapter 6 compares and contrasts the findings of the case studies and draws out some common lessons for biofuel development in other potential producer countries.

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Chapter 2

Biofuels trade and sustainable development: the case of sugarcane bioethanol in Pakistan

Shaheen Rafi Khan, Moeed Yusuf, Selina Adam Khan and Reza Abbasy

1. Introduction[1]

Renewable energy in general, and biofuels in particular, has begun to look like an increasingly viable mitigation option for addressing climate change. For rich countries they offer prospects for meeting emission reduction commitments. For low- and middle-income countries they offer potential to reduce energy import bills as well as earn precious foreign exchange. However, there are risks associated with biofuel produc-

1. This chapter is based on Biofuels trade and sustainable development: the case of Pakistan (2007) by Rafi Khan, S., S. Adam Khan and M. Yusuf. International Institute for Environment and Development (IIED) working document. Available to download at: www.iied.org/pubs/display.php?o=G02286

tion. Global environmental benefits also generate adverse local environmental impacts as forests are cut down to grow 'energy' crops. Similarly, multinationals offer price incentives to farmers to switch from food to fuel, thereby threatening food security.

A global biofuel economy, with a division of labour favouring the most efficient producers, would be a key boon to developing countries. Their year-round growing seasons and cheap farm labour offer a valuable competitive advantage over colder, high-cost rich countries. Yet the emerging global market in biofuels is running into political trouble. Rich country farm lobbies provide a momentum to biofuel development, but they also demand protectionist barriers. To encourage biofuel production, European Union governments spent at least 3.7 billion euros (US$5.2 billion) in 2007 on subsidising biofuel production (Cronin 2007). When Pakistan got special access to EU markets in 2002 and began shipping bioethanol, EU farm lobbies persuaded Brussels to change its policy and re-establish tariffs. The USA also imposes an extra US54 cents per gallon import duty. In addition, almost every country has its own biofuel standard with different specifications (*ibid*).

The Introduction provides a backdrop and a context for this chapter, which is essentially a scoping exercise. Its objectives are to: i) assess the production potential of energy crops in Pakistan, ii) evaluate the foreign exchange savings potential from reduced fossil fuel imports and the foreign exchange earnings potential from bioethanol exports, iii) assess the sustainable development implications of increased bioethanol production and trade, and iv) suggest economic and institutional policy options to promote the production, domestic use, and exports of bioethanol. The study also presents anticipatory policy measures and identifies research gaps where more work needs to be done to maximise sustainable development at minimum risk. Section 2 provides a description of Pakistan's bioethanol sector. Section 3 describes the bioethanol value chain. Section 4 provides an overview of domestic and key international policies governing biofuel production and trade. Section 5 focuses on the main sustainable development concerns related to bioethanol production and use. Section 6 sums up the major arguments.

2. Pakistan's biofuel sector

In the context of this study, the term 'biofuel sector' refers to the primary, secondary and tertiary stages of production. The process includes sugarcane production, sugar refining, and the conversion of molasses to biofuel. In Pakistan's case, the end product is bioethanol.

2.1 Contribution of sugarcane and sugar production to the national economy

The sugar industry in Pakistan is the second largest after textiles. Currently there are 76 operational sugar mills in the country (Government of Pakistan 2006a). Sugar production in Pakistan has shown an upward trend since the 1990s. From a level of 2.89 million tonnes in 1991–92, production reached 4 million tonnes in 2003–04 (*ibid*). Nevertheless, sugar production has fluctuated over the years, primarily due to unpredictable sugarcane yields. An increase in sugarcane production is possible through yield increases, since yields are currently well below the global average. In contrast, the scope for area expansion is limited (Government of Pakistan/IUCN 1992).

Table 1: Sugar production and yield in Pakistan

	Punjab	Sindh	North-West Frontier Province	Pakistan total
Area (thousand hectares)				
2000–01	615.5	238.8	105.9	960.8
2001–02	656.8	240.7	101.5	999.7
2002–03	735.3	258.6	104.9	1,099.6
2003–04	709	259.9	104.8	1,074.5
2004–05	644.7	214.9	106.4	966.4
5-year average	669.5	253.7	105.8	1,029.7
Production (thousand tonnes)				
2000–01	2,6740	12,049.7	4,784.4	43,606.3
2001–02	31,803.1	11,416.3	4,787.2	48,041.6
2002–03	33,168.6	13,797.6	5,049	52,055.8
2003–04	3,4023	14,611.8	4,745.6	5,3419
2004–05	3,3048	9,357.4	4,816.2	47,244.1
5-year average	2,8693	14,837.8	4,803.5	48,371.2
Yield per hectare (production/area)				
2000–01	43.44	50.46	45.18	45.38
2001–02	48.42	47.43	47.16	48.06
2002–03	45.11	53.35	48.13	47.34
2003–04	47.99	56.22	45.28	49.72
2004–05	51.26	43.54	45.27	48.89
5-year average	42.86	58.49	45.40	46.98

Source: (Government of Pakistan (2006b)

In most years, Pakistan consumes all the sugar produced domestically, meeting excess demand through imports. Pakistan imported 0.27 million tonnes of sugar in 2004–05 and faced a domestic shortage again in 2005–06, which had to be met through imports. In the few years when the country produced surpluses, high production costs prevented exports. Despite sugar prices more than doubling since 1992, Pakistan continues to remain globally uncompetitive. However, the emerging markets in bioethanol offer prospects for making sugarcane production economically viable (Government of Pakistan 2006a).

2.2 Bioethanol production potential

Pakistan's bioethanol production has grown rapidly: by 3 per cent in 2000, 7 per cent in 2001, 9 per cent in 2002 and 14 per cent in 2003. Bioethanol is produced entirely from molasses, a direct by-product of the sugarcane crushing process. Other indigenous raw materials (such as maize, rice, wood pulp and other forest residues) are available in large quantities, but the cost of producing bioethanol from sugarcane is substantially lower than that for other available sources. The sustainable development implications are, therefore, positive. Sugarcane bioethanol production will not displace food crops or cause deforestation due to land clearance so there is large untapped potential to convert raw molasses to bioethanol provided the right kind of policy incentives are in place.

Table 2 shows the production levels of molasses since 1990. The fluctuating trend tracks sugar production. In part, molasses production has also been held back somewhat by a slight improvement in the sugar recovery rate.[2]

Table 2: Molasses production in Pakistan (million tonnes)

Year	Punjab	Sindh	North-West Frontier Province	Pakistan total
1990–91	0.61	0.47	0.04	1.12
1991–92	0.54	0.58	0.04	1.17
1992–93	0.63	0.65	0.05	1.33
1993–94	0.97	0.68	0.05	1.69
1994–95	1.01	0.59	0.05	1.65
1995–96	0.82	0.50	0.04	1.36
1996–97	0.80	0.48	0.03	1.32
1997–98	1.24	0.68	0.06	1.98
1998–99	1.28	0.76	0.08	2.11
1999–00	0.80	0.53	0.06	1.40
2000–01	0.90	0.55	0.04	1.50
2001–02	1.22	0.52	0.08	1.82
2002–03	1.30	0.66	0.09	2.05

Source: Pakistan Sugar Mills Association, *Annual Reports 2003* (date unknown)

Despite the increase in sugar and molasses production, bioethanol production has remained very small in terms of its contribution to the national economy. As will be shown later, the unrealised potential reflects policy lapses particularly the absence of an incentive framework. Until recently, the bulk of the raw molasses was exported, with only minor quantities converted to industrial alcohol for domestic use and export. An even smaller proportion was converted into bioethanol for export. While a recent policy

2. In absolute terms, recovery is still low at 8–9 per cent compared to other major sugar producing countries (the Philippines, Cuba), where the recovery is over 10 per cent.

impetus has enhanced interest in the sector, unpredictable global demand (largely due to European import restrictions) has dampened industry interest in producing bioethanol.

2.3 Alcohol exports

Export of molasses has remained between 0.70 million and 1.75 million tonnes over the years. However, over the past five years, a substantial proportion of this was converted into three grades of alcohol: fuel or anhydrous; neutral or extra-neutral (ENA); and industrial or rectified ethanol (REN).

Table 3: Pakistani export of molasses

Year	Quantity (thousand tonnes)	Value (million rupees)
1990–91	776.07	0.82
1991–92	947.00	1.35
1992–93	892.62	1.40
1993–94	703.45	0.99
1994–95	769.64	1.21
1995–96	806.40	1.85
1996–97	1,056.13	2.02
1997–98	1,359.33	2.54
1998–99	1,688.51	1.80
1999–00	1,748.00	2.20
2000–01	1,190.01	2.46
2001–02	1,607.38	3.90
2002–03	1,272.63	2.65

Source: Pakistan Sugar Mills Association, *Annual Reports 2003* (date unknown)

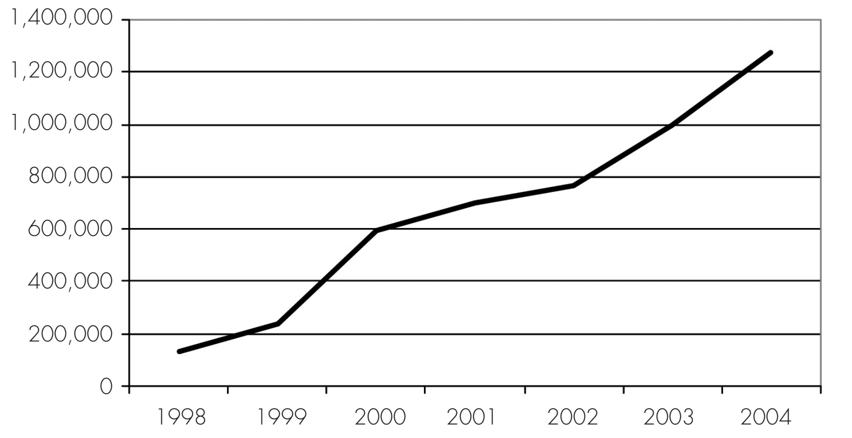
Pakistan exports two forms of alcohol: undenatured ethyl alcohol and ethyl alcohol spirit.[3] Currently, 21 distilleries in the country operate at roughly 60 per cent capacity, converting on average 1.8 million tonnes of molasses (Rana 2007). Fuel grade ethanol, which is blended in petroleum products, fetches the highest price in the world market. Requiring 99.8 per cent purity, pure alcohol can be converted into fuel ethanol through the simple molecular sieve process.

Alcohol exports have increased rapidly over the past five years, as indicated by the trend data in Figure 1. The bulk of exports went to Japan and the EU, with Italy being the single largest recipient within the EU. However, exports to the EU as a whole declined in the wake of Pakistan's removal from the Generalised System of Preferences (GSP) scheme (see subsection 4.2). Pakistan exported around 167,610 tonnes of alcohol

3. The different grades of alcohol are being produced from molasses with a ratio of 1:5, meaning that 5 tonnes of molasses are required to produce 1 tonne of alcohol.

during 2006 and about 22,975 tonnes during first two months of 2007. The average export price for different grades of alcohol was in the range of US$560–680 per tonne. Total earnings amounted to US$100.6 million in 2006. The value-add in molasses through its conversion into alcohol has enabled exporters to earn eight to ten times more foreign exchange (Rana 2007).

Figure 1: Pakistan's industrial alcohol exports



Note: Measurement in litres
Source: Federal Bureau of Statistics (statistics from various years)

The main destinations for Pakistani industrial alcohol exports in 2004 were: Italy (30 per cent), Japan (18 per cent), France (10 per cent) and Turkey (9 per cent).[4] Including The Netherlands, more than 50 per cent of Pakistan's total industrial alcohol exports went to the EU prior to the imposition of the revised GSP (see subsection 4.2) (Schnepf 2006).

3. The bioethanol chain

3.1 Sugarcane production

Pakistan is the world's fifth largest sugarcane producer. However in terms of per acre yield, it compares unfavourably with other major producers. The low yield is a consequence of poor agronomic practices. Land is poorly prepared using simple cultivators, which do not plough the fields to the depth required for a deep-rooted crop like sugarcane. Seed qualities are also often poor and the seed rates used are low, resulting in lower plant populations. Further, while fertilisers are applied heavily, their use is for the most part unbalanced. Another factor constraining sugarcane yield is poor management of the 'ratoon' (sugarcane stubble crop). A recent survey found that as many as 50 per cent

4. More recent figures are being compiled.

of the farmers consider the ratoon crop a bonus and maintain the cane crop as ratoon (WWF-Pakistan 2004). However, average yields of the ratoon crop are low even by Pakistani standards.

Water availability is also a serious problem. Sugarcane cultivation coincides with the summer months when water is scarce and competing crops limit the availability of water for it. Other serious concerns are water-logging and high salinity in a number of areas under cane cultivation and sugarcane yields are thus lowered drastically, as is the sugar content in the cane (Hassan 2007). Moreover, despite being the fifth largest sugarcane producer, Pakistan ranks 15th in terms of global sugar production. The low sugarcane yields, stagnant acreage, and low sugar recovery ratios are the major reasons for the high cost of production of sugar in Pakistan, compared to other major sugar producers worldwide.

Table 4: Major sugarcane producers of the world

	(US$ 1000)	Metric tonnes
Brazil	8,725,914	420,121,000
India	4,825,286	232,320,000
China	1,819,452	88,730,000
Thailand	1,029,610	49,572,000
Pakistan	981,260	47,244,100
Mexico	937,277	45,126,500
Colombia	827,669	39,849,240
Australia	794,369	38,246,000
Philippines	643,870	31,000,000
USA	535,948	25,803,960
Indonesia	529,635	25,500,000
South Africa	451,230	21,725,100
Argentina	400,861	19,300,000
Guatemala	373,860	18,000,000
Egypt	339,278	16,335,000
Vietnam	311,550	15,000,000
Cuba	259,625	12,500,000
Venezuela,	182,776	8,800,000
Peru	147,467	7,100,000
Iran	135,005	6,500,000

Source: FAO (2003)

As indicated earlier, sugarcane is the largest non-grain crop produced in the country after cotton (WWF-Pakistan 2004). Sugarcane is grown on nearly 1 million hectares, which represents 4 per cent of the total cropped area (Government of Pakistan 2005a). A large proportion of the farmers growing sugarcane own less than two hectares each. Such farms cover a total of approximately 140,000 hectares. Underscoring the disparity, farms over four hectares cover the bulk of the cropped land area (see Table 5).

Sugarcane owners fall into one of three tenure classes: landowner, tenant/sharecropper, and lessee. A study of the socio-economic impact of sugarcane cultivation in Pakistan found the majority of growers in Punjab to be landowners, while most cultivation in the North-West Frontier Province (NWFP) was undertaken by tenants (WWF-Pakistan 2004). No sugarcane cooperatives exist in the country. Growers continue to interact with their buyers individually.

About 80–85 per cent of the total sugarcane production goes towards the production of sugar (Khan and Farooq 2005). The remaining 15–20 per cent is converted into 'gur', a local crumbly, brown, unrefined variant of sugar, which is largely produced and consumed in the North-West Frontier Province (NWFP).[5]

Table 5: Area under sugarcane by farm size

			Farms reporting sugarcane		
Size of farm (hectares)	Total farm area (hectares)	No of farms	Participation (%)	Area (hectares)	Participation (%)
All farms	6,620,224	838,997		88,4214	
Under 0.5 ha.	1,290,098	39,830	4.75	10,085	1.14
0.5–1 ha.	1,099,330	76,786	9.15	31,647	3.58
1–2 ha.	1,425,370	179,563	21.40	99,307	11.23
2–3 ha.	966,411	160,269	19.10	116,255	13.15
3–5 ha.	890,755	183,963	21.93	181,941	20.58
			76.33		49.68
5–10 ha.	580,200	124,965	14.89	165,855	18.76
10–20 ha.	260,791	51,837	6.18	126,129	14.26
20–40 ha.	77,773	16,318	1.94	83,187	9.41
40–60 ha.	15,277	2,718	0.32	22,542	2.55
60 ha. and above	14,054	2,720	0.32	46,539	5.26
			23.65		50.24

Source: Government of Pakistan (2003)

The government establishes the support price of sugarcane annually, based on various economic considerations.[6] While the aim is to protect small-scale sugarcane growers from exploitation, policy loopholes mean that this aim is not achieved. The most important policy failure relates to zoning. Under the zoning laws, sugar mills can

5. Gur is a consumer item not linked to the biofuel production chain except that its production signifies a trade-off with sugar, and therefore affects molasses production (Naqvi 2005).

6. The key variables considered in the pricing policy include: cost of production of sugarcane, market prices of the crop, nominal and real prices, economics of fertiliser use, domestic demand, supply, stocks, prices of sugar, comparative economics of sugarcane and competing crops, prices of gur, average wholesale prices of sugar, international market dynamics, import and export parity prices, and efficiency of sugarcane production (Government of Pakistan 2005b).

only purchase from designated areas; the purpose being to restrict the growth of sugar mills and hence prevent the creation of excess capacity. Lobbying by the sugar mills has made such zoning selective. The government has succumbed to the wishes of large investors and instituted de-zoning arrangements, which allow sugar mills to purchase from anywhere. This creates pricing distortions that adversely affect small-scale farmers, who then are compelled to sell at distress prices due to oversupply. The middleman ('beopari') and the premature crop contractor also exploit small- and medium-scale sugarcane farmers. The farmers' financial dependence (for loans) on such intermediaries forces them to accept the price on offer. Finally, during the harvesting season, sugar mills withhold immediate payments. The potential loss of weight (see subsection 5.2.1) through orchestrated practices forces the farmers to sell at less than the official price.

The Afghan refugee influx, however, provided a temporary reprieve to the NWFP farmers since gur is a preferred consumer item in Afghanistan. Gur-making is a cottage industry and tax exempt. Therefore, given the higher profit margins of gur-makers, producers are able to pay better prices to the sugarcane farmers in the NWFP.

3.2 Alcohol production

The essential characteristics of the sugar industry were discussed in subsection 2.1. Cane crushing produces sugar and the molasses by-product. The molasses-to-bioethanol conversion process is conducted in distilleries. Currently, 21 distilleries exist in the country. Table 6 provides the installed capacities of them.

The majority of the distilleries are attached to sugar mills and are situated on-site. This makes integration of the bioethanol production chain relatively simple. The mill receives the cane, crushes it for sugar, stores the molasses in storage tanks on-site, and then passes it on to the distillery for industrial alcohol production. Industrial alcohol can be converted into fuel ethanol in a simple process by using molecular sieve technology, which requires a capital expenditure of US$1.5 million and can be completed in five to six months (Government of Pakistan 2006c).

As many as eight distilleries have installed the sieve technology to process industrial alcohol into fuel ethanol. The fuel ethanol conversion plant is linked to the industrial alcohol plant as part of an integrated production process. Notwithstanding this integrated production cycle, we found during our interviews that the distilleries are unable to satisfy their entire demand from internal molasses production so they have to purchase additional molasses from other sugar mills that do not have distillation facilities.[7]

7. Interview with Ahsan Ahmed, Deputy Managing Director, Noon Sugar Mills and Distillery, 7 March, 2007.

Table 6: List of distilleries and installed capacities (2005–06)

Name	Litres/day	Metric tonnes/day	Metric tonnes/year
Frontier – Takhat Bhai	14,000	11	2,800
Premier – Mardan	46,000	37	9,200
Khazana – Peshawar	23,000	18	4,600
Crescent – Faisalabad	22,000	18	4,400
Noon – Bhalwal	80,000	64	16,000
C.S.K. – Phalia	125,000	100	25,000
Shakarganj-I – Jhang	160,000	128	32,000
Shakarganj-II – Jhang	100,000	80	20,000
Crystaline – Sargodha	100,000	80	20,000
Chishtia – Faruqia	100,000	80	20,000
United Ethanol – Sadiqabad	100,000	80	20,000
Haseeb Waqas – Nankana	125,000	100	25,000
Tandianwala – Faisalabad	125,000	100	25,000
Habib – Nawab Shah	143,500	115	28,700
Al Abbas – Mirpur Khas	170,000	136	34,000
Shah Murad – Thatta	125,000	100	25,000
Dewan – Thatta	125,000	100	25,000
Uni Col – Mirpur Khas	100,000	80	20,000
Mitiari – Hyderabad	100,000	80	20,000
Pinnacle – Badin	125,000	100	25,000
Murree Brewery – Rawalpindi	9,000	7	1,800
Total	2,017,518	1,614	403,500

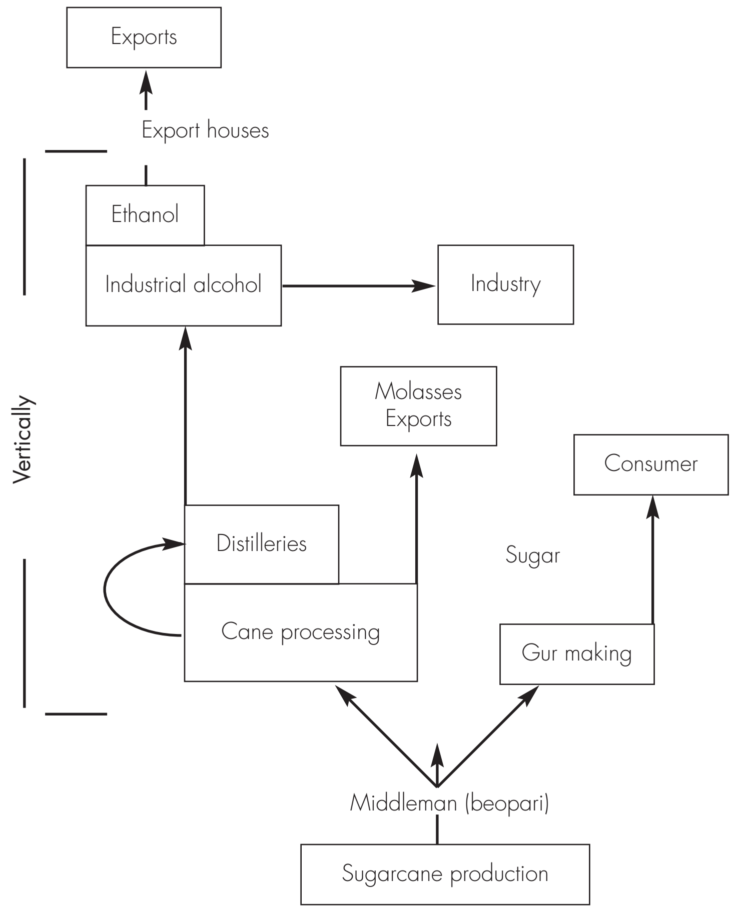
Source: Karachi Chamber of Commerce and Industry (data provided on request)

3.3 Alcohol distribution

Distilleries in Pakistan have three major buyers for their products:
1. Industrial alcohol for domestic industry (various purposes).
2. Fuel ethanol is currently only being sold domestically in small quantities to Pakistan State Oil (PSO) as part of a pilot project. PSO blends the ethanol with petrol in a 10 per cent ratio.
3. The third, and predominant, outlet is exports.

Industrial and fuel ethanol are exported through international trade houses, which act as intermediaries (*ibid*). They are brought to the port of Karachi from distilleries throughout the country for onward shipping to different parts of the world. The bulk of the bioethanol exported is used in various industrial processes. The final consumers of exported bioethanol are oil refineries, where the bioethanol is blended with petrol in a 10:90 ratio. No Pakistani distilleries, however, deal directly with the end-users of bioethanol.

Figure 2: Bioethanol sector flowchart



4. Bioethanol promotion policies

4.1 Domestic policies

The correct mix of domestic policies can produce desirable economic and environmental outcomes. Such polices should focus on export and import substitution, which will generate both foreign exchange earnings and savings. To date, one of the main reasons for the retarded growth of the bioethanol industry is the lack of enabling government policies that could motivate the private sector by supporting its demonstrated willingness to invest. Sustaining such investment requires the correct mix of policy incentives and political will.

4.1.1 Import substitution

Pakistan imported petroleum products worth US$3.1 billion in the 2006 fiscal year, which accounted for 85 per cent of the total oil consumption in the country. This also constitutes a large portion of the country's trade deficit. Clearly, a shift towards local fuel ethanol consumption would save the country considerable foreign exchange. Any decrease in foreign exchange earnings or government revenue (due to reduced molasses exports, or subsidies and tax breaks that may be necessary to incentivise the fuel ethanol industry) would be more than offset by the foreign exchange gains due to a decrease in oil consumption. Below we present four future scenarios for fuel ethanol use in the country and the estimated reduction in the oil import bill under each scenario

Both the economics and production conditions for bioethanol are favourable. Fuel ethanol is highly price-competitive with petrol. While a detailed comparative estimate has not been attempted, the rough estimate is that the unit cost of production is approximately half that of petrol, accounting for crude import and processing costs. The raw material molasses is abundantly available. Also, the potential for producing fuel ethanol from major crops such as rice and maize, and wood pulp and forest products has not been tapped. Pakistan used 1.6 million tonnes of petrol in the fiscal year 2006. A 10 per cent blend represents a foreign exchange saving of US$300 million, a sum that doubles

Table 7: Foreign exchange saving in terms of oil import reductions

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Assumptions:	The entire production of molasses is used to make fuel ethanol; i.e., there is no export of molasses.	Entire production of molasses is used to make ethanol, such that 50% of molasses is used to make fuel ethanol and 50% is used to make industrial ethanol; i.e., there is no export of molasses.	Current exports of molasses continue (0.450 million tonnes); the rest is converted to fuel ethanol.	Current exports of molasses continue (0.450 million tonnes); 50% of the remainder is converted to fuel ethanol and 50% to industrial ethanol.
Estimated production of fuel ethanol.	284,240 MT*	142,120 MT	198,740 MT	99,370 MT
Potential foreign exchange savings through reduction in oil imports.	US$125,065,600	US$62,532,800	US$87,445,600	US$43,722,800

*** MT = metric tonnes**
Source: Author's own calculations

Box 1: The Pakistan Sugar Mills Association's recommendations

- A mandatory 10 per cent blending with petrol to be announced after consultation with the oil companies. To make it viable for them, substantial tax breaks may be announced. Most obvious in the list of incentives for the Sugar Mills Association is the removal of General Sales Tax (GST) on the sale of industrial alcohol, which is currently imposed. While this will only impact government revenues marginally, it may in fact prove consequential in incentivising domestic sales of ethanol if enough demand is generated. Throughout the world the blending programme is introduced with full support of the government and by offering major incentives to the industrial stakeholders. No change in car engines is required for a 10 per cent blend.
- A 10 per cent blend can be increased, subsequently, with minimal changes in the engine.
- All automobile companies must be given a target to produce a certain percentage of flexible fuel cars by a certain date. This percentage should then increase in the following years.
- Other sources of raw material, maize, wheat, rice, potatoes, sorghum etc., should be explored by the Ministry of Food, Agriculture and Livestock (MINFAL).
- As the programme moves ahead and the consumption of fuel ethanol increases, the sugar industry can make ethanol directly from cane juice, as is done in Brazil and many other countries.
- For the programme to succeed it is imperative to set the price of fuel ethanol according to the price of molasses. A system of determining the price of molasses can be agreed in consultation with all the stakeholders.
- To ensure the availability of molasses, the government might have to restrict the export of molasses, as is done in several countries. However, this can be done only by taking all stakeholders into confidence.

Source: Government of Pakistan (2006c)

at a (feasible) 20 per cent blend. The private sector has swung its weight in favour of fuel ethanol production, stipulating the conditions presented in Box 1.

In July 2006, Pakistan State Oil (PSO) and the Hydro Carbon Institute of Pakistan (HDIP) announced a pilot project to introduce blended fuel within the country, aimed at meeting the energy shortfall. In three PSO petrol pumps (Karachi, Lahore and Islamabad), fuel ethanol is being blended with petrol in a 10:90 ratio (E10). However, there is a contradictory aspect to this initiative: despite fuel ethanol's potential and private sector backing, policy support is still only nascent. Furthermore, the prognosis is not encouraging. While the government has directed the petroleum ministry to develop a long-term fuel ethanol conversion plan, it appears almost certain that the oil lobby will stall progress.

The private sector communicated certain policy proposals to the government, and these were highlighted repeatedly during our interviews with the sector's representatives. These included a ceiling on molasses exports and a subsidy on bioethanol production to compensate for the fluctuation in molasses prices. To date, however, there has been no visible government response. In fact, the government's move to allow PSO, a state-owned oil company, to conduct a background study on the feasibility of bioethanol clearly illustrates the influence of the oil lobby. An equally obvious signal was the move to put the bioethanol promotion mandate within the Ministry of Petroleum and Natural Resources (MoP&NR) rather than the Ministry of Industries or the Ministry of Environment. The policy provenance clearly needs to shift if any pro-ethanol initiative is to succeed. As further evidence of the pro-oil bias, Pakistan has initiated an aggressive domestic policy to explore indigenous reserves. Foreign investors have been provided with highly attractive terms to invest in the oil and petroleum sector in the country. A number of concessions and exploration licences have been accorded to various multinational entities during the past few years.

4.1.2 Export promotion

As long as current policy on fuel ethanol is dictated by the oil sector, import substitution will be a slow process. Better immediate prospects lie in export promotion. As indicated, Pakistan presently exports over 160,000 tonnes of industrial alcohol and bioethanol, earning a little over US$100 million in foreign exchange, which is well below potential earnings. While industrial alcohol and fuel ethanol have a higher value-added component and fetch a substantially larger price, molasses continues to be exported in bulk, notwithstanding the recent increase in fuel alcohol exports. As Table 8 indicates, a mismatch exists between the revenues and the amount of exports; the same amount converted to industrial alcohol or fuel ethanol would yield substantially higher foreign exchange earnings.

A perverse domestic policy, which contributes to this sub-optimal outcome, is the high central excise duty and sales tax on alcohol. This needs to be removed to increase price competitiveness both abroad and domestically (the domestic comparison is between bioethanol blend and petrol prices). Internationally, too, tariff restrictions apply which were noted earlier and will be discussed in more detail in the next section. However, negotiating tariff cuts is an extended process. In the interim, and especially in the light of the demonstrated positive external environment, Pakistan could follow India in imposing a ceiling on molasses exports.

The pricing issue, however, is a complex one and elicits different perspectives from various stakeholders, such as sugar producers, energy consultants, academics, and sugarcane farmers. The opposing views underscore the need for further research to arrive at an informed consensus. These alternative views are presented in Box 2.

Table 8: Export of Pakistani molasses

Year	Quantity (thousand tonnes)	Value US $ million
2001–02	1,742.7	70.30
2002–03	1,272.6	44.21
2003–04	1,457.3	44.98
2004–05	1,151.4	71.62

Source: Government of Pakistan (2005a)

Box 2: Pricing bioethanol – a debate

The petroleum sector view on setting optimal prices proposes to compare bioethanol against the fossil fuel alternatives, while working back from the retail price. Such an approach minimises the risk for policymakers of coming up against the information asymmetries that a cost of production (COP) approach would entail. The current practice of the MoP&NR is to peg the prices of petroleum products at the base to international market prices. In other words, producer prices of petroleum products in Pakistan are based on international prices plus an allowance for transportation of products to Pakistan. The same pricing practice needs to be applied to bioethanol. Under this policy, the price of fuel grade ethanol offered to local consumers by the government would be linked to the international market price of ethanol (for instance, the last six-month average of the world price of ethanol). The Ministry of Environment concurred with this view; pointing out that in terms of energy equivalence, ethanol prices at Rs. 25/ MMBTU (million British thermal units) were comparatively higher than petrol. If it were possible to include the environmental aspect, such as carbon dioxide emission reductions, one might be able to get a more accurate measure of price competitiveness.

If this approach were to be adopted, then price subsidies would need to be offered for environmental or social reasons, with an additional mark-up to incentivise industrialists to take a risk. Concurrently, other forms of renewable energy should also be explored, with the caveat that other forms of renewable energy (with the exception of hydropower) are not cheap. Further, with the ‘economic accessibility of energy’ being positively correlated with the human development index, it is therefore essential that energy be further subsidised to sustain threshold levels of consumption by the poor.

The sugar industry strongly contested what they saw as a flawed approach to pricing ethanol. In the first place, retail prices did not form an appropriate pricing benchmark, especially for comparative purposes, as fossil fuels immediately become non-competitive, with oil prices rising continuously. Accordingly, a COP approach was more appropriate. The term ‘information asymmetries’ was creating some confusion. The bottom line was that the low COP is underpinned by an abundant availability of molasses. In effect, it was a combination of the government’s discriminatory pricing policies (against ethanol) and external tariff and non-tariff restrictions that had inflated ethanol prices, both domestically and abroad. The sugar industry only required that such policy biases be removed, and that they could produce ethanol competitively, without the need for ‘environmental’ and ‘social’ subsidies.

Sugar farmers raised an important point. If the government were, in fact, to remove domestic taxes on ethanol production, then a part of the windfall gains they would enjoy consequently should be passed on to farmers. The sugar industry, they argued, already received subsidies through various government interventions in order to ensure food security. These comprised a 10 per cent import duty, a 35 per cent regulatory tax, and interest rate subsidies. In addition, over the past two years, sugar produced in excess of the previous two years’ volume enjoyed excise duty exemptions. The Ministry of Agriculture concurred. From 40 kilograms of sugarcane it is possible to extract about 3.6 litres of molasses, which when converted to ethanol could earn up to Rs.18 per litre. The estimated COP of ethanol was as low as 25 per cent of this revenue. As such, the conversion of molasses to ethanol represented a reduction in the COP of sugar, which accrued to the sugar industry. Unfortunately, this would not increase the incomes of sugarcane growers.

4.2 International policies

4.2.1 Tariff preferences

Until recently, Pakistan was the second largest industrial alcohol exporter to the EU after Brazil, under the General System of Preferences (GSP). Initially, Pakistan and six other countries exported industrial alcohol to the EU under a 'no tax' regime following a dispensation given in the EU anti-narcotics policy.

In May 2005, the Commission of Industrial Ethanol Producers (CIEP) of the EU accused Pakistan and Guatemala (the largest duty-free exporters for the period 2002–04) of dumping ethyl alcohol in the EU market, causing material harm to domestic producers. The commission dropped proceedings a year later when full custom tariffs were restored on Pakistani imports. Differentiated tariffs on bioethanol and feedstock (raw molasses in Pakistan's case) represent tariff escalation, which discriminates against the final product (*The News* 2 July, 2005). Reflecting these tariffs and closer monitoring of industrial alcohol exports to the EU, ethyl alcohol prices went up.

Subsequently, following a complaint lodged by India, a World Trade Organization (WTO) panel concluded that by granting tariff preferences to 12 countries under this special arrangement, the EU was violating General Agreement on Tariffs and Trade (GATT)/WTO preferential treatment obligations. The EU consequently removed Pakistan from the GSP. In the revised GSP regime, the anti-drug system has been replaced by GSP Plus (sometimes known as GSP+), for which Pakistan does not qualify. Eligibility requires countries to demonstrate that their economies are poorly diversified and consequently are dependent and vulnerable. Furthermore, GSP-covered imports from such countries must amount to less than 1 per cent of total EU imports under GSP; Pakistan's industrial alcohol exports are just above 1 per cent. Thus the country does not qualify under either of the two criteria. The industrial sector holds the view that the Ministry of Commerce should have hired legal help and filed an appeal with the EU to revise this decision. Industrialists even offered to share the costs of hiring strong defence lawyers, but the government took no action.

The local distilleries have consequently begun to suffer losses and some have ceased operations. After 2002–03, the number of distilleries in the country had increased from six to 21 (although not all of these produced fuel ethanol). However, given a rise in molasses exports post 2003–04, alongside the more stringent EU tariff measures, the distilleries were soon running under capacity. Currently, at least two distilleries have shut down, and another five are contemplating this option (Rana 2005).

Currently there is no unique customs classification for bioethanol. Industrial alcohol is traded under the code '22 07', which covers both denaturated (HS 22 07 20) and undenatured alcohol (HS 22 07 10).[8] Both types of alcohol can be used for bioethanol production (European Commission 2005a). Despite this lack of specific customs classification, there is already evidence indicating that the use of tariffs is common practice in coun-

8. See: www.wcoomd.org/ie/en/Topics_Issues/HarmonizedSystem/DoucmentDB/0422E.pdf

tries keen to protect their domestic agricultural and biofuel industries from external competition. Moreover, the actual tariffs vary. For instance, the EU and the USA have trade agreements that grant different market access conditions to various countries.

4.2.2 Technical, environmental and social standards

Environmental and social standards are now part of the global trading regime. There is little dispute on whether such sustainable development issues should be linked to trade; the question now is how it should be done. While rich countries continue to insist upon the stringent implementation of such standards, low- and middle-income countries are becoming increasingly wary of the use of standards as hidden trade barriers. Moreover, since standards do not tend to be uniform, it becomes virtually impossible for resource-constrained producers in low- and middle-income countries to develop variants of their products to conform with standards specific to a particular destination.

Bioethanol trade has been no exception in the debate over standards. The EU, a major market for Pakistani industrial alcohol exports until 2006, has imposed domestic fuel quality limits on the use of bioethanol and biodiesel. A maximum of 5 per cent blending is allowed, thus limiting the biofuel market. For biodiesel, further directives necessitate the production of biodiesel predominantly from rapeseed oil and not from soya bean oil or palm oil. In addition, the European Commission's *Biomass Action Plan* (European Commission 2005b) is contemplating certification to ensure that any biofuel imported is produced from crops grown in an environmentally sustainable manner. Individual EU members, such as The Netherlands and UK, are already developing certification schemes. A number of additional voluntary measures to ensure imports of 'sustainable' biofuel are also under way. The varying standards requirements across rich countries present additional compliance problems for technically and institutionally unprepared low- and middle-income countries (Dufey 2006).

Pakistan, in principal, has supported standards in the global trading regime. But, concurrently, as a low-income country, it has repeatedly opposed any measures that may allow rich countries to use standards as 'protective' devices against free trade. Its stance on the EU agricultural support, which includes energy crops, echoes that of the G-20 block within the WTO. Pakistan seeks an end to EU subsidies to its farmers, especially 'Amber Box' subsidies.[9] Negotiations on the EU's agricultural support, however, continue with no end in sight.

4.2.3 Institutional uncertainty

Biofuels and bioethanol continue to remain unresolved issues in the WTO, complicating its trade facilitation. Experts claim that the WTO has never really probed energy issues because few energy-producing countries have been members of the organisation;

9. Subsidies are generally identified by boxes in the WTO; with green representing permitted, red as forbidden and amber to slow down or reduce.

biofuels have warranted even less attention as they constitute only a small percentage of the world's energy supply (Hagstrom 2006). The WTO classifies bioethanol as an agricultural product, making no distinction between its use as fuel and for other purposes; biodiesel is classified as an industrial product, thus 'having two competing fuels with different rules' (*ibid*).

Fuel ethanol as an environmental good is the subject of yet another debate. Weber Amaral, CEO of the Brazilian Biofuels Institute, predicts that the discussion around biofuels is likely to become more complicated as the range of products used to make biofuels expands. Amongst other things, classification could affect how fuels are treated during trade talks and whether governments will be allowed to pay biofuel producers export subsidies. Furthermore, there has been a call for world standards on biofuel contents, as well as rules and regulations on subsidies on biofuel crops, in a 2006 report published by the International Food and Agricultural Trade Policy Council (Howse *et al.* 2006).

The report proposes that, given the optimistic forecasts for biofuel growth prospects, the WTO and others must act now to regulate rules and standards that are currently very inconsistent. The report also warns against government intervention aimed at protecting the domestic fuel market, as it threatens to stunt the growth in trade (intervention includes tax incentives and high tariffs and subsidies). Furthermore, it recommends a unified classification for biofuels. According to the President of the International Food and Agricultural Trade Policy Council (as quoted by Reuters AlertNet) developing countries are 'wildly producing biofuels' and if no decisive action is taken governments could end up 'cross-subsidising' biofuel by-products like glycerol. She went on to say that with rules for things such as import standards varying from country to country the WTO, the World Customs Organisation and national governments must work together to make sure that the future biofuel trade runs smoothly (Ryan 2006).

Pakistan stands to gain from increased bioethanol trade. Within Pakistan, agricultural subsidies have been withdrawn for virtually all crops, largely due to lack of resources and the IMF/World Bank-led structural adjustment of the economy that has been undertaken since the 1990s. Overall agricultural production in Pakistan is taxed; sugarcane production, which is the only crop relevant to the bioethanol industry, is not subsidised. In fact, a major worry is the gradual shift of farmers away from sugarcane to more economically lucrative crops.

5 Sustainable development impacts

This section attempts to identify the potential sustainable development impacts of increased bioethanol production. The economic aspects such as import substitution, export promotion, energy security, and predictability of production have previously been assessed.

5.1 Sustaining sugarcane production

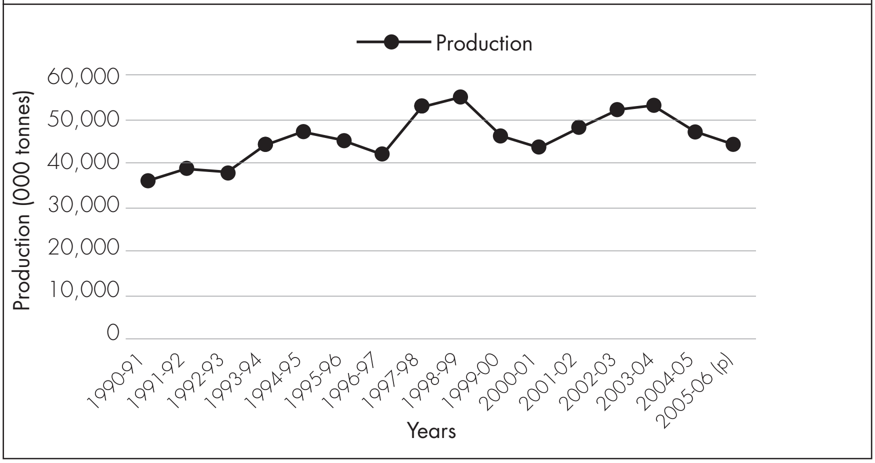
Sugarcane production is driven by a national policy that emphasises self-sufficiency in sugar. In the short to medium term, such a policy potentially generates derivative benefits in the shape of bioethanol production. Essentially, these benefits would ensue from the alternative use of the abundant stocks of molasses, provided the correct policy and economic incentives are in place for such conversion. There are no backward linkages with sugarcane production *per se*. As indicated, it is the concern with food security that drives the government to seek ways to incentivise sugarcane growers, or to find alternatives such as sugar beet.

However in the long term, the sustainable development concerns associated with the production of feedstock may materialise if bioethanol production in Pakistan takes off. In view of the growing scarcity of water and land, land-use conversions (deforestation) and crop switching (undermining food security) would then become legitimate concerns.

On average, over the five years to 2005, Pakistani sugarcane production averaged 50 million tonnes per annum, as compared to the requirement of nearly 75 million tonnes to meet the capacity of its installed sugar mill production.

The lack of predictability is linked to variable water supply. Sugarcane is a water-intensive crop requiring between 64 and 80 acre-inches. While Pakistan has adequate surface and groundwater, the difference between good and bad production years is contingent upon rainwater. During drought years, sugarcane production drops substantially. In years of high rainfall, sugarcane production rises, on occasion producing gluts. For the future, sugarcane shortages have been forecast as the norm as the discrete water supply sees increasing demand to meet agricultural, household, energy and industrial needs. Consequently, growers have begun to shift to crops such as maize and sunflower that require much less water and mature over a much shorter period.

Figure 3: Fluctuating sugarcane production in Pakistan



Source: Government of Pakistan (2006d)

Approximately 75 million tonnes of sugarcane input is required to satisfy the 6.7 million tonne domestic demand for sugar (Government of Pakistan 2006d). Over the last decade, however, mills have received just 35 million tonnes of sugarcane on average (*ibid*). Clearly, in years when sugarcane production is low, not only does sugar production suffer but so does molasses output. The Ministry of Food, Agriculture and Livestock (MINFAL) is attempting to promote sugar beet as a viable alternative to sugarcane, both for sugar and bioethanol production. However, annual production currently stands at just 300,000 tonnes and the crop is grown mainly in the NWFP (*ibid*). In 2002, the government of Pakistan started experimenting with various varieties of sugar beet in order to determine its feasibility in the Pakistani climate. Thus far, experiments in Punjab, Singh and NWFP have produced encouraging results. Imported beet seeds from France and Germany have proved to be resilient enough to do well, thus allaying concerns about beet's inability to mature under the high temperatures experienced in Pakistan.[10] The advantages of beet are higher yields (above 50 tonnes/hectare), significantly less water requirements, and a higher conversion ratio from beet molasses to bioethanol (Khan, unpublished). Sugar beet can also be intercropped with sugarcane. Interview responses confirmed that the government would need to provide a substantial subsidy to the mills to convert their production processes to beet since concerns about the high capital cost to process beet were raised. Another way to address these concerns is to enhance sugarcane yield. The yield has increased only marginally over the past five years and is currently about 50.1 tonnes/hectare, which is well below the global average of 60 tonnes/hectare (Khan, unpublished) (see subsection 3.1).

A possible long-term equity issue relates to the conversion of sugarcane or beet production to 'cash crop' agriculture, with its attendant negative spin-offs. One can envisage added impetus for corporate agricultural giants to take over production and thus marginalise small-scale producers in a bid to concentrate sugarcane or beet production. Moreover, agricultural encroachments into ecologically sensitive areas could also be an unwelcome consequence (Kruglianskas 2005).

5.2 Social impacts

5.2.1 Pricing issues

The government price support policy aims to ensure fair prices for sugarcane growers while keeping consumer welfare in mind. Equity concerns emerge from market imperfections. Middlemen (see subsection 3.1) play a key role in sugarcane procurement and often end up exploiting small-scale farmers, forcing them to sell at distress prices. In collusion with mill owners, they orchestrate delays at the mill gate; the problem becomes exacerbated during surplus years (Government of Pakistan 2005b). The farmer has no option

10. Interview with Inayatullah Khan, Cane Commissioner of Pakistan, Ministry of Food, Agriculture and Livestock, 20 February, 2007.

but to accept the price offered (lower than the support price) or face further delays. Large-scale farmers are better placed as their crop represents a large proportion of the mill intake and they also have greater political clout (Government of Pakistan 2006a). Small-scale farmers are indebted to middlemen for their consumption and input needs and this also leads to under-pricing. Furthermore, a report by the Agricultural Prices Commission of Pakistan indicates that the scales installed to weigh sugarcane do not provide correct readings (*ibid*); however, given the high level of illiteracy among small-scale growers, such practices go undetected. Moreover, mills are also known to make undue deductions, contending that sugarcane quality is low and contains high trash content (*ibid*).

The effects of government intervention are also felt in the molasses and industrial alcohol markets. While the benchmark prices for these products/by-products are determined in global markets, the government distorts relative prices by taxing locally produced alcohol (see subsection 4.1.2).

5.2.2 Labour issues

A lifecycle analysis suggests little impact on employment whether the *status quo* is maintained or there is increased bioethanol production. In the short to medium term, value-added is likely to occur as a result of switching from molasses to bioethanol production, which has no back effects on either sugarcane or sugar production. In the long term, if Pakistan finds substantial markets abroad for bioethanol and this triggers land-use changes, it may trigger discernible impacts both in growing sugarcane and processing.

The sugar sector in Pakistan employs nearly 75,000 people and the sector suffers from over-capacity. While unions exist, sugar mills often threaten redundancies in order to right-size the industry. Labour unions find it difficult to negotiate with employers as the sugar cartel exercises enormous influence over decision-makers in the country (Memon 2002).

Labour conditions by and large are no different than in other Pakistani industries that produce for domestic consumption. Pakistan, in general, has made progress in meeting global labour standards in export-oriented industries. However, the performance has remained dismal in situations where client pressure to conform has been absent. On average, industrial wages in sugar processing remain on a par with industries in other sectors. However, the situation is markedly worse in the province of Sindh, where instances of employers not complying with labour laws, withholding employee benefits agreed upon in original contracts, and punishing workers for involvement in union activities are commonplace (IUF 2001).

Unlike the sugar industry, industrial alcohol production is highly capital intensive and requires a few skilled plant operators and engineers. Adding value in the form of bioethanol is again a highly capital-intensive process, requiring little or no additional labour. Taking realistic projections for Pakistan's bioethanol production in coming years, there is little possibility that the bioethanol sector would become a major employer. At the same time, however, an analysis suggests that no labour displacement would occur as a result of an increase in fuel ethanol production. First, as fuel ethanol is produced from a by-product of the sugar production process, there is no question of labour displacement within the sugar mills. The other potential concern is with regard to labour displacement in the oil industry, as fuel ethanol may end up replacing oil consumption. Again, for the foreseeable future, an increase in the blending ratio beyond 10 per cent is not envisaged so oil refining processes are not likely to be discontinued (this is distinct from revenues for the oil companies, which may drop).

5.2.3 Food security concerns

Globally, a somewhat sensationalised scenario is being represented in which the activities of the biofuels sector engender unhealthy competition between 800 million motorists and 2 billion hungry people. This could be a legitimate long-term concern for Pakistan although in the short to medium term, sugarcane and rice (two major production and export items) offer solid prospects for meeting domestic fuel demand at an E25 fuel blend.[11] Also, as cited previously, considerable scope for sugarcane yield increases exists and also for intercropping with sugar beet. But should Pakistan decide to go for higher blends and/or substantially higher bioethanol exports in future, corporate intrusions displacing food with fuel could become a reality. Accordingly, there is a concurrent need to explore alternatives to biofuel use, such as improved public transportation, increased vehicle efficiency, and hybrid vehicles. With regard to biofuels production *per se*, and in a food security context, preferred long-term policies would involve avoiding distillation from food grains such as wheat and corn, which Pakistan also grows in abundance – as well as encouraging the cultivation of energy crops on marginal lands. The latter would also generate poverty alleviation benefits.

5.3 Environment

Environmental impacts are evident at every step along the bioethanol value chain. Key stages include: i) sugarcane production, ii) production of molasses, iii) distillation of molasses, and iv) greenhouse gas (GHG) emission reductions through the use of blended fuel.

Perhaps the most adverse environmental impacts occur at the sugarcane production stage; such impacts derive from poor management practices. Environmental issues associated with cane production include: impacts on soil, vegetation clearing, groundwater use and contamination, pesticide pollution, and oxygen depletion in freshwater bodies. Sugarcane cultivation in Pakistan is known to cause soil erosion, soil alkalinity, and a consequent reduction in the soil's nutrient holding capacity, as well as soil salinisation. Fertiliser and pesticide use is also often inefficient and ineffective, which apart from increasing costs of production also leads to poorer groundwater quality and contamination of water bodies via pesticide residues. Moreover, oxygen depletion in water bodies is caused by inefficient harvesting practices that lead to water run-off containing substantial quantities of cane juice. Finally, air pollution is caused by the predomi-

11. The bioethanol potential for rice husks and hulls has still not been explored in Pakistan.

nant practice of post-harvest burning of the sugarcane trash. While this is designed to achieve ratooning success and pest and disease prevention, it allows ash and smoke to escape into the atmosphere (WWF-Pakistan 2004; Government of Pakistan 2006a).

Production of molasses, the second leg in the bioethanol production cycle, also has environmental concerns associated with it. Since molasses is a by-product of sugarcane processing in sugar mills, all environmental concerns related to the sugar industry also apply to molasses production. While the sugar industry discharge includes solid, gaseous and liquid waste, it is the last two that are harmful from an environmental perspective. The solid waste includes bagasse and press mud. The former is used as a fuel source within the industry and is thus recycled while the latter is mostly used by farmers in the vicinity of sugar mills as compost.

The level of gaseous discharge from the sugar industry is largely dependent on the source of fuel. Hydrogen sulphide, sulphur dioxide, oxides of nitrogen, carbon monoxide and trace metals are all discharged in varying degrees. Most literature on Pakistan suggests that these emissions remain well below the National Environmental Quality Standards (NEQS) limits. An exception is the smoke discharged from mills using fuel oil as a source of energy for the boilers, where the discharge is often found to be above NEQS limits. Finally, wastewater flowing out of sugar mills can potentially be highly polluting unless treated efficiently. It is worth noting that the track record of the Pakistani sugar industry and distilleries in this regard has been exceptionally good (WWF-Pakistan 2004).[12]

The next step in the production chain involves the processing of molasses into industrial bioethanol and further into fuel bioethanol. This process takes place in the distilleries. Wastewater flowing out of distilleries is highly contaminated; it can pollute fertile land and harm aquatic life in water bodies if left untreated. The rough proportions of waste in the outgoing effluent are provided in Table 9.

Table 9: Typical distillery wastewater composition

Parameters	Values
pH	4.0 ~ 4.5
Biological oxygen demand (BOD5)	40,000 ~ 45,000
Chemical oxygen demand (COD)	80,000 ~ 1,000,00
TSS (Total Suspended Solids??)	3000 ~ 5000 mg/lit
Sulphates	4000 ~ 6000 mg/lit
Chlorides	4000 ~ 6000 mg/lit
Potassium (K+)	4000 ~ 10000 mg/lit
Phosphate (PO4)	100 ~ 150 mg/lit
Calcium (Ca++)	500 ~ 700 mg/lit.

Note: pH – hydrogen-ion concentration. Above 7 indicates acidity, 7 is normal, below 7 indicates alkalinity
Source: (Talib 2001)

12. See also: www.redpml.cu/Biblioteca%20virtual/tema10/Cambios%20ambientales%20en%20la%20industria%20azucarera%20de%20Pakistan.pdf

While environmental legislation (the Pakistan Environmental Protection Act of 1997) exists to ensure industrial waste treatment in Pakistan, the implementation of these regulations is lax. The extensive technical and financial resources required for a robust monitoring and verification mechanism are not available (Akbar and Khwaja 2006). Only industries that find a clear advantage in adhering to environmental stipulations tend to implement regulations conscientiously. The distillery industry falls into this category.

Notwithstanding the general lack of effluent treatment by industries in Pakistan, most of the distilleries in the country have installed treatment plants, albeit operating with varying degrees of efficiency. The major push factor for distilleries to be environmentally conscious is the cost saving associated with waste treatment. The distillery wastewater treatment is an anaerobic process through which the organic components of the wastewater are converted into biogas, with the excess sludge production being extremely small. The two major products of the treatment process are methane gas and carbon dioxide. Methane gas is recycled as an energy source in the distilleries, with as much as 70-90 per cent of the total energy requirement being met from methane (Akbar and Khwaja 2006) – in effect, distilleries have a 'closed carbon cycle' (CCC). The final discharge, when diluted with subsoil saline water, has biological oxygen demand (BOD) and chemical oxygen demand (COD) concentrations reduced by as much as 97 per cent and can be used for land irrigation (Talib 2001). The environmental gains from treatment are thus obvious. More important from the point of view of the distilleries, however, is the cost saving as a result of treatment.

Table 10: Waste concentrations in treated distillery effluent

Parameters	Values	Performance
pH	7.5~7.6	Alkaline
BOD5	4,000~4,500 mg/lit	90% reduction
COD	27,000~33,000 mg/lit	Approx 65~67% reduction

Source: Talib (2001)

Despite the reduction in contaminants, waste concentrations are still higher than the nationally set NEQS standards. However, this points to the unrealistically low levels of concentrations stipulated in official standards rather than any problems in the treatment process (*ibid*). In fact, distillery plants maintain a reasonable level of technological sophistication in treatment, especially in the medium- and large-sized distilleries.

Regarding end use, the consumption of fuel ethanol in automobiles compared to fossil fuels leads to a substantial reduction in GHG emissions. The blended fuel provides a higher octane content without any presence of lead (traditionally used in petrol as a booster), thus enhancing car performance and, at the same time, reducing disease-causing emissions from car exhausts. Although no estimates specific to Pakistan are available, the general norm is that for blended petrol carrying 22–24 per cent fuel ethanol, reduction of fossil carbon dioxide from the tailpipe could be as high as 80 per cent.[13] Moreover, the fact that fuel ethanol has a positive net energy fuel balance is also widely acknowledged. For instance, a recent study found that on average a gallon of fuel ethanol contains 56 per cent more energy than the energy required to produce it (Salameh 2005). While such estimates may not provide a good proxy for the potential benefits in Pakistan – given the varying production technology and practices – they nonetheless do point to some potential net environmental gain by using fuel ethanol rather than fossil fuels. However, there is a partial offset. Pre-harvest burning of sugarcane is a common practice in Pakistan and generates GHG emissions and also air pollution in general. Moreover, despite the CCC we observed in the plants we visited, replication on a larger scale would make the CCC a more difficult option. Hence, emissions during the industrial alcohol and fuel ethanol production process would remain an enduring problem.

Ultimately, the sugar industry has the potential to generate projects under the Clean Development Mechanism (CDM) to earn carbon credits. The E10 blend is an immediate possibility. With all the potential benefits, institutional and policy support is essential.

6. Conclusions and recommendations

Given that the bioethanol industry in Pakistan is only starting to develop, this paper can be considered as anticipatory policy work and it can therefore propose a concrete set of policy recommendations and identify gaps in information about how to promote an industry that maximises sustainable development opportunities and minimises risks.

The promotion of bioethanol presents a win-win scenario for Pakistan. The country incurs an oil import bill of US$3.1 billion every year. Substituting petrol with bioethanol could result in considerable foreign exchange savings. Moreover, under current conditions there is no trade-off between bioethanol and the food production cycle. Environmentally, beyond the traditional environmental risks associated with the agricultural phase, the bioethanol production process in distilleries demonstrates a CCC. Moreover, bioethanol substantially reduces GHG emissions from automobiles, at the same time allowing for better vehicle performance.

Despite the potential advantages of bioethanol as fuel, progress in promoting it lacks impetus. The oil refining companies, in collusion with the petroleum ministry, have thus far managed to keep a lid on private sector involvement in popularising bioethanol use. The private sector, rather than being given incentives, faces domestic taxes on industrial alcohol sales. In addition to the domestic policy biases, major importing countries have also imposed restrictions on Pakistan, which have ended up compromising the country's export potential. The EU imposed tariffs under the revised GSP that negatively impacted the distillation industry. The loss of international markets has resulted in the closure of two distilleries and another five are contemplating shut-down. Furthermore, institutional uncertainties and unresolved issues especially pertaining to bioethanol classification may complicate the development and global growth of the industry. Initiatives such

13. See: www.saabbiopower.co.uk

as the EC Biomass Action Plan may present further barriers in bioethanol exports from developing countries such as Pakistan.

Another major concern involves the sustainability of bioethanol production. In Pakistan, bioethanol is produced from molasses generated as a by-product of sugarcane crushing. While sugarcane is a major crop, the lack of scope for area expansion of sugarcane and lowering yields of the crop are likely to cause severe sugarcane shortages in the future. Bioethanol production will therefore suffer as a result. While sugar beet has the potential to make up the shortage, it will only be able to supplement sugarcane over the long term. Other major crops do offer possibilities, the pros and cons of which need to be explored.

In essence, the domestic policy biases, export barriers, and concerns with regard to sustainability of sugarcane, all lead to a poor prognosis for future development of bioethanol as a renewable fuel source in Pakistan. While the potential both for domestic use as well as exports remains high, key fiscal, policy and external constraints will have to be addressed if positive outcomes are to accrue.

In light of the above, decision-makers should consider the following steps along the fuel bioethanol production chain:

1. Remove local taxes on the sale of industrial alcohol.
2. Impose a ceiling quota on the export of molasses from the country.
3. Allow duty-free import of the machinery required to convert industrial alcohol into bioethanol.
4. Reduce collateral and/or institute revolving leases for investors willing to set up distilleries or import machinery.
5. Institute an aggressive marketing campaign within the public sector to apprise users about the availability and benefits of E10. In addition, individual oil companies apart from PSO should be allowed to set up E10 stations and run their own marketing campaigns.
6. Increase the number of pilot projects experimenting with E10 after a marketing campaign; remove PSO's monopoly on the experiment.
7. The government should allow the Ministry of Industries rather than the Ministry of Petroleum to take charge of bioethanol development.
8. Until domestic demand rises, the Trade Development Authority of Pakistan (previously the Export Promotion Bureau) must be mandated to seek new markets for the country's industrial alcohol and fuel ethanol, perhaps through a dedicated unit.
9. Given the substantial gap in academic and technical research on the benefits of bioethanol usage in Pakistan, both the public and private sectors should invest in research to determine the potential gains and major pitfalls in expanding the fuel bioethanol industry.
10. The government must ensure that its price support policy for sugarcane is implemented and market imperfections due to the negative role of middlemen are removed. One option is to introduce a formal marketing mechanism by virtue of which designated agencies could act as middlemen between farmers and mills, ensuring that farmers get the officially stipulated price.

11. There is a need for effective control over the sugar mill owners. The sugar mills behave in the form of a cartel, which creates difficulties for sugarcane growers. Sugar hoarding is a common practice and though irrelevant to bioethanol production per se, it suggests the potential for molasses hoarding in the future if domestic demand for molasses increases multi-fold. The Monopoly Control Authority must take proactive initiatives in this regard.
12. The merits of zoning and de-zoning for sugarcane marketing are debatable and the scheme ought to be revised to benefit the sugarcane growers.
13. A multi-pronged approach is required to tackle low sugarcane yields. This would include discouraging farmers from using discarded or low yielding varieties and introducing new disease-resistant varieties as alternatives. In addition, education programmes to ensure better crop management practices are recommended.
14. Application of Geographic Information Systems (GIS), better land preparation practices, integrated water management practices, and integrated pest management are already well-known solutions and need to be stressed through better farmer education programmes. Wastewater treatment in sugar mills and distilleries is also widely practised and must be emphasised further through environmental protection agencies to bring non-conforming units into the fold.

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List of people interviewed during the preparation of this paper

Inayatullah Khan, Cane Commissioner of Pakistan, Ministry of Food, Agriculture and Livestock. Interviewed 20 February, 2007.
Ahsan Ahmed, Deputy Managing Director, Noon Sugar Mills and Distillery. Interviewed 7 March, 2007.

Chapter 3

Biofuels trade and sustainable development: the case of sugarcane bioethanol in Costa Rica

Carlos Murillo

1. Introduction[1]

The significant rise in oil prices and the uncertainty about the future behaviour of oil have made alternative sources of energy that were not profitable in the past, or were not seen as having the characteristics for major industrial development, now viable. What will the impact of increased production of bioethanol on sustainable development be? To what extent can the rise in production of bioethanol affect food security or food cost? How does the increase in cultivation for sugarcane affect the environ-

1. This chapter is based on Murillo, C. (2007) *Biofuels Trade and Sustainable Development: The case of Costa Rica,* International Institute for Environment and Development (IIED) working document. Available to download at: http://www.iied.org/pubs/display.php?o=G02288

ment, due to increased use of agri-chemicals, more demand for water, and air pollution from fires? These concerns are at the core of the evolution of energy policies in a small non-oil producing country like Costa Rica, with a high dependency on oil imports. Nevertheless, the country has the necessary weather and soil conditions for the production of alternative sources of energy, such as bioethanol from sugarcane. This chapter analyses the accumulated experience in the bioethanol sector of Costa Rica, its lessons and constraints, and explores – starting with government policies and the availability of natural, financial and institutional resources – how to develop the bioethanol sector, as well as the possible social, environmental and economic implications of such development.

After this introduction the paper continues (Section 2) with a brief description of some relevant aspects of Costa Rica's trade policy and energy sector. Section 3 sums up the country's experiences with bioethanol production during the 1980s, and later during the former and current administrations. Section 4 analyses production costs, trade trends and supply capacity, among others issues relevant for the bioethanol sector in Costa Rica. Afterwards the paper continues with sections analysing sustainability in respect to its economic, social and environmental aspects (Section 5) and the role of the state (Section 6). The paper's conclusions are the subject of Section 7.

2. Costa Rica's trade policy and energy sector

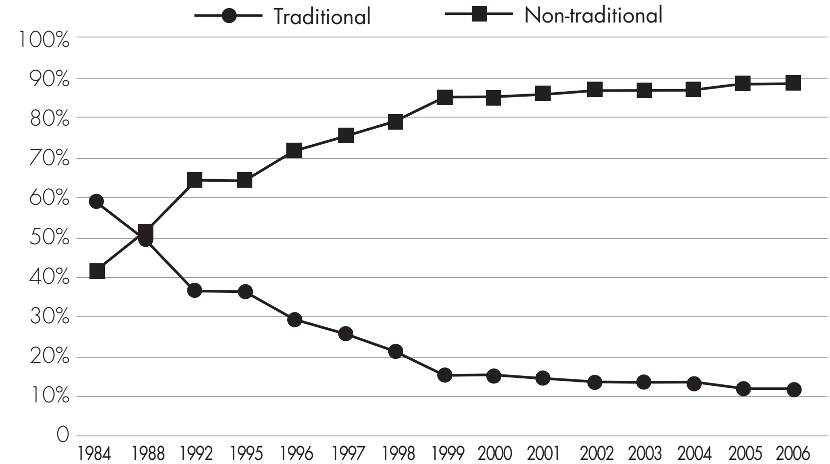
During the last two decades, Costa Rica has moved towards trade liberalisation and at present is the most open economy in Central America, and one of the most open in Latin America. Besides joining the General Agreement on Tariffs and Trade (GATT) in 1990 and being a member of the World Trade Organization (WTO) since its creation in 1995, Costa Rica has signed six trade agreements and 14 bilateral investment agreements. At present the average tariff is 6.5 per cent and foreign direct investment has grown to US$1,410.8 million in 2006.

In 2006 the Costa Rican economy grew by 8.2 per cent (during the period 2003–07 the average growth rate was 6.2 per cent). It has an unemployment rate of 4.6 per cent, and in 2007 16.5 per cent of the population were considered to live below the poverty line. Costa Rican export diversification is also relevant; the country is currently exporting 3,796 products (having changed its exports structure from comprising 60 per cent traditional products in the 1980s to less than 15 per cent today). Non-traditional products represented approximately 89 per cent of total exports in 2006 (see Figure 1).

Costa Rica is part of the Central American Common Market, a trade integration created at the beginning of the 1960s (and going through a transformation towards open regionalism since the 1990s) in which trade liberalisation has deepened amongst its members without increasing barriers to third parties.

The country has been strengthening environmental regulations and institutions simultaneously. Environmental protection is a constitutional right (Article 50 of the Political Constitution); Costa Rica has had an environmental ministry (Ministerio de

Figure 1: Costa Rica's traditional and non-traditional export products (1984–2006)



	1984	1988	1992	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Traditional	59	49	36	36	29	25	21	15	15	14	13	13	13	11	11
Non-traditional	41	51	64	64	71	75	79	85	85	86	87	87	87	89	89

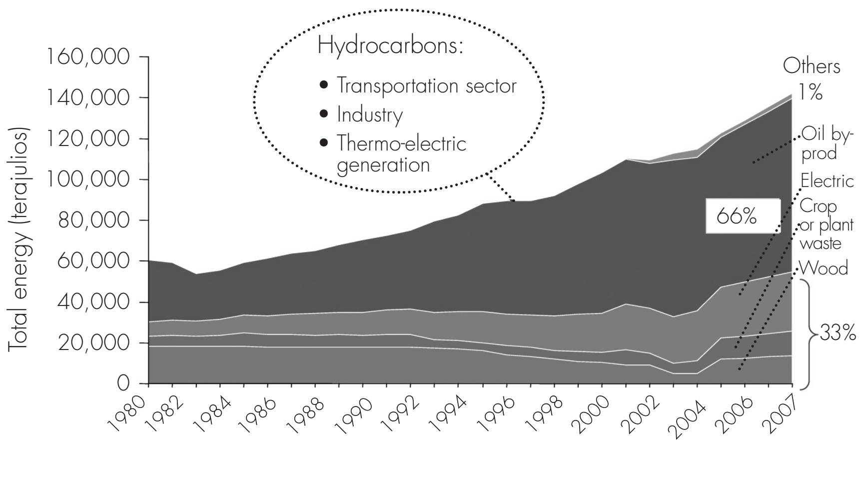
Source: author's analysis using statistics from the Ministerio de Comercio Exterior (COMEX), Government of Costa Rica.[2]

Ambiente y Energía, or MINAE) since 1990, and has enacted several laws related to the environment, among which are the National Law of Environment (1995), the Law on Biodiversity (1998), and the Forestry Law (1996). Costa Rica has also signed 14 multilateral environmental agreements. Twenty-five per cent of the country is comprised of protected areas, and an environmental service programme has allowed 51 per cent reforestation of the country. In terms of its infrastructure and natural beauty, in 2007 the country was considered the premier environmental destination in Latin America, and also the tenth in the world (according to a country ranking from Future Brand, a consultancy firm that is part of the Interpublic Group).

Like other non-oil producing countries, Costa Rica has been affected by the sustained rise in oil prices (expected to go over US$100 per barrel by the end of 2008). Oil imports have increased from US$526 million in 2003 to US$1,436 million in 2007 – a rise of 36.6 per cent in four years. This now represent slightly more than 5.6 per cent of gross national product (GNP), twice as much as in 2002. During the last few years, efforts have been made to reduce the country's oil dependency. According to Matamoros (2007), sources of energy in 2007 were distributed as shown in the following figure.

2. See: http://www.comex.go.cr

Figure 2: Sources of energy in Costa Rica (2007)



Source: Matamoros (2007)

3. Costa Rica's experience with bioethanol

3.1 Initial experience: the 1970s and 1980s

Interest in alternative sources of energy emerged in the 1970s as a result of the international oil crisis, which highlighted the issue of the world's economic sustainability and the possible exhaustion of non-renewable resources (as well as a lack of alternative renewable sources). Daniel Oduber's administration (1974–1978) faced the impacts of the first energy crisis. He initiated a strong boost to government participation – it was the time of the 'entrepreneur state', which was introduced to increase productive activities that were usually developed by the private sector. This policy was based on the assumption that the government would intervene in strategic sectors if the private sector could not provide resources. Oduber's administration strengthened a state corporation that was established at the end of the previous Figueres administration (1970–1974): Corporación Costarricense para el Desarrollo (CODESA), an institution that also created a series of companies such as the Central Azucarera Tempisque S.A. (CATSA), which was dedicated to sugarcane cultivation and industrialisation.

Two other facts faced by the Oduber government were high coffee prices and, at the end of his term, lowering sugar prices. The former brought the necessary resources to develop a series of productive and cultural activities that brought dynamism to the economy and thus a positive image for the government.[3] The energy crisis and low sugar prices were an incentive for the government to look to Brazil and emulate its

3. Costa Rican President (1910–1914) Ricardo Jiménez said that 'The best Treasury Minister is a good coffee harvest' (Meléndez 1983).

actions related to bioethanol production. Oduber s administration established the Renewable Fuels Programme as a way to address the oil price rise created by the energy crisis. In 1977 the government introduced basic guidelines to launch the national production and use of sugarcane-based bioethanol. In 1987 a distillery for anhydride alcohol was installed at Central Azucarera Tempisque South America (CATSA) with a double purpose: to face both the energy crisis and the low sugar prices, which were below the cost of production at that time.

In the 1979–1980 sugarcane harvest (during the Carazo administration of 1978–1982), 2.5 million litres of alcohol were produced. In the following two harvests (1980–81 and 1981–82), 2.1 million and 1.9 million litres were produced respectively (Ruiz 1987, cited in Chaves 2003). In 1981, SEPSA,[4] a department of the Ministry of Agriculture and Livestock (Ministerio de Agricultura y Ganadería, or MAG) published the document *Basic Guidelines for a National Programme of Carburating Alcohol*.[5]

During the second oil crisis, the government introduced a 20 per cent bioethanol/80 per cent petrol mix (also known as 'E20') using alcohol produced by CATSA – a product later known as 'gasohol'. This mix was sold in 33 petrol stations in the metropolitan area of San José between April 1981 and November 1982, then in 1983 its use stopped. During 1982, 4.1 million gallons of gasohol were consumed (out of a total of 40.1 million gallons of fuel used in that year) and in 1983, out of the same total of fuel, 545 thousand gallons of gasohol were used. In the next year, only the surplus of the preceding year was used. Amongst the reasons behind the failure of this programme were:

- It was an optional programme (e.g., it covered only a small part of the country and was voluntary for distributors and consumers).
- The petrol stations did not have the correct infrastructure.
- Consumers were not well informed on how to take care of engines, which created insecurity over the effects the mix had on their vehicles (Chaves 2003).
- The end of the oil crisis resulted in the stabilisation of oil prices.
- The incoming government had little interest in continuing or strengthening the programme.

Interest in the bioethanol sector was renewed when Costa Rica became a beneficiary of the Caribbean Basin Initiative (CBI) and the United States – within that initiative – promoted bioethanol production and exports. This brought diversification to the sugar industry and added value to its by-products.

The US Caribbean Basin Economic Recovery Act (CBERA) (approved in August 1983) became valid on 1 January, 1984. The CBI is a unilateral tariff exoneration concession by the government of the United States for many Caribbean products (almost all of them are at zero tariff), to promote 'a stable political and economic climate in the Caribbean region'. The main difference compared with the Generalized System of Pref-

4. Secretaría Ejecutiva de Planificación Sectorial Agropecuaria (Executive Secretariat of Agricultural Sectorial Planning).

5. *Lineamientos Básicos para un Programa Nacional de Alcohol Carburante* (1981).

erences (GSP) of 1974 is that the products enter the list individually, after a study by the United States government. Exceptions are similar to the ones of the CBI; however there are many products, especially agricultural, that form part of the CBI but not the GSP. The CBI product list is superior to that of the GSP – all products benefiting from the GSP are part of the CBI, but the opposite is not true.

As part of the initiative, duty-free status is granted to fuel bioethanol under certain conditions. If bioethanol is produced from at least 45 per cent local feedstocks (e.g., bioethanol produced from sugarcane grown in the CBI beneficiary countries), it may be imported duty-free. If the local feedstock content is lower, limitations apply on the quantity of duty-free bioethanol imported. Nevertheless, up to 7 per cent of the US market may be supplied duty-free by CBI bioethanol containing no local feedstock. In this case, hydrous ('wet') bioethanol produced in other countries can be shipped to a dehydration plant in a CBI country for reprocessing. After the bioethanol is dehydrated, it is imported duty-free into the US. Currently, imports of dehydrated bioethanol under the CBI are far below the 7 per cent cap (approximately 3 per cent in 2005). In 2005 the cap was about 240 million gallons, whereas only about 100 million gallons were imported under the CBI in that year (Yacobucci 2006).

This CBI opportunity motivated Liga Agricola Industrial de la Caña de Azúcar (LAICA, the Costa Rican national sugarcane body) and CATSA to collaborate in 1984, and to produce and export alcohol in 1985. This process was preceded by strong lobbying amongst sugarcane producers in the Costa Rican Congress to reform Article 433 of the fiscal law, which since 1885 had established the state's monopoly of the Fábrica Nacional de Licores (FANAL) for the manufacture of alcohol.

In 1984 the Taboga sugarcane mill was built, a new distillery that produces and exports alcohol. The first production came with the 1985–86 harvest, and brought 898,683 litres of anhydride alcohol and 988,595 litres of hydrated alcohol. As a consequence of the preferences/quotas established by the CBI, LAICA built a dehydrating plant in Punta Morales during the same year, collaborating with another rectifier plant to import and process low-quality alcohol from the Caribbean and Europe for later re-export to the US. The government once again became interested in bioethanol production and proposed a strategy to be launched in 1988, giving enough time for petrol stations to carry out necessary adjustments and for consumers to be properly informed. However oil prices went back to normal, so the programme was never implemented and remained only a good intention.

3.2 Recent experiences with bioethanol production

During the Pacheco administration (2002–06), biofuels started to receive attention once again. In the National Development Plan 2002–06 (Plan Nacional de Desarrollo or PND), five development principles were established, among which were environmental aspects 'satisfying hydrocarbon demand with an optimum product quality, reasonable prices and caring for the environment' is defined as one of the main objectives.

Amongst the policies formulated to reach this goal, the following were established:

- Research on development.
- The use of clean technology.
- Pilot projects in alternative fuel use.

Amongst the strategic actions, research on biodiesel, liquefied gas, hydrogen, vegetable oil and alcohol were highlighted. Another was reducing fossil fuel dependency through the execution of at least one experimental project with biofuels. In the IV National Energy Plan 2000–15, yet another important decision was stated, the objective being to eliminate methyl tertiary butyl ether (MTBE) beginning in 2005. This was preceded in 2003 by a strategy to oxygenate petrol with bioethanol or another environmentally and economically convenient product.

In February 2003 the government enacted two executive decrees and formed two commissions:

1. Decree No 31087 MAG-MINAE created the Commission MAG-MINAE-RECOPE-LAICA (Ministry of Agriculture and Livestock, Ministry of Environment and Energy, the Costa Rican state refinery, and the Industrial Agricultural Association of Sugar Cane) in order to design a strategy for the development of carburating bioethanol, incorporating at least three aspects: MTBE substitution, commercialising petrol mixed with bioethanol, and fixing the percentage composition of the mix.
2. The other decree (No 31818 MAG-MINAE) established the commission to design the strategy for biodiesel development. However, an appeal of unconstitutionality regarding Article 7 of this decree (which enables the execution of the programme) made it impossible to apply the measure (Horta 2006).

The Pacheco administration implemented a regional pilot project (which used a mix of regular petrol with bioethanol) in the Central Pacific and North regions of the country. This project incorporated two components: i) the use of the mixture 10/90 bioethanol/petrol (or E10) in 30 vehicles from Refinadora Costarricense de Petróleo (RECOPE, the Costa Rican state-owned oil refinery enterprise) and the monitoring of their performance; and ii) the management and logistics of the bioethanol/petrol product, from the point of manufacture in RECOPE to the point of sale in petrol stations.

The scope of this project was widened and the Barranca facility was also chosen to participate, supplying 64 petrol stations in the Guanacaste province and Central Pacific region, using a mix with 8 per cent bioethanol. It met the demand of approximately 66,000 vehicles, representing around 12 per cent of the national car market (GTZ 2006). Two public programmes were developed to disseminate information and receive feedback: one in Puntarenas and the other in Liberia (two province capitals). The pilot project started in February 2006 and concluded in June 2007.

The RECOPE component of the pilot project showed a 10 per cent mix of bioethanol in petrol did not reduce vehicle performance. Test results on emissions from the E10 mix were always under the established emission limits set by the Ministry of Public Works and Transportation (MOPT).

In the case of the pilot project in Barranca, the initial reaction was a decrease in petrol sales from petrol stations. Consumers felt like guinea pigs they became upset and threatened to sue RECOPE; there was a clear need for more information aimed at consumers and technical assistance for the petrol stations. The first reaction of the press was mainly negative, highlighting problems in vehicles and interviewing (and expressing the opinions of) people with little knowledge on the matter. However, with time there was a change in attitude. Pilot project consumers accepted the product, but this was not true on a national level. Since November 2006 there have been no complaints; press reports have been positive and have highlighted the environmental and social benefits. The pilot project has been followed up and the experience associated with world trends (RECOPE 2007).

It is worth pointing out that nationally produced bioethanol was not used for this pilot project: international bidding to supply the bioethanol was won by a Brazilian company, which then supplied RECOPE. RECOPE made an investment of US$3 million to buy the bioethanol. The pilot project has had an administrative cost of US$30,600 to date.

The present administration (the Arias Sánchez administration, 2006 onwards) gives special attention to the energy sector. President Arias met the Vice-President of Brazil, José Alencar, the day after his inauguration and they agreed to exchange experience and unite efforts in the biofuels sector, taking advantage of the vast experience Brazil has developed in the last two decades (Rothkopf 2007). Similarly, the President has said he is not going to give up on exploring the possibility of finding oil in the country. The former administration forbade the exploration of oil deposits in Costa Rica; they cancelled a concession to explore oil fields in the country that had been granted to the Texas-based company Harken Energy.

In December 2005 the Meso American Integration Program (PIEM in Spanish) launched a new initiative with Central American countries   Panama, Dominican Republic, Mexico, and Colombia   to promote regional energy integration, strengthen the markets for oil products, natural gas and electricity, and maximise energy efficiency and the use of renewable sources. This initiative was framed within the Plan Puebla Panama (PPP) and the Central American Integration System (SICA) leadership. Within the PIEM there was a project to build an oil refinery to supply the needs of the region with the support of Mexico, which could finance part of it and give technological support. Honduras and Panama were included in the list of countries that could provide a site for the refinery but the Pacheco administration did not submit Costa Rica for consideration.

Immediately after Arias attained power (2006), the country changed its position and forwarded its name to be considered for the refinery, which would have the capacity to process at least 230,000 barrels per day (bpd) of crude oil (known as 'Mayan crude') produced by Mexico,. At the time of writing a decision on the site has not been taken – the value of the construction is estimated at between US$3–4 thousand million and is calculated to start functioning in four years' time (Ruiz-Caro 2006). But the Costa

Rican government has not been idle; in the package of agreements that Arias brought from his visit to China (as a result of renewed diplomatic relations between both countries) there is a cooperation agreement between the Chinese National Oil Corporation and RECOPE to access technical support, enlarge the national refinery and, in the first stage, move from processing 20,000 to 40,000 bpd. These measures signify a clear determination by the current administration to develop a broad energy policy that includes oil by-product markets as well as biofuels, and to include more private participation within the energy market, which up to now has been mainly managed by the state.

Another decision Arias took was to derogate the two technical commissions on bioethanol and biodiesel created by the former administration. Instead, the National Biofuel Commission was established with decree DE-33357-MAG-MINAE, to give integrated treatment to the biofuel issue and reorientate former efforts developed by the previous commissions.

In the National Development Plan (PND) 2006–10, the current administration acknowledged the high dependency of the national energy matrix on oil imports, and identified the following national challenges: to reduce dependency on imported fuels; to take better advantage of renewable energy in the country; and to produce 100 per cent of the country's electricity from renewable energy sources.[6] In terms of biofuel goals, the objective is to develop a national industry by incorporating agri-industrial production and biofuel consumption in a sustainable way on a national level during the present administration.

The political commitment stipulated in the PND is to legislate so that an oil wholesale and retail market can be created to help the fuel industry (including biofuels) to develop in a sustainable investment context. Likewise, the goal is to have a prompt and adequate response to society's fuel needs in the context of today's world trends: mitigating greenhouse gas emissions and improving the environmental quality of fuel.

Recently the Arias government launched a national energy strategy with four components:

1. An energy strategy, with an energy security goal.
2. An environmental strategy dealing with climate change with the aim to be carbon neutral by 2021.
3. An agricultural strategy to reactivate the agri-industry, creating a national market for biofuels.
4. A social strategy, emphasising the use of the biofuel market to reactivate the agri-industry in areas of social vulnerability.

Box 1 details short- and medium-term actions determined by the present administration in the National Biofuels Programme launched in November 2007.

6. In 2004, Costa Rica generated 99 per cent of its electricity from local renewable sources: 80 per cent hydroelectric, 16 per cent geothermal, 3 per cent wind and only 1 per cent fossil fuel combustion, making it one of the cleanest power sectors in the world.

Box 1: National Biofuels Programme strategy for fuel development

Short-term actions (first six months)

1. Design and execution of a market strategy focused on a national programme of communication to inform the population of basic facts so that their biofuel consumption is positive and beneficial.

2. Validate experiences in the national context, determining the impact of biofuel on vehicle performance and safety as well as on maintenance costs (amongst others) in order to verify that biofuel consumption is not harmful to vehicles.

3. Diagnose the system infrastructure to establish an inventory of needs including assets, technology, human resources, information systems, and organisational and budgetary design for the preparation of the actors who will facilitate the change.

4. Strengthening of market capacities involved in production, trade, and consumption of biofuels.

5. Budget projection of the investment for the purchase and trade of biofuel with priority given to purchase in the national market.

6. Generate the legal framework for the operation of the biofuels market with a 'biofuel decree' being a bridge to a 'law on biofuels', to be promoted in the medium term.

7. Design and implement a framework of knowledge management based on international experience and aiming to develop Costa Rican technologies on agri-energy cultivation in order to increase the effectiveness and efficiency of the biofuels programme.

Actions in the medium and long term (one to four years)

1. Develop the legal sustainability to produce, trade and consume biofuel fundamentally through the promulgation of a 'law on biofuels'.

2. Develop R&D on biofuels widening the management of knowledge, involving higher education institutions, promoting innovations, and exporting technology and services as a way to finance scientific activity.

3. Increase the consumption of biofuels in the next three years, achieving around 200 million litres of biofuel consumed annually; promoting the re-conversion of all consumers and especially large-scale ones.

4. Minimise producer risk giving insurance to agri-energy cultivation that is profitable and efficient to both producer and the INS (National Institute of Insurance), allowing access for small-scale producers and promoting local socio-economic development.

5. Generate alternative means of financial support by establishing a fund for financing agri-energy projects in a sustainable way and facilitating the inclusion of small-scale producers.

6. Assist in the development of exports infrastructure taking advantage of the country's potential to place its surplus in international markets, where the demand is increasing. The state and the actors involved should agree on the development of ports infrastructure for this purpose.

4. The bioethanol sector

The Costa Rican sugarcane sector is quite well organised and has had its own legislation since 1940. It is led by the Liga Agrícola Industrial de la Caña de Azúcar (LAICA), founded in 1965, and constitutes a non-governmental entity under public legislation. The regulatory framework of the sector has been modified over time and currently the sector is ruled by the Organic Law of Sugar Cane Agriculture *and* Industry N° 7818, promulgated in September 1988. The goals of the law are to maintain an equitable relationship between the sugarcane producers and sugarcane mills, in order to guarantee rational and fair participation in each sector. Article 5 of the law gives LAICA the power to 'trade alcohol, sugar, honey and other by-products of the sugarcane industry whenever it is convenient, with national industry or any other'.

The National Institute of Agricultural Technology (INTA in Spanish) of the Ministry of Agriculture and Livestock, and the Department of Sugarcane Research and Extension (Dirección de Investigación y Extensión de la Caña de Azúcar, or DIECA in Spanish) within LAICA, promote sugarcane production and technology transfer. LAICA has an ongoing research programme for propagating new varieties that can adapt to different ecosystems in the country. Seventy-five different varieties of sugarcane have been identified so far. The research aims for greater adaptation to different zones and better productivity and phytosanitary standards, and has resulted in varieties bearing the LAICA name (Pérez 2006).

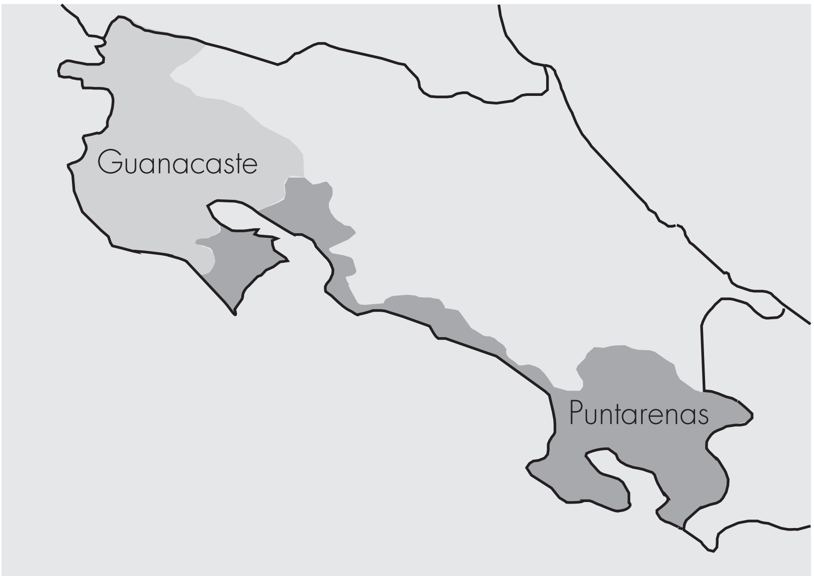
4.1 Production trends

Sugar is the fourth largest agricultural export product in the country, with a 0.5 per cent share of total national exports. Almost 42 per cent of the total production is exported. Its main export markets are Canada (42.1 per cent), Russia (30.8 per cent) and the United States (25.6 per cent). The cultivation area under sugarcane is approximately 51,000 ha, primarily in the Guanacaste, Central Pacific and Puntarenas regions.

The sector has 44 non-independent producers composed of 16 sugarcane mills, and 28 major producers of at least 5,000 MT (metric tonnes) annually each. They benefit from high levels of technology such as laser land levelling, irrigation systems and mechanised cultivation. Independent sugarcane producers are small in terms of size of production and comprise 10,761 producers. Their mechanisation level depends on the productive unit size. Ninety per cent of all sugarcane production comes from productive units with less than 7 hectares. At harvest time the sugar sector employs 30,000 workers with 20,000 in the non-harvest season (which represents 11.7 per cent and 7.8 per cent of agricultural employment respectively). Due to a lack of labour, the tendency is for producers to mechanise work as much as they can (Leal Fortuny 2007).

National production of bioethanol during 2003–06 was estimated at 40–42 million litres per year. The production of bioethanol is carried out in three different locations: CATSA, Taboga Sugarcane Mill, and LAICA (in Punta Morales). CATSA has the capacity to produce 200,000 litres of bioethanol per day, and Taboga 150,000 litres. Together

Figure 3: Sugarcane-producing areas in Costa Rica



Source: author

Table 1: Milling capacity of non-independent sugarcane mills

Sugarcane mill	Installed capacity (metric tonnes per day)
Taboga	6,500
CATSA	6,300
El Viejo	6,200
El Palmar	4,500
El General	4,000
Quebrada Azul	3,000
Victoria	2,700
Atirro	2,300
Juan Viñas	1,700
Cutris	1,400
Costa Rica	1,200
Argentina	900
Providencia	800
Santa Fe	720
Porvenir	700
San Ramón	680

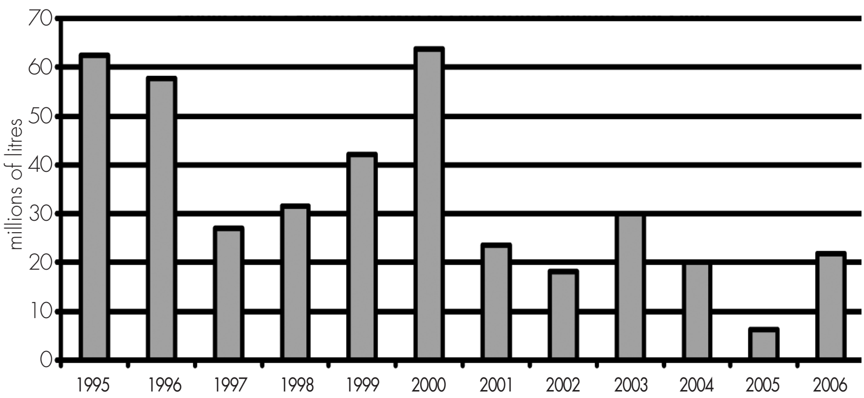
Source: Leal Fortuny (2007)

Table 2: Bioethanol production capacity	
Sugarcane mill	Installed capacity (alcohol litres/day)
CATSA	200,000
Taboga	150,000

Source: Chaves (2003)

they provide a total capacity of 42 million litres per harvest. LAICA has a dehydrating capacity of 110 million litres per season and carries out a 'maquila process' whereby LAICA is supplied with imported hydrated alcohol, which is then processed and exported to the United States.

Figure 4: Costa Rica exports of bioethanol



Source: author's own analysis using data from LAICA

During 2001–02 Costa Rica imported 1.28 million litres of hydrated alcohol from Europe. This volume was four times lower than that imported during 1999–2000. Imports from the European Union have diminished drastically because of European Union regulations (Rothkopf 2007).[7]

Despite the fact that in Costa Rica bioethanol has been produced for 27 years and exported for 21, as a carburant it is still not part of the energy matrix of the country due to the favourable exporting conditions of the CBI. This incentive seems set to continue because of: i) the interest of the United States in doubling the current demand to reach 28.4 million cubic metres by 2012, according to the Energy Bill recently approved by Congress, ii) the favourable conditions given by CAFTA (the Central America Free Trade Agreement) in extending the benefits of the CBI, and iii) because of the rise in the demand of bioethanol worldwide.

7. Reform to the Common Agricultural Policy (CAP), September 2006. Directives: 2003/30/EC; 2003/96/EC. Regulations: (EC) 670/2003; (EC) 2336/2003; (EC) 1907/2006.

A key question concerning the decision to use E10 in the petrol mix at a national level is whether the country is capable of responding to the national demand, given the current installed capacity and the possibilities of expansion.

Horta (2004) designed a projection for the Central American region to determine the need for expansion of a cultivated area in order to be able to meet the projected national demand. He calculated productivity to be 75 tonnes of sugarcane per hectare, and productivity of six litres of bioethanol anhydride per metric tonne of processed sugarcane for sugar (molasses ethanol) and 75 litres of bioethanol when the cane is destined directly to make biofuel (sugarcane juice bioethanol). He then considered a mixture of 10 per cent bioethanol in petrol and the use (as a raw material) of 75 per cent of the available molasses, to be completed with direct sugarcane juice in the quantities necessary to match the demand of the national market.

Using data available in 2004, Horta concluded that, given a 10 per cent ethanol mix with petrol, and considering Costa Rica's existing installed capacity to produce bioethanol, a 26.5 per cent increase in the country's sugarcane production area would be needed.

Horta also estimated the storage requirements necessary to be able to have bioethanol available all year round. His estimates point to storage demand between harvests of 61.3 thousand cubic metres for a 100-day harvest. Bioethanol can be stored either by producers or distributors, depending on their interests. Storage carries costs and risks but given the seasonal character of the product cannot be avoided.

Other issues that the country must address in order to develop the bioethanol industry are transportation and distribution. Production is carried out in different places – currently Puntarenas and Guanacaste – but it could also be done in other areas (such as the Northern region if there were to be an expansion of cultivation). RECOPE would be responsible for mixing the bioethanol product (in order for the mixture to be homogeneous), therefore the bioethanol would have to be transported to its installations. RECOPE has four plants: Moín (294 kilometres), Barranca (110 kilometres), La Garita (36 kilometres), and El Alto de Ochomogo (20 kilometres) from San José. Bioethanol must be transported in tanker trucks because it cannot be exposed to water and therefore requires dedicated pipelines. In general the storage, production and distribution of the mixture to distributors will require organisation between the different actors, as well as the determination of costs, which will affect the price at the pumps.

Horta (2006) argued that RECOPE could use specialised pipelines to transport bioethanol to petrol stations within the country. Brazil has vast experience in this field and the contacts between Costa Rica and Brazil already exist for technological support.[8]

Another important issue is the implication for employment, especially in rural areas. Horta (2004) looked at two scenarios. Scenario one estimated a high level of mechanisation and a 160-day harvest, resulting in productivity of 120,000 daily litres of bioethanol and a need for 455 direct workers per year. Scenario two reflected a less

8. During the first stage. In the third or fourth quarter of 2008, RECOPE will acquire equipment for the reception, mixing, and control of bioethanol at the four locations.

mechanised sector, with a 100-day harvest and a need for 1,775 direct workers. Based on these scenarios and estimating a demand of bioethanol of 84,500 m3, he concluded that a less mechanised process would bring a high demand for a labour force of 12,499 rural workers while one with a higher level of mechanisation would bring a lower demand of 2,002 rural workers.

For industrial employment, he estimated an average requirement of 150 workers/year for distilleries with a capacity of 120,000 litres daily and a harvest of 130 days. This gave a result of 813 workers. The study assumed that for calculating indirect employment, three indirect workers were necessary for each direct post, resulting in a total of 13,311 direct employment posts and 39,934 indirect ones a total overall of 53,246 jobs in the case of the high demand for employment scenario two. For the low demand first scenario the general total resulted in 11,260 employment posts overall. Horta considered that as industry became mechanised and increased efficiency, it would move from the high demand scenario two to the low demand scenario one.

Costa Rica suffers from a scarcity of labour; in general, labour comes from Nicaragua for the duration of the sugarcane cutting period. For this reason the sector will tend to become mechanised in order to minimise the effects of the labour shortage.

Using data from 2005 for Costa Rica, Horta (2006) points out that with the current installed capacity of the country (350,000 litres daily) 48 per cent of the projected bioethanol demand could be covered (the estimated gasoline demand is 900 million litres per year) using a mixture of 10 per cent bioethanol (90 million litres of anhydride ethanol per year).

4.2 Production costs

The determination of bioethanol production costs is more difficult than it seems to be at first glance. Key reasons behind this are the variability in technologies, production routes, integration levels of sugarcane production, and information from producers who have a tendency to inflate estimations. Also, the sugarcane mills produce sugar and electricity, adopting arbitrary rules of costs distribution. Horta (2006) uses sugarcane production costs given by LAICA, which correspond to a specific region of the country (Guanacaste). Assuming an exchange rate for the colón with respect to the US$ of 476.23 and an average productivity of 85 metric tonnes per hectare, the cost of the sugarcane is US$17.35 per tonne. This is high compared to Brazil, where the cost is around US$10 per tonne.

According to Horta (2006), production of direct bioethanol from sugarcane juice could result in 85 tonnes per ha and 75 litres of bioethanol per metric tonne of sugarcane could result in three scenarios to estimate bioethanol cost:

1. Raw material costs correspond to 40 per cent of the total cost of bioethanol, resulting in a cost of US$0.577/litre.
2. Raw material corresponds to 50 per cent of the total cost of bioethanol, resulting in a cost of US$0.462/litre.

3. The unit cost of raw material (estimated at US$ 0.231/litre) is added to the distillery and extraction processing cost (using Brazilian cost data = approximately US$0.075/litre), resulting in a total cost of US$0.306/litre.

The first scenario seems to show the highest cost, doubling that of Brazil (which is about US$0.25/litre). The cost achieved in the third scenario is very unlikely to happen in reality because it is based on Brazilian costs (reflecting higher productivity and benefiting from economies of scale). The second looks more feasible initially because of the percentage of raw material used and the estimates supported by national data. These estimates are, however, made under the assumption that sugarcane juice is used directly, a situation that does not occur in Costa Rica where bioethanol is produced from molasses instead, thus incurring a higher cost.

The dehydration of imported hydrated alcohol, as part of the process of exporting anhydride carburating bioethanol to the United States, has been a profitable activity due to prices in international markets and preferential conditions in the frame of the CBI. Hydrated alcohol is imported at US$0.17/litre and anhydride alcohol is exported at US$0.34/litre. Thus for the sugarcane cutting season of 2001-02, 1,283,000 litres of alcohol were imported from Europe and an almost identical volume exported to the United States, giving a net profit of US$2,960,000.

Chaves (2003) makes a global revision of costs where a large disparity can be perceived, and where all values are significantly less than the ones estimated for Costa Rica.

Table 3: Bioethanol production costs

Country	Cost (in US$/l)
Australia	0.145
Brazil	0.222
Colombia	0.24-0.30
France	0.386
India	0.261
Mexico	0.185
Thailand	0.152
United States	0.231-0.286

Source: author's analysis based on Chaves (2003)

It is expected that, as this industry consolidates, it will increase its productivity and improve its technology, and therefore costs will go down. However, it will be difficult to achieve the same level of efficiency/costs as in Brazil, given, for example, Costa Rica's small-scale production as well as the fact that it produces bioethanol from molasses – Brazil produces it from sugarcane juice, which is more efficient, and also uses the bagasse[9] for co-generation.

9. This is the biomass remaining after the sugarcane stalks are processed to extract their juice.

4.3 Value chains

With respect to bioethanol production and export there are two value chains: one based on the national production of bioethanol and another based on bioethanol maquila processing. National production is supported by the distilleries at CATSA and Taboga, with a production capacity of 350 million litres daily, and fed by national producers (which in 94.7 per cent of cases are small-scale ones). Bioethanol maquila processing is carried out by the LAICA distillery in Punta Morales, which transforms imported alcohol for export to the United States.

Table 4: Bioethanol exports by sugar sector in the harvests (2000–01 to 2004–05)

Harvest	Gallons	Price FOB Punta Morales (US$/gallon)	Totalincome FOB (US$)
2000/2001	6,228,651	1.3429	8,364,682
2001/2002	4,820,412	1.2646	6,096,124
2002/2003	7,928,883	1.2196	9,670,203
2003/2004	5,004,204	1.4447	7,229,483
2004/2005 *	1,555,644	1.4447	2,247,439
Average	5,107,558.8	1.3433	6,721,586.2
Growth rate (%)	-24,23	1,47	-23.11

Source: LAICA (2006)

4.4 Trade trends

As mentioned in Section 2, Costa Rica has had quite a proactive trade policy, and has achieved unilateral trade liberalisation successfully. It has trade agreements with six countries (plus one with CAFTA that is close to being ratified) and is currently negotiating an association agreement with the European Union conjointly with the rest of Central America. The main purpose of these agreements is to consolidate a more stable and predictable access to market. Within these negotiations, the topics of sugar and bioethanol have had several hearings with quite predictable results. In the case of sugar there is a highly protected market.

Despite having exported bioethanol for 21 years, there has not been any clear Costa Rican trade policy with respect to the promotion of bioethanol exports. In some administrations (see Section 3) there have been some isolated efforts motivated mainly by the international oil crises, but they have not been consistent; in terms of exports there have not been other initiatives beyond the CBI proposal. This is not due to an internal market supply policy because bioethanol is not part of the national energy portfolio but because the emphasis of the sugar sector has been on the production of sugar and its more traditional by-products. The bioethanol trade has not been seen as a market niche to be developed.

As already explained, the CBI allowed the entry of bioethanol free of tariffs to the United States from countries that would benefit from such an initiative, provided that the 'origin rule' be respected, which was 45 per cent of value-added. However, it also allowed an imports quota with flexible value-added requirements for member countries, giving the possibility of maquila processing of hydrated alcohol to bioethanol for export to the United States.

In the Harmonized System for Designation and Codification of Merchandise (HS) there is no specific tariff code for bioethanol. For the purposes of tariffs, bioethanol is accounted for within the code '2207', which covers denatured alcohol (220720) and alcohol without denaturalisation (220710). Both can be used for the production of biofuels.

The consolidated tariff of Costa Rica for sugar at the WTO is 45 per cent. With respect to the negotiations of the Doha Round, specifically on environmental goods and services, the country has not yet stated a clear position with respect to treating bioethanol as an environmental or ecological good. The Brazilian proposal on that matter is relatively new, and Costa Rica as yet does not have a definite position.

Sugar is amongst a reduced list of sensitive products in the Central American region. Its production is fundamentally for local demand and there is high protection in all countries. Recent regulations have been established for bioethanol that define its specificities and characteristics, and there is currently a tariff-free trade.

4.4.1 The Central America Free Trade Agreement (CAFTA)

Costa Rica has had to follow a difficult path to ratify this trade agreement with the Unites States. After finishing trade negotiations in January 2004, the Pacheco administration (2002–06) delayed submission of the agreement to the Costa Rican National Congress, anxious about the strong opposition from half the population of the country and leaving the decision to the new administration. The Arias administration (2006 onwards), after several attempts and aware of the political fatigue that could undermine the approval of the agreement in congress, agreed to leave the approval to a national referendum – which finally occurred in October 2007, with 51 per cent votes in favour and 48 per cent against. Congress approved the implementation laws that were a requirement for the agreement to become valid in December 2008.

The agreement defines immediate free trade for bioethanol that complies with the origin rule of the agreement, i.e., with a national value-added of 45 per cent. It also establishes a quota of 31 million gallons, with a flexible origin rule that allows importing inputs including dehydrated and hydrated alcohol.

Of the six trade agreements signed by Costa Rica, three of them exclude sugar (Dominican Republic, CARICOM[10] and Panama); two of them establish quotas

10. The Caribbean Community and Common Market.

(Mexico, Chile); and one of them defines a eight-year gradual opening of the market before the total elimination of tariffs (Canada). In the case of CAFTA a quota was defined; it remains to be seen how sugar will be treated in the current negotiations with the European Union.

With the exception of Panama, which proposes a ten-year gradual reduction, agreements define a free tariff trade for bioethanol. This could be beneficial for bioethanol exports; however, this policy will be influenced by international prices, the supply of the country in question, and the competitiveness of the sector.

Overall we can conclude that while the signed trade agreements promote a free trade of bioethanol, this has not yet turned into an effective trade among the signatory countries. It could be, however, that the change in the international situation in relation to oil will create the conditions necessary to make this happen.

4.5 Supply capacity

Today, Costa Rican bioethanol production is focused on satisfying export needs. There is no national consumption of bioethanol beyond the pilot project mentioned previously in this paper, which is limited to a specific region of the country, and bioethanol used in that project is imported from Brazil. If the country is indeed interested in satisfying a national demand for E10, it would have to increase the cultivation area of sugarcane by 26.5 per cent. There are available lands for such an extension but implementation would depend on several factors. First, the use of the mix should be compulsory. Second, the government will have to decide how to meet the bioethanol demand. There might be a willingness to pay a higher price for the cost of local production in order to promote the bioethanol sector in the country. Alternatively, there may be greater interest in lowering the production cost of the mix and importing bioethanol for local consumption.

It is not yet clear which strategy will be implemented by the Costa Rican government. On the one hand, the National Biofuels Programme[11] exists, which will promote sugarcane and bioethanol production in depressed areas of the country to combat poverty, though for now there is no explanation as to how these policies will be put into action (purchase and distribution of lands, incentives for production, etc.). On the other hand, RECOPE is already buying bioethanol through open, public, competitive biddings in which international companies can participate. It does not seem as if the government wants to subsidise national companies and turn the development of the bioethanol sector into a fiscal burden. The factors that will determine whether national production satisfies local consumption are: international prices of sugar (especially the preferential ones); the international price of bioethanol; and the oil price and the productivity of the sector. At present there is no clear policy stating that production must be for local or international consumption (or both); it seems as if the decision will be determined by costs and prices of bioethanol and its inputs.

11. See: http://www.minae.go.cr/biocombustibles.html

5. Sustainable development impacts of bioethanol

5.1 Economic sustainability

One of the concerns regarding the standardised use of bioethanol in petrol is related to supply. If Costa Rica wants to be self-sufficient it has to develop storage capacity. This becomes imperative in view of the seasonal character of the raw material. Although it is entirely possible that the country will be able to develop this capacity in the future, it is important to remember that currently there is a complete dependency on hydrocarbon imports, and that the country is not in a position to guarantee a supply in the event of an international shortfall. The tendency at international level is for the market for biofuels to consolidate, and this will mean more stability, better technology, and more producers and consumers. The country counts on an installed capacity that without much additional investment could supply almost 50 per cent of national E10 demand without increasing the area of sugar production. Assuming that this will be the situation in the short term, the country can import the necessary amount of bioethanol (as Costa Rica has done with other products, such as rice, for which internal production does not supply the national demand, or as is done globally with oil products). If necessary, the country can change the percentages of the mixture – for instance by changing to 8 per cent bioethanol, 92 per cent petrol (E8) – in such a way that it can reflect the supply capacity. What must be understood here is that being self-sufficient is not a necessary condition to rolling out the use of the bioethanol-petrol mix nationally. Furthermore, the country already has vast experience with alcohol imports.

5.1.1 Currency savings due to oil imports substitution

As Section 2 highlights, oil imports in 2007 represented more than 5.6 per cent of the Costa Rican GDP, almost doubling in four years. The international trend for the oil barrel price is to increase; therefore it is expected to continue – at least in the mid-term. This current increase in oil prices makes the processing of substitute products profitable now; it is therefore timely for Costa Rica to develop these alternative products in order to lessen its dependency on oil, protect the environment, and stimulate new productive activities in the economy.

It should be noted that bioethanol will not be a substitute for petrol but that it will be used as a mixture, and that in the short term this mixture must be E10. Moreover, it seems that the benefits of using bioethanol have more to do with foreign currency savings and positive environmental impacts than the lowering of fuel prices, at least in the short term.

However, given the high cost of oil and its by-products, the use of bioethanol becomes more profitable each day. Horta (2006) estimates parity costs and calculates them for sugar producers by considering the different prices in the international markets. He estimates prices for molasses and sugar exports, both for the international surplus market and the United States preferential market. Table 5 shows the parity costs for each product and market; given these prices, the sugar market has the most difficulty competing (with the United States preferential market as its destination). Horta then defines the parity price for bioethanol, based on the price of petrol and MTBE that would be substituted by bioethanol. Using data from 2005, the price of regular petrol is US$0.47/litre and US$0.50/litre for super; the price of MTBE in Central America was calculated at between US$ 0.43/litre and US$ 0.47/litre for that year. If we use the second scenario (see subsection 4.2) from Horta's estimation of the production cost (i.e., when raw material corresponds to 50 per cent of the total cost of bioethanol), the resulting price is US$0.43/litre thus making bioethanol use in the country already profitable. If it is considered that petrol prices have increased since then, it is clear that bioethanol use is increasingly profitable and it can mean significant positive economic impacts for the country.

Table 5: Parity prices of bioethanol in Costa Rica (2003–04 harvest)

Reference		Parity price (US$/litre)
Product	Price (US$/kg)	
Molasses: external market FOB, surplus.	0.044	0.131
Molasses: external market FOB, American quota.	0.051	0.152
Sugar: external market FOB, surplus.	0.170	0.284
Sugar: external market FOB, American quota.	0.440	0.735

Source: Horta (2006)

5.1.2 Product diversification

How are Costa Rican sugarcane producers affected by having an additional alternative for the use and sale of their product? The international sugarcane market is highly protected: in general countries have to negotiate quotas, have only limited access to different markets, and sugar prices fluctuate. From this point of view, having an alternative use and thus a new destination market gives sugarcane producers a greater degree of flexibility and a larger demand for their product and consequently represents a more favourable situation in regards to price, with the following two incentives for the national producer.

5.1.3 Value-added

Bioethanol production adds value to the production of sugarcane and creates and promotes conditions for the development of an industry around bioethanol and other by-products. Using the parity prices mentioned previously, it can be seen that if the molasses and sugar producers substitute bioethanol, the price they would receive is much more than they would get if they were to continue producing molasses or sugar for the surplus market. On the other hand, if distributors buy bioethanol at cost prices from molasses or sugar producers from the surplus market, they would also have savings, and thus have a wide negotiation margin in which both may be favoured (and this is without considering the final consumer). The only instance in which it is more profitable to produce sugar is when it is destined for the United States preferential market.

5.1.4 Employment and income generation

As mentioned in subsection 4.1, assuming a less mechanised production scenario, bioethanol production can generate 12,499 agricultural jobs and 813 industrial ones, creating 13,311 direct jobs, and 39,934 indirect jobs giving a combined total of 53,246. With further mechanised production, jobs total 11,260 (2,002 agricultural, 813 industrial, and 8,445 indirect).

If we consider only the maquila processing of bioethanol, the impact on employment is low, with benefits basically arising out of the difference between prices for imports and the US purchase price of bioethanol, which benefits the industrial sector of bioethanol only.

5.2 Environmental sustainability

The impact that bioethanol production would have on the environment depends on whether the bioethanol is produced locally or imported from countries with lower prices. At present, there is no local demand because there is no national use of a bioethanol-petrol mix and the small production volume is exported. Therefore environmental impacts are very small, if they exist at all.

Sugar production and bioethanol manufacturing, like most production activities, have environmental impacts (Arce *et al.* 2004), and these are seen in changes in land use (agricultural frontier expansion and related impacts on biodiversity); soil quality (fertilisers, erosive processes); water use (irrigation, competition with alternative uses, scarcity in some regions); water pollution (vinasse, a final by-product of the sugar industry); air quality (fires, boiler pollution); and GHG emissions. Like any other productive activity they should be moving towards cleaner and more sustainable production. However, this is not reflected in the current situation even though, for instance, fires are illegal. To a considerable extent, this reflects a general lack of industrial compliance and poor environmental management in the country.

5.2.1 Air pollution

By analysing the structure of energy consumption by source, it can be seen that oil represents 67 per cent of consumption, with transportation consuming more than 50 per cent of oil. Besides its economic consequences, this has important environmental implications due to high air pollution from an increasing number of vehicles in Costa Rica: from 472,000 in 1998 to 830,000 in 2007 (Agüero 2007). This is aggravated by vehicles produced prior to 1989, though this tendency has been decreasing in the last few years. A more environmentally friendly mix, such as E10, would have an important beneficial impact on air pollution.

Key positive environmental aspects of using bioethanol within the petrol mix come from the substitution of additives like methyl tertiary butyl ether (MTBE) and lead, which cause usage problems and undesirable emissions.

5.2.2 Greenhouse gas emissions

Chaves (2007) mentions that a hectare of sugarcane sequestrates approximately 19 tonnes of atmospheric CO2 per annum. According to studies (Aguirre 2007, cited in Chaves 2007), substituting fossil fuel with sugarcane by-products produces 2.6 kilograms less CO2 per litre of anhydride ethanol. With an E10 mix in Costa Rican petrol, and with a demand for bioethanol of 90 million litres of anhydride ethanol per year, it can be estimated that 234,000 tonnes of CO2 (or 63,800 tonnes of carbon) can be avoided annually. Horta (2006) estimates that if an avoided tonne of carbon at a conservative price of US$5, along with the scope of the Kyoto Protocol and the valid mechanisms of carbon trade, US$320,000 can be saved each year through the use of E10 by Costa Rica.

5.2.3 Impact on agricultural frontier/land use

The impacts of the use of land for monocultivation (and all the problems that can be related to this type of crop) will, to a significant degree, depend on the country's strategy. Chaves (2007), using data from the Ministry of Planning, argues that in Costa Rice there is an important area of land that has potential for farming, despite the area being dedicated to forestry and forest (estimated to be 37 per cent of the national total). Chaves adds that other land that is currently underused (pastures and areas of very low productivity) could also be utilised. The current government visualises the production of bioethanol as a way to stimulate the agri-industry and develop it in zones where there are high levels of poverty and social limitations. On the other hand, consideration must be given to the constraints resulting from a small labour force, which can be a restrictive variable for production expansion beyond certain limits.

An aspect that could act in favour of bioethanol development is the current legislation in Costa Rica that promotes the adequate use of land. These include:

- The Forestry Law 7575 of 1996.
- The Law of Use, Management and Conservation of Land 7779 of 1998.
- The General Law of Health 5395 of 1973.
- The Organic Environmental Law 7554 of 1995.

The current administration clearly states its environmental policy in the National Development Plan (PND) 2006–10. It acknowledges that environmental management in the country has been contradictory or inconsistent. On the one hand, there have been some significant achievements, such as the Environmental Services Programme (ESP) and its impact on reforesting the country which went from 21 per cent forest cover in 1986 to the current 51 per cent. On the other hand, Costa Rica has the most polluted hydroelectric watershed in the Central American isthmus.

The government argues there is no incompatibility between economic growth and the promotion of environmental sustainability. On the contrary, it maintains that both are imperative for development, which is the ultimate objective of the political proposals of the 2006–10 administration.

> 'Costa Rica urgently needs to accelerate its economic growth to reduce poverty, but it is not just any economic growth. We aim to be a country that bets on clean industries based on knowledge, more than in a predator use of natural resources, whose economic rationality in the long term is very arguable. To put it in outlined terms: if our economic growth shall be economically sustainable in the long run, we should be concerned that it is going to be environmentally sustainable in the short run. The ultimate goal of environmental policy is human development, which is the growth of options for people. This is why conservation is not enough; it is necessary to ensure the use of natural resources; a sustainable use, certainly, but use in the end.'
> *Source: National Development Plan (PND) 2006–10*

The present administration has launched a programme of carbon neutrality, i.e., the nation's carbon emissions must be compensated with activities or programmes that bring about carbon sequestration. From that point of view, a bioethanol production programme can help in achieving this goal. The mixture of bioethanol with petrol is less polluting than petrol alone, so in that sense better air quality is being promoted.

Environmental impacts of bioethanol production can be controlled or mitigated by establishing goals and promoting technological change as well as the development of new knowledge (Horta 2006). The Brazilian experience is a good example of efforts to make sugarcane production a more sustainable activity. The Brazilian sugarcane industry has minimised the use of agri-chemicals in the last two years. Recycled materials and vinasse have served as fertilisers and pests such as 'broca' (*Diatraea saccharalis*) have been fought with biological methods. There has been a reduction in sugarcane fires (the goal is to eliminate them by 2021) and agricultural zoning and classification of lands has taken place.

5.3 Social sustainability

The strengthening of the agricultural sector and of socially depressed areas is amongst the goals of the biofuels strategy of the current government. It is not yet clear how these policies will be implemented so it is perhaps too early to speak about social impacts.

5.3.1 Small producers' participation

An interesting aspect of the Costa Rican sugar sector in the last few years has been the increase in small-scale producers. According to Liga Agricola Industrial de la Ca a de Az car (LAICA), between the harvests of 2000 and 2005 there was a significant increase in the number of producers (97.2 per cent). The producer group that grew more than any other within this sector produced less than 250 tonnes per harvest. LAICA attributes this to the organisation of the sector. This emphasises the important role of the small-scale producer in the sector.

Amongst the actions of the government to help small-scale producers has been the creation of a development bank that supports activities or projects that demand – in the short term a larger financial risk than commercial banks are prepared to take. Another initiative is the establishment of a programme with funds for small- and medium-scale entrepreneurs, which promotes this kind of production unit and helps them to prepare for the opening of markets (through the signing of trade agreements) so they can also take advantage of access to these,.

5.3.2 Food security

Horta (2004) assumes that to be able to supply the national demand for E10, a 26.5 per cent increase in the cultivation area will be required. Given weather conditions and current land use, it should be possible to expand production without creating competition with other agricultural products and/or develop areas that are socially and economically depressed. This should complement the generation of income instead of representing competing land use. Because of the weather conditions that sugarcane requires, the products against which it would potentially compete against, in terms of land use, are pineapple, melon and rice. In this situation the decision on what to produce would then depend on access to markets, technology available, and how the productive chain is determined. From the institutional point of view there is enough legislation to avoid an irrational and irresponsible use of land.

Moreover food security could be strengthened by creating conditions that generate income through employment or profits, which would allow more people to purchase basic foodstuffs. The option of sugar production for bioethanol means creating more employment opportunities in the rural sector. According to Horta, even though the increase in jobs is not necessarily big, it is meaningful with respect to the economically active population in the rural area.

6. The role of the state

In Costa Rica there is a state monopoly in respect to oil by-product imports, processing, and distribution at the wholesale level. As previously discussed, there was a state monopoly up to 1985 (through the Fábrica Nacional de Licores) in the manufacture of alcohol. An important tradition can be traced regarding the intervention of the state in these sectors, one which raises the question: how should the country produce and distribute biofuels?

One of the objectives of the present administration is to create an open fuel market – including biofuels – in which both the state and the private sector participate. For this to happen it will be necessary to make significant changes in the organisation and institutions of the energy sector a process that will require time to implement.

At the moment it seems as though the best incentive the state can give to biofuel market development is by rolling out the use of the bioethanol/petrol mix nationally and making its use obligatory; to date this has only been attempted at a pilot project level. Another task in which the state can play an important role is to provide information on the implications, benefits and precautions linked to the use of bioethanol. A third way to promote the bioethanol sector is to support adequate agri-industrial technological development for bioethanol production.

Regarding bioethanol prices, there should be careful analysis to ascertain the most advantageous route for the country to take. This might involve letting market forces determine the price based on opportunity prices (when the price makes it irrelevant whether bioethanol or another product is produced) compared to the prices of international markets, and based upon opportunity prices compared to other sugarcane products. Alternatively the price could be determined by the government, beginning with the costs of production or reference prices (the parametric formula) (Horta 2006).

Amongst the concerns raised by the promotion of the bioethanol sector are the negative social and environmental impacts that could be generated. These could be mitigated if there were the adequate legal and institutional conditions to address the different challenges. In respect to the environment, even though the country has solid legislation and functioning institutions, there are reasonable doubts about the capacity of the government to enforce the relevant legislation and develop an environmental management framework that reduces negative impacts. Indeed, a key difficulty faced by Central American countries when signing the trade agreement with the United States is that it made them commit to enforcing their own legislation, with trade sanctions and fines to be levied in the event that they did not. Although Central American governments did not want this to be included in the agreement, they accepted it (but asked for an environmental cooperation agreement that would help them with financing and technical support to improve legislation enforcement). Costa Rica is one of the countries in a better position to undertake such enforcement, but it is still far from doing so in a satisfactory way therefore it is prudent to be concerned about environmental legislation compliance if there were to be a expansion of the bioethanol sector.

Regarding social impacts, the most important concerns which became clear during the referendum discussions on the trade agreement with the US are poverty and social inequality. The tendency in the last 10 years has been for the gap between poor and rich to become larger, and for there to be no decrease in levels of extreme poverty. For the past 20 years, around 20 per cent of the Costa Rican population has remained below the poverty line (with the exception of 2007 when it came down to 16.5 per cent). It is germane to ask which sectors of the population will benefit from signing these trade agreements and who will benefit most from economic liberalisation. This is why the government must define a social (education, health, etc.) investment policy that promotes more benefits for the disadvantaged majority and thus counteracts the tendency to financially favour those who are already wealthy. The country has strong social traditions and institutions, but there must be clear and explicit policies established in respect to the emerging bioethanol sector specifically in terms of how to avoid undesirable social impacts.

7. Conclusions

Acknowledging the heavy burden of oil costs on the national economy and considering that this tendency is very unlikely to change in the mid-term, it is worth weighing up the potential benefits of promoting alternative sources of energy, particularly bioethanol. The Costa Rican trading experience with bioethanol and the country's current installed capacity are good starting points to launch a strategy in this field.

At present, bioethanol is not part of the national energy portfolio, but given current international oil prices, national bioethanol production and consumption already has the potential to be profitable. The great majority of studies point out the favourable conditions that Costa Rica has to promote the bioethanol sector, as well as the economic, social and environmental benefits this could bring about. However, just as with any other activity, bioethanol production has a variety of implications for different areas, and thus a well-planned strategy is required to minimise possible negative impacts.

The first stakeholder in this type of endeavour would be the state, which should establish the normative and institutional framework for the development of such an activity. In the case of Costa Rica, first steps are already being taken; these consider aspects such as national roll-out of the use of E10, a price-fixing mechanism, and the way in which RECOPE (the state corporation) and the private sector can participate. Then there are the sugarcane producers and sugarcane mills, which must improve productivity, develop environmentally friendly practices, and promote the participation of small- and medium-scale producers. Also important are the lessons that can be drawn from similar or previous experiences: there must be a sustained information campaign developed at a national level to inform consumers about the benefits of introducing the E10 fuel, and to minimise concerns regarding how vehicle engines will be affected and should be maintained.

An appropriate strategy would allow the country to reduce its dependency on oil imports and with the subsequent savings it would be able to stimulate the agricultural sector and promote a better distribution of income via employment and opportunities for small- and medium-scale producers. Possible negative environmental impacts that the activity may bring about could be minimised if the government and production sector take responsibility and there is adequate promotion of clean technologies, research and development.

Brazil is a good example of a country that has made a development decision to promote its bioethanol sector and after two decades it is capitalising on the benefits (which have the potential to be increased even more). Therefore the development of the Costa Rican bioethanol sector must be seen as a mid-term project where benefits will not necessarily be seen immediately. The activity is a challenge for the country but there are the required institutions and human resources in place, and this is a favourable international moment that can only increase the probabilities of success. If this is done satisfactorily, positive results should be felt in the environmental, economic and social areas in the long term.

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Chapter 4

Biofuels trade and sustainable development: the case of South African bioethanol

Anton Cartwright

1. Introduction[1]

This chapter explores biofuels trade and sustainable development issues from a South African perspective. South Africa does not yet have a significant biofuel industry and does not engage in biofuel trade. The focus is on the potential for bioethanol trade to and from South Africa to contribute to sustainable development. Sugarcane and maize, the two feedstocks that are most likely to be used in bioethanol production in South Africa during the initial phase, form the basis for analysis. It is assumed that production

1. This chapter is based on Cartwright, A. (2007) *Biofuels Trade and Sustainable Development: An analysis of South African bioethanol.* International Institute for Environment and Development (IIED) working document. Available to download at: http://www.iied.org/pubs/display.php?o=G02285

levels will remain close to E8, which is the level targeted by the industry. Accordingly, South Africa will remain a relatively small bioethanol producer, and the extent and nature of trade will depend on comparative policies and prices in the South African and export markets.

Section 2 briefly describes South Africa's liquid fuel sector and the nature of petrol and diesel demand in South Africa. Section 3 introduces South Africa's bioethanol industry by examining potential feedstocks, processing capacity, and emerging policy issues. Section 4 explores South Africa's potential to export bioethanol in terms of relative prices, market access, domestic support for a South African industry, and ability to comply with international bioethanol standards. Section 5 analyses the sustainability implications of bioethanol exports from South Africa by assessing the potential macroeconomic, environmental and social impacts of such exports. A key question arising from this paper is whether or not South Africa can rise to the economic governance challenge of drawing on its legislative instruments in a coherent fashion to ensure that a Southern African Development Community (SADC) bioethanol industry delivers on its potential. The factors influencing this outcome are discussed in Section 6. Section 7 lays out conclusions and recommendations arising from the study.

2. The South African liquid fuel sector

South Africa consumes 0.7 per cent of global petrol, 0.4 per cent of global diesel and 0.3 per cent of global crude oil. The relatively low consumption of crude oil is due to the capacity, developed during years in economic isolation, to synthesise oil from coal. Thirty per cent of South Africa's liquid fuel requirement is synthesised in this way by the former state-owned company, Sasol. A further 8 per cent is derived from natural gas (Wilson *et al.* 2005).

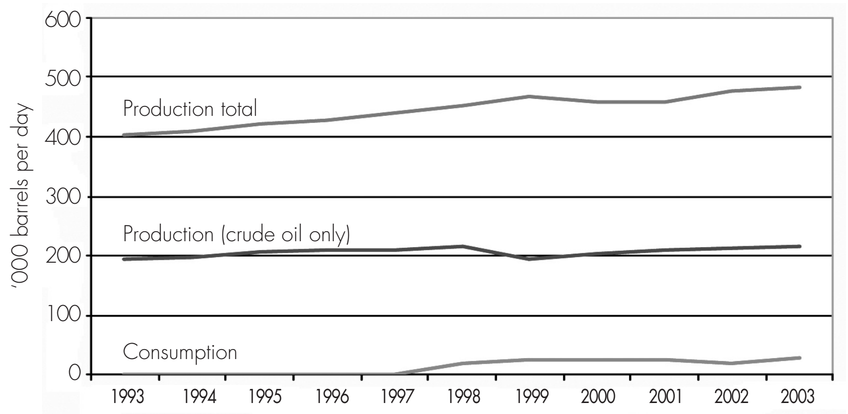
Annual vehicle fuel consumption ranges between 20–25 billion[2] litres. This accounts for one third of South Africa's total energy consumption by energy, and 70 per cent by value. Expenditure on liquid fuels accounts for 8 per cent of gross domestic product (GDP) (US$16.6 billion), or US$41.44 per day on liquid fuels.

Just less than 65 per cent of South Africa's total liquid fuel consumption and 14 per cent of the country's total energy consumption is derived from imported crude oil. The bulk of South Africa's oil imports comes from Iran, although imports from Kuwait, the United Arab Emirates, Saudi Arabia and Nigeria are increasing. Due to capacity constraints, the country is unable to make up this shortfall with Sasol's synthesised fuel or by refining crude oil, a situation that requires refined diesel and petrol to be imported at huge cost (currently at US$0.63 per litre but often much more on the spot market) in addition to its crude oil imports. A summary of petroleum production and consumption in South Africa is shown in Figure 1.

Fuel imports cost South Africa an estimated US$7 billion per annum and account for 12–20 per cent of all South African imports – easily the most significant trade item.

2. The word 'billion' is used here as meaning a thousand million.

Figure 1: Petroleum production and consumption in South Africa, 1993–2003



Source: EIA (2004)

International oil price inflation drives domestic inflation in South Africa, and oil price hikes in 2007 forced a breach of South Africa's monetary policy, with inflation rising above the mandated upper limit of 6 per cent in the second half of the year. Oil price inflation has also been behind a widening of the current account deficit, leading to a 30 per cent depreciation of the South African rand against the US dollar between the end of 2005 and mid-2007 (World Bank 2005; South African Reserve Bank 2006; Monetary Policy Council June 2007; National Treasury *Budget Review* 2007).[3] The destabilising economic impact of South Africa's dependence on imported crude oil is a key motivation behind the country's drive to develop a biofuel industry.

Currently the only significant substitute for mineral transport fuels is biofuel, which includes bioethanol and biodiesel.

3. South Africa's bioethanol industry

Bioethanol was a feature of South Africa's liquid fuel mix between 1930 and the late 1960s, but subsequent cheap and plentiful crude oil rendered the industry uneconomic. South Africa has been party to the recently resurgent interest in biofuels. Until December 2007, industry hopes had focused on the *Draft Biofuels Industrial Strategy of the Republic of South Africa* (hereafter the '*Draft Biofuel Strategy*'), a document that was compiled following an extensive feasibility study. The strategy, which was approved by Cabinet in November 2006, prescribed a target of 4.5 per cent of liquid road transport fuel market penetration (3.4 per cent of total liquid fuel, which includes fuel used in aviation, heating and cooking) by 2013 – roughly half of the renewable energy target. To achieve this

3. See Chapter 2, 'Economic policy and outlook' at:
http://www.treasury.gov.za/documents/national%20budget/2007/review/isbn.pdf

target, the draft strategy proposed statutory blending so as to ensure E10 blends in 80 per cent of petrol and B5 biodiesel blends in those regions that can supply biodiesel. This would have resulted in a net penetration of 8 per cent and 2 per cent in the petrol and diesel markets respectively.

In December 2007 the government undertook a significant and surprising retraction of its biofuel ambitions, mandating substitution targets of 2 per cent of liquid fuels for all biofuels, limiting the extent of fiscal support, and moving to prevent the use of maize as a feedstock on food security grounds.[4] If half the new target were supplied by bioethanol this would limit South Africa's bioethanol production to a meagre 58 kilotons per annum. It remains to be seen whether private sector initiatives, some of which have already sunk capital into production and processing capacity, will develop their own markets and surpass government goals. It is not yet clear how the private sector will react to this policy shift, what level of biodiesel and bioethanol will be used to meet the target, and whether or not demand will result in the scaled-down targets being surpassed by private sector efforts.

As yet very little biofuel is produced in South Africa, although investments in processing capacity have been made. The industry is characterised by a wide range of often conflicting claims and speculative behaviour as stakeholders jostle for recognition and attempt to shape policy to their benefit. In seeking to meet the anticipated demand, the indication has been that the South African bioethanol industry will, in spite of government efforts to prevent the use of maize as a feedstock, rely on locally cultivated maize and sugarcane in the initial period.

3.1 Bioethanol feedstocks

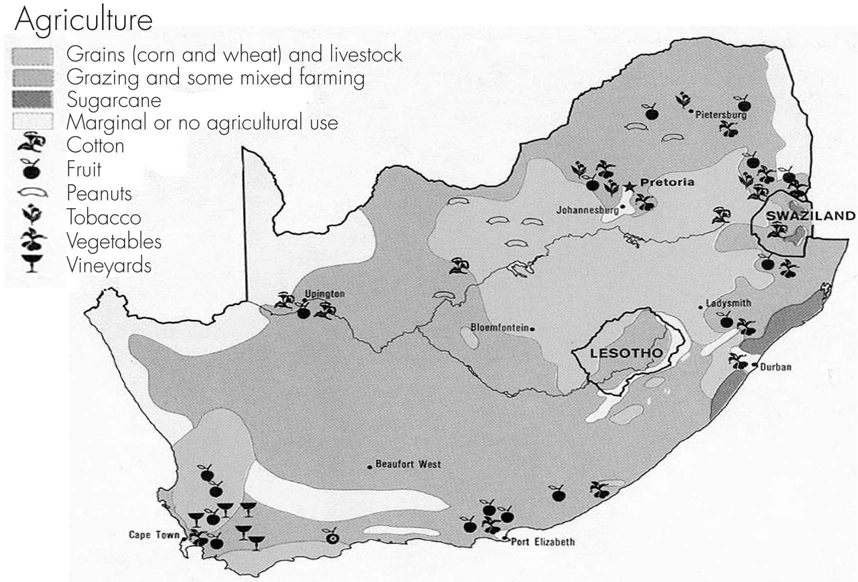
Only 13 per cent of South Africa is considered arable, and much of this land is exposed to unreliable rainfall. However, a strong agricultural sector was established during the apartheid era when the political dispensation guaranteed markets, provided state subsidies, and ensured cheap labour. Since 1994, South Africa's first democratic government has reduced support for commercial agriculture from 18 per cent of farm receipts in 1992 to 2 per cent in 2005 and 5 per cent in 2007.[5] During the same period, the Marketing of Agricultural Products Act (No.47 of 1996) dismantled the statutory single channel marketing boards that had previously guaranteed markets for agricultural produce in favour of unregulated marketing in which produce is traded on the Agricultural Markets Division of the South African Futures Exchange (SAFEX).

The post-apartheid rationalisation has seen agriculture's revenue decline at an average rate of 10 per cent per annum. Agriculture now represents less than 2.5 per cent of GDP and accounts for 10 per cent of all employed people.

4. This development does not alter the general conclusions of this document, and it remains to be seen whether or not private sector initiatives will seek to produce more biofuel than can be accommodated under the strategy, necessitating exports or a higher level of uptake in the liquid fuel sector.

5. As measured by the OECD's Producer Support Estimate.

Figure 2: Map of South Africa's crop-producing areas[6]



Source: From Map No. 503971 (1979), available online at: www.lib.utexas.edu/.../south_africa_ag_1979.jpg. Note the map does not capture the recent rapid expansion of sugarcane in the Inkomati River Basin north of Swaziland, an area that now accounts for a quarter of South Africa's sugarcane and in which sugarcane is irrigated.

An ongoing agrarian reform programme has sought to establish a black commercial farming class through the provision of preferential access to land, water, grant funding and credit. With a few notable exceptions – one of which is provided by the sugar industry – these efforts have been piecemeal and slow. As a result, the 25,000 commercial farmers in South Africa remain predominantly white. Aside from the commercial agricultural sector, an estimated 8 million subsistence farmers on 1 million hectares of land, struggle to support their livelihoods. The subsistence sector is characterised by inadequate infrastructure, high degrees of land degradation, low yields and low returns.

The two crops that are most likely to supply South Africa's bioethanol industry in its initial phase are maize and sugarcane. Maize is the country's most important staple food, accounting for 41 per cent of the average national calorie intake in 2004 (FAOSTAT 2007). Local consumption of maize has, however, been decreasing at 0.4 per cent per annum, as access to the food market improves and alternatives become available (BFAP 2006). South Africa does not have a large guaranteed maize surplus, but typically manages to export 3 million metric tons over and above the 8 million tons that are consumed locally every year. South Africa's maize surplus is important to the food security of the southern African region, with its propensity for drought and famine. Assuming a ton of maize can produce 400 litres of bioethanol, the *Draft Biofuel Strategy* estimates that one fifth of the average surplus would be required to substitute 4 per cent of liquid fuel consumption by 2013.[6]

Maize farmers receive US$80–160 per ton for their produce in commodity markets. If maize was converted into bioethanol and sold at the price that is recommended in the *Draft Biofuel Strategy* (US$0.51 per litre) it would be worth US$204 per ton.

In South Africa 430,000 hectares of sugarcane are cultivated, three quarters of which is suitable for harvest every year. In the 2005–06 season, 21 million tons of sugarcane were harvested, yielding 2.5 million tons of sugar (SASA 2007). Prices for sugarcane and 'recoverable value'[7] in 2005–06 were set by the industry at ZAR 173.59 (US$23.9) per ton and ZAR 1,389 (US$191.85) per ton respectively. Unlike other agricultural sectors in South Africa, the sugar industry operates under the jurisdiction of the Department of Trade and Industry and has retained a measure of price support against imports.

The industry further distinguishes itself by operating a successful small-scale outgrower scheme. There are 23,471 small-scale black growers (roughly half the total number of growers in South Africa) operating on land parcels that average 8 hectares in size. Collectively these growers supply 11 per cent of the country's sugarcane, under contract farming arrangements to one of the three major mills.

South Africa is the largest producer of sugarcane in the SADC region, but in 2006 for the first time produced less than half of SADC's sugar as Swaziland, Mauritius and Zambia increased their yields. Typically, South Africa exports half of its sugar yield. If diverted to bioethanol production the surplus could produce an estimated 274 kilotons of bioethanol – enough to supply more than half of the 466 kilotons (E8) target proposed in the *Draft Biofuel Strategy*. A ton of exported sugarcane returns roughly US$24 in revenue to South African growers. The same ton could earn US$41 for growers if converted into bioethanol, or substitute the need for US$45 worth of petrol imports (based on 80 litres bioethanol/ton of sugarcane and 95 per cent of the prevailing basic fuel price being paid for bioethanol).[8]

Once processing costs are included, it is unlikely that maize and sugarcane farmers in South Africa will receive significantly more for produce that they supply to the bioethanol industry than they do when selling it as food. Farmers typically receive the equivalent of US$0.45 per litre of bioethanol when selling their produce as food in the

6. Four per cent would constitute half of the E8 target that the draft strategy proposes be met with maize.

7. 'Recoverable value' (RV) is the measure on which growers receive payments and is closely related to sucrose content. The average RV content for the South African crop ranges between 12–13.5 per cent.

8. These yields have been achieved in Brazil and southern Africa according to Illovo Sugar Ltd./Partners for Africa (2004). In general South African producers get higher RV (sucrose) yields than their Brazilian counterparts, but the refining of bioethanol in South Africa is currently less sophisticated.

domestic market. This should be compared to the US$0.51–0.53 per litre that is proposed in the Draft Biofuel Strategy (Biofuels Task Team, BTT, 2006). Nonetheless, farmers in both sectors are supportive of a local bioethanol industry on the grounds that it will expand and possibly stabilise their marketing options (Dr John Purchase, pers. comm.).[9]

3.2 The processing of bioethanol

3.2.1 The value chain

The processing facilities required for bioethanol production from maize and sugarcane are different.

South Africa already manufactures small volumes of bioethanol by fermenting the molasses produced as a by-product of its sugar industry. This bioethanol is not used in fuel but as potable alcohol, in paints and inks, and by the pharmaceutical industry. Between 50–70 per cent of this bioethanol is exported, predominantly to African countries and to Europe. Woods and Brown (2004) estimate that South Africa's molasses yield could substitute 0.91 per cent of the region's petrol by 2015. If a biofuel industry of any significant scale were to be created, however, sugarcane juice (which is a more efficient source of bioethanol and which is capable of supplying larger volumes) would have to be used.

Ethanol Africa, the leading maize-based bioethanol producer in South Africa, predicts that it will receive 490 litres of bioethanol from a ton of yellow maize. A United States Department of Agriculture (USDA) survey of 78 plants in the United States, however, suggests they may be overestimating their yields. The survey revealed an average of 394 litres of bioethanol produced per ton of maize (Miguez, pers. comm.).[10]

Ensuring bioethanol constitutes 8 per cent (E8) of South Africa's petrol mix would require a more than ten-fold increase in South Africa's bioethanol fermentation capacity (Peter Starling, pers. comm.).[11] If new infrastructure was created to process this bioethanol, this would cost ZAR 1.4 billion and ZAR 1.8 billion (US$0.19–0.25 billion) for sugarcane and maize respectively (BTT 2006). In reality South Africa's sugar processing mills currently operate at between one fifth and half of their capacity (Van Rooy, pers. comm.)[12] and both the sugar and the maize industry could easily convert existing processing capacity so as to manufacture bioethanol. The available capital is likely to halve the required investment estimates presented by the Biofuels Task Team,

9. Dr John Purchase is member of the South African Biofuels Association, a Presidential Advisor and a former member of Grain SA.
10. José Domingos Gonzalez Miguez is Executive Secretary of the Ministry of Science and Technology in Brazil.
11. Peter Starling is Managing Director of the Durban Branch of NCP Alcohol, a global producer of high concentration fermentation alcohols.
12. Dawie van Rooy is the Production Manager at Transvaal Suiker Beperk, a South African sugar processor.

but private sector investors appear reluctant to incur this cost without government support for a large mandated market and levy waivers. The respective bioethanol value chains for sugarcane and maize are presented in Tables 1 and 2, showing expected gains to farmers, transporters, processors and retailers.

Table 1: Bioethanol from maize value chain

Feedstock/ farming	Transport from farm to processing	Processing	Transport	Retail
Small-scale: 0.75 tons/ha (some higher), 30% of feedstock supply.	Aim is for minimum transport costs.	Processors pay US$0.35–0.38/ litre of bioethanol for maize feedstock. Processors responsible for feed preparation and purification.	Transport to ports can be expensive, typically by truck freight (10–15%) of retail cost	Processors sell to local retailers at 95% of basic fuel price, US$0.60/ litre. Bioethanol equates to 70% energy of petrol. Retailers responsible for blending and quality assurances.
Large-scale: (commercial) 3.2–4.0 tons per hectare, 70% of feedstock supply.		Estimates of US$0.05/litre (Ethanol Africa's Bothaville plant).		Retailers sell to public (at local petrol price US$0.97).
Growers receive US$151/ton of maize delivered (market price).		25% of maize feedstock value retrieved by processors in sale of by-products (DDGS* provides US$ 0.10/ litre of bioethanol; carbon credits could provide US$ v0.002/ litre).	Sea freight of bioethanol is inexpensive.	Exported bioethanol is subject to potential duty of US$0.15/litre.
Up to 36% of the value of retailed bioethanol.	0 – 0.1% of retail value.	Processors secure 8.6% of retail price, 18.5% if the retail price is included. Significant increases when petrol price increases.	Processing and retail accounts for 10–15% of retail price.	Retailers secure 45% of bioethanol value if they supply local market, 28% if bioethanol is exported.

*** Dried distillers grain from solubles**

Table 2: Bioethanol from sugar value chain

Feedstock/ farming	Transport from farm to processing	Processing	Transport	Retail
Average yield: 40 tons/ha dryland and 110 tons/ha irrigated.	Growers located within 80 km of mill due to economics of sucrose production. US$ 0.02/litre	Processors pay equivalent of US$0.30/litre of bioethanol for sugarcane feedstock. Processors responsible for feed preparation and purification.	Transport of bioethanol to ports relatively inexpensive as most mills located close to ports – 5% of retail cost.	Processors sell to local retailers at 95% of basic fuel price, US$0.60/ litre. Bioethanol = 70% energy of petrol. Retailers responsible for blending and quality assurances.
11% of crop currently provided by small-scale black growers.		Production cost estimates roughly US$0.05/litre.		Retailers sell to public (probably at local petrol price US$0.97).
Growers receive US$23.90 per ton of cane. Equivalent to US$0.30 per litre of bioethanol.		US$0.025/litre retrieved from sale of bagasse.	Sea freight of bioethanol is inexpensive.	Exported bioethanol is subject to potential duty of US$0.15/litre.
Growers secure 29% of retail price of bioethanol.	Transport between growers and mill accounts for 2% of retail price.	Processors secure 18.5% of retail price, 21.8% if sale of by-products is included.	Total transport costs between mill and retail accounts for 5–8% of retail value.	Retailers secure 45% of bioethanol value if they supply local market, 28% if bioethanol is exported and duties and freight is paid.

3.2.2 The costs of bioethanol production

Internationally, the cost of producing a litre of bioethanol varies greatly, as do reported estimates of these costs (see Table 4 for a range of estimates for various countries). In order to compete with imported petrol on a cost basis, South African bioethanol would have to be cheaper than the 'basic fuel price', an import parity price used to determine the domestic fuel price. In December 2007 the basic fuel price for 95 unleaded petrol was US$0.63 per litre. This is also the price that is paid to Sasol for its 'synfuel'. Levies and custom duties added another US$0.43 per litre. In order to compete unassisted with imported fuel on an energy equivalent basis (i.e., assuming that bioethanol provides 72 per cent of the energy of petrol), South African bioethanol would therefore have had to be produced at ZAR 3.02 per litre (US$0.46).

The costs of producing dryland sugarcane (US$20 per ton) and maize (US$75 per ton) in South Africa can be very low (Cartwright *et al.* 2007), creating the potential for cheap biofuel. Official estimates of the cost of bioethanol production range between US$ 0.41 per litre (Ethanol Africa, pers. comm., based on their Bothaville plant, which has capacity for 190 million litres per year) and US$ 0.52 per litre, which is presented in the *Draft Biofuel Strategy.* Based on these cost estimates, the ability of South African bioethanol to compete with imported petrol is contingent upon oil prices in excess of US$70 per barrel, maize prices below ZAR1,100 per ton (circa US$150/ton), and sugar prices below US$250 per ton. (There is, of course, a positive correlation between the price of oil and bioethanol feedstocks.)

There is a case, however, for expecting the process of 'learning-by-doing' to reduce processing costs over time. In Brazil, the cost of processing bioethanol has dropped by some 10 per cent/year over the past three years as a result of efficiency and scale enhancements (Hamelinck *et al.* 2005; Miguez, pers. comm.). Provided these gains are not offset by feedstock price inflation, they can be expected to enhance the viability of the industry.

Most established bioethanol-producing countries have relied on public subsidies to support their industries, and aspirant bioethanol producers in South Africa have lobbied government for the same support. The pricing of South Africa's liquid fuels is subject to a range of domestic and international levies, which collectively comprise 41 per cent of the retail price. By providing the bioethanol industry with exemption from certain fuel taxes, South Africa would forego fiscal revenue but support the emergence of a local industry, with ancillary benefits for rural development and fiscal stability. It is not in the South African government's perceived interests to undermine its oil refining capacity by placing refiners under price pressure. The Biofuels Task Team estimated that if bioethanol producers were required to sell bioethanol to the petroleum industry at 87 per cent of the basic fuel price, refiners' profits would remain stable (BTT 2006). This makes the price paid to bioethanol processors as volatile as the international oil price. Adopting such an approach would have seen bioethanol manufacturers paid US$0.55 per litre in December 2007. When compared to the prices that bioethanol manufacturers would pay for feedstock in order to sustain farming activities (US$0.45–0.46 per litre) this provides an adequate profit margin for processors. Whether or not this would allow for the recouping of capital expenditure is less clear. More critically, this profit margin would be cut if the international price of oil were to fall. In an attempt to support all players in the processing chain, the *Draft Biofuel Strategy* proposed that bioethanol be sold at 95 per cent of basic fuel price (US$0.60 in December 2007). However, in its latest move the South African Cabinet opted only for a waiving of the fuel tax, which compromises 16 per cent of the retail price, and did not stipulate a price at which bioethanol ought to be sold. The combination of reduced biofuel targets and limited fiscal support is likely to see some bioethanol producers, particularly those using maize feedstocks, operate outside the domain of a state-regulated market and pursue markets outside South Africa.

The potential sale of bioethanol by-products and emissions reduction certificates from the Clean Development Mechanism (CDM) could boost the viability of the value chain, especially for processors. By-product revenue is included in the estimates above, but aggressive marketing of by-products could enhance their contribution. There is an equal danger, however, that the large quantities of by-products being produced internationally by bioethanol industries will deflate the value of these products and undermine their contribution to bioethanol viability.

The registration of a United Nations Framework Convention on Climate Change (UNFCCC) Clean Development Mechanism methodology for biofuels could assist the viability of South African biofuels by facilitating carbon trading and access to the associated revenue (Bakker 2006).[13] The development of such a methodology is currently the attention of a strategic collaboration between the Food and Agricultural Organization (FAO) and the UNFCCC (Gustavo Best, pers. comm.).[14] The collaboration aims to pave the way for future biofuel projects by submitting and attaining approval for a biofuel methodology. The Biofuels Task Team estimates that carbon revenue could return an additional US$0.015 per litre to sugarcane bioethanol and US$0.002 per litre for maize bioethanol. In total the Biofuels Task Team estimates that, based on E8, the sale of maize and sugarcane by-products could generate US$56 million and US$14 million, respectively.

4. International bioethanol trade from South Africa

4.1 South Africa's bioethanol trade

The United Nations Commodity Trade Statistics Database (COMTRADE) data show that in 2004 the chief bioethanol importers were the US (352,000 tons), India (337,000 tons), the Republic of Korea (223,000 tons), Japan (160,000 tons), Sweden (134,000 tons), Jamaica (107,000) tons and The Netherlands (137,000 tons). The chief supplier of all these trades was Brazil, although Bolivia is recorded as exporting an additional 37,000 tons to The Netherlands.

A number of commentators, e.g., Coelho (2005); F.O. Licht (2006); and Walter *et al.* (2007), have interpreted COMTRADE data showing South Africa exporting just under 200,000 tons of undenatured bioethanol (strength greater than 80 per cent alcohol) throughout the period 2000–04 as being an indicator of South Africa's significance as a bioethanol exporter. The reality, however, is that South Africa does not

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13. It should be noted that due to high transaction costs, the CDM has proven generally cumbersome and unprofitable to date, especially for South Africa.

14. Dr. Gustavo Best is the UN-FAO's Senior Energy Co-ordinator, based in the FAO's Natural Resources Department

currently export bioethanol for use in the fuel market. The COMTRADE data are comprised of small proportions of the 40,000 tons of bioethanol that is manufactured from sugarcane molasses and the ethanol produced by Sasol as a co-product of its Fischer-Tropsch process.

In both instances this ethanol is exported for use in the potable alcohol, pharmaceutical and paint industries. Sasol's high purity ethanol plant at Secunda in South Africa produces 115,000 tons of industrial ethanol annually. The product is marketed in Europe, the US, the Far East, Africa (most notably Nigeria), the Middle East and the Asian subcontinent. The production of this ethanol is as a by-product of synfuel processing; it is energy intensive, and is associated with significant greenhouse gas (GHG) emissions. Experimental use of this ethanol in motor vehicles encountered difficulties and has been discontinued (Dr John Purchase, pers. comm.). The ethanol reported in COMTRADE data may, in addition, include small quantities of fortified wine and spirits that have been either incorrectly or illegally classified in an attempt to avoid the import tariffs that are levied on potable alcohol.

Apart from the industrial bioethanol produced by the sugar industry, there is currently very little bioethanol being produced in South Africa. Potential bioethanol manufacturers interviewed in the course of this study were awaiting a finalisation of the 'Biofuels Industrial Strategy' and an indication of the level of support they could expect from the South African government. The strategy that was approved by Cabinet in December 2007 provides significantly less support than had been anticipated. To a certain extent the lack of government support has been offset by rising oil prices and it remains to be seen to what extent private bioethanol manufacturers will pursue manufacturing and marketing independently of state support. There are no restrictions on where South African producers of bioethanol may sell their produce and it is plausible to imagine that producers might export their bioethanol if foreign markets offer the greatest profits. Where South African bioethanol ends up is likely to depend upon:

- The price received in South Africa relative to the price available on export markets.
- Domestic policies supporting bioethanol production and export.
- The emergence of international bioethanol standards with which South Africa can comply.
- Access to regional and international markets at prices that deliver a profit to South African producers.

4.2 Relative prices for South African biofuels

There is no legislation restricting the sale of bioethanol from South Africa. The relatively small volumes of bioethanol that are likely to be produced in the medium term will almost certainly be sold in the market that offers the highest price. On a purely financial basis, it makes sense for South African growers to export bioethanol if the price they receive, once the bioethanol has been freighted and import duties have been paid, is higher than the price received in the domestic market. The domestic market price is likely to be linked to the basic fuel price (BFP), which itself is linked to the import parity price of petrol. The BFP is determined by exchange rates and the international oil price and is highly volatile. At the time of writing this paper it was US$0.64 per litre. In an attempt to support all players in the processing chain, the Biofuels Task Team proposed that bioethanol be sold at 95 per cent of the BFP. Based on these figures, any country offering to pay South African producers more than US$0.60 per litre once transport and import duties have been paid might be considered a viable export partner.

The transport component of export costs, most notably the transport to ports, increased steeply in the past two years and represents 10–30 per cent of the final price (Dr John Purchase, pers. comm.). As such, export viability is likely to depend greatly on the proximity of production plants to coastal export facilities and the ability to secure reasonably priced freight. Maize growers interviewed in the course of this research are generally located in the hinterland, unlike their sugarcane-growing counterparts. These growers considered the cost of transporting their maize or bioethanol to the coast and then freighting it generally unfeasible. For sugarcane growers the logistical costs of bioethanol export are less prohibitive, making it potentially more profitable as an export.

The Chicago bourse provides the most reliable source of international ethanol prices (including non-crop sources of ethanol).[15] According to the bourse, ethanol was traded at US$0.62 per litre in December 2007. Based on what is known about production costs in other countries (see Table 3), only the Euro-zone countries and the United Kingdom have the potential to provide a viable export market for South African bioethanol at current prices.

Table 3: Bioethanol production costs*

Country/feedstock	Estimates Dufey, Vermeulen and Vorley (2007)	Estimates South African BTT Feasibility Study (2006)	Estimates UNCTAD (2006)
South Africa (sugar-cane and maize)	–	US$0.45–0.46	US 0.41
Brazil (sugarcane)	US$0.25	US$0.23	US$0.27
Thailand (cassava)	US$0.27	US$0.29	
Australia (sugarcane)	US$0.38	US$0.32	
USA (maize)	US$0.40–0.50	US$0.47	US$0.41
European Union (wheat/sugar beet)	US$0.51–0.80	US$0.97	US$0.61 and 0.68 respectively
China (sugarcane 2005)	US$0.53	–	–
Chicago bourse (July 2007)	–	US$0.55/ litre	–

*** Excluding taxes and subsidies**

15. See: http://www.cbot.com/cbot/docs/85189.pdf

SADC countries, many of which are dependent on fuel imports from South Africa, could provide a further viable market for South African bioethanol. Whether or not Europe will source its bioethanol from South Africa, or from countries such as Brazil, Guatemala and China – which are currently able to provide bioethanol more cheaply than South Africa – will depend on the export and import preferences between the respective countries. Brazil and Guatemala are, at present, the two chief origins of bioethanol imported into Europe.

4.3 Access to regional and international markets

The trading of agricultural commodities is notoriously irrational, often reflecting influences that have little to do with price or comparative advantage. This is particularly true of bioethanol trade, which receives twice as much government support as biodiesel (Steenblik 2007). None of the countries currently supplying bioethanol for fuel has avoided the need to support their industries (Kojima *et al.* 2007; RFA 2007a). In 2006, the extent of government support for Organisation of Economic Co-operation and Development (OECD) countries producing bioethanol was estimated at US$11 billion, and this is predicted to rise to US$15 billion in 2007 (Steenblik 2007). The most frequently cited rationale for these subsidies is energy security, although in reality it is very difficult to distinguish between long-standing efforts aimed at supporting OECD farmers and support for biofuels (Kojima *et al.* 2007).

The prevailing government support for biofuel producers in industrialised countries distorts both the price and the international flow of bioethanol and deprives developing countries, such as South Africa, of the full benefit of bioethanol trade while limiting the extent to which their production capacity can develop. Trade-distorting support for biofuels can be divided into two categories: support for growers of crops (including barriers to aspirant biofuel crop importers), and support for retailers of biofuels (including tariffs charged on biofuel imports).

Bioethanol imports to South Africa are currently duty-free. South African bioethanol processors stand to receive a full fuel tax exemption amounting to US$0.17 per litre up to a level that will provide for a 2 per cent penetration of the liquid fuels market. Maize growers receive no protection against imports and typically receive a price that is determined by the import parity price of maize and the size of the South African harvest (Vink and Kirsten 2002). In general, South African farmers receive very little state support; it dropped from 18 per cent to just over 2 per cent of farm revenue between 1992 and 2002, and now represents 5 per cent (OECD 2006).

South Africa's sugar sector is subject to industrial rather than agricultural policy. The sector is protected by an import duty imposed on non-SADC supplies and set at the rand (ZAR) value of the difference between the 'dollar-based reference price' and the 20-day moving average of the London International Financial Futures and Options Exchange 'No.5 white sugar' price (Lorentzen *et al.* 2007). The tariff is roughly US$70 per ton of sugar. Imports from SADC countries are subject to the 1998 SADC Sugar

Table 4: Country comparison of production costs*			
Country/feedstock	Import levies to country	Minimum landed price of SA bioethanol (10–15% transport costs)	Production cost estimates range
South Africa (sugarcane and maize)	None		US0.41–0.46
Brazil (sugarcane)	20% *ad valorem* (removed completely as of 1 January 2007)	US$0.46–0.50	US$0.23–0.27 (may be as low as US$0.18 in 2007)
Thailand (cassava)	25 per cent *ad valorem*	US$0.65	US$0.29–0.45
Australia (sugarcane)	*5% ad valorem* plus US$0.34	US0.84	US$0.32–0.38
USA (maize)	US$0.135 plus 2.5% in sum, about 46% *ad valorem*	US$0.62	US$0.40–0.50
European Union (wheat/sugar beet)	US$0.262 in sum, about 63% *ad valorem*		
China (sugarcane 2005)	Not known	Not known	US$0.53
United Kingdom	US$0.36	US$0.86	US$0.70–1.05
Canada	9 % *ad valorem*	US$0.55	US$0.50

*** With the landed cost of South African bioethanol including duties and transport.**
Sources: UNCTAD (2006), Steenblik (2007)

Co-operation Agreement (appearing as Annex VII of the SADC Protocol on Trade), which permits SADC surpluses to be sold tariff-free but in quotas that are scheduled to expand incrementally, with the view of achieving essentially free Southern African Customs Union trade in sugar after 2012.

Given the disparity between the level of support for the South African bioethanol sector and in its potential export markets, it is not surprising that the focus of the emerging bioethanol industry in South Africa is firmly on the domestic market. As a commodity analyst at South Africa's FinWeek Journal recently observed: 'It wouldn't be practical to think that we could export ethanol profitably from South Africa to Europe or to any country where agriculture is subsidised, even on farms that are much more productive than South Africa's large areas of marginal agricultural land'(Theunissen 2007). If the

South African industry is to mature and expand beyond the levels stipulated by policy, export markets will necessarily become important.

Based on current production costs estimates, South Africa could produce bioethanol at US$0.41 per litre. Once import duties and transport had been paid, the effective price of South African biofuels in the US would be at least US$0.62 per litre, and in the European Union US$0.77 per litre. A great unknown in these estimates is the cost of transport, the most significant component of which is transport from processors to ports. Transport costs have been factored into this analysis at 10 per cent of retail value, but could range between 10–40 per cent.[16] Table 5 presents a comparison of country production costs (with the landed cost of South African bioethanol including duties and transport). It suggests South Africa would struggle to compete in the bioethanol export market given current prices and import duties.

4.4 Domestic policies supporting bioethanol production

The South African biofuel industry is emerging within the context of the 1998 *White Paper on Energy* and the *White Paper on Renewable Energy,* approved by Cabinet in 2003. In spite of vested state interests, the 1998 White Paper acknowledges that benefits could be derived from the use of alternate transport fuels and renewable energies. The 'Renewable Energy Strategy' outlines a 'new energy regime' and sets the target of generating 10,000 GWh of renewable energy by 2013.

A biofuel strategy, proposing a biofuel target of 3.4 per cent of all liquid fuel (4.5 per cent of vehicle fuel) by 2013, was set to become a crucial component of the 'Renewable Energy Strategy', potentially contributing two thirds of the renewable energy required. The scaling back of this target to 2 per cent of all vehicle fuel in late 2007 represents a significant dilution of this ambition. To meet the proposed target, the government was to draw on the Petroleum Products Licensing System to mandate E8 and B2 blends. Mandatory blending was to have provided a 'captured market' (Dr John Purchase, pers. comm.), removing uncertainty for investors and permitting forecourt infrastructure to be used in retail. Mandatory blending is, however, a controversial policy instrument as it transfers risk from producers to tax payers and creates a bureaucracy-dependent agricultural sector, which can in turn amplify risk (Steenblik 2007).

It remains to be seen how the South African government intends to allocate responsibility for meeting the revised target, and whether or not it will seek to cap biofuel production at the targeted levels. A number of potential interventions by which the local industry might be supported are summarised in Box 1.

As such, South Africa has the policies and the budgets in place to support the development of a bioethanol industry capable of contributing to poverty alleviation and addressing important environmental concerns. The problem with much of the legislation is that it is not implemented, or where it is implemented it is in a piecemeal manner

16. Because bioethanol absorbs water and other impurities in pipelines it is best transported in dedicated pipelines or with dedicated freight fleets, both of which increase the cost.

Box 1: Policy support measures in South Africa

- Bioethanol that complies with agreed specifications will receive a 100 per cent fuel levy reduction, equivalent to 16 per cent of the current petrol retail price. This levy will accrue to retailers but should enhance the viability of the entire value chain. Forcing producers to register in order to qualify for fuel levy exemption facilitates regulation of bioethanol quality and growing conditions (BTT 2006; Makenete, pers. comm. 2007).[17]
- Certain government fleets committing to E85 (bioethanol denatured with petrol), which may be used in dedicated or flexi-fuel engines.
- A producers' stabilisation hedge fund. If the oil price were below US$45/bbl, biofuel producers would receive support. If the oil price were above US$65/bbl, producers would pay in. The hedge available to producers would be catered for under the 1977 Central Energy Fund (CEF) Act's Equalisation Fund Levy. At the extreme low price of US$35/bbl this hedge would require state fuel price support of ZAR 0.012 per litre.
- Accelerated tax depreciation write-off (50:30:20 per cent over three years) for investments in biofuels. The mechanism was approved by the National Treasury in 2002 and equates to roughly US$1.71/bbl crude oil.
- In September 2005 the National Treasury approved a Renewable Energy Subsidy Scheme, which is implemented by the Department of Minerals and Energy (DME). The subsidy provides for US$0.024 per litre for bioethanol up to a maximum of US$2.85 million for bioethanol and biodiesel in the 2006/7 financial year.
- In July 2006, the National Treasury released a Discussion Paper on Environmental Taxes for comment. The paper proposes extending this incentive to bioethanol, and that the basis for incentives be linked to overall externality benefits (cited in DME 2006).
- Local governments, led by the city of Cape Town, and acting upon the National Vehicles Emissions Strategy,[18] have drawn up air quality and climate change plans. Cape Town, which is a member of the International Council for Local Environmental Initiative's Cities for Climate Change programme, aims to introduce cleaner fuels through its Integrated Metropolitan Environmental Policy, and has converted some its municipal fleet to biofuel.
- The meagre support that has been retained for South African agriculture is reserved for black economic empowerment initiatives. Such initiatives are able to benefit from subsidised access to land (under the Land Reform for Agricultural Development programme and Municipal Commonage scheme); water (under the Water Allocation Reform programme); credit (from the Industrial Development Corporation and the Land Bank); as well as direct grants for infrastructure (under the Consolidated Agricultural Support Programme and the Local Economic Development Programme). 'Stacking' this support and linking aspirant black sugarcane and maize farmers with the requisite technical expertise and markets could reduce the private cost of production and greatly enhance South Africa's competitiveness in international bioethanol markets.

17. Andrew Makenete is President of the South African Biofuel Association.
18. This strategy became the Joint Implementation Strategy for the Control of Exhaust Emissions from Road-Going Vehicles, gazetted as Notice 3324 of 2003. Available at http://www.info.gov.za/gazette/notices/2003/25741.pdf

and does little to remove uncertainty for investors or to attract private sector investment.

On the international front, South Africa has entered into two politically celebrated trilateral partnerships with Brazil and the United Kingdom, and with India and Brazil. These agreements, defined by memoranda of understanding, are aimed at investment in production capacity and in knowledge transfers from Brazil to African countries, including South Africa. The agreements make no reference to liberalising market access or to future trade agreements, and as such provide no basis on which to establish bioethanol trade (DME 2006).

4.5 Emergence of an international bioethanol standard with which South Africa can comply

Assuming public and private interests in South Africa can combine to create a viable bioethanol industry, international trade will further require standardisation of the terms, definitions, and quality controls that are applied to bioethanol. The Fuel Quality Directive of the EU, responsible for EU fuel quality standards, currently imposes standards relating to hydrocarbon content and requires bioethanol to be processed with isobutylene to produce ethyl tert-butyl ether (ETBE) (in order to make it less volatile). In addition, Brazil and the USA are currently working on an international standard for bioethanol that will facilitate its trade in international commodity markets (Dufey, pers. comm.).

The South African Bureau of Standards (SABS) oversees standards that stipulate viscosity, colour and chemical composition specifications for petrol and diesel. The South African bioethanol industry has the choice of whether to adopt SABS standards or comply with European or American standards that would be more exacting, but which would facilitate an export-focused industry.

A key quality hurdle for South African bioethanol companies seeking to penetrate the export market revolves around the current practice of using MTBE (methyl tertiary-butyl ether). While MTBE makes blending easier, and may present certain air quality benefits, concerns prevail that it can cause health problems. MTBE use is the norm in South African petrol and MTBE would feature in blended South African bioethanol. MTBE is, however, banned in the USA and Western Europe.

5. Sustainable development implications

Establishing a bioethanol industr whether on the back of international trade or a domestic effort is expected to present economic and environmental benefits, but also has the potential to create environmental risks, new concentrations of economic power, and local food shortages. International trade in South African bioethanol could exacerbate these risks.

In a medium-sized and newly open economy, in which economic governance has yet to gain traction, predicting the manner in which interventions and changes will feed through the system and impact upon people's lives is difficult. Below is an attempt to highlight both the financial and external costs and benefits that are likely to arise from a South African biofuel sector and potential biofuel trade.

5.1. Macro-economic impact

According to the *Draft Biofuel Strategy* (DME 2006), by applying a social accounting matrix (SAM) to the E8 scenario, South Africa's crude oil refining sector would suffer a small negative impact, but this would be compensated by a positive impact on the biofuel refining and agricultural sectors. Estimates suggest that in conjunction with a biodiesel supply of B2, meeting a target of E8 would contribute 0.11 per cent (or US$0.23 billion) to South Africa's GDP. Crucially, since roughly 40 per cent of the costs in the bioethanol supply chain accrue to growers, and a number of processing plants have established local operations, growth would take place in rural economies that are currently characterised by rising poverty. The ability to replace imports in this way could reduce the current account deficit by US$0.511 billion per annum. Since it is this deficit that is partially responsible for South Africa's exchange rate volatility and macro-economic uncertainty (Monetary Policy Council of South Africa 2007) a biofuel sector could have a stabilising influence on South Africa's economy and enhance long-term growth prospects.

An important consideration is whether the potential benefits outweigh the fiscal impacts arising from a fuel levy exemption or other supporting policies. The National Biofuels Task Team feasibility study (2006) estimates that fiscal shortfalls would be easily compensated by the estimated US$101 million increase in GDP arising from a successful biofuel industry, even without considering the additional GDP created by the emergence of a new industry.

5.1.1 Gains from trade

Petrol imports cost South Africa US$280 million in 2006, and the need for imported refined fuel increases at 3–5 per cent per annum. An E8 bioethanol penetration would reduce imported petrol by 7 per cent by 2013. Using a portion of existing sugar and maize exports to reach this target would forego an estimated US$190 million in agricultural exports (FAOSTAT 2007), but this loss would be covered by the US$280 million worth of saved petrol imports.

Assuming that all bioethanol production would be exported, an export-oriented biofuel industry would, however, continue to expose South Africa to the full vagaries of the mineral fuel market, and would export the environmental and health benefits associated with domestic burning of bioethanol as opposed to petrol (see subsections 5.2 and 5.3 below). But on macro-economic grounds the industry should not rule out the possibility of exporting biofuel. Where export market prices are set to become higher than domestic prices, the current account benefits of exported biofuel could outweigh those of an import substitution strategy.

Finally, there is the additional suggestion that South Africa could import bioethanol from countries such as Brazil or Zambia. In such instances South Africa would benefit from a fiscal saving as well as the environmental benefits of biofuels relative to mineral fuels.

5.1.2 Employment

Redressing unemployment in South Africa, which runs at 25–40 per cent depending on the method of estimation (see, for example, StatsSA 2003; McCord 2004 Noble *et al*. 2006) is a national priority. The biofuel sector is more labour-intensive in absolute terms and per unit of capital investment than the crude oil sector (BTT 2006). The feasibility study that preceded the *Draft Biofuel Strategy* estimated 40–45 direct jobs would be created per 100 kilotons of biofuel processing plant capacity. While a vibrant biofuel industry has the potential to stimulate the agricultural economy, it should be noted that the propensity for agriculture to create employment has been repeatedly overestimated in South Africa (Lorentzen *et al*. 2007). The 55,000 new jobs predicted by the feasibility study seem improbable, especially as most bioethanol will not be produced from new maize and sugar crops. In the sugarcane industry, intensified production techniques arising from bioethanol feedstock supply may actually lead to increased mechanisation of the harvest and reduced employment. In general it is more likely that a vibrant bioethanol sector will assist rural economies to arrest the current trend towards insecure employment and labour shedding. Crucially, employment created or protected is likely to be in rural areas that are currently subject to increasing unemployment and growing poverty.

5.2 Environmental issues

A bioethanol-based economic expansion in South Africa will require actions that bring the region's natural resource limits into stark focus (Sachs 2005; SAfMA 2005). The use of crops for biofuels and the expansion of cropping in order to supply biofuel crops whether for the domestic or export market are expected to have both positive and negative impacts.

5.2.1 Greenhouse gas (GHG) emissions

One of the motivations for introducing biofuels is the consequent reduction of GHG emissions. South Africa, as an Annex 2 signatory to the Kyoto Protocol, does not confront a GHG emissions reduction target in the 2012 commitment period. But as a significant global polluter, and the largest emitter of GHGs in Africa, there is increasing pressure on the country – along with India, Brazil and China to voluntarily reduce its emissions, including those arising from liquid fossil fuels. The transport sector accounts for 24 per cent of South Africa's total GHG emissions; the 30 per cent of transport fuel that is generated from coal by Sasol is a particular problem. The Fischer-Tropsch synthesis that is applied in this process is particularly energy intensive and accounts for roughly twice the GHG emissions, on a life cycle basis, of imported crude oil. A 2002 Pew Centre study of South Africa's transport sector concluded that under 'business as usual' scenarios, vehicle GHG emissions would rise by 82 per cent between 2000–20.

The cultivation and processing of biofuels is not, however, carbon neutral. No life cycle analysis has been done on the emissions released in South Africa's biofuel sector but according to the Brazilian and US experience with sugarcane and maize bioethanol respectively, it can be argued that sugarcane is a relatively GHG-efficient fuel. This is due to the use of bagasse in generating the energy required by sugar refineries. As Miguez (pers. comm.) points out, Brazil's emissions gains are self-perpetuating: the more bioethanol in the market the greater the opportunities for transporting cane without burning fossil fuels and the greater the availability of bagasse for co-generation that can then be used in agriculture and in processing. A ton of cane in South Africa currently produces 30 kWh of energy from bagasse, although this could be increased to 200 kWh with better technology (Otto 2004). Maize would achieve similar reductions if it used solar power, wind energy and animal waste to power the refining processes, but these technologies remain expensive in South Africa.

The proposed target of 2 per cent of vehicle fuels would result in roughly 500,000 tons of CO2 equivalent being saved annually in South Africa (based on BTT 2006). While any reduction in South Africa's emissions should be seen as positive, this figure represents less than 0.15 per cent of the country's current emissions and is less than the annual incremental increase in emissions. In terms of the GHG reductions, Johnson (pers. comm.) points out that replacing the synfuel created by Sasol could deliver significantly greater emissions reduction (as well as financial) gains than the proposed bioethanol target.

5.2.2 Water scarcity

Water scarcity is arguably a more pressing environmental issue in South Africa than climate change, although the two are clearly linked (Cartwright 2007). Water availability varies greatly across South Africa but at least 11 of the country's 19 catchments are critically water stressed (DWAF 2004). On average the population of South Africa has access to 1,200 cubic metres of water per person per year, but roughly one fifth of the population survives on less than the 50 litres a day prescribed by the WHO as the essential minimum. Water scarcity combines with poor water quality, raising the level of waterborne diseases and contaminants. These in turn inflict debilitating health impacts on South Africa's population, particularly in the context of the national HIV/AIDS pandemic.

Agriculture accounts for 60 per cent of water consumption in South Africa. The production of dryland maize in South Africa requires roughly 1,100 m^3 of water per ton of yield. Assuming 400 litres of bioethanol are received from a ton of maize, 2.75 m^3 of water is required to produce a litre of maize bioethanol. In contrast, sugarcane is extremely water intensive and is irrigated in the northern regions of the country. Based on Lorentzen *et al.* (2007) a ton of efficiently farmed sugarcane requires 1,600m^3 of water for production; this figure can be tripled where irrigation is inefficient. Assuming 80 litres of bioethanol can be processed from a ton of sugarcane (Miguez, pers. comm.) then a litre of sugarcane bioethanol would require 20m^3 for production.[19]

Opportunity cost can be a difficult measure to estimate and apply, and very few countries consider the scarcity value of water in estimating biofuel production costs. But significantly, the South African economy is water-constrained in all of the regions in which sugarcane and maize are produced. In addition, the opportunity cost of water is considerably higher than in other SADC countries producing maize and sugarcane.

If bioethanol requires additional sugarcane plantings, or entrenches the use of water by sugarcane growers in catchments that are already water stressed, this will affect water that is legally reserved for international transfers, the meeting of basic human needs, and the maintenance of hydrological habitats under the National Water Act (NWA) of 1998.

Overall, water scarcity is likely to provide a definitive and constraining influence on South Africa's capacity to produce biofuel, particularly bioethanol from sugarcane.

5.2.3 Land-use change and biodiversity losses

In addition to its 90 million hectares of cultivated land, South Africa also has under-utilised (or wholly unutilised) land that could be brought under cultivation in order to meet the growing bioethanol demand. A 2000 study established the availability of land resources for an additional 1.4 billion litres of biodiesel (Fairbanks *et al.* 2000). The *Draft Biofuel Strategy* estimates that 3 million hectares of arable land, out of a total of 15 million hectares of arable land and 84 million hectares of pasture land nationally (FAOSTAT 2004), is available in the former homelands for agricultural expansion.

Bringing additional land under cultivation would affect the environment. Soil tillage, nitrate run-off, and replacing traditional habitats with monocultures disrupt ecosystems and related biodiversity. The fear is that a bullish export market could lead to injudicious cultivations that exacerbate existing land degradation, involve encroachment into unsuitable areas, expose farmers to high-risk ventures, and impose longer-term environmental risks on regional inhabitants. This risk is particularly acute in the case of sugarcane, which has already undergone a rapid recent expansion, some of it on unsuitable land (Cartwright *et al.* 2007) and where yields in Mpumalanga and on the south coast of KwaZulu Natal have begun to decline (Cartwright *et al.* 2005). However, South Africa should be able to meet moderate (E8) targets by using existing maize and

19. Estimates include the water used in crop production only. It is assumed that the refining processes operate on 'closed-loop' water systems and do not consume excessive water. Where this is not the case it is assumed that similar amounts of water are used in the processing of bioethanol from maize and sugar.

sugarcane surpluses, thus reducing the risk of land and biodiversity losses. Were a viable export market to develop, however, it would prove very difficult to prevent expansion of the area under cultivation.

An expansion of agricultural lands should not proceed without due diligence with regards to habitat destruction, as is required by the National Environmental Management Act (107 of 1998) (NEMA) and the UN Convention on Biological Diversity. At the same time it should be noted that the indigenous vegetation of the former homelands was once a combination of grassland and thicket, but has long-since been changed beyond recognition. In this sense the cultivation of feedstocks is unlikely to cause the same extent of habitat disruption, biodiversity losses, or GHG emissions as the deforestation of indigenous forests in Uganda, Indonesia and (to a lesser extent) Brazil[20] (Monbiot 2004; OECD 2007) and should therefore not be compared to it.

5.2.4 Genetically modified crops

Genetically modified (GM) crops occupy a controversial place in South Africa's public discourse. In reality, less than 5 per cent of the maize crop is genetically modified, and domestically grown sugarcane is not yet genetically modified.[21] Insect resistant GM yellow maize has been introduced with some commercial success in KwaZulu Natal. GM crops have the potential to increase the supply of bioenergy in South Africa, where growing conditions are harsh and investment in agricultural infrastructure is low. On the other hand, concerns have been raised about the cross-pollination of crops and the effect of GM crops on human health via the inevitable contamination of by-products. In addition, GM insect-resistant crops produce the toxin *Bacillus thuringiensis*, which could promote the development of super-resistant pests and insects.

South Africa has the regulatory instruments to oversee a managed use of GM crops. In May 1997, the South African Parliament passed the Genetically Modified Organisms Act (No. 15 of 1997). In November 1999, an Executive Council, Registrar and Advisory Committee were appointed to oversee the implementation of the Act.

5.2.5 Air pollution

South Africa committed to improving its air quality in the National Environmental Management: Air Quality Act (2004). Vehicle emissions, in conjunction with oil refineries and coal-fired power stations, are the source of poor air quality in South Africa's major cities. Both Johannesburg and Cape Town experience severe smog six months of the year, caused by pollution and temperature inversions. In Cape Town, more than half

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20. The University of Leeds and Worldland Trust released a high-profile study (Righelato and. Spracklen, 2007) showing that where deforestation takes place to cultivate biofuel crops, the net carbon balance can be negative.
21. GMO sugar beet and sugarcane are under trial in the US. Brazil is also developing GM sugarcane varieties.

the air pollution is produced from vehicle emissions (Haskins, pers. comm.).[22] The problem is caused by a combination of ash and sulphur and nitrogen particulates (SOx, NOx). Bioethanol emits no SOx, and reduced levels of carbon monoxide (CO) and hydrocarbons relative to petrol. Bioethanol combustion in engines releases less NOx than petrol combustion, but the use of nitrogen fertilisers in the cultivation of bioethanol crops negates any overall benefits. No official figures exist for South Africa but in the USA diesel ash causes 21,000 additional deaths per year through chronic respiratory illnesses (Health Effects Institute 2000); in the United Kingdom the related figure is estimated to be 24,000 premature deaths per annum (City of London 2006).

Collectively, biofuels could have a small but positive impact on South Africa's urban and peri-urban air quality. This impact would be lost were biofuels not used for domestic consumption but for exports.

5.3 Social issues

The introduction of a biofuel industry is likely to benefit some people and disadvantage others. South Africa is a country defined by socio-economic disparity,[23] and it is important that the disadvantages and risks created by a biofuel industry do not further undermine food security, employment creation and environmental integrity, thereby exacerbating the problem. Ideally the poor would share in the direct benefits generated by biofuels, including revenue, employment and safer living conditions.

5.3.1 Food availability, price and access

Much concern has been raised over the impact of biofuels on food supplies, particularly the availability of food for the poor. It is this concern that has seen the prohibition of maize as a feedstock in South Africa's biofuel strategy. In 2007, the Governor of the South African Reserve Bank urged bioethanol efforts to focus on sugarcane as a feedstock and not maize in order to avoid staple food price inflation (*Business Report*, 5 August 2007).

In its crudest form this issue is structured as a trade-off between the world's 800 million motorist (or South Africa's 8 million motorists) and the 815 million people estimated by the FAO (2005 and 2006) to be food insecure (Brown 2006). The debate is understandably emotive, but frequently misrepresents the dynamics between access to food and the production of fuel. That the emergence of a global biofuel industry will make demands on the crop production sector seems obvious, but the issue of food security is too often confused with the concepts of 'food production' – the physical yield of

22. Craig Haskins is the former City of Cape Town official in charge of air pollution and climate change.
23. South Africa has a Gini coefficient (a measure of the inequality of a distribution, a value of 0 expressing total equality and a value of 1 maximal inequality) of 0.59, as estimated by the United Nations. Other estimates range between 0.77 and 0.54.

crops that is apportioned to the food market, and 'food self-sufficiency' – the isolationist policy of supplying all the food consumed by a population, which when pursued undermines the welfare gains possible from comparative advantage-based trade.

It is, however, 'food security' – the physical and economic access to sufficient, safe and nutritious food (as determined by food production, and patterns of food trade and distribution, as well as the ability to access food) – that is relevant in any assessment of the impact of bioethanol on food. More precisely, it is the impact of a South African bioethanol industry on the food security of the 14 million most-poor South Africans that should be assessed. The impact of increased demand for biofuels on food security is complex and difficult to predict. There is the potential for biofuel feedstocks to reduce the volume of crops that enters the food market, especially in the short term. At the same time, increased demand for food and biofuel crops could trigger investment in agricultural infrastructure and production supply responses that could increase the production of food even more rapidly than has been the case in the past 50 years, during which South African food supply has grown four-fold (Vink and Kirsten 2002).

More importantly, South Africa is increasingly well integrated into the regional and global food market. Where food shortages arise, South Africa is able to draw on a wide range of potential food exporters to meet the deficit and ensure food security. As such, food security impacts created by bioethanol and heightened competition for land and water resources are more likely to manifest in food price inflation than in absolute food shortages.

In South Africa, recent food price increases have been cited as a portent of what is to come if South Africa pursues bioethanol production (Sugrue and Douthwaite 2007). Food price inflation was 9.5 per cent through the third quarter of 2007 higher than broader consumer inflation. More specifically, for the year ending December 2006, maize prices increased by 28 per cent and the sugar price rose by 12.6 per cent. Sugar price increases were indeed the result of Brazil withdrawing sugar exports to support its bioethanol industry, but this was a temporary phenomenon. When supply responses were triggered in 2006–07, sugar price inflation settled to 3.8 per cent (National Agricultural Marketing Board 2007). The maize price increase was due to a low domestic harvest and to higher global commodity prices.

These increases should not be linked to the influence of South Africa's bioethanol sector, which barely exists. On the contrary, a major driver of recent food price inflation in South Africa has almost certainly been higher oil prices, and the embedded energy in food products (FAO 2007; RFA 2007b). In addition, global prices for a range of commodities are in an inflationary phase of their cycle as demand, most notably from China, increases. Maize prices have increased particularly quickly as they respond, from a very low base in 2005, to increasing consumption of meat and demand for animal feed (OECD-FAO 2007; RFA 2007b).

A number of factors combine to suggest that the risk to food insecurity arising from bioethanol production may not be as pertinent as some forecasts propose:

- South Africa's biofuel target of 2 per cent of vehicle fuels by 2013 can be produced with existing sugarcane surpluses. Indeed the *Draft Biofuel Strategy* estimated that South Africa could produce up to E8 with its maize and sugarcane surpluses, implying that initial international demand for South African bioethanol could be satisfied without any impact on domestic food security.

1. The co-product of bioethanol produced from maize – Dried Distillers Grains with Solubles (DDGS) and molasses from sugarcane can be used as animal feed. Bagasse from sugarcane provides a source of co-generated energy. Additional supply of bioethanol co-products could deflate the cost of animal protein production in South Africa and reduce demand for energy.

- Unlike Europe or the USA, South Africa has unutilised and underutilised land that, provided rainfall is adequate or water can be legally provided, could be brought under cultivation to increase supply. Bioethanol-triggered investment could go some way to overcoming the structural constraints that impede small-scale black agriculture and food supply in the former homelands. Where this has been successfully achieved (such as in the wool and sugarcane sector) significant supply-side capacity has been unlocked. As Jeremy Wakeford of the University of Cape Town's School of Economics points out: 'The best way to help people and secure food supplies is to teach more productive farming techniques and ensure they become more than mere subsistence farmers by being part of the biofuels boom.' (Wanneburg 2007).
- The efficiency gains likely to follow from a more intensive agricultural sector are expected to have a deflationary effect on the supply of agriculture and food in general.
- Imported petrol is one of the key drivers of food price inflation. Substituting this import with locally produced bioethanol will remove this inflationary pressure.
- Concentration of market power and anti-competitive behaviour have been a source of food price inflation in the past but have recently been the focus of South Africa's increasingly vigilant Competition Commission. There is some evidence that food market competition is increasing, as is access to the food market (Vink and Kirsten 2002). One indicator of this trend is the erosion of South Africa's longstanding rural–urban bias in food prices. The price of a loaf of bread in rural areas is currently US$ 0.025 above that in urban areas, but this disparity has been decreasing steadily over the past four years. Interestingly, it is market concentration that has driven Mexico's tortilla price up by 400 per cent, and not the demand for biofuels (as is so frequently suggested in the popular media).[24]

As such, the trade-off between the all-important concept of food security and bioethanol production need not be as direct in South Africa as critics such as Brown (2006) imply. This is not to say that a domestic bioethanol industry could not undermine the ability of some of South Africa's poorest people to access sufficient food at affordable prices. Indeed this risk could become acute during the periodic agricultural droughts that affect the country, when low production in conjunction with demands from bioethanol processors might push prices up. South Africa's poorest population cohorts spend 62 per cent of their income on food (51 per cent if they live in cities and

24. See: http://www.crikey.com.au/Politics/20070131-Biofuels-demand-sparks-Mexicos

towns) and maize price increases have a dramatic impact on their welfare. The problem could be more acute in those SADC countries such as Namibia, Botswana and Zimbabwe that rely on the export of South African food surpluses to maintain their own food security.

The key to avoiding these adverse localised food security impacts within South Africa is to ensure increased agricultural productivity, and to marshal the opportunities and revenue streams that are generated by an emerging bioethanol sector in favour of the poor.

5.3.2 Poverty, welfare and small-scale farmers

By deploying its regulatory influence over land, water, trade and financial support, the government in South Africa has the ability to influence the location and the extent of bioethanol crop production, and to ensure that some of the employment and revenue streams that are generated accrue to people who would otherwise be adversely affected by the growth of the sector. South Africa's land redistribution and restitution programme aims to transfer 30 per cent of arable land to black people by 2012. To date the transfer has been too slow, but a further feature of the programme has been the inability of those households that have acquired land to access agricultural commodity markets. The emergence of a new, highly regulated market for biofuels provides the opportunity to extend market opportunities to land reform beneficiaries and other emerging black farmers, particularly as it seems that bioethanol processors will rely on contracted growers – and not the market – to procure their feedstock. Contract farming arrangements, as used by the sugar industry, permit the transfer of capital, extension services and markets to small-scale rural growers, and provide a good basis for rural development efforts. Relative to the option of allowing existing commercial farmers to monopolise the biofuel industry, such an approach will require additional effort, especially from the Department of Agriculture and Land Affairs. The required effort can be justified by the political priority of establishing a stable and profitable black commercial farming class.

As a minimum, the securing of tenure rights for poor rural households should accompany any expansion of the bioethanol industry in order to ensure that rising land prices benefit, and do not further marginalise, the poor (Dasgupta 1992; Chichilnisky 1994).

5.3.3 Health and safety

Bioethanol is less flammable than paraffin and petrol and can be used in a gel form as an illuminating and cooking fuel. Bioethanol gel does not offer the same emissions reduction benefits as liquid bioethanol, but does remove the danger created by the use of illuminating paraffin for lighting and cooking in South Africa's rural and informal peri-urban settlements. Liquid paraffin is a major cause of human burns and of shack fires in South Africa. Although official figures on shack fires in South Africa are not available (it is not a distinct cause of death in the records), every year 'many thousands' of people are harmed by paraffin and paraffin burns, most of them children (PASASA 2007). The Paraffin Safety Association of South Africa estimated that in 2006 in the Cape Town Unicity (metropolitan area) alone, shack fires cost the local government ZAR13 million (US$1.79 million) (PASASA 2007). Bioethanol gel would also provide benefits, relative to paraffin, in terms of indoor air quality. Indoor air pollution is closely related to respiratory illness in women and children and is a causal factor in the poverty of South Africa's poorest households.

There is a danger that bioethanol will find its way into potable alcohol, where it would have intensely adverse health implications for those who consumed it. To avoid this happening it has been proposed that bioethanol producers be registered and that bioethanol be denatured on site and stored with a bittering agent. This would not, however, be easily enforceable where fuel was being sold into the export market and outside of domestic regulatory reach.

6. A SADC-wide approach to trade?

Unless prices or international trade rules change, South African producers face little incentive to sell their bioethanol to traditional export markets. Alternatively, South Africa might benefit from a SADC-wide focus on its bioethanol (Johnson 2007; E4tech 2006). Indeed, South Africa is committed to increasing regional trade within the Southern African Customs Union (SACU). Within SACU, increasing quotas of duty-free sugar trade aim to render sugar trade duty-free by 2012. No SADC country currently imposes any border duty on the importation of bioethanol and South Africa already exports petrol and industrial ethanol to a number of SADC countries.

The rationale for such exports, however, confronts many of the same counter-arguments that have presented for international exports. A more prudent approach, therefore, may see South African companies investing in SADC countries in order to produce bioethanol. Bioethanol from other SADC countries might be imported to South Africa, which consumes 80 per cent of SADC's petrol, and could also be exported. This approach, which appears to be receiving speculative investment from South African companies, would be consistent with South Africa's policy aim to lead to an economic integration of SADC countries.

On the positive side, some SADC countries have both 'African Caribbean Pacific' (ACP) and 'Least Developed Country' status and qualify for preferential access to the EU and US markets. This access could sway the viability of bioethanol production. The opportunity costs of land and water in other SADC countries are considerably less than in South Africa, particularly in those countries that straddle the inter-tropical convergence zone where precipitation is high (Turton *et al.* 2002; Lorentzen *et al.* 2007). Labour, too, is generally cheaper in South Africa's regional neighbours. South Africa's three sugar processing companies already have investments north of South Africa based on these favourable attributes and the associated comparative advantage, and could extend these to develop a bioethanol sector. A concerted effort by South African companies, motivated by the incentive of biofuel export revenues, to invest in agricultural production in these countries could overcome existing infrastructure and technology constraints and create local employment and enhance the productive capacity of the agricultural sector in general.

Furthermore, over the next few years ACP and SADC members will be granted phased-in tariff-free access to the EU markets under the Everything-but-Arms (EBA) Initiative. This process is expected to be completed before full SADC liberalisation kicks in by 2013. Because of the scheduled reduction in the EU sugar market intervention price, SADC sugar producers from places like Zambia, Mozambique, Swaziland (and perhaps even Zimbabwe) are likely to replace the less competitive Caribbean producers in their sugar exports to the EU.

For maize-based bioethanol, the great disparities in production costs across SADC countries create potential for welfare-enhancing intra-SADC trade. Such a SADC-wide approach, however, is not without its risks. Most SADC countries experience periodic food insecurity and are dependent on South Africa for food exports in times of shortfall. In most SADC countries, the challenge of managing the food–fuel balance is greater than in South Africa and the legislative capacity is less. In these countries, even more than in South Africa, there is a risk that a burgeoning bioethanol industry will accentuate food shortages, particularly in times of drought. In 2006 an estimated 12 million people in the SADC countries experienced life-threatening food shortages, needing a net maize import to the region of 2.8 million tons (FAO 2007).[25]

The often-cited notion that food security risks are specific to the use of staple crops, such as maize, in feedstocks is not always true. A booming sugarcane-based bioethanol industry would attract investment and resources away from maize, for example, and impact on production across a range of alternative agricultural products, including maize.

It would also be more difficult to monitor environmental impacts in many of these countries than in South Africa. Ideally, SADC countries would not compete in terms of the laxness of the legislation they impose on agribusiness, and the commitment to develop bioethanol in the least-developed SADC countries would be preceded by the type of research and institution-building that would enable the sustainable development of this sector. In the past, however, it has not been uncommon for agribusiness corporations to undermine weak governments and the development of robust policy in SADC countries so as exploit natural resources and maximise their share of the export opportunities.

A further danger of a SADC-wide approach to bioethanol trade is that unsophisticated SADC economies would become overly reliant on bioethanol production, at the expense of a diverse set of secondary and tertiary economic activities. Were farmers in a small middle-income country such as Swaziland, in which innovation is typically slow, to become dependent on the production of sugarcane feedstock for bioethanol exports, they would find themselves in a precarious position if the market suddenly switched to second generation cellulosic bioethanol, or if OPEC kept oil prices artifi-

25. See: http://www.fao.org/giews/workstation/page.jspx

cially low so as to undermine the development of the biofuel industry (Mathews 2007).

A number of SADC (and other) countries appear to have taken cognisance of the potential and risks associated with a SADC-wide bioethanol industry. The Brazil/UK/Southern Africa Bioethanol Partnership was originally intended as a trilateral partnership with South Africa, but was expanded due to South Africa's limited potential relative to the obvious potential of the region. The partnership supports the diversion of sugarcane to bioethanol, the increase in sugarcane yields and the expansion of sugarcane cultivations as a means of establishing the regional industry (E4tech 2006).

7. A sustainable way forward: conclusions and recommendations

7.1 Conclusions

Contrary to the inference drawn by a number of authors, South Africa does not export bioethanol for fuel. The ethanol that is often included in bioethanol trade analyses is, in fact, a by-product of South Africa's oil from coal initiative and from the sugar industry. Neither type of ethanol is used as a transport fuel.

In December 2007, the South African Cabinet scaled back the country's bioethanol ambition and proposed a mandatory blending target of 2 per cent vehicle fuel by 2013 – a move that has yet to manifest in industry reaction. The anticipated benefits of a South African bioethanol industry include rural employment (although not on the scale projected by the Biofuels Task Team), current account benefits and economic growth, but sceptics have drawn attention to the food insecurity threat and potential loss of natural environments that could be created by a burgeoning South African biofuel industry.

Given the small scale of South Africa's emerging bioethanol industry relative to global demand, and the unregulated nature of bioethanol transactions, it is likely that the bulk of bioethanol produced in South Africa will end up in the market that provides the greatest returns to manufacturers and retailers. Whether or not this is an export market will depend on relative prices, trade regulations, import barriers and transport costs, as well as quality considerations. Emerging South African bioethanol policy proposes to pay local manufacturers US$0.60 per litre for their bioethanol. Once transport costs and import tariffs have been paid it is unlikely that either the US, Europe, Canada or Australia will be able to offer a more attractive price than this. In Brazil, India, Thailand and Indonesia where import tariffs are not prohibitively high the cost of local production is significantly lower than that in South Africa. There is some potential, however, for export markets to absorb that bioethanol that exceeds the relatively small quota that is mandated for local consumption.

In order for bioethanol trade from South Africa to become attractive to local producers, trade legislation applying to bioethanol would have to be relaxed, or South Africa would have to remove or lower its supportive statutory price and the cost of production in South Africa would have to decrease. Alternatively, South Africa should seek to invest in the productive capacity of other SADC countries, many of which have preferential access to the EU and US markets and enjoy lower opportunity costs of labour, land and water. Where such investment unlocked the productive capacity of SADC countries, it could off-set potential conflicts between food and biofuel production.

The overarching conclusion of this study is that the development of a bioethanol industry in South Africa could make a positive, but circumscribed and fairly limited, contribution to South Africa's development. This conclusion is based on the prediction that the benefits of having a local bioethanol industry (including insulation against oil price volatility, an improved current account balance, climate change mitigation, and investment and employment in rural communities) are likely to become more important and valuable in the future, especially relative to the alternative of increased fossil fuel combustion.

South Africa has the institutional and legislative architecture to ensure that small-scale farmers benefit from feedstock production, biodiversity is protected, water profligacy is avoided, quality control is upheld, and that GM crops are used safely. The head of South Africa's Biofuel Association, Andrew Makenete, articulates an example of how this could work when he says: 'If it is a key criterion of a licence that biofuel producers must source feedstock from emerging farmers, then the biofuel industry can immediately create a market for the rural poor.'[26] Deploying this architecture may prove more difficult where the industry adopts an export focus, especially where importing countries place little emphasis on supporting South Africa's domestic priorities. Private transactions between South African bioethanol manufacturers and international bioethanol brokers would make it difficult to manage the scale and the nature of the industry most critical in this regard is the water consumed by sugarcane feedstocks. In addition, it would leave South Africa fully exposed to the vagaries of liquid fuel imports and would export any positive environmental and health benefits arising from the use of bioethanol as opposed to petrol.

7.2 Recommendations

Based on the findings of this study the ability of bioethanol trade to contribute to sustainable development in South Africa could be greatly enhanced by considering the following points:

1. Ensuring that land and water tenure for poor and marginalised people are secure prior to bringing land under bioethanol crop production. In this way the chance of these people being incorporated into the emerging industry is enhanced. Similarly, any appreciation of land and water values arising from bioethanol-related demand will benefit poor and marginalised people rather than further disenfranchising them.
2. Prior to crop production in a particular basin, the 'human' and 'ecological' water reserve should be secured as is required by the National Water Act of 1998.

26. See: http://www.mg.co.za/articlePage.aspx?articleid=303720&area=/breaking_news/breaking_news__business/

3. Identifying the potential for agricultural intensification and identifying suitable (low ecological impact) land for expanded production are necessary prerequisites for government support to the sector. It is not possible for the government to stipulate where private sector biofuel initiatives establish themselves, but effective public sector support (including infrastructure) for growers in suitable rural areas would incentivise private sector refining capacity in these areas and limit ecological impacts.
4. Ensuring compliance with broad-based black economic empowerment and the 1997 Basic Conditions of Employment Act legislation prior to issuing producers and processors with supply contracts, fuel levy rebates, or preferential access to international markets is not only a policy requirement, but would permit the industry to fulfil its socio-economic potential.
5. South Africa possesses sophisticated water, biodiversity, agricultural and social legislation, but significant challenges remain for South Africa in terms of policy implementation. The ability to meet these challenges will determine the extent to which bioethanol production and trade contributes to sustainable development.
6. Exploring the potential for production of bioethanol in other SADC countries, in concert with developing the South African industry, could yield great benefits for South Africa. Such an approach would allow South Africa to divert its land and water from agriculture into sectors and activities that are currently water-restricted but capable of generating more employment and revenue than agriculture. In pursuing a regional rationalisation of southern Africa's biofuel industry in this manner, South Africa should be cautioned not to export environmental degradation or food insecurity to these countries.
7. It is important that bioethanol remains part (and not the whole) of a comprehensive South African renewable energy effort. It would, for example, be disproportionate for bioethanol to contribute the 30 per cent of South Africa's renewable energy target implied by the *Draft Biofuels Strategy* and the Department of Minerals and Energy's 2003 *White Paper on Renewable Energy.*
8. Current oil prices in excess of US$90/bbl enhance the viability of bioethanol production and trade, but a hedging facility (in which producers pay into a stabilising fund when the oil price is above a certain level and draw from this fund when the oil price is low) would contribute to stable and sustainable production and trade.
9. Maintaining an active biofuel research component is important. Using sugar and maize in the initial stages of bioethanol production should not prohibit exploration of new crops such as jatropha, sunchoke (insulin sugar), jojoba, diatomic algae and palm oil as well as new technologies. The so-called 'second-generation' biofuel production technologies such as syngas production from the gasification of biomass (the 'biomass-to-liquid' process), and cellulosic bioethanol are not yet financially proven but may well become established in the near future. The South African industry should be capable of moving with technological progress as it takes place. This should include transitions to hydrogen and fusion technologies.

10. South Africa should, in the early stages, pursue the potential for 'emissions reduction' revenue arising in tandem with bioethanol trade. It is not possible to claim emissions reduction revenue once an industry is established since the reductions then become part of the 'business as usual' baseline.

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Biofuels trade and sustainable development: the case of Ecuador's palm oil biodiesel

María Amparo Albán and Helena Cárdenas

1. Introduction[1]

Global biofuels production illustrates the complexity of harmonising the different variables of sustainable development. Pursuing environmental protection and implementing social standards, while ensuring economic feasibility in industrial activities, is vital for low- and middle-income countries in order for them to compete in the global economy. Additional elements – such as food security risks, biofuels production subsidies, and volatility of commodity prices – make the biofuels scenario even more complex, challenging the strategic position and capacities of low- and middle-income countries to become key global players in the biofuels market by taking advantage of their privileged access to natural resources and their land availability for agricultural production.

In Ecuador, the palm oil industry took the lead in producing biodiesel for export. Production is still not very high, but shows potential for the development of a whole new industrial sector. On the other hand, palm oil is experiencing a high international price, leading to a diminished interest in the production of biodiesel from the local palm oil industry.

1. This chapter is based on Albán, M.A. and H. Cárdenas (2007) *Biofuels Trade and Sustainable Development: The case of Ecuador's palm oil biodiesel,* International Institute for Environment and Development (IIED) working document. Available to download at: http://www.iied.org/pubs/display.php?o=G02287

With this background in mind, this Introduction offers an initial analysis of the production and trade of biodiesel in Ecuador in the light of its impacts on sustainable development, with the aim of contributing information for policymakers and the private sector involved in this field. There follows an overview of the Ecuadorian economy and specifically of the palm oil and biodiesel sectors (Section 2); some relevant issues related to palm oil biodiesel trade (Section 3); and a preliminary analysis of key economic, environmental and social impacts of palm oil biodiesel (Section 4). Finally, Section 5 comprises a conclusion and provides recommendations.

2. Overview of Ecuador's economic conditions and its palm oil biodiesel sector

2.1 Ecuador's economy

Throughout the last decade (with the exception of the years 1999 and 2000) the economy of Ecuador has shown increased activity, with an unexpected growth in the gross domestic product (GDP) – especially after 2000, when the country reached one of the highest economic growth rates in Latin America. This economic push came after a very depressed period in the late 1990s when the economy underwent one of the strongest recessions ever registered (Albán *et al.* 2006). This economic standstill gave rise to a radical change in the monetary and exchange policies of the country, and the US dollar was adopted in 2000.

Ecuador's economic growth in the period 2000–06 is mainly attributed to the strong increase in petroleum oil activity, including the increase in petroleum oil production due to the operation of a new pipeline for oil products (OCP), and the increase in hydrocarbon prices. In addition, reduced inflation contributed to an improvement in the competitive levels of local production.

The country has achieved an annual trade surplus since 2004. However, the composition of Ecuadorian exports is strongly dominated by primary products: in 2004, 78.7 per cent of total exports were primary against 21.3 per cent industrial. Moreover, exports are very specialised – the main exports are crude petroleum oil (approximately 65 per cent), banana, plantain and shrimp.

Such a trade background, together with a move to use the US dollar, has provided lower rates of competition for Ecuadorian products in relation to those of neighbouring countries. One of the consequences of the dollarisation process is that Ecuador can no longer use exchange policies to assist its market competitiveness. Also, recent juridical and political instability have contributed to a drastic reduction in foreign direct investment (FDI),[2] compromising Ecuador's role in the international market.

The conditions place Ecuador in a difficult position in seeking alternative sources of economic growth, consolidating its international market, and in creating policies for

2. In 2003 the direct investment rate was reduced by 61.1 per cent, the highest reduction in the last decade.

the promotion of an industry based on value-added products and technological development. These goals are to be pursued through trade policies.

2.2 Ecuadorean energy deficit

Paradoxically, despite the fact that Ecuador's petroleum oil exports constitute a significant source of income to the national economy, the country still has a serious shortfall in generating enough energy to satisfy its domestic demand. National institutions have not invested adequately to cope with increasing demand coming from the rise in population and industrial growth.

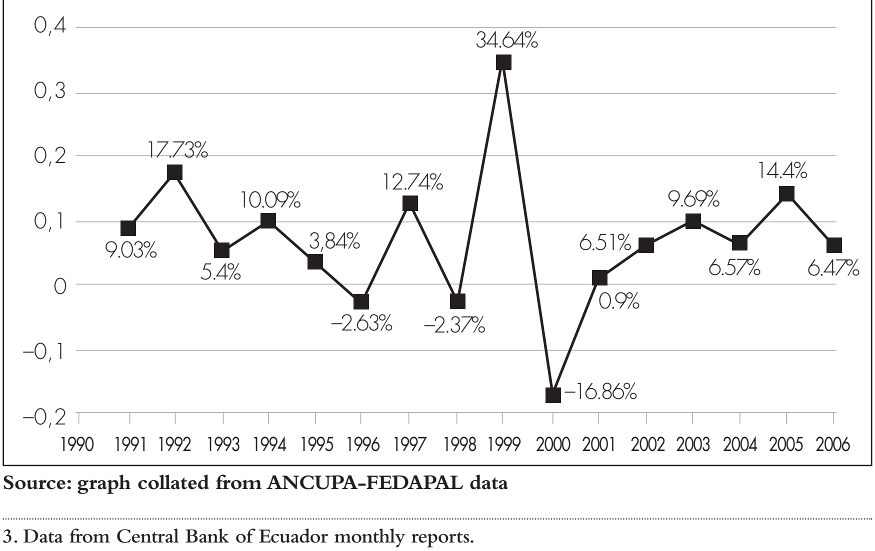
Crude petroleum oil production alone accounted for 20–23 per cent of GDP from 1995–2005, while the oil refining industry accounted for 4.8–8.6 per cent of GDP during the same period.[3] Although the refining sector has increased production in the last four years, this increase has been relatively small and not enough to meet national demand.

National demand for refined products has also increased, thus exacerbating the problem. Between 2005–06 alone, demand for diesel fuel increased by 13.2 per cent.[4] To satisfy the demand Ecuador has to import approximately 40 per cent and 60 per cent of its diesel and petrol needs respectively.

2.3 The palm oil sector

The palm oil agricultural sector accounted for 1.3 per cent of Ecuadorian GDP in the period 1999–2005 while the palm oil manufacturing accounted for 0.4 per cent in the

Figure 1: Ecuadorian palm oil production annual growth (1990–2006)



Source: graph collated from ANCUPA-FEDAPAL data

3. Data from Central Bank of Ecuador monthly reports.
4. Statistic calculated with information from the Ministry of Energy.

same period (Carvajal 2006). Although such percentages represent a small share of national GDP, it is important to acknowledge that the palm oil sector is in a state of continuous growth. During 1990–95 it experienced an average growth of 9.2 per cent; during 1996–2000, 5.1 per cent; and during 2000–05, 7.6 per cent (Carvajal 2006). Projections indicate that the sector will continue increasing its importance to the national economy in the coming years.

The palm oil sector has become a very dynamic agri-industrial activity that generates employment, promotes enterprises, and creates national economic resources through its exports. These benefits have grown throughout the years of palm oil production in the country, which started in the 1950s.

2.4 Biodiesel production

There are four palm oil processing companies in Ecuador, ALES, EPACEM, DANEC and La Fabril, all of them financed by private Ecuadorian capital. La Fabril and ALES are located in Manta, EPACEM in Santo Domingo, and DANEC in Sangolquí. Only La Fabril has produced biodiesel. Biodiesel production represents a small share of oil palm production corresponding to approximately 0.8 per cent in 2005 and 0.4 per cent in 2006.[5]

In 2005 La Fabril produced US$80 million in palm oil derivatives and US$110 million in 2006. Only 3 per cent came from biodiesel. In 2005 La Fabril produced 2,000 metric tons of biodiesel per export ship (one per month). In 2006, biodiesel production reached between 2,000 and 3,000 tons per month – an annual production of 35,000 tons – which represented US$5 million–8 million per export ship.[6]

Biodiesel production is a fairly new segment in the Ecuadorian palm oil sector, but there is interest from other palm oil processing and extractor companies in joining the initiative.

2.5 National policies on biodiesel

In December 2004, the government of defeated president Lucio Gutierrez issued Executive Decree 2332, stating that the production and commercialisation of 'biocarburantes del agro' (agricultural biofuels) was to be of national interest. By this decree the Biofuels Programme Advisory Council and the Biofuels Programme Technical Committee were created. The Advisory Council is in charge of issuing national biofuel policies, while the Technical Committee (which includes officers from the different public and private institutions and which is coordinated by the Ministry of Energy and Mining) provides technical support and advice for the council. The Programme Advisory Council is chaired by the President and includes representatives of the ministries of Energy, Agriculture, and Foreign Trade and the state-owned Petroleum Company, PetroEcuador.

Private sector and agribusiness representation at the council consists of the Ecuado-

5. Statistics calculated by authors with data from La Fabril and ANCUPA.
6. Interview with Carlos González-Artigas, General Manager of La Fabril.

rian National Union of Cane-Farmers (UNCE), the Ecuadorian National Federation of Sugar Producers, the Ecuadorian Association of Alcohol Producers (APALE) and the Association of Fuels Distributors.

Two sub-committees were created once the biofuels programme decree was signed, one for bioethanol production and the other for biodiesel production. However, the biodiesel programme is still in its initial phase and has only accomplished about 10 per cent of its intended activities.

So far only one meeting of the technical committee has taken place for the biodiesel programme and no written reports have been produced. Until now, only biodiesel sampling activities have been implemented. The next actions to be directed by the Biofuel Programme Advisory Council are to conduct studies on the potential geographic zones for the cultivation of palms for biodiesel production,[7] and to ascertain what technical and technological assistance is required. These studies will provide data on the number and type of bio-refineries that will be needed. So far there are no reports on plans by PetroEcuador to invest in bio-refineries or plant for biodiesel production.

In addition to the biodiesel promotion plan, the biofuel programme includes a bioethanol promotion plan. In fact, the bioethanol programme is more advanced and a pilot project is ready to start in Guayaquil. This will last at least a year and will perform an economic, technological and environmental analysis of the feasibility of mixing bioethanol with regular petrol. Three private companies producing bioethanol are already committed to selling their production to PetroEcuador in order to cover the costs of the Guayaquil pilot project.

2.6 Palm oil biodiesel processing and palm oil value chains

Because palm oil biodiesel production accounts for such a small share of palm oil production, the biodiesel value chain analysis must be built on to the whole palm oil value chain.

The palm oil value chain comprises agricultural palm production, oil extraction and the industrial process (which produces several by-products including biodiesel). Palm oil production can therefore be divided into three phases: an agricultural phase, an agri-industrial phase and an industrial phase. The agricultural and agri-industrial phases accounted for 1.3 per cent of GDP between 1999–2005, while the industrial sector accounted for 0.4 per cent in the same period.

- The agricultural phase includes all the growing stages of the palm trees up to the point when the fresh fruit bunches (FFB) are ready for oil extraction. The activities of this phase include planting, weed control, disease and infection control, nutritional management, water management, pruning, harvesting, and FFB collection and transportation. Palm oil agricultural investment (excluding extracting activities) accounts for US$840 million to date, corresponding to 81.5 per cent of total palm oil sector investment.[8]

7. According to information provided by the Ministry of Agriculture, potential areas for the crop's production could be areas previously cultivated for coffee and cacao.
8. Interview with César Loaiza and Freddy López, ANCUPA-FEDAPAL, January 2007.

- The agri-industrial phase includes the second step of FFB transportation from stock centres to mills, usually carried out by trucks and other vehicles, and the oil extraction process. The palm FFB go through several steps in the extracting processes including sterilisation to avoid acidity in the extracted oil; separation of the fruit from the bunches; digestion, to break up the plant cells in order to release the oil in them and to detach the pulp from the nuts; extraction, to obtain the oil through press machines; and clarification, the process of collection and purification of the extracted oil (Carvajal 2006). These processes produce three products: crude palm oil (CPO), palm kernel oil, and the palm cake (what is left from the palm fruit after the oil is extracted). These are stored at the plant before being sent to the refineries.
- The industrial phase incorporates various advanced manufacturing processes that include refining the oil and generating by-products. The GDP share of the palm oil industrial phase accounts for 2.7 per cent of the national industrial GDP. The investment level of the industrial phase is approximately US$190 million, which corresponds to the 19.5 per cent of the total palm oil sector investment (Loaiza and López, *ibid*). This figure includes the oil extracting activities.

The four processing firms, La Fabril, ALES, EPACEM and DANEC, are involved in the three value chain stages.

2.6.1 Biodiesel processing

Biodiesel is one of the palm oil derivatives produced during the industrial phase. After African palm is cultivated and the palm oil is extracted, the crude palm oil is processed to obtain the 'steres metilico' of biodiesel. The biodiesel production process consists of mixing an alcohol (in most cases methanol) with the palm oil. Two substances result from this chemical reaction: biodiesel and glycerine.

The technology used for this process includes machinery for catalysing, distillation, and chemical and physical filtration. The technology had already been developed in various countries and Ecuador could have acquired it from Colombia, Brazil or some European or Asian countries.[9] La Fabril (González-Artigas, pers. comm.), however, chose not to use expert advice from abroad to develop the technology, adapting its existing plants and has had no difficulties with the process (González-Artigas, pers. comm.). As yet there has been no attempt to build a bio-refinery for biodiesel production.

Estimates of the cost of building a bio-refinery show great variation – between US$3,600,000 and US$24,000,000, size and sophistication largely determining projections. Decisions on what is needed depend on the scale of production that Ecuador will be engaged in. So far, there is no defined legal framework for the acquisition of this kind of technology; and no regulations or standards have been established yet on intellectual property rights, support, or other measures to acquire it.

9. Interview with Romel Vargas, representative of ANCUPA-FEDAPAL.

2.6.2 Palm oil and biodiesel value chains

Currently, the area under palm oil cultivation is about 207,000 hectares, involving 5,515 producers. According to the palm sector census carried out by ANCUPA in 2005 (as shown in Table 1) 62.9 per cent of the producers are small-scale (landowners with 1 to 20 hectares) and 32.6 per cent are medium-scale (landowners with 21 to 100 hectares).

Table 1: Stratification by cultivated area (2005)

Range (ha)		Area (ha)	Area (%)	Producers (number)	Producers (%)
From 1 to 10	(62.9% of producers)	14,327.6	6.9	2,306	41.8
From 11 to 20		18,664.4	9.0	1,163	21.1
From 21 to 50	(32.6% of producers)	49,080.5	23.7	1,336	24.2
From 51 to 100		38,783.2	18.7	464	8.4
From 101 to 200	(4.9% of producers)	31,145.8	15.0	175	3.2
From 201 to 500		17,775.0	8.6	52	0.9
From 501 to 999		11,282.4	5.4	10	0.2
More than 1,000		26,226.5	12.7	9	0.6
	TOTAL	207,285.4	100	5,515	100

Source: SIAGRO-ANCUPA (2005)

Thus, palm oil production in Ecuador is mainly carried out by small- and medium-scale producers; although this might be slowly changing with the arrival of new and larger companies, which are increasingly investing in the sector.

About 140,000 to 180,000[10] direct and indirect jobs are currently created by the palm oil sector. Some 70 per cent of them are created during the agricultural and agri-industrial phases of the value chain (*ibid*). The share of GDP of the palm oil agricultural and agri-industrial phases is important, accounting for 15.2 per cent of the national agricultural GDP for the period 1999–2005 (Carvajal 2006).

Today there are some 40 oil extractor companies in Ecuador. All of them are Ecuadorian companies and during the past 10 years they have achieved good quality production (Vargas, pers. comm.). The industry currently produces 340,000 tons/pa of crude palm oil. National consumption is estimated to be approximately 200,000 tons/pa. Thus there is an export potential of 140,000 tons/pa of palm oil or by-products. The very small share that biodiesel has of palm oil production (0.8 per cent in 2005 and 0.4 per cent in 2006), indicates that the increase in palm oil production has not been accompanied by an equivalent increase in biodiesel production.[11]

10. Estimation calculated by La Fabril.
11. Statistic calculated by authors with data from La Fabril and ANCUPA.

In the palm oil value chain, small-scale producers sell their product directly to extracting companies, so that there are no intermediaries. Some of the extracting companies are independent, some are associated with palm farmers, and others are affiliated with the processing industries. In some cases, large-scale producers are also owners of the extracting companies. All four processing companies own extracting facilities, but they also have supply contracts for crude oil and palm fruit with extracting companies and agricultural producers respectively. This applies to La Fabril and its biodiesel production as well. Figures 2 and 3 summarise palm oil and biodiesel value chains.

Figure 2: Palm oil value chain

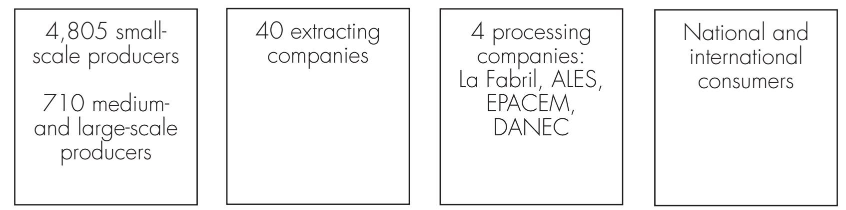
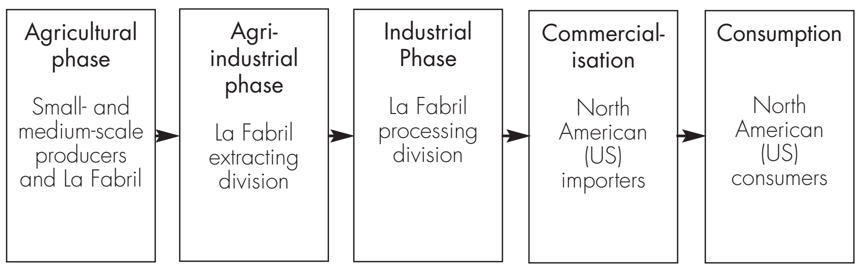


Figure 3: Biodiesel value chain



2.7 Prices and production costs

Biodiesel production costs include capital and operation costs. Capital costs include the industrial plant costs (65 per cent) plus those from the supporting infrastructure (35 per cent). Costs within the industrial plant break down as shown by Table 2.

Estimates relating to the capital costs of biodiesel plants vary greatly, from US$3,600,000 to US$24,000,000, depending on the expected production level. Supporting infrastructure includes tanks, batteries, administrative and auxiliary services buildings, and the construction area. A preliminary assessment, based on data provided by La Fabril, indicates that to meet a target of 1,300,000 barrels (or 210,000,000 litres)[12] per year, the company would require an investment of around US$44 million (solely for operational facilities).

12. 50,000 palm oil hectares/year yield 1,300,000 barrels (or 210,000,000 litres).

Table 2: Biodiesel industrial plant expenses	
Item	Cost distribution/%
Processing equipment	35
Pipes and annexes	21
Electrical installation	12
Metallic structure	10
Automat and security	9
Isolation	7
Civil structure	3
Installation *in situ*	3

Data source: Percival (2007)

Table 3: Biodiesel production operation costs (per cent shares)	
Biodiesel cost	Cost/%
Vegetable oil	76.3
Methanol	5.3
Catalytic	1.3
Transformation cost	17.1
Total	100

Data source: Percival (2007)

From the operational costs, approximately 83 per cent corresponds to inputs (vegetable oil and chemical products); the remaining 17 per cent corresponds to transformation costs including labour, maintenance, depreciation, public services, insurance, administration, sales and auxiliary services (see Table 3).

Current operational costs for palm oil biodiesel vary from around US$810-925 per ton in the different markets. According to the *World Biodiesel Price Report* (F.O. Licht 2007), the prices for biodiesel (palm oil methyl ester, or PME) range between US$825 and US$910. These costs include those for vegetable oil, catalytic methanol and methanol, but not the transfer value and do not include taxes or labour costs.

In May 2007, the operational cost in Ecuador was US$875 per ton of biodiesel. This cost corresponds to US$119 per barrel (US$2.8 per gallon), a much higher price than for conventional Diesel No.2. This price does not include the conversion which corresponds to about US$190.[13] In addition, the transportation cost per biodiesel ton from Manta (La Fabril) to Esmeraldas (refinery) – the most likely scenario for this company – is around US$22 per ton.[14] In total, these costs would represent US$1,087 per ton (US$148 per barrel or US$3.5 per gallon). Therefore Ecuadorian biodiesel operational costs are relatively high for the external market, raising the question of the profitability of the business.

13. Criteria provided by Carlos González-Artigas, La Fabril General Manager.

14. Angel Sepeda is a representative from PetroEcuador and is a member of the Biofuel Programme Technical Committee. Interviewed January 2007.

It is important to stress that biodiesel costs fluctuate constantly because of its dependence on palm oil and petroleum prices. As shown in Table 3, vegetable oil costs are the most influential item within the biodiesel operational costs (76 per cent), and as subsection 4.1 in this paper further explains, the biodiesel price contingency on crude palm oil and petroleum oil prices makes palm oil biodiesel costs not only highly variable but also unpredictable.

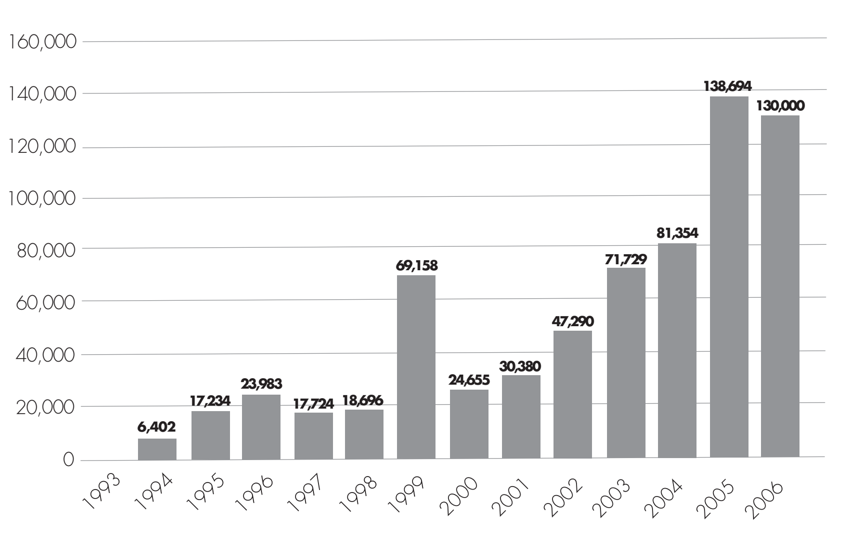
3. Trade issues

3.1 Palm oil trade

Ecuador is the seventh largest global palm oil producer and the second major producer in South America.[15] Nevertheless, its production represents only 0.95 per cent of world production – the two largest palm oil producers, Malaysia and Indonesia, together account for 86 per cent of the world's output. Two other important producers are Nigeria and Thailand, with 2.4 per cent and 2 per cent of the world output, respectively.

Currently, Ecuador exports approximately 40 per cent of its palm oil production (including semi-processed and finished products). Figure 4 shows palm oil exports from 1993–2006.

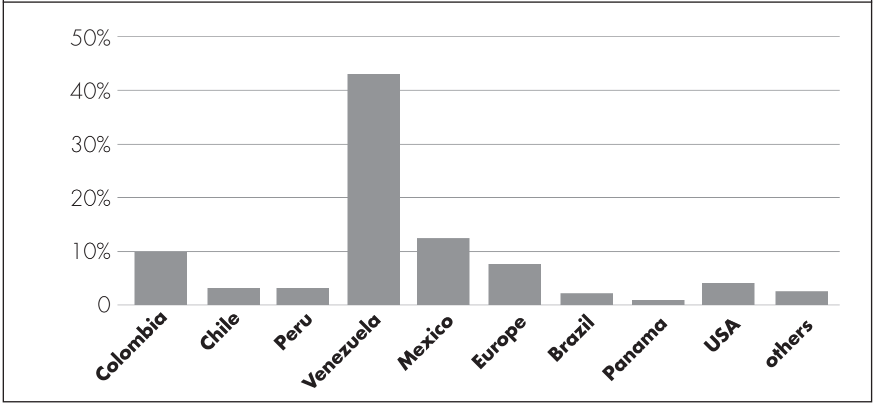
Figure 4: Ecudorian palm oil exports



Source: graph collated by the Ecuadorian Federation of African Palm Producers (FEDAPAL)

15. The major palm oil producer in South America is Colombia, with 2 per cent of the world's production.

Figure 5: Destinations for Ecudorian palm oil exports (2004–06)



Source: Graph collated with data from ANCUPA-FEDAPAL

3.1 Main trade partners for palm oil products

As shown in Figure 5, the main destinations for Ecudorian palm oil exports during the last few years include Venezuela, Mexico, Chile, the European Union, Colombia, Brazil, the United States and Panama.

3.2 Biodiesel trade

Ecuador has been producing biodiesel since 2005 through La Fabril. So far, the fuel has only been exported and not consumed internally because there is no legal or technical framework yet to encourage domestic consumption. All the biodiesel has been exported to the United States: 24,000 tons (3,358,000 gallons) in 2005, and 35,000 tons (10,780,000 gallons) in 2006 (González-Artigas, pers. comm.).

However, according to ANCUPA-FEDAPAL statistics, by 2009 an estimated 240,000 palm oil hectares will be cultivated and crude palm oil production will rise to 400,000 tons, of which 200,000 tons could be exported. There are ambitious projects being planned by private palm oil products processors. (For example, La Fabril is currently planning to increase palm oil cultivation for biodiesel production though it preferred to keep the data for potential hectare numbers off the record.)

Every hectare of cultivated oil palm yields 4,200 litres of biodiesel per year (Camacho 2007). Therefore, 100,000 cultivated hectares (which is the target for expansion) could produce 420 million litres of biodiesel per year, which translates into 110.5 million gallons of biodiesel per year.

The nascent national biofuel programme has been designed to include biodiesel production as a national priority to help cover the national demand for diesel, which suggests that Ecuador's palm oil production would have first to supply the national market. Initial calculations show that Ecuador's production would – in principle – be sufficient to supply both national and international markets. These calculations include the following considerations:

- The national biofuel programme's assessment of a policy for mixing Diesel No.2 with biodiesel (B2 or B5). In the case of B5, the required biodiesel amount would be around 1,187,000[16] barrels/year[17] (equivalent to 161,937 tons per year).
- If the national petroleum diesel demand keeps its current increased rate of 13 per cent, within three years the biodiesel national demand would reach 233,658 tons. Over the same period, there would be 100,000 new hectares producing palm oil (expected to start this year), yielding 359,015 tons – 35 per cent higher than the expected national demand.
- Moreover, although La Fabril is the only company in Ecuador producing and exporting biodiesel, there are several companies involved in the processing and extraction of palm oil that are interested in exploring biodiesel production.

However, the former analysis is based on data and projections assessed for 2006. By 2007, the vulnerability of biodiesel prices increased, affecting the decision of La Fabril and other palm oil companies to increase production for biodiesel.

There are no attempts by PetroEcuador to invest in agricultural resources or industrial plants in order to produce biofuels itself (Sepeda, pers. comm.). In that sense, there is a clear tendency for private companies to take the lead in biofuels production, while the Ecuadorian government takes a supportive role in promoting policies and technical support through the ministries of Agriculture and Energy and PetroEcuador.

Ecuador may still have opportunities for exporting biodiesel. Environmental concerns and energy demand are likely to influence several countries' desires to import Ecuadorian biodiesel. The current situation with respect to prospective partners is described in Box 1.

It is important to point out that although these results would probably increase imports levels in the short term, there are several other external factors with a bearing on trade in the long term.

3.3 International trade agreements

A policy framework for biofuels trade has not yet been discussed at the World Trade Organization (WTO). However, as biofuels trade increases in popularity and significance, it becomes a matter of concern for policymakers worldwide. Ecuador has been a WTO member since January 1996 and, as a country with an undeveloped but potentially emergent biofuel industry, has been following the developments of this debate and the progress of the negotiations at the unsuccessful Doha Round, including the General Agreement on Trade and Services (GATS) and the Non-Agricultural Market Access Negotiations (NAMA). Key issues of concern include:

16. Calculated from the national demand for Diesel#2, which was 23,725,000 barrels in 2006.

17. Information provided by the Ministry of Agriculture and prepared by the Biofuels Programme Advisory Council.

Box 1: Potential export markets for Ecuadorian biodiesel

Brazil is currently the biofuels production pioneer, especially for bioethanol. The country also produces biodiesel, especially biodiesel based on soya bean oil and 'higuerilla' (castor oil). However, it has a deficit in its domestic market. The current national policy promotes the consumption of B2. Therefore, Brazil is currently looking to import biodiesel from available markets. Moreover, the National Biodiesel Programme in Brazil is aiming for a biodiesel mix of 5 per cent by 2013 and 20 per cent by 2020. Thus, there have already been attempts by Brazil to negotiate a trade agreement on biofuels with Ecuador,[18] although such negotiations have not yet been carried out.

The European Union is a *sui generis* case; even though the EU is a net importer of vegetable oils, EU countries have developed their own biodiesel sector, largely out of environmental concerns. The EU is the main biodiesel producer worldwide, and accounts for 95 per cent of biofuel global production (Dufey 2006). Nevertheless, as biodiesel consumption in the EU increases, its capacity to satisfy its own demand will be limited. Biofuels currently account for about 1.4 per cent of EU fuel consumption and biodiesel represents about 82 per cent of the EU biofuel market (Dufey 2006). This share of biofuels (and particularly biodiesel) will most likely rise, and the EU has a limited capacity for producing vegetable oils to be used as raw materials for biodiesel production. Consequently, it is expected that the EU will increasingly import biodiesel from foreign markets. The EU does have trade protection for biodiesel, which is subject to an *ad valorem* duty of 6.5 per cent. Ecuador, together with Papua New Guinea, the Ivory Coast, Nigeria and Colombia, will benefit from preferential access to the EU market for its palm oil products (with a zero per cent tariff on palm oil products) (Earley *et al*. 2005). Given this *ad valorem* duty, however, Ecuadorian exporters would be incentivised to export crude palm oil instead of biodiesel.

The United States already produces biofuels and promotes its production and consumption through taxes and other support measures. In 2007 the US government called for a mandatory fuel standard that would require 35 billion[19] gallons (132.5 billion litres) of alternative fuels to be used by 2012 (Kutas *et al*. 2007). The US biodiesel market is based on soya bean oil and is increasing. All the Ecuadorian biodiesel production is destined for the US. Moreover, through the 1991 ATPA (Andean Trade Preference Act) and the 2001 ATPDEA (Andean Trade Promotion and Drugs Eradication Act), Ecuadorian crude palm oil has preferential access (zero per cent tariff) to the US market. Nevertheless, lack of clarification regarding biodiesel classification means it is not clear whether biodiesel would enter as a 'chemically-modified palm oil product' (in which case the preferential access treatment would not apply). On the other hand, the USA provides subsidies for biodiesel consumption, which will indirectly benefit biodiesel exporting countries as long as the US biodiesel internal demand expands (González-Artigas, pers. comm.).

Other potential markets include Latin American countries such as Chile and Mexico, who have announced their willingness to use biofuels within the transport fuel sector.

- The lack of a unique biofuels classification within the multilateral trading system.
- The fact that biofuels classification within the 'Harmonised System' (HS) codes makes no distinction between whether they are used as fuel or for other purposes.
- Government measures to protect domestic biofuel production.
- Technical and environmental standards.

18. Interview with Mauro González, representative of the Ministry of Energy and member of the Biofuel Programme Advisory Council.
19. In this instance, 'billion' is used to express a thousand million.

3.3.1 Biofuel preferential market access status

Another issue of concern is biodiesel preferential market access. Countries are allowed to import biofuels (such as Ecuadorian biodiesel) at lower tariffs while retaining tariff protection for domestic non-fuel products that are under the same HS classification[20] – possible if the WTO member that wants to import such a product introduces a further sub-classification in its domestic nomenclature. This process would not require permission from, or negotiations with, other WTO members but would be subject to the normal transparency obligations of Article X of the General Agreement on Tariffs and Trade (GATT); obviously such tariff provisions would have to provide 'Most Favoured Nation' (MFN) treatment to 'like products' (Howse *et al*. 2006). However, there is still uncertainty about the extent to which environmental impacts from production methods could, or could not, be used as parameters for determining 'unlike products'.

Because of its position as a low- and middle-income country, Ecuador is a beneficiary of trade preferences from the European Union and the United States. However, currently, biodiesel from Ecuador is not a beneficiary of any tariff preference system, while bioethanol is a beneficiary under the European Union Generalized System of Preferences (GSP+).

The original US Generalized Preference Program for Developing Nations was created in 1973 and this programme granted preferential access to 4,100 Ecuadorian products. This system was renewed specifically for the Andean countries under the ATPA (Andean Trade Preference Act) in 1991, when 2,000 Ecuadorian products were added to the original GSP, and in 2001 under the ATPDEA (Andean Trade Promotion and Drug Eradication Act) where 171 more products were included. Biofuels, however, as a relatively new product in the international market are not explicitly mentioned in the ATPDEA list[21] for preferential treatment. Nevertheless, bioethanol exports from the Andean Pact and NAFTA are excluded from the 'extra tariff' of US$54 cents/gallon (which applies on top of the 2.5 per cent standard tariff).

On the other hand palm oil products, and other agricultural products that constitute inputs for biodiesel production, are included in the ATPDEA provisions.[22] It is important to note that palm oil or its constituent parts are included but with the condition that they are not chemically modified. In this case, biodiesel could not be exported to the US as a palm oil derivative because crude palm oil passes through a chemical process of transesterification in order to become biodiesel.

20. Neither WCO nor WTO obligations would prevent a WTO member from applying a lower rate of tariff than that bound for a six-digit or higher HS classification to some sub-set of goods within that classification, as long as it provides MFN treatment to 'like products' (Howse *et al*. 2006).
21. But they are included, for example, in the free trade agreements that Peru and Colombia are currently negotiating with the United States.
22. The ATPDEA was recently extended for an eight-month period, starting on 30 June, 2007. This period relates to the time frame for congressional approval of Colombian and Peruvian free trade agreements and therefore it is not yet clear whether this current regime will be further renewed for Ecuador and Bolivia.

The European Union's GSP does grant preferences, but only for bioethanol. There are no specific EU trade preferences for biodiesel on the table, only a proposed amendment to the standard EN 14214, in which the use of a wider range of vegetable oils is asserted, to the extent feasible without significant adverse effects on fuel performance and respecting sustainability standards (Howse *et al*. 2006). However, it is not clear whether this amendment applies to EU countries, to other countries, or to both.

It is important for Ecuador to acknowledge that even when the WTO 'Enabling Clause' tool is present in the GSP scheme (which, amongst other rules, advocates for non-discriminatory and non-reciprocal action) there are also conditions through which the importing country can determine whether or not it will be granting the preferences. In the case of biofuels, such conditions could be highly related to sustainability criteria, and such criteria could raise possible discrimination amongst different low- and middle-income countries. There have been cases when the Appellate Body[23] held that: 'under certain circumstances, the non-discrimination requirement in the Enabling Clause would in fact permit a rich country to treat different low- and middle-income countries differently in the preference scheme' (Howse *et al*. 2006). Consequently, Ecuador should thoroughly analyse its biodiesel programme in order to assure sustainability standards are attained in the event that the product is eligible for preferential access to rich countries' markets in the future.[24] The European Commission, for instance, has asserted in its report on the EU Strategy for Biofuels (EC 2006) that while providing support for low- and middle-income countries' biofuels sectors, it will ensure that processes are consistent with its own development policy as well as with national and sector development policies, taking into account not only environmental but also social aspects.

3.4 Ecuador's trade policy on biodiesel

The Ecuadorian legal system is not yet capable of administering the export of biofuels. Ecuador uses a system of tariff classifications that includes two main international agreements to which it belongs: the World Custom Organization (WCO) and the Andean Community. This system includes 10 types of tariff classification. The first six belong to the WCO, through the Harmonised System; the next two (seven and eight) belong to the Integrated Andean Tariff system (a system called the 'Nandina code'), and the two last (nine and ten) are currently part of a national nomenclature. These last two classifications will be included and harmonised for 2007 within the Integrated Andean Tariff system and it is expected that the system will have 15 digits by 2008, in order to be consistent with the European nomenclature tariffs system.[25]

23. A standing body of seven persons that hears appeals from reports issued by panels in disputes brought by WTO Members.

24. It is important to note that the definition of sustainability standards is still a matter of concern. The Appellate Body has suggested that the criteria for development needs could be determined based on references to multilateral instruments. However, as Howse *et al*. (2006) suggest, this situation points out the need for developing international standards and multilateral sustainable development instruments.

25. Mauro Benavídez, Ministry of Industry and Competitiveness, interviewed 2006.

Within the Ecuadorian tariff system for foreign trade, there is no specific nomenclature for biofuels and therefore there is no tariff code yet. Thus it is not possible for the Ministry of Foreign Trade or the Ecuadorian Customs Office to know under which tariff code or classification Ecuador is exporting biodiesel.[26] Although Ecuador is a member of the WCO, it has not yet adopted the classification of the Harmonized System for biodiesel under Chapter 38 (Subheading 38 24 90). Ecuador is using the fourth amendment of the WCO Harmonised System and this classification is not a part of it. Furthermore, within the Andean Community there have not yet been discussions on the topic of biofuels trade policies.

Nevertheless, there is currently a system under which Ecuador trades palm oil and its constituents. Oils in general are organised under Chapter 15, with the following tariff classifications: 15 11 10 00 for crude palm oil; 15 11 90 00 for palm oil fractions (excluding processed-ready product but including refined edible oil); 15 13 21 10 for crude palm kernel oil; and 15 13 29 10 for refined palm oil. Moreover, the processed-ready derivatives of palm oil (such as butter, soaps, cosmetics etc.) do not belong to a single classification, but rather come under the classification for each one of these individual products.

Regarding Ecuador's policy framework for biodiesel national consumption, no relevant steps have been taken to set up and articulate guidelines for production and trade. However, if the new government endorses the national biofuel programme's implementation, this process could take between two and three years (González, pers. comm.). In addition, the lack of financing is a key issue that is preventing the development of this programme, especially regarding biodiesel. To date, the biodiesel programme has been stalled at the sample-characterisation stage.

4. Preliminary identification of key sustainable development impacts of biodiesel production and trade in Ecuador

The biofuel industry is relatively new in Ecuador and only small quantities of biodiesel have been produced by one large private company, La Fabril. Biodiesel production and trade have not yet thoroughly developed in Ecuador, either in respect to its legal framework or as an economic diversification strategy. No policies have been yet formulated, meaning that regulations on trade or environmental and socio-economic standards have yet to be established.

Nonetheless, analysis and discussions on the potential of biofuel production and trade have already started and some impacts on sustainable development can be identified. Key impacts are predicted on the basis of the existing experience with palm oil production and anecdotal evidence from the incipient biodiesel production industry.

26. There are several options such as 'oils': 15 15 90 00; 'other lubricant oils': 27 10 19 38; or others.

4.1 Economic impacts

4.1.1 National savings through reduced diesel imports

Ecuador is a diesel importing country, with imports generally accounting for 40–45 per cent of the national diesel demand. In 2006, the national demand for Diesel No.2 was 23,725,000 barrels per year and from this amount 10,000,000 barrels were imported (Sepeda, pers. comm.), which represents a 13 per cent increase with respect to the 2005 diesel demand. Additionally, projections on future supply and demand amounts of diesel show that the Ecuador supply capacity will peak in a few years at 14,600,000 barrels, while the national demand will continue to increase, and is expected to reach 40,200,000 barrels by 2025. Table 4 shows imports by cost and volume (in barrels) from 1998–2006.

Table 4: Ecuadorian fuel imports (1998–2006)

Product	Volume/ barrels	Cost, insurance and freight/ US$
Nafta of Octane (NAO)	32,719,205	1,615,303,184
Diesel	47,328,650	2,154,453,479
Liquefied petroleum gas (LPG)	51,149,597	1,714,184,049
Total	131,197,452	5,483,940,711

Source: Ministry of Energy and Mines (2006)

Ecuador currently generates a palm oil surplus of around 140,000 tons. Therefore the alternative of producing palm oil biodiesel locally represents an opportunity for reducing the national dependence on diesel imports. But in terms of national savings, the real benefits of producing and using biodiesel are very much related to biodiesel prices in the national market as the following analysis suggests.

As of December 2006, diesel is imported at US$82 per barrel, which corresponds to US$1.95 per gallon. The government sells it at US$1 per gallon in the local market, meaning that there is a loss of approximately US$40 per barrel, or nearly 50 per cent, which is compensated by governmental subsidies (González, pers. comm.). In the case of diesel imports, therefore, 50 per cent of such imports expenditures are non-refundable and come from the government budget.

In the case of promoting the use of B5 (5 per cent biodiesel and 95 per cent Diesel No.2) the projected national demand for biodiesel for 2007 would be approximately 3,405 barrels of biodiesel per day, which corresponds to 1,242,700 barrels per year (Ministry of Energy and Mines, 2006). This means that Ecuador would avoid importing 1,242,700 barrels of diesel for 2007, accounting for US$101,901,400 (priced at US$82 per barrel). Due to the aforementioned subsidies, this translates to US$50,950,700 in non-refundable state capital. Obviously, though, this is not the amount of national savings, because even if PetroEcuador did not have to buy the 5 per cent of biodiesel from the international market, it would have to buy from local producers of palm oil biodiesel instead.

Any new alternatives in the fuel sector represent an opportunity for Ecuador to redefine its national policies in relation to government support for this sector. Annually, Ecuador spends an estimated US$2,600 million in subsidies for liquified petroleum gas, diesel and petrol (Sepeda, pers. comm.), a very significant amount when compared to the size of the Ecuadorian economy – almost a third of the fiscal budget each year. Therefore, if the Ecuadorian government launches a national biofuel programme, it would need to allocate subsidies for biofuel production so as to make it profitable for the domestic market; at present biodiesel prices are not competitive with diesel prices. Biodiesel costs (excluding processing and transportation costs) correspond to US$119 per barrel (US$2.8 per gallon).

For an accurate estimate of actual national savings on diesel imports, it is necessary to know the internal biodiesel prices as well as any public policy that will be implemented. These are not yet determined. Analysis of biofuel subsidies and the scope, duration and sustainability of the biofuel sector must be undertaken if such measures are to be taken.

4.1.2 Technology-based production and industrial development

The desirable path for Ecuador's industry is to promote more value-added and technology-based production. Biofuels could be an alternative for endorsing such technological progress, not only at the level of crude palm oil production but even further – in terms of industrial growth and value-added development.

However, the current low profitability of producing biodiesel compared with other palm oil products (e.g., crude palm oil profitability is approximately 3 per cent, while that of biodiesel is only 1.5 per cent) (González-Artigas, pers. comm.) constitutes the key factor preventing companies from producing biodiesel (see sub-section 4.1.4, below).

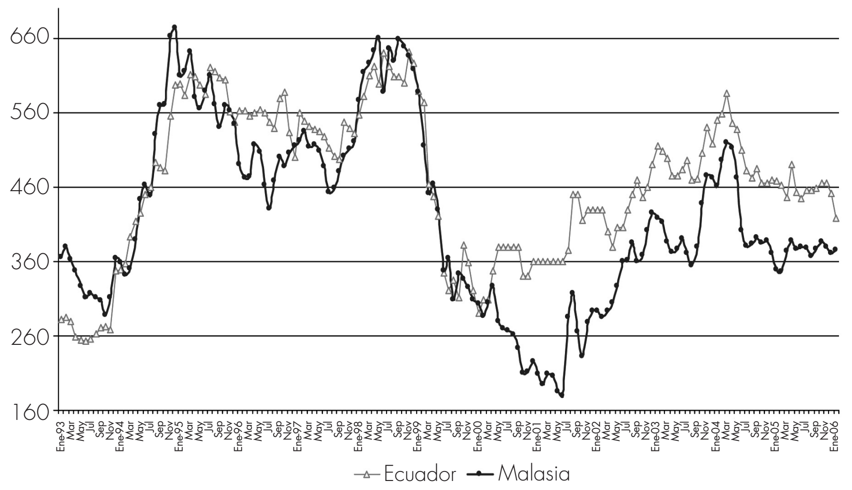
4.1.3 Price volatility

Biodiesel prices are volatile because they depend on two international markets – vegetable oils and petroleum oil – whose prices are already extraordinarily sensitive.

Ecuador is a price-taker, being especially dependent on the palm oil prices of Malaysia, the world's main producer (see Figure 6). International crude palm oil (CPO) prices are highly volatile because of the product's interchangeability with other edible oils (such as soya bean, rapeseed and sunflower, amongst others). However, this influence may decrease in the future because of steadily increasing CPO production in comparison with other vegetable oils.

In addition, biodiesel prices are contingent upon petroleum oil prices, as biodiesel substitutes products for petroleum oil derivatives, a market which is highly interven-

Figure 6: CPO comparative prices: Malaysia and Ecuador



Source: ***Oil World*****, as cited in ANCUPA-FEDAPAL (2006)**

tionist (e.g., by the OPEC cartel) and thus subject to continuous fluctuations.

Price volatility and unpredictability for biodiesel are key reasons why palm oil producers in Ecuador have decided not to enter the biodiesel business. Indeed La Fabril, the only company that produced biodiesel during 2005–06, stopped production in 2007 because profitability was not guaranteed (González-Artigas, pers. comm.).

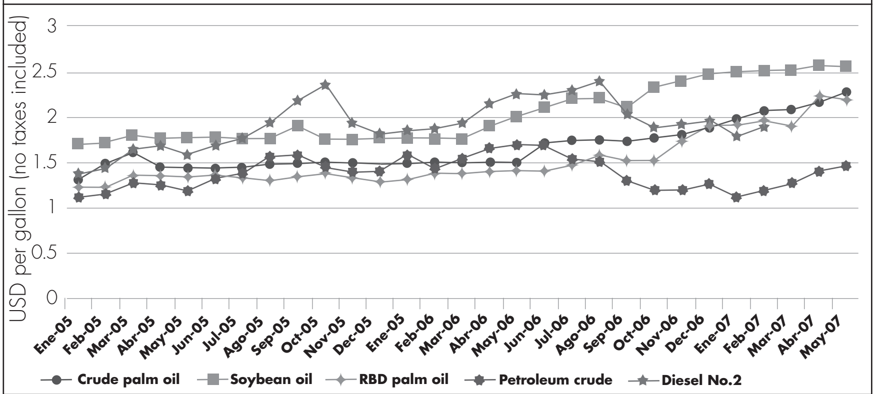
Biodiesel production clearly presents risks in terms of profitability and economic stability for Ecuadorian palm oil producers that engage in this alternative business. The economic risk is even greater where there is a lack of available and secured markets for biodiesel. These facts impose important considerations for the palm oil sector in this country.

4.1.4 Competitiveness

The competitiveness (and profitability) of the biodiesel business is directly related to capital and production costs, as well as the final product prices. Capital costs for biodiesel production are within a normal range of industrial plant prices, and the final production costs depend on the scale of production. Ultimately what matters to the producer is the relation between the production costs and the final prices, a relation that in the Ecuadorian context has not proved to date to be the most beneficial.

About 75 per cent of the production costs correspond to vegetable oil. In recent months, palm oil prices have increased due to rising global demand both for food and fuel. However, petroleum oil prices, particularly diesel prices, have actually decreased

Figure 7: Vegetable oil versus petroleum versus Diesel No.2 prices



Source: Percival (2007)

since mid-2006 (see Figure 7), which means biodiesel production under these circumstances is not competitive.

4.1.5 Employment

The palm oil sector currently creates 90,000 direct and 50,000 indirect jobs. This means one direct job for every 2.3 cultivated hectares and one indirect job for every 4.14 hectares cultivated (calculation based on ANCUPA statistics, Vargas, pers. comm.). Direct jobs involve employment in agriculture and the industry, including the different industrial levels of oil extraction and processing products. Indirect jobs include, amongst others: provision of materials (such as fertilisers), transportation, and machinery rental. The biodiesel industrial process has the same labour requirements as other palm oil processed products (Vargas, pers. comm.). According to La Fabril, an additional 50,000 palm oil hectares for biodiesel production would create approximately 22,000 direct jobs and 12,000 indirect jobs (see Box 2).

It is expected that the national bioethanol programme would create 200,000 direct jobs, as it would be necessary to cultivate 50,000 additional hectares of sugarcane and four workers are needed for each hectare.[27]

Although this sector creates a relatively lower number of jobs in comparison to other exporting sectors (e.g., bananas and flowers), other social considerations indicate a greater contribution of the industry to socio-economic development. These include equal employment opportunities for communities from different ethnic backgrounds and, in some areas, a reduced pressure on forestry resources that are exploited by populations lacking other economic alternatives. Various palm-producing companies develop social management plans that aim to provide an economic alternative to the population within

27. Statistic from interview with Victor Camacho, representative of the Ministry of Agriculture and member of the Biofuels Programme Technical Committee.

Box 2: Projection of impacts on employment and livelihoods

La Fabril's has 1,395 direct industrial employees, 543 of whom are located at the general headquarters in Manta and 230 at their operations in Guayaquil. Out of these, 50 workers were involved in biodiesel operations, which accounts for 3.6 per cent of total industrial direct employment. In January 2006 the operation started with seven employees working at headquarters and ended in December with 38, while the Guayaquil plant started with 15 and finished the year with 22. However, as previously mentioned, in 2007 there was no biodiesel production.

La Fabril is developing a project to forge partnerships with small-scale rural producers. To partner La Fabril, these producers will need to be the legal owners of, on average, 20 hectares of land. The company will encourage, and perhaps assist, small-scale producers to legalise their land ownership and then incorporate them into the project. Small-scale producers would supply La Fabril with palm fruits, from which the company would extract and process the biodiesel. The cultivation of 20 hectares would generate profits of approximately US$20,000 per year and would give the average family of four workers a monthly income each of around US$500 per month (González-Artigas, pers. comm.). The La Fabril project, financed with a loan from a multilateral financial institution, would provide producers with technical support.

their area of intervention (and who mainly depend on timber activities) – either by creating employment or by training them in micro-business generation (Albán *et al.* 2006).

4.2 Social impacts

Traditionally, African palm production in Ecuador has been linked with significant social impacts. Key negative impacts are summarised in Box 3.

A main worry amongst NGOs was that new palm oil plantations would be established on primary native forest. However, the environmental authority in Ecuador has created a system of environmental licences, which are granted only to companies that follow legal environmental norms and can present environmental impact studies and mitigation plans. Despite such processes, the level of acceptance of this activity is not yet entirely positive. There is still a strong feeling that the palm oil sector could cause negative social and environmental impacts.

Box 3: Key social and environmental impacts associated with palm oil cultivation

1. Land concentration: reducing (or removal of) indigenous lands in the Amazon, and Afro-Ecuadorian lands at the coast.
2. Farmers' migration to towns, cities, and forest areas that had not previously been impacted including territories of Afro-Ecuadorian and indigenous communities, thus causing social conflict.
3. Loss of forest leading to a shortage of construction materials, the disappearance of long-established harvesting and hunting activities, and the loss of traditional medicines and agricultural techniques.
4. Reduction of biodiversity when primary native forests are utilised.
5. Other impacts include increased land prices; market dependence; an increased need for money, capital and technology dependence; and advance payments and indebting processes.

Consequently, some enterprises have turned to a more comprehensive social policy, defining strategic activities to collaborate with nearby communities, and working to avoid negative social problems. Some companies have decided to implement social programmes as part of a corporate strategy. For example the partnership plan between La Fabril and small-scale producers involves technical assistance; helping small-scale farmers to legalise land ownership; assisting them with the processing of credit lines; regulating incorporation of small-scale producers' lands; and respecting limitations based on relevant environmental protection laws (González-Artigas, pers. comm.). La Fabril is also promoting the cultivation of other crops among small-scale producers in order to reduce their dependence on only one product. La Fabril itself has implemented this policy, growing several crops and generating different products to avoid being exposed to such vulnerability (González-Artigas, pers. comm.). However, this vision of corporate social responsibility is not yet widespread among palm oil producers.

Programmes covering areas such as education and public health are also expected to be promoted, not only through palm oil companies but also through tax resources that the palm oil sector generates. Various companies are already implementing information campaigns about their operations in rural sectors.

4.2.1 Labour standards: rural livelihoods and workers' health

The salary of palm oil workers is regulated by law. The National Commission on Salaries establishes the wage increase for agrarian workers each year. Due to migration – which has removed more than 500,000 workers from the agricultural workforce in the last five years – agrarian workers now constitute a scarce human resource and are being paid more than before as a result.

Nevertheless, living conditions in palm oil cultivated areas still need to be improved. Most plantations are located in rural areas with conditions below the national average, according to social indicators from the *Social Indicators Integrated System of Ecuador* (2006). In that sense, the above-mentioned plan of La Fabril's to partner small-scale producers would have a positive impact on livelihoods.

A key concern, however, relates to the impacts on farmers, workers and their families arising from the use of agrochemicals – both through direct contact or indirectly through ingestion of polluted water. In 1998, Fundación Natura reported that 58 per cent of agriculture workers from the palm oil plantations exhibited hepatic illness and skin diseases of varying degrees of severity, due to exposure to pesticides, carbonates, and phosphoric-organic materials (Albán *et al.* 2006). These impacts are still occurring, although companies are trying to align their processes to appropriate usage of agrochemicals and their frequency has declined, especially in recent years.

4.2.2 Food security

Palm oil production does not represent a threat to food security in Ecuador in straightforward nutritional terms. This is because the palm oil domestic supply in Ecuador not only meet national demand but, in fact, produces a large surplus, which is used for industrial manufacturing of non-food products such as soaps and detergents. Nevertheless, there are two aspects in which biofuel production may threaten food security: through its impacts on palm oil prices and on land use.

In terms of land use, food security concerns may arise if land for palm oil cultivation was extended over areas designated for food crops. In Ecuador some palm oil hectares are being cultivated on lands previously utilised for agriculture that had become less profitable (e.g., banana, soya bean, rice and corn). Research carried out by La Fabril indicated that palm oil plantations would be three times more profitable than soya and twice as profitable as corn (González-Artigas pers. comm.). A key issue therefore is finding the right balance between land used for food purposes and those for fuel uses. There are no studies currently available on this, nor is there any existing legal framework that could protect and differentiate those lands that should be kept for food crops and those where new palm oil plantations for biodiesel purposes could be cultivated without creating a threat to food security.

4.3 Environmental impacts

During the last decade, there has been increasing environmental institutional development in Ecuador, including the creation of various bodies and a legal framework, and there are now several regulating and planning instruments in force. However, in a nation that only regained democracy in 1979, the environment it is not always considered a national priority and there is a lack of an adequate budget to strengthen environmental control and monitoring. Consequently, even though Ecuador's environmental policy landscape has experienced significant advances in the last few years; it still has loopholes – especially in the implementation of monitoring and control systems. It also lacks an adequate national framework to guide discussion and integration of all production activities in order to reach consensus in setting environmental goals.

4.3.1 Land use and forests

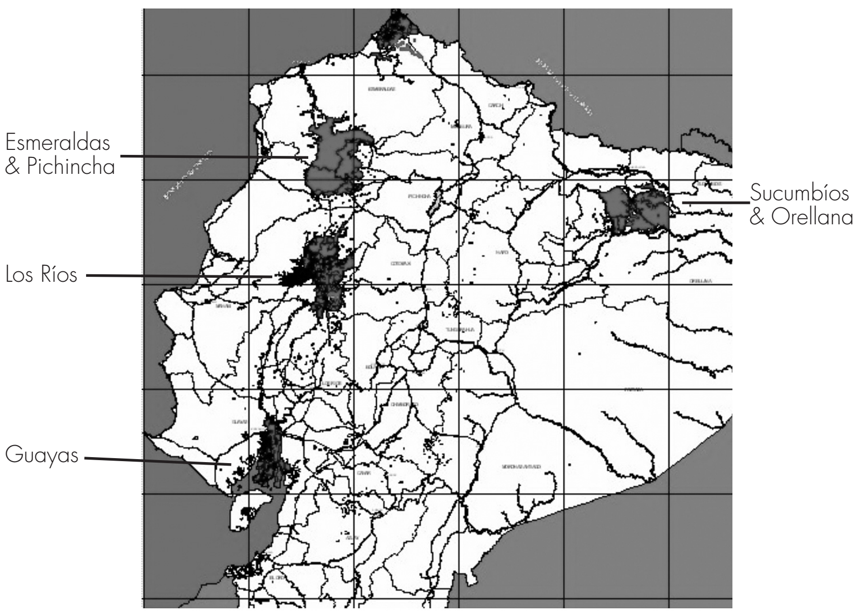
Currently, there are 207,000 hectares of palm oil cultivation in Ecuador (see Figure 8), located in the provinces of Esmeraldas (39 per cent), Pichincha (16 per cent), Los Rios (15 per cent), Sucumbios (5 per cent), Orellana (2 per cent), Guayas (2 per cent), and others (21 per cent) (statistics taken from the National Agriculture Census 2005).

Deforestation rates fluctuated between 0.5–2.4 per cent during 1980–1990, with an average of 1.5 per cent during 1991–2000. The deforestation rate for tropical forests for the latter period was 1.5 per cent. Ecuador currently ranks as the country with the ninth highest deforestation rate in a context in which the 10 countries with the highest deforestation rates account for 50 per cent of annual global deforestation (all statistics, Sánchez 2006).

Although there is no formal data on deforestation levels caused by the palm oil sector in Ecuador, it has been identified as one of the causes of deforestation in addition to the expansion of the agricultural frontier, the colonisation processes, and the increase of large-scale productive activities (especially oil and mines, and the cultivation of shrimp, bananas and flowers). Primary forest deforestation due to palm oil plantations has mainly occurred in the provinces of Pichincha and Esmeraldas, in an area known as Santo Domingo de los Colorados; in the provinces of Sucumbíos and Orellana; in the Amazon region; and in a few other areas in Guayas. These are tropical areas where climate and soil are favourable for palm plantations, and therefore their forests are the most vulnerable to deforestation.

Projections indicate that areas cultivated with African palm will reach 240,000 hectares by 2009 (Vargas, pers. comm.). In view of the increase in demand for palm oil biodiesel, ANCUPA is asking the Ministry of Agriculture to conduct studies to determine potential zones where African palm could be cultivated (Vargas, pers. comm.). La Fabril predicts an expansion of oil palm cultivation of several thousand hectares for its biodiesel project, although it prefers to keep the exact number of hectares required off the record. The company's new plantations would be located in the provinces of Guayas, Los Rios and El Oro, because these are less environmentally sensitive than Esmeraldas or the Amazon (González-Artigas, pers. comm.). On the other hand, ANCUPA has not

Figure 8: Main palm oil cultivation areas (2005)



Source: graph collated by ANCUPA (2006)

ruled out the possibility for future plantations in Esmeraldas[28] and the Amazon Basin, where a large number of palm oil plantations already exist (Vargas, pers. comm.).

In agronomic terms, Ecuador has 2.5 million hectares of land favourable for palm oil cultivation, including some previously used for agriculture. However, 1 million of these hectares comprise primary forests and palm cultivation in these areas is banned by environmental law. For new companies to engage in palm oil production, they must present an environmental impact study and obtain an environmental licence, which – among other requirements – specifies that primary forests must be conserved. However, as discussed above, the institutionalisation and implementation of environmental laws is still incipient, especially regarding compliance and monitoring activities. Most of the palm oil producers that are already operating do not have such a licence.[29] To combat this problem, ANCUPA has created a new department to provide technical support for the environmentally friendly operations of members.

4.3.2 Environmental impacts on air, water, soils, geomorphology, and terrestrial and aquatic ecosystems[30]

These include:

- Air: air quality is affected by various stages of palm oil production including: opening up areas and cutting down existing vegetation; chemical treatments necessary for oil palm cultivation; and the polluting emissions that are produced by machinery, vehicles and (most notably) that are emitted from chimneys during the processing of crude oil.
- Water: some of the main impacts include modification of the natural drainage systems, with important effects on fauna and vegetation; pollution due to the application of chemical products; water quality deterioration because of industrial processes during crude oil extraction; and the pollution of groundwater.
- Soils: the establishment of new cultivation plots has the largest effect on soil, especially where there is a replacement of primary forests. Monocultivation is also a biodiversity concern as it consumes nutrients and leaves a non-fertile soil for other productive alternatives. The removal of branches through mechanical processes causes land compacting. During the industrial phase, key concerns include soil pollution due to spills of fuels and lubricants, and the disposal of solid wastes.
- Geomorphology: impacts include spillages especially due to drainage construction, the seriousness of which depends on the extent of the drains that are built. Other effects result from changes in the landscape, generally caused by the construction of buildings.
- Terrestrial ecosystems: negative effects are caused when cultivation takes place on lands that have not been previously used for agriculture. Populations of insects, reptiles, birds and mammals, and plants such as gramiceas and herbaceas, are vulnerable.

28. Esmeraldas is located in the northwest of Ecuador and is part of the Chocó Manabí ecosystem, a very environmentally sensitive and pristine area.
29. Interview with Mateo Ponce from the Environmental Department at ANCUPA.
30. This section is largely drawn from Albán *et al*. (2006).

- **Aquatic ecosystems**: chemical product effluents can have diverse negative effects depending on the location of the projects.

4.3.3 Greenhouse gas (GHG) emissions, the Clean Development Mechanism (CDM) and carbon sequestration

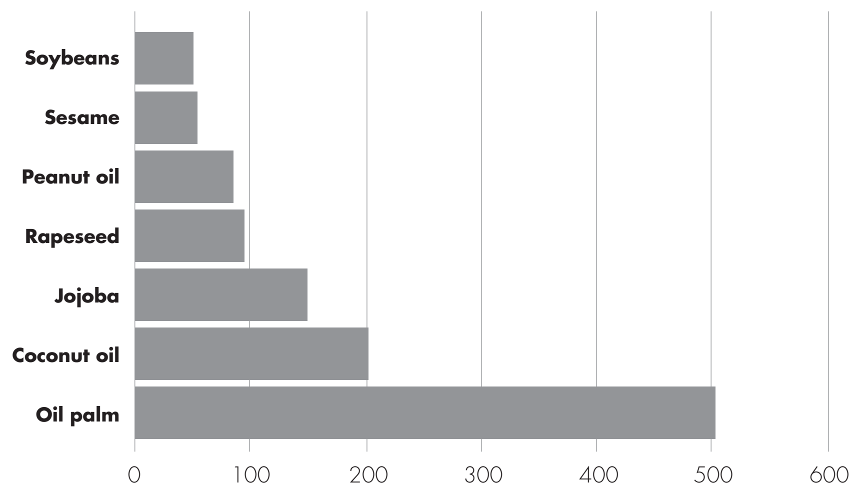
Greenhouse gas (GHG) emissions

The impacts of biodiesel production on GHG emissions are directly related to land-use impacts. As Figure 9 shows, compared to other feedstocks African palm is one of the most efficient crops for biodiesel production in terms of yield (per litre of biodiesel production) and therefore would have a lesser overall impact on the cultivation of natural or agricultural areas compared to other types of feedstocks.

However, in the GHG emissions equation, environmental studies show that African palm carbon dioxide emissions are not only a result of the nocturnal plant respiration process, but also of petroleum-based pesticides, herbicides, and fertilisers used for cultivation. Indeed, in addition to carbon dioxide considerations, an analysis of palm oil nitrous oxide emissions during the plant's lifecycle and production processes is also required. Nitrous oxide is another greenhouse gas with a significant impact on the environment.

To date, there are no specific studies in Ecuador or the Andean region on palm oil biodiesel GHG emissions throughout the production and distributions stages. Neither La Fabril in Ecuador nor another palm oil company in Columbia have conducted such studies. Nevertheless, data obtained through secondary sources by these companies advo-

Figure 9: Biodiesel yield (gallons per acre) of various crops



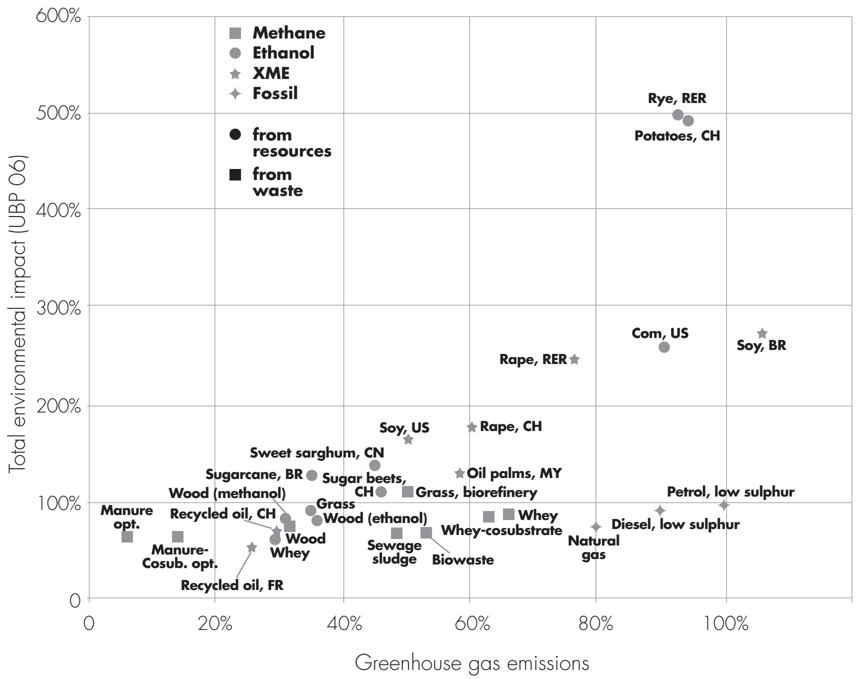
Source: Johnson and Heinen (2007)

cate the reduction of general biodiesel GHG emissions in relation to petroleum diesel, especially of nitrous oxide, formaldehyde, and acetaldehyde. The expected reduction of nitrous oxide is between 15–20 per cent (Bernal 2001).

On the other hand, the Swiss Federal Institute for Material Testing and Research (EMPA) carried out a GHG emissions and overall environmental assessment for different biofuels, comparing them with the impacts of petrol fuels. The following figure shows this analysis, in which: 'the green (shaded) area means a particular fuel has both lower greenhouse emissions and a lower overall environmental impact than petrol' (Doornbosch and Steenblik 2007).

According to this figure, palm oil biodiesel would not have a better overall environmental and GHG emissions performance than diesel, but it is worth noting that the palm oil biodiesel sample used for this analysis was from Malaysia. Nevertheless, the results for Malaysian palm oil biodiesel are somewhat better than the scores for US soya bean oil and Chinese rapeseed oil, and much better than RER[31] rapeseed and Brazilian soya bean oils.

Figure 10: Greenhouse emissions related to fossil alternatives and overall environmental impact assessment



Source: Zah *et al.* cited in Doornbosch and Steenblick (2007)

31. Ecoinvent country code for Europe, Swiss Federal Institute for Material Testing and Research (EMPA).

Clean Development Mechanism (CDM) projects

The Clean Development Mechanism (CDM) under the Kyoto Protocol is an international instrument to combat climate change. Ecuador signed and ratified the Kyoto Protocol and created CORDELIM in 2001 (the National Office for the Promotion of the CDM in Ecuador). This institution is being financed and supported by some multilateral agencies' programmes and is currently working under UNDP support. Since November 2006, Ecuador has increased the number of projects registered with the CDM Board at the United Nations Framework Convention on Climate Change. The current projects cover areas such as hydroelectricity, biomass energy generation, better practices for animal waste, and other activities that are currently accessing carbon certificates markets worldwide and helping to mitigate the greenhouse effect.

But at present no biofuel projects have been registered at CORDELIM, and in the specific case of palm oil biodiesel production it is not clear whether they would be accepted as CDM projects, nor is it clear what the requirements would be. Evidently, much progress is still needed in order to create a legal framework that establishes guidelines and fosters effective activities for coping with the effects of climate change.

A World Wildlife Fund report (WWF 2005) suggests that palm oil companies could buy the ecosystem services of artificial carbon sequestration through a voluntary commitment to contribute to issues of climate change – which is an option that is currently under analysis, especially in rich countries. Artificial carbon sequestration uses technology for creating carbon sinks by capturing carbon dioxide from industrial processes, such as power plants, and transporting it to appropriate locations, injecting it into aquifers or fossil fuel deposits underground.

Although the possibility for Ecuadorian companies to participate in such new alternatives is low due to economic and technological constraints, there are international companies that have already come forward to offer such services to palm oil producers in Ecuador.[32] Moreover, ANCUPA is already analysing new alternatives for carbon dioxide sequestration from palm oil extractors, such as utilising oxidation pools and managing effluents instead of releasing them into the atmosphere (Vargas, pers. comm.). Another – potentially more affordable – initiative for managing the carbon emissions generated from palm oil industries in Ecuador is based on the waste and palm trunks being utilised to produce plywood. This would be a way to create lasting products for use in the building industry, thus 'locking in' the carbon that would otherwise be emitted by the palm trunks decaying in the ground. Moreover, this would also reduce the need for plywood production from forest-derived trees. In Malaysia, the world's biggest palm oil producer, the Malaysian Palm Oil Board (the body responsible for governing the palm oil industry in Malaysia) and the government agency FELDA (the Federal Land Development Authority) together with companies such as Business Esprit Sdn Bhd, are at the forefront of this initiative.

Palm oil producers in Ecuador are already looking at these options (Ponce, pers.

32. *Ibid*

comm.[33]) as it is probable that artificial carbon sequestration and waste management during biofuel production could be considered as CDM projects. However, it is important to bear in mind that in Ecuador these ecologically friendly practices would be carried out by large-scale industrial producers and, to a lesser extent, by medium-scale producers. For small-scale producers, who represent more than 60 per cent of palm oil producers in Ecuador, such goals would be more difficult to attain – although not impossible, as ANCUPA (or other associations through corporations or cooperatives) could foster ecologically friendly practices, for example through ecosystem services.

4.3.4 Other air emissions associated with biodiesel

The Biofuels Programme Technical Committee analysed samples of different mixes of biodiesel with regular Diesel No.2. Although there are no official data yet available, preliminary results show that the mixtures provide a major reduction of sulphur content and other contaminants in relation to regular diesel. In Ecuador, Diesel No.2 has a content of 5,000 to 6,000 ppm sulphur, while the diesel premium's sulphur content is approximately 500 ppm.[34] The global aim is to reduce sulphur content in diesel to zero ppm. This is realistic in fuel of 100 per cent biodiesel (González, pers. comm.). However, the use of 100 per cent biodiesel is not currently feasible due to a lack of production availability and technological restrictions. Vehicle engines would need to be modified and the production of biofuel would have to increase considerably.

5. Conclusions and recommendations

5.1 General conclusions

Ecuador's natural conditions and geographical location are ideal for the development of palm oil plantations. Today price volatility, profitability uncertainties, and the absence of a regulatory system and a national policy framework to guide the sector are key issues determining the feasibility of biodiesel production and exports. Currently, palm oil prices are more reliable than those for new industrial biodiesel, the price of which is tied to that of fossil fuels and other oil products.

From a trade point of view, subsidies and other governmental support measures from rich countries do not represent a serious threat to Ecuador's biodiesel exports so far. Nonetheless, the challenge for Ecuador will be to find new markets and to comply with technical and environmental standards and regulations. A key challenge that biodiesel trade faces is that Ecuador has yet not defined a HS classification. One option to be evaluated would be a separate HS classification.

33. Ponce, Mateo. Environmental Department at ANCUPA. Interviewed: December 2006.

34. In places such as Europe, diesel premium is of much better quality, reaching as low as 30–50 ppm of sulphur content.

Regarding environmental concerns, palm oil production that has taken place in ecologically sensitive areas has historically been the cause of distrust. Currently, however, it is not clear whether palm oil-based biodiesel future production will take place in sensitive areas.

Along with environmental concerns, social and labour issues also raise questions. For example, to what extent will new plantations and investment benefit rural communities close to plantations? There is therefore a need, on the one hand, to promote responsible environmental and social standards amongst companies operating in the sector and on the other to generate the adequate legal framework for biofuels covering the whole lifecycle of biodiesel production. In that sense, technical and environmental standards are to become key requirements to proving the sustainability of biodiesel, especially in international markets.

However, the capacity of public institutions in Ecuador to respond adequately to the expansion of the biodiesel market is still deficient. Thus the strengthening and building of national capacities on standards and certification, in tandem with the development of the biodiesel industry, will become a key element for a successful development of an export-oriented industry. International political will to curb carbon emissions might be brought into play through support for such sustainability efforts, especially in trade, technological development, and consumption and trade guidelines.

5.2 Recommendations

In order to overcome many of the above-mentioned challenges it is recommended:

1. National and international market and prices trends and prospects are analysed, and Ecuador's potential to supply biodiesel in a sustainable way is evaluated.
2. The long-term implications of government policies to support biodiesel development are analysed, including impacts on government revenues and assurance that the overall economic, social and environmental benefits of these policies outweigh their costs. The distribution of state resources in Ecuador, in particular, is a sensitive issue that warrants careful appraisal and evaluation.
3. Biofuels international standards and possible trade barriers are assessed.
4. Local capacities on standards and certification are created.
5. Parameters and geographical determinations to define territories for oil palm cultivation extension are created, taking into consideration the location of natural forests, agricultural frontier extension, food security, and other relevant socio-economic and environmental issues.
6. More rigorous enforcement of oil palm plantation management is promoted.
7. Palm oil producers are encouraged to join international processes such as the Roundtable on Sustainable Palm Oil (RSPO) and the recently launched Round Table on Sustainable Biofuels (RSB).
8. Research on alternatives for carbon sequestration that could be implemented by palm oil and biodiesel producers is promoted.

9. Organised and fair participation of small- and large-scale producers in an efficient way is promoted in order to attain sustainability goals without undermining positive environmental or socio-economic impacts. The Brazilian Social Seal is an option to be carefully analysed for the Ecuadorian context.
10. Analysis of the impacts of using alternative feedstocks for biodiesel production that do not directly compete with food production is promoted. (e.g. *Jatropha curcas* and castor oil).

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Chapter 6

Conclusions and recommendations

6.1 Review of case study findings

The case studies in this book have looked at the potential and pitfalls in pursuing the expansion of biofuels production. The countries concerned, Pakistan, Costa Rica, South Africa and Ecuador, all have significant production of crops that could be (and in some cases are) processed into biofuels, but as yet there has been no major development of the biofuel sector. All the case studies conclude that biofuel development could be a win-win with potential to meet a number of policy goals both economic and environmental – and in some cases social. Sustainable development challenges are acknowledged, such as finding suitable land that does not compete with food production, but these are not considered insurmountable. Nevertheless, much would depend on the rate of expansion and the policy framework put in place.

6.1.1 Factors affecting biofuels development

Even though in the past exports have been an important driver of biofuel production in all four countries – for example, in Costa Rica and Pakistan, which have benefited from preferential market access to the USA and the European Union – it is fossil fuel import substitution that is currently the key driver behind market development. Three of the countries have pilot projects to try out mixing biofuel with oil-based petrol and diesel, and all four have plans for this or have set objectives for biofuels concentration in the fuel mix as part of their biofuels strategy. This reflects the high dependence of these four countries on oil imports even though three are themselves producers of crude oil. Pakistan, for example, imports 85 per cent of its total oil consumption, while for South Africa, fuel imports are its most significant trade item. Fossil fuel import substitution brings opportunities in terms of enhanced energy security through energy matrix diversification and foreign currency savings. This, coupled to the fact that the oil market is one of the most distorted and volatile markets in the world – with a few producing/exporting countries arranged through a sub optimal structure (a global cartel) – means that local production of biofuels allows foreign currency savings ameliorating the trade balance. For South Africa, it is estimated that meeting a target of a blend 8 per cent of bioethanol in petrol (E8) and a 2 per cent blend of biodiesel in diesel (B2) would reduce the current account deficit by US$0.5 billion per year.

While providing a strong motivation for import substitution, the volatility of the oil market is also a complicating factor for the development of the biofuels sector. Changes in crude oil prices affect the price that biofuels can fetch, but they also affect the costs of production through their impact on the price of fertilisers and other agrochemical inputs. In such circumstances, investment in biofuels will be risky. In Ecuador, even though conditions are ideal for palm oil, the private sector has shown little interest in biodiesel development because of the unpredictability of returns.

Subsidies to oil-derived energy to meet domestic objectives, as in the case of Ecuador and South Africa, represent further competition challenges for the domestic use of biofuels. This highlights the importance of national policies to create a level playing field thus allowing biofuels to compete. None of the four countries has moved very far with this. In Ecuador, even though a Biofuels Programme Advisory Council has been set up, the lack of a national policy framework is considered by the case study authors to have hampered biodiesel development. In Pakistan, industrial alcohol is taxed and no subsidies are available for bioethanol. The dominance of the fossil fuel oil energy industry and the ambiguous status of biofuel as an agricultural product competing with extractives may have something to do with this. In Pakistan, the biofuel mandate has been given to the Ministry of Petroleum, which has been directed to develop a long-term fuel bioethanol conversion plan. While this seems commendable from the point of view of policy coherence, the case study authors express concern that the powerful oil lobby will stall progress. In Ecuador, in contrast, development of the sector has been led by the palm oil industry/sector and the state-owned oil company has not got involved at all. This isolation from the main fuel producer may have hampered the introduction of a supportive policy environment for biofuels.

The limited experience with export of biofuels in these countries shows the marked effect that trade preferences have on trade and production patterns and the potential dangers of relying too heavily on such preferences. Pakistan was a large exporter of industrial alcohol to the EU until it was removed from the General System of Preferences (GSP). Costa Rica's exports have been driven by US preferences granted under the Caribbean Basin Initiative (CBI), but this has not stimulated local production of feedstocks but rather the import of alcohol from the EU for further processing. The other two countries do not currently enjoy trade preferences and different responses to this situation are suggested. The South Africa case study argues that the country might do better to invest in biofuel development in neighbouring Southern African Development Community (SADC) countries that do have a favourable position in trade agreements. The Ecuador case study suggests that the way to access trade preferences in the future will be through strict adherence to sustainability standards. The authors see access to export markets as a more effective leverage point for good practice than domestic policy. In contrast, the South Africa case study, based on its sugar exporting experience, expresses the view that rapid expansion in biofuels driven by exports could make it hard for the government to regulate the industry and prevent undesirable impacts.

6.1.2 Potential positive impacts of biofuels development

In all four countries, smallholders play an important role in the production of the feedstocks considered in the studies. In Pakistan, 76 per cent of sugarcane farmers hold less than 5 hectares and 35 per cent less than 2 hectares. In Costa Rica, 90 per cent of all sugarcane production is from farms with less than 7 hectares. Similarly in Ecuador, 63 per cent of palm oil producers are small-scale farmers with less than 20 hectares. Even in South Africa, where larger farms are more common, there is a successful small-scale outgrowers scheme with land parcels averaging 8 hectares and supplying 11 per cent of the country's sugarcane. This suggests that with the right supportive policies, biofuel development could bring benefits to smaller farmers. But in Costa Rica and South Africa, the case studies suggest that the benefits for farmers are more likely to be in the form of diversification rather than increases in returns.

The effect on employment is another important potential factor in biofuel expansion. The case studies bring some realism to the analysis, questioning some of the optimistically high estimates for job creation. Official estimates of 55,000 created jobs in South Africa's national biofuel strategy are considered improbable because of the high degree of mechanisation. Similarly in Pakistan it is pointed out that the sugar sector currently has over-employment while processing of alcohol is highly capital intensive. In Ecuador, the palm oil sector creates fewer jobs than other products such as bananas and flowers. Because Costa Rica has a rural labour shortage, it will be migrant workers from Nicaragua that will be affected. What is crucial, though, is where jobs are created as this affects the overall social benefit. In South Africa, areas where employment may increase or stabilise as a result of biofuels development are also areas subject to increasing unemployment and poverty.

Other positive impacts identified in the case studies are principally environmental. Urban air quality will improve with inclusion of biofuels in the fuel mix, with reductions in lead in Pakistan and sulphur in Ecuador. In South Africa, there are potential health and safety benefits for low-income users if bioethanol is marketed in gel form for lighting and cooking. Greenhouse gas (GHG) emission reductions from the use of biofuels are likely but small and depend on how well emissions in feedstock cultivation and processing are controlled. In Pakistan it is noted that pre-harvest burning in sugarcane areas would need to be restricted. In South Africa the emission reductions with the government's 2 per cent target for biofuels in the fuel mix will be less than the annual growth in emissions. Other options such as replacing the fuel that is currently made from coal would deliver significantly greater emission reductions. While revenue from carbon projects is identified by the case studies as a possibility, it appears that only for South Africa has there been any analysis of the potential. This case study finds that the carbon revenues would add very little, just US$0.015 per litre for sugarcane bioethanol and US$0.002 per litre for maize-based biofuels. This, coupled with the cumbersome nature of CDM procedures, means that carbon revenues are unlikely to be an important source of revenue for the biofuel sector in these countries.

6.1.3 Potential negative impacts

The main potentially negative impacts examined in the case studies are the environmental and food security implications of expanding feedstock production. Costa Rica, for example, would need to expand its production area by 26.5 per cent in order to meet a 10 per cent blending target. The key issue is the type of land on which expansion takes place. There has been some effort to identify suitable land such as underused pastures and degraded areas – but the definition of such areas is contentious. Three of the countries have legislation that in theory would prevent expansion of biofuels in forest areas and other unsuitable areas, but enforcement is weak. In Ecuador, for example, palm oil producers are required to carry out an environmental impact assessment (EIA) and to apply for an environmental licence but very few do so. In South Africa there are already some worrying precedents as sugarcane has expanded rapidly on unsuitable land and in some areas yields are declining. Areas where sugarcane and maize are produced in South Africa are water-constrained, raising questions about the wisdom of expanding production further. It is noted that even though the country has the institutional and legislative architecture to ensure good environmental and social performance, this will be difficult to maintain if expansion is rapid. If production is for home consumption, the government will have various policy levers of supply contract conditions and licences. If production is for export, ensuring good practice will be harder.

As there is so little biofuel production at present in these countries, food security impacts arising from the diversion of food crop areas to production for fuel have not been evident so far. What little production there is has been using surplus production or by-products. The case studies' analyses of the potential implications for food security show how difficult (and contentious) these are to predict. Each country's situation is different and much depends on the extent and pace of biofuel expansion as well as how governments prepare for this situation.

In the case of Pakistan, there is ample scope for expansion based on existing production of molasses without extending the area dedicated to sugar cane. But if success in biofuel production from molasses led to further expansion based on extension of sugarcane cultivation, then food security could be a concern. In the case of Costa Rica, it is argued that it is possible to expand by developing biofuels in areas that are socially and economically depressed but this presupposes a strong government influence over the areas where expansion takes place. In Ecuador, there is evidence that palm oil, given its higher return, has been displacing food crops, so expansion driven by biofuel demand would raise concerns about food security. The Ecuadorian government has no legal framework to protect and differentiate lands for food crops. In South Africa, where the poorest spend as much as 62 per cent of their income on food, it is argued that expansion in biofuel production would be just one of a number of factors including oil price inflation that would drive increases in prices of food crops such as maize. Moreover, there is plenty of unutilised and underutilised land in South Africa that could accommodate biofuel feedstocks. But the greatest risk to food security is drought, and expansion of biofuels could exacerbate these effects. The case study author argues that the key to avoiding localised food security impacts is increasing agricultural productivity and that a highly regulated biofuel industry could be made to work in favour of the poor.

What emerges is that before embarking on any rapid expansion of biofuels these governments need to do more specific research on food security implications and how to prevent negative impacts.

6.2 The merits of biofuel expansion in the case study countries

While noting the possible negative effects, the case studies all conclude that biofuel development is worth exploring by their respective countries and has potential to meet a number of policy goals such as rural development. But all point to the need for public policy changes at the national level to promote development of the industry, principally by helping domestic production compete against imported oil products. Without this supportive framework at the national level, biofuel development is unlikely to take off. In addition, action from government and other stakeholders is necessary to ensure that the biofuel sector makes a positive contribution to sustainable development, with environmental and social safeguards to prevent food security problems and expansion in unsuitable areas.

The measures emphasised to promote biofuel development vary between the countries reflecting their different contexts and experiences. The South Africa case study proposes a stabilisation fund for biofuel producers to address the problems posed by volatile oil prices. In the light of the significant consumer opposition encountered with its pilot project, the Costa Rica case study stresses the importance of informing consumers about the benefits and performance of blending biofuel with petrol and diesel. The lesson here is that how pilot projects for such blends are introduced and consumer relations handled may be as important, if not more important, than any economic benefits from import substitution. The Pakistan case study recommends a number of measures aimed at aligning incentives for domestic biofuel production. These include removing domestic taxes on alcohol, imposing a ceiling on molasses exports and allowing duty free import of machinery to convert alcohol to bioethanol. It also recommends that the Ministry of Industries should take on the mandate for bioethanol development rather than the Petroleum Ministry. The Ecuador case study stresses the need for subsidies to biofuels to match those currently given to other fuels.

6.3 Environmental and social safeguards

All the case studies, particularly South Africa's, argue that the state should play an active role in ensuring that the industry has good environmental and social performance. For Costa Rica, it is argued that the state needs to provide a normative framework. For Ecuador the need for parameters for land-use planning and determination of appropriate land for cultivation of biofuel feedstocks is stressed. A similar recommendation is made for South Africa with the added emphasis on the policy levers open to the government to influence environmental and social performance in the biofuel industry. The government can identify suitable locations for expanding production and direct public sector support to these areas. It can also ensure compliance with black economic empowerment and employment legislation before issuing supply contracts. The authors of the Ecuador case study take more of an outward-looking focus, recognising that safeguard policy instruments exist and the problem is promoting their enforcement. They therefore stress actions that will reinforce existing policies. These include encouraging producers to take part in international processes on best practice in biofuel and palm oil productions, building capacity on standards, and certification and examining the possibility of introducing a certification and labelling scheme along the lines of the Social Seal in Brazil.

6.4 Lessons for other countries

In spite of the cooling in enthusiasm for biofuels, demand in rich countries is still likely to increase as many biofuel blending targets remain in place and increasing attention is being given to their potential in the aviation sector (IEA 2008). This should represent a significant opportunity for low- and middle-income countries as these are generally the lowest cost producers, with a production potential that exceeds their national demand.

But given the unfavourable treatment of biofuels in the World Trade Organization (WTO) framework, the prevalence of domestic support policies for feedstock production in rich countries, and the threat of increased protectionism in the current economic crisis, it will be difficult for low- and middle-income countries to capitalise on this comparative advantage in the short term. It would not be wise for them to make exports the main thrust of a strategy to expand the biofuel sector, particularly for small and medium-sized countries like the ones reviewed here. However, developing a biofuel sector aimed initially at supplying the national market efficiently, but with attention to the whole supply chain from feedstock cultivation to processing and distribution, can prepare the way for entry into the export market in the longer term. Alignment with international technical and sustainability standards will facilitate this.

While the economic case for biofuels as a means of import substitution may seem very clear, expansion of the sector will not happen unless governments put in place a supportive policy framework that allows biofuels to compete with oil-derived products. This is particularly important where governments currently subsidise diesel and petrol to keep prices low for businesses and consumers. This will also enable governments to have some influence over how the industry develops and to ensure that adverse environmental and social impacts do not result.

Supportive policies to give biofuels the same treatment as oil-derived products are essential but not sufficient. There is a need to achieve coordination between the different government ministries involved – agriculture, energy, industry and finance. This may be one of the greatest challenges. In addition, developing a domestic biofuel industry to supply petrol and diesel blends requires consumer acceptance. Governments need to inform consumers about the benefits of these blends and address concerns about impact on performance and availability. The experience of Costa Rica's pilot project shows just how important this is.

Biofuels are just one of a number of options that countries need to pursue to diversify their energy supplies and reduce reliance on fossil fuels. They cannot be expected to solve all of a country's energy problems. Developing a biofuel sector will be a long and costly process and the benefits may only become apparent in the medium term.

While the actions of host country governments are critically important in developing a sustainable biofuel sector, other stakeholders have a role to play. The private sector needs to be willing to try out new crops, new measures to improve productivity and develop environmentally friendly practices, and new ways of organising production so that participation of small- and medium-scale producers can be promoted. Multi-stakeholder processes involving civil society as well as the private sector are important to develop sustainability standards that are appropriate to each country context.

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Biofuels, trade and sustainable development

The last five years have seen the emergence and growth of the biofuels sector and its growth into a global industry. Many countries, low-, middle-income and rich, have implemented ambitious targets and policies to promote significant biofuel industries. Yet this rapid growth in biofuels production has not been without controversy as concerns have been raised by a wide range of stakeholders about the environmental and social impacts of biofuel production and about the cost-effectiveness of some biofuels support policies. As a consequence, enthusiasm for biofuels amongst policymakers has waned, and some countries have drawn back from ambitious biofuels development. In the midst of this backlash against biofuels it is easy to conclude that they are high risk and that the best option is to avoid them altogether. But the reality is more complex. Generalisations must be avoided and each case should be examined on its merits, taking account of the site-specific factors. This book presents case studies from Pakistan, Costa Rica, South Africa and Ecuador which give a low- and middle-income country perspective on the potential for biofuels development. Each case study, prepared by experts from each of the four countries, examines the potential for developing the biofuels sector in the national context, explores the tradeoffs for economic development and the sustainable development implications.

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