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Specific Environmental Effects of Trade Liberalization: Sugar

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EXECUTIVE SUMMARY*

This paper is the second in a series that is examining whether trade liberalization resulting from the Doha Development Round, and from other narrower sets of negotiations, might have adverse environmental effects that could be ameliorated if governments correctly anticipate them. The sugar sector, like the oilseed sector addressed in IPC Issue Brief 16, is also strongly influenced by energy markets as expected price increases for fossil fuels stimulates interest in renewable fuels such as ethanol and biodiesel. The adverse environmental effects resulting from increased production of renewable fuels has been taken into account in the following analysis.

Sugar is among the most protected agricultural commodities, and almost all countries intervene in the sugar market in one way or another. Yet demand for sugar is comparatively inelastic. One would therefore expect trade liberalization to have large effects on the location of production but not to significantly change consumption patterns. While trade liberalization will generally reduce agricultural commodity output at the global level as production subsidies are constrained, it will boost output in some countries. Over the years, there have been a variety of econometric studies that have estimated the effects of varying degrees of liberalization, and these serve as a guide to the direction and scale of production impacts.

Sugar is produced from both sugar beets and sugarcane. In general, trade policy reform will result in contraction of sugar beet production in developed temperate zone countries with high current price support levels, and in expansion of sugarcane production in the most efficient tropical countries. Beets are grown in rotation with cereal and oilseed crops, and a shift in the mix will be largely neutral from an environmental perspective. Sugarcane is often, but not always, a monoculture and its environmental impacts can depend on what crops it replaces and the nature of any new land brought under cultivation.

Superimposed on these changes will be the effect of rising demand for fuel ethanol which will further stimulate expansion of sugarcane plantings. As in the oilseed sector, the impacts of biofuel developments are likely to be greater than those from sugar trade liberalization, and they may have pronounced environmental effects. There are procedures and technologies for government and industry to address many of these effects, and an advance indication of possible detrimental environmental impacts should prove helpful to government and private sector representatives tasked with addressing them. Advances in technology and development of certification programs that encourage sustainable sugar crop production could also contribute to more beneficial outcomes.

This paper examines three case studies where sugar output will grow if liberalization occurs: Brazil, Indonesia, and China. The first two are cane producers, and China produces both cane and beets. The environmental impacts of this expansion could be significant at both the agricultural stage and the industrial processing stage. They may include loss of biodiversity, air pollution from cane burning and factory emissions, solid waste from processing, and contamination of ground and surface water from erosion and by fertilizers and crop protection chemicals. The paper also look at Turkey as a case study where sugar output will contract.

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The matrix approach used in this paper to try to assess the environmental impacts of sugar trade liberalization and expected increase in demand for energy crops is not a fine-edged tool. Readers should understand it as a checklist of environmental considerations rather than an assessment of degree of impact. This makes it difficult to compare results for the few countries reviewed as case studies. Nevertheless, there is value in the common themes that emerge:

- **This will mostly be a sugarcane issue** because sugar beets generally have a higher cost of pro duction that limits their fuel ethanol potential, and trade liberalization will reduce subsidized produc tion of sugar beets in industrial countries.
- **Resource endowments are of critical importance** for assessing environmental outcomes. The availability of suitable land and an adequate water supply is the key to expansion of sustainable sugarcane production. Of the three cane countries discussed, Brazil is best endowed and China is least.
- **Enforcement of existing environmental laws and regulations is needed**; such action is more important than developing new environmental rules. Enforcement is weak in all three cane coun tries, and unless that changes, the environmental impacts of expanded sugarcane production could be worse than we have portrayed.
- **Technological advances could ameliorate some of the anticipated adverse environmental impacts**.
- **The net effect of biofuel production is uncertain**, considering the potential environmental conse quences analyzed in this paper. In other words, the trade-off of the net positive effect on air qual ity of substituting ethanol for petroleum transportation fuels, for the net negative effect of expanded crop production is an uncertain calculation.
- **The social pluses of increased employment probably more than offset any social negatives** from displacement of indigenous populations and a shift from diversified cropping to sugarcane monoculture.
- **Improved economic prospects in developing countries may lead to more environmental awareness** and increased public and private activity to safeguard the environment.

It will be important to monitor the shifting production patterns of sugar crops and their environmental impacts over the next few years. This is a task that both governmental and non-governmental organizations can share.

SECTION 1: INTRODUCTION

This paper is the second in a series assessing the sustainability of any agricultural production increases that result from trade liberalization achieved through a conclusion to the WTO Doha Development Round of negotiations on agriculture. An earlier IPC Issue Brief analyzed the environmental impacts one might expect in the oilseed sector due to the combination of trade liberalization and growing demand for biodiesel.[1] The purpose of this two-part series is to identify potentially adverse environmental impacts of trade liberalization so that relevant national governments can plan and implement efforts to ameliorate such effects.

Sugar is an interesting commodity to analyze in this context for two reasons. Sugar markets are among those most distorted by market access barriers and domestic subsidies, and therefore hold the potential for the greatest production, consumption, and trade changes resulting from a Doha Round agreement. As in the case of oilseeds, production of sugar crops is increasingly influenced by demand for biofuels linked to rising prices in energy markets.

Sugar is the world's primary caloric sweetener. World consumption was about 144 million metric tons in 2004/05. Starch-based sweeteners produced from crops like corn or wheat, e.g. crystalline dextrose and glucose or fructose syrups, are the next most important caloric sweeteners, but are a distant second with annual consumption estimated at only about twenty million tons on a dry basis, with half of that being in the United States.

Roughly three-quarters of world sugar needs are produced from sugarcane in tropical or sub-tropical climates, and the remaining quarter comes from sugar beets grown in the temperate zones of Europe, North America, and Asia. On average, beet sugar is more expensive to produce than cane sugar, with production for the most part confined to industrialized countries whose support policies and import barriers keep internal sugar prices at levels high enough to maintain a beet industry. Trade liberalization and related reductions in domestic support would be expected to reduce world area planted to sugar beets in those industrialized countries but further stimulate sugarcane plantings.

SECTION 2: ASSUMPTIONS

2.1 Assumptions on trade liberalization

This study focuses primarily on the agriculture negotiations in the Doha Development Round but also takes into account the growing number of bilateral and regional free trade agreements, as well as the reforms that the European Union has made in its sugar policies. In the Doha Round, WTO members are engaged in negotiations in three areas:

- Reduction of domestic supports linked to production;
- Elimination of export subsidies; and
- Increased market access.

While negotiations were suspended in mid-2006 and the timetable for resumption of talks is uncertain, progress has been made in a couple of areas and the Round at least remains alive. For purposes of this analysis, the paper assumes that a successful outcome would involve a 50 percent reduction in bound tariffs in the lowest band, increasing to 80 percent in the highest band, and amber box support reduction commitments of 50 percent for those in the lowest band, 60 percent for the United States and Japan, and

70 percent for the European Union. We also assume that fewer than 5 percent of tariff lines will be treated as sensitive, and that associated requirements for tariff rate quota (TRQ) expansion will still lead to sugar trade liberalization.

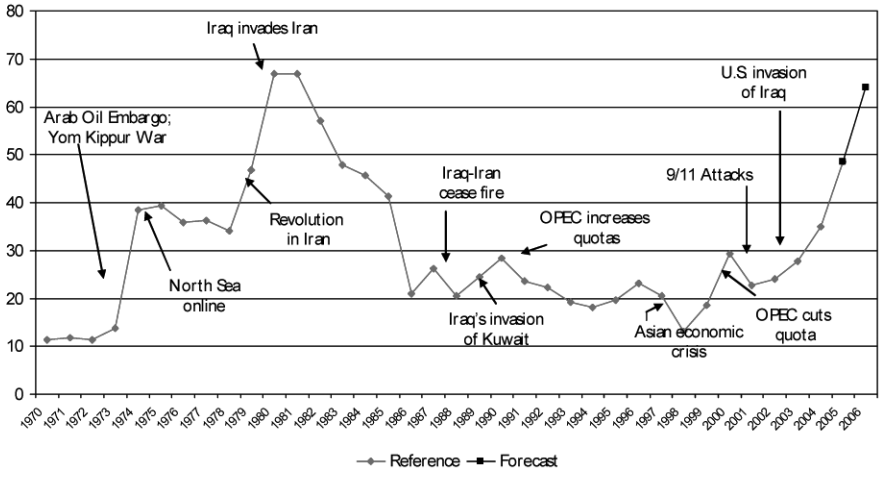
In the case of the blue box, we assume that it will include the US countercyclical payments and some EU payments, but would be capped at 2.5 percent of the value of production. Negotiators could agree to reduce the de minimis provision from 5 percent to 2.5 percent, and will likely require overall trade distorting support (the sum of amber box, blue box, and de minimis) to be reduced by 50-75 percent, depending on the band. Agreement in principle has already been reached on elimination of export subsidies by 2013 and on the need for disciplines on export credits and state trading enterprises, although much remains to be worked out.

2.2 Assumptions on energy markets

Worldwide enthusiasm over renewable fuels such as ethanol is associated with the sharp increase in petroleum and natural gas prices since 2003 (illustrated in Figure 1). This is expected to have significant impacts on production of grain and sugar crops in the short run, and on agricultural production and use in the longer term. Similar enthusiasm during prior energy price booms, has dissipated when prices returned to more normal levels. No one can easily predict the future course of world petroleum prices, but for purposes of this paper we have assumed that crude oil will average $65 per barrel in 2006 and will not average below $40 per barrel annually during the balance of the decade. That level provides a continuing but not extravagant incentive for expansion of production of fuel ethanol from sugar crops.

Figure 1

World oil prices (1970-2006), based on US refiner acquisition cost for imported crude oil (in 2003 $/barrel)



SECTION 3: THE WORLD SUGAR SECTOR

Sugar is a major constituent of world food and biomass supplies. As shown in Table 1, the production of sugarcane ranks second only to cereals despite a sharp disparity in area harvested. Sugar beets are the other major sugar crop but planted area has actually declined in recent decades as cane sugar has captured a growing share of the world market. Cane and beets account for about 2 percent of world crop area. For comparison, cereals account for 57 percent and oil crops for 21 percent. The recent trends in cane and beet area are illustrated in Figure 2.

Sugar is an important and generally inexpensive source of caloric energy in the world food supply. About 55-60 percent of world cereal production or 1,300 million tons is processed and consumed directly as food, with the remainder being fed to livestock and poultry or used for industrial purposes or seed. The protein meals from oil crops are also mostly fed to animals, so the oil component consumed by humans is roughly 100 million tons. Sugar's 146 million tons are thus of the same order of magnitude as vegetable oil but not as important as cereals.

The relative importance of beets and cane has changed in recent decades. During the 1960s, beet sugar accounted for 40-45 percent of world sugar consumption. That share has declined steadily for a number of reasons to about 25 percent currently. Productivity growth in terms of crop tonnage per hectare has been about the same for the two crops, as illustrated in Figure 3, so productivity was not a major factor behind the decline, and sugar recovery per ton of raw material has been increasing for both crops. Constraints associated with production or marketing quotas in the European Union and the United States contributed to some degree to beet's declining share of the market, as did the dissolution of the Soviet Union and its subsequent inability to maintain its comparatively inefficient beet production.

However, one major factor in beet acreage decline has been the fact that most of the growth in consumption over the last forty years has been in developing countries that have tropical or semi-tropical climates better suited to sugarcane than sugar beets. Local farmers expanded sugarcane production to meet that growing demand. A second major factor has been increased productivity in Brazil's cane sector, which has led to a rapid expansion in output in recent years. That expansion more than offset a precipitous decline in Cuba's sugar production after subsidies from the Soviet Union ended. Brazil and India together now account for almost 50 percent of land devoted to sugarcane worldwide. Australia, Pakistan, China, Mexico, and Thailand together account for another 23 percent.

Table 1: Area and Production of Major Crops: 2004

Crop	Area Harvested (mil. ha.)	Production (mil. metric tons)
Cereals	680	2,264
Oil crops	246	609
Pulses	71	60
Roots & tubers	53	715
Fruit	51	503
Vegetables & melons	51	866
Sugarcane	20	1,324
Coffee	10	8
Cocoa	7	4
Sugar beets	6	249

Source: FAOSTAT database

Table 2 shows the ten leading producers and consumers of sugar in 2004/05. The top 5 are the same in both cases and account for roughly half of total world production and consumption. Table 3 shows the leading exporting and importing countries. Brazil dominates exports, whereas sugar imports are much less concentrated. (The EU figures include intra-EU trade. Net EU exports and imports in 2004/05 were approximately 5.4 and 2.3 million tons, respectively.)

Figure 2
World Sugar Crop Area Harvested

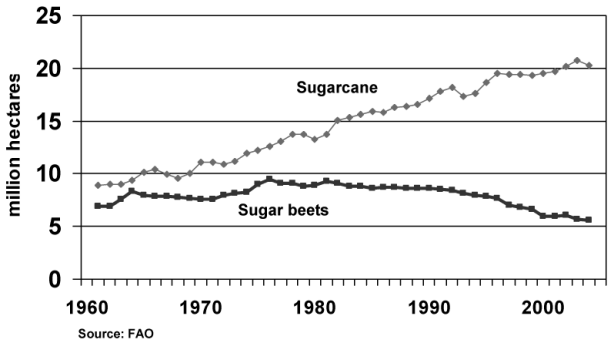


Figure 3
World Sugar Crop Yields

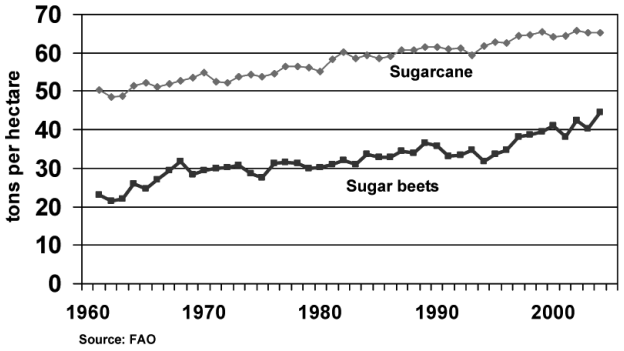


Table 2: Leading Sugar Producers & Consumers in 2004/05

Producers	mil. m.t.	Consumers	mil. m.t.
Brazil	29.7	India	20.1
EU	22.0	EU	17.9
India	13.8	China	12.4
China	9.9	Brazil	10.9
US	7.1	US	9.3
Mexico	6.0	Russia	6.4
Australia	5.7	Mexico	5.4
Thailand	5.4	Pakistan	4.2
Pakistan	3.4	Indonesia	4.0
Colombia	2.7	Egypt	2.6
Other	39.2	Other	52.7

Source: F.O. Licht

Table 3: Leading Sugar Exporters & Importers in 2004/05

Exporters	mil. m.t.	Importers	mil. m.t.
Brazil	19.2	EU	6.5
EU	9.3	Russia	3.4
Australia	4.4	India	2.4
Thailand	3.4	UAE	2.1
UAE	2.0	Indonesia	1.9
Colombia	1.2	US	1.8
Guatemala	1.1	South Korea	1.6
South Africa	1.1	Japan	1.3
Cuba	.9	China	1.3
Argentina	.4	Canada	1.2
Other	11.4	Other	26.5

Source: F.O. Licht

SECTION 4: MAJOR CHANGES TO THE SECTOR

In one respect the sugar sector has been relatively immune to change – world consumption grows like clockwork at 1-2 percent per year. The price elasticity of demand is comparatively low and until the current 2005/06 marketing year there has simply not been very much price variability in most markets over the last two decades to which consumers can even respond.

However, there have also been some important changes in the sector in both absolute and relative terms. In Section 3 we highlight some of the shifts in market share that have taken place between beets and cane and within the cane sector. In this section we focus on four areas of change: increased competition from other sweeteners, growing production of fuel ethanol from sugarcane, the effects of trade liberalization and domestic policy reforms, and rising environmental concerns associated with sugar crop production.

4.1 Competition from other sweeteners

While sugar remains the gold standard of sweeteners, people have continually searched for alternatives for three reasons: cost, functionality, and calorie reduction. Today there are significant volumes of alternative sweeteners available in the marketplace. These include starch-based sweeteners, high intensity sweeteners, and polyhydric alcohols. And of course, there is still honey, which was the first sweetener.

The technology for producing sweeteners from starch was developed over the course of the 19th century and production grew slowly through the mid-20th century. In the early 1970s, technologies using enzymes and catalysts were developed that allowed glucose to be converted to fructose. Today there are two main products – a 42 percent and a 55 percent fructose syrup. In Europe these are referred to as isoglucose and in the United States as high fructose corn syrup, or HFCS.

High-intensity sweeteners are also playing an increasing role in foods and beverages. Saccharin was the first high intensity sweetener to gain commercial importance. Cyclamate was introduced in the 1960s and was followed by aspartame in the 1970s, acesulfame potassium in the 1980s and sucralose in the 2000s. Because high-intensity sweeteners do not have much bulk, their main use has always been in beverages. Finally, there are the polyhydric alcohols. These have varying degrees of sweetness, lower calories, and do not promote tooth decay so they are widely used in “sugar-free” gums and confectionery, mouthwash, toothpaste, etc. Sorbitol has historically been the most prominent of these products, but the list, familiar to anyone who reads ingredient labels, also includes substances like mannitol, maltitol, erythritol, and xylitol. Sugar will continue to face competition from all of these sweeteners over the coming decade, but if domestic supports are cut back in the EU, US, and Japan, sugar could regain some cost competitiveness in those markets. And if the EU, Mexico, and other countries that currently limit starch sweetener production to protect their sugar industries were to loosen those restrictions, starch-based sweeteners would begin to play a greater role in those countries.

4.2 Fuel Ethanol

The outlook for world ethanol production in 2006 is for continued strong growth because the recent increase in oil prices has boosted worldwide interest in such alternative fuels. Regulations as a result of national and international efforts to combat greenhouse gas emissions have also encouraged interest in this cleaner fuel, and subsidized production and/or mandated use of ethanol is helping the industry grow.

Even though the bulk of production still comes from Brazil and the United States – two countries with elaborate fuel ethanol programs – there are interesting developments in other countries as well. Some of these are resulting in the establishment of new production centers, in addition to the two traditional ones in the western hemisphere.

This is a metric world, US bushels, gallons, barrels, and pounds notwithstanding. In discussing the world ethanol situation, international convention is to use liters as the basic unit of measure. US readers can divide by four to get the approximate equivalent in gallons. Sometimes analysts use metric tons – a unit of weight rather than volume. Much of the international data is reported in hectoliters, i.e. 100 liters, abbreviated as "hl". And sometimes the trade and price data are reported in terms of cubic meters, i.e. 1,000 liters or 10 hl. The main conversion factors and definitions needed to follow world ethanol developments are shown in Table 4.

Table 4: Useful conversion factors

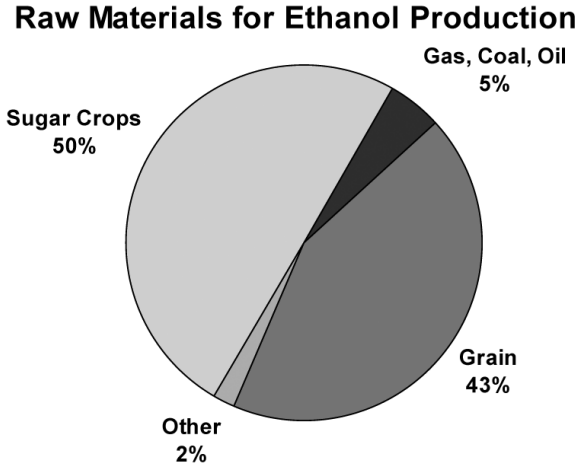
US	Metric
1 gallon = 3.785 liters	1 liter = 0.2642 gallons
1 barrel = 42 gallons	1 barrel = 158.98 liters
1 bu. corn = 56 pounds	1 cubic meter = 1000 liters
1 metric ton = 39.368 bu. corn	1 hectoliter = 100 liters
1 gallon ethanol = 6.59 pounds	1 metric ton = 1266 liters ethanol

Fermentation versus synthetic

Ethyl alcohol (ethanol) is a two-carbon alcohol produced either synthetically from the hydration of ethylene or naturally from the fermentation of carbohydrate materials. Practically and scientifically, pure ethyl alcohol synthesized by direct or indirect hydration from natural gas, coal, or petroleum products does not differ from that obtained by fermentation with subsequent distillation. The synthetic form now constitutes only 5 percent of overall output worldwide.

Fermentation, in combination with distillation, provides the major source of ethanol through agricultural crops such as grain, sugarcane, sugar beets, molasses, fruit, wine, cellulose, and numerous other sources. In grain, dry milling and wet milling are commonly used processes. While corn represents over 95 percent of the feedstock for ethanol production in the United States, cane sugars are utilized for roughly 50 percent of production worldwide. All beverage alcohol, the largest part of fuel ethanol and more than half of industrial ethanol relies on the fermentation method.

Figure 4



During fermentation, yeast converts sugars such as sucrose or glucose to ethanol. However, not all agricultural raw materials are broken down into simple sugars readily. Through popular wet or dry milling processes, starchy materials are converted to sugars for fermentation. Ethanol production from grain utilizes only the starch, an abundant and typically low-value component. A variety of highly valuable co-products are produced from the remaining protein, oil, minerals, vitamins, and fiber and are sold as vegetable oil and high-value feed for livestock.

Ethanol produced through fermentation ranges in concentration from a few percent up to 14 percent where fermentation stops. The product is then concentrated by distillation of hydrous solutions, separating the alcohol from the water through evaporation. The resulting alcohol may be near 100 percent pure (anhydrous) or still have some residual water in it (hydrous). Most beverage ethanol, for example, is only 40-50 percent ethanol.

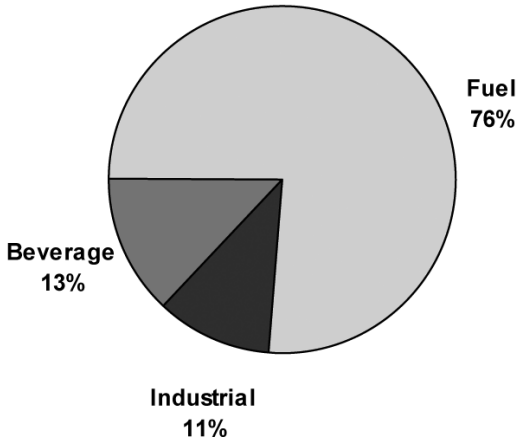
Competing uses – beverage, industrial and fuel

Production of ethanol for beverage purposes through fermentation and distillation began thousands of years ago. As societies became more industrialized in the 19th century, ethanol found new applications in the chemical and manufacturing sectors and a base level of industrial usage gradually developed.[2] With the advent of the automobile, ethanol found its first major use as a fuel but was quickly displaced by cheaper petroleum products. The sharp rise in crude oil and gasoline prices in the 1970s prompted government action in Brazil, the United States, and a few other countries encouraging fuel ethanol in order to reduce dependence on expensive imports of petroleum products. Policies adopted included favorable tax treatment, mandates, and direct subsidies. (Once oil prices declined, however, programs suffered.)

In the 1990s, environmental concerns with respect to air pollution and climate change began to play a role in support of fuel ethanol. And with the sharp increase in world petroleum prices in 2005, ethanol has become theoretically competitive as a fuel in many countries even without subsidies, although production capacity outside Brazil and the United States is still very limited. Today, estimated world ethanol use is distributed as shown below. Ethyl alcohol is denatured (made unfit for human consumption) when used for fuel or industrial purposes.

Figure 5

World Ethanol Use



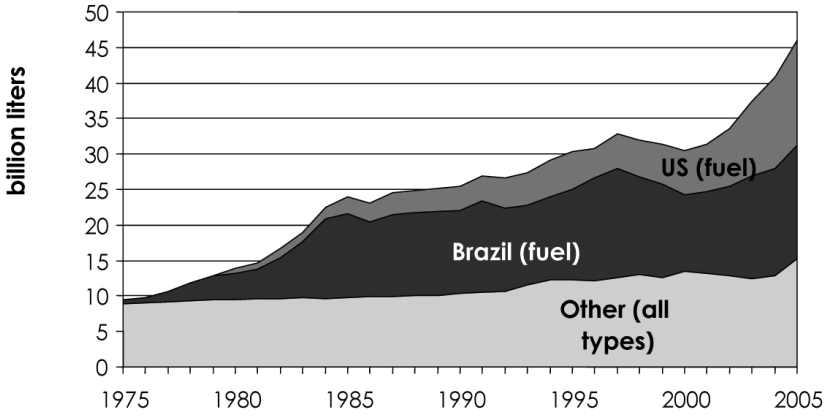
As a fuel, ethanol is a high quality octane enhancer and oxygenate, capable of reducing certain types of air pollution and improving automobile performance. In spark ignition engines, it emits significantly less carbon monoxide and air toxic pollution than gas, thereby reducing the amount of harmful emissions. Fuel ethanol can be classified as anhydrous or hydrous. The more common anhydrous is a product of dehydration with a minimum alcohol content of 99.3 percent. Hydrous forms (containing up to 7.4 percent water) can also be used as an alternative to gasoline in automobiles designed for their use, primarily found in Brazil.

History of production

World ethyl alcohol production has expanded dramatically in recent decades due to the fuel ethanol programs in Brazil and the United States. The chart below, based on F.O. Licht data, gives a good sense of what has happened since 1975. During the 1990s, the fuel ethanol programs in those two countries alone accounted for 60 percent of world ethanol production. Traditional beverage and industrial uses plus the small volume of fuel ethanol in other countries constituted the remainder and did not expand much in the last quarter of the 20th century, averaging 1.6 percent growth per year. However, growth in the most recent 10 years has averaged 2.7 percent annually as a strong world economy has pushed up traditional use (and perhaps as better statistics have been kept).

Figure 6

World Ethanol Production



Source: F.O.Licht

Ethanol is believed to provide net benefits to the environment compared to gasoline in use as a motor fuel. Ethanol replaces additives containing heavy metals or MTBE,[3] contains no sulfur, allows the use of catalytic converters, has negligible particulate emissions due to its simple structure, and reduces carbon monoxide emissions. Carbon dioxide, a byproduct of fossil fuel vehicles, is one of the most harmful of all greenhouse gases responsible for trapping heat in the atmosphere and leading to global temperature increases. For every ton of hydrated ethanol produced from sugar, carbon dioxide emissions are reduced by 0.17 tons. The same amount of anhydrous ethanol from sugar reduces emissions of the greenhouse gas by 0.25 tons. [4] Ethanol does contribute to smog, however, because it is more volatile than some other additives.

Over the longer term, advances in technology are expected to make cellulosic raw materials the preferred feedstock rather than grain or sugar crops. This will likely raise different issues with respect to environmental impacts.

4.3 Impact of trade liberalization

Successfully concluding the Doha Development Round would likely have a considerable impact on world agricultural production, consumption, and trade. But trade liberalization is also occurring on a bilateral or regional basis through free trade agreements (FTAs). Furthermore, it is occurring as a result of unilateral reforms being implemented, not entirely voluntarily, by the European Union. Over time, the effects of these piecemeal efforts can be profound. In the case of sugar, the proliferation of FTAs, the reform of the EU sugar regime, and the potential Doha impacts all merit discussion.

FTAs

Most FTAs have either excluded sugar or limited the degree of liberalization. For example, sugar is the only product that has not been liberalized in the Mercosur agreement among Argentina, Brazil, Paraguay, and Uruguay. As other countries in the region have entered into various forms of association with Mercosur, sugar has continued to be treated as an exception. In the case of the FTAs being pursued by the United States, sugar has been among the most sensitive products and US negotiators have taken care not to liberalize trade in any meaningful way. Sugar was totally excluded from the agreement with Australia, and the additional access promised to Colombia, the Dominican Republic, and the Central American countries has been nominal, totaling less than 200,000 tons.

Nevertheless, while trade in sugar may remain restricted, trade in sugar-containing products is increasingly liberalized and this tends to undermine the traditional protectionist techniques. For example, the United States used to export more sugar in products than it imported, but in the last ten years the balance of trade has shifted to the point where net imports of sugar in products are almost 800,000 tons and imported sugar-containing products account for about 12 percent of total sugar consumption in the country.

The pace of this liberalization will most likely continue. The WTO estimated in 2003 that if all FTAs then being negotiated took effect, over half of the world's merchandise trade in 2006 would be among countries linked by such agreements.[5]

The European Union is of course the world's most economically significant customs union and became more so with the admission of ten new member countries in 2004. The EU also has over thirty preferential trade agreements with other countries or groups of countries. To some extent this puts competitive pressure on the United States to follow a similar path as a hedge against failure of multilateral talks. This means that sugar and sugar-containing products will be under continued pressure to liberalize. This will also be accompanied by changes in domestic regimes to enact agricultural policy reforms.

EU sugar reform

Over the past decade the European Union has implemented a series of reforms in its Common Agricultural Policy that have replaced high market support prices with decoupled direct payments to producers. While the European Commission always intended to eventually address sugar, two separate action-forcing events have triggered reform in that politically sensitive sector. First, in 2001 the EU passed its Everything But Arms Regulation, which eliminated tariffs on almost all imports from the world's forty-eight least developed countries. Apart from armaments, the exceptions were sugar, rice, and bananas, which are to be fully liberalized by 2009.

Second, in September 2002 Brazil, Australia, and Thailand, supported by about twenty other countries, challenged the EU's sugar export subsidies in the WTO. In October 2004, the dispute settlement panel

ruled that the EU had exceeded its Uruguay Round export subsidy commitments by a large margin since 1995. The EU appealed, but in June 2005 put forward an aggressive reform proposal.

On November 24, 2005, the European Union's Agriculture Ministers finally reached agreement on a reform package for the sugar regime to take effect with the 2006/07 crop. The price support reduction proposed by the Commission was reduced from 39 percent to 36 percent, and the implementation was spread over four years rather than two. Farmers will receive 64.2 percent of the income loss via a decoupled payment (versus 60 percent in the earlier proposal). Processors will receive 730 euros per metric ton of sugar for restructuring, i.e. getting out of the business of producing sugar. The restructuring aid declines to 625 euros in 2008/09 and 520 euros the following year. It is expected that EU sugar production will decline from nineteen million tons in 2005 to just thirteen million tons in 2010, with much of the decline taking place in the first year. In fact the production quotas for 2006/07 have been cut by 2.4 million tons to 15.0 million tons because the EU still has surplus sugar it needs to use up.

This reform has significant implications for the world sugar market in general, and in particular for the EU's former colonies that have benefited from preferential access for more than 1.3 million tons to the EU market. The African, Caribbean, and Pacific (ACP) countries will see their guaranteed minimum price for raw sugar decline from 524 euros to 335 euros beginning in 2008. While the EU has offered some adjustment assistance, the ACP countries have deemed it totally inadequate and have protested this significant erosion of a major preferential trading arrangement. Some of the Caribbean and African beneficiaries will probably cease sugar production entirely without the high prices that the EU has been paying for their sugar. Others with reasonable production costs, like Swaziland and Zimbabwe, will come out ahead because of increased trade volume.

For the world market as a whole, the EU reform is a seismic shift. The EU has been the principal exporter of high quality refined sugar, accounting for more than half of fully-refined sugar exports, and its five-six million tons have accounted for twenty-thirty percent of total white sugar trade. The only other big white sugar exporters are Brazil at about seven million tons, Thailand at 2-2.5 million and Colombia at 500,000 tons. With the prospect of a big decline in refined sugar exports from the EU, investors have been building new refineries or expanding existing facilities in the Middle East, North Africa, and South Asia to serve the main export markets. This is creating new export demand for efficient raw sugar producers like Australia and Brazil, who will supply the raw sugar that those refineries will require.

The Doha Development Round

Several significant studies have attempted to estimate the effects of multilateral sugar trade liberalization on production, consumption, trade, and prices. ABARE, the Australian Bureau of Agricultural and Resource Economics, was responsible for several. Other notable work along these lines was done by university economists. FAO compared the results of half a dozen of these recent studies at an August 2004 workshop in Rome.[6]

The most recent such study is one done by Amani Elobeid and John Beghin at Iowa State University.[7] They use a partial equilibrium model based on 2002 market data and policies to examine three scenarios. The first removes all trade and border distortions such as tariffs, quotas, export subsidies, and state trading. The second removes domestic production policies that either support or constrain output in addition to

removing the trade distortions. The third removes domestic consumption distortions in addition to those in trade and production. In each case the impacts are traced through 2011/12.

For the purposes of this study, the projections for Scenario 2 served as a basis for deciding which countries were likely to experience the greatest changes from trade liberalization to their sugar sectors. In that scenario, world sugar production and consumption decline by 4 million tons or almost 3 percent. For major countries and regions the paper calculates the average change in production relative to the baseline for a ten-year period after the assumed liberalization, in this case 2002/03 through 2011/12. Countries for which major sugar production declines are projected include Japan and the members of the European Union. Small percentage declines occur in the United States, Mexico, and India. Countries in which the scenario shows large production increases in both absolute and relative terms include Australia, Brazil, China, Cuba, Indonesia, and Turkey. Countries with large absolute increases (greater than 100,000 tons) but less than a 10 percent increase from the baseline include Pakistan, South Africa, and states of the Former Soviet Union. (In the FSU, impacts would also vary by country).

The countries with sugar production increases of more than 100,000 tons are shown in Table 5. To estimate the change in harvested area, we used FAO and USDA data on the ratio of sugar production to the tonnage of sugar crop that is processed and the average cane or beet yield per hectare. The calculated impacts range from 23,000 hectares in South Africa to 350,000 hectares in Brazil. This does not include any additional increases attributable to FTAs, EU reforms, or fuel ethanol demand. Nor does it include any analysis of potential effects of changes in ethanol subsidies or trade restrictions.

In selecting countries to review as case studies of environmental sustainability, we have focused mostly on those with expanding sugarcane production. In Section 6 we look at potential developments in Brazil, China, and Indonesia. For a case study of sugar beet impacts, we look at Turkey, where despite the projections of the model just cited, plantings are likely to shrink as a result of trade liberalization rather than expand.

4.4 Sugar Crops and the Environment

Arguably, agriculture always has an environmental impact. But with modern practices and technology in crop and livestock production, such impacts can be mitigated. However, it is also clear that economic and population growth are straining world soil, air, and water resources, and adversely affecting biodiversity in some countries where new areas are being brought under cultivation.

The main environmental effects resulting from trade liberalization in the sugar sector will arise from changes in the scale of production in particular countries, i.e. whether more or less land is being used to produce sugar beets or sugarcane. It is also possible that trade liberalization could have environmental effects as a result of a change in production methods where producers face either higher or lower prices in their market, but such effects are difficult to predict and estimate. In some countries, improved incomes due to higher sugar prices and expanded exports might also lead to more environmental awareness and action to safeguard the environment.

The environmental effects of sugarcane and beet growing are in some places no different than those from the cultivation of any other crop. However, the extensive water demands of sugarcane and some of its cultivation practices make it a poor choice for some areas. Increased production in countries where the potential for expansion in sugar production is great has raised fears that large expanses of land will be transformed to a sugarcane monoculture with corresponding adverse reductions in biodiversity and in soil,

air, and water quality. Likewise, the increasing demand for biofuels causes concern about the extent of both cane and beet acreage growth.

Sugarcane Growing

Sugarcane is essentially a deep-rooted tropical grass, grown worldwide between latitudes of 30 degrees North and 30 degrees South, and typically grown in monocultures, rather than interplanted with other crops. Sugarcane requires large amounts of sunshine and rain throughout the entire year as well as nutrient-rich soils. If rainfall is not plentiful enough, irrigation is necessary and is provided routinely in many countries.

Once sugarcane is planted, it takes between fourteen and eighteen months for the plants to fully mature. After that, canes are harvested periodically (in a “ratoon” system) until after several years their number and quality diminish. Modern cropping harvests cane at shorter intervals. When the roots are removed, a new stand is planted, usually after an intervening rotation crop. Fields are weeded regularly, requiring high volumes of manual labor in developing countries where machines are too expensive or inappropriate for the terrain. The jobs are an important source of employment for rural developing areas, but cane harvesting is one of the most physically demanding jobs in agriculture, with regular exposure to hazardous conditions.

Cane fields are also harvested by machine, but workers are used to clear cane from difficult terrain. Fields are normally burned prior to harvest in order to remove dead leaves from the plants, rid the fields of snakes and other animals, and make cutting easier. Although green cane is increasingly harvested to avoid this practice, cane fields are still routinely burned in many areas.

Once the sugarcane crop is cut, the stalks are transported to a mill as soon as possible to avoid loss of sugar content. Of the total cane taken to the mill, about 17 percent of the mass emerges as sugar or molasses. The remaining organic material is known as bagasse, which can be used for fuel or animal feed but is usually burned as boiler fuel in the cane mill. Burning bagasse or letting it decompose can negatively contribute to increased greenhouse gases and global warming.

Major environmental effects include:

- Water use: sugarcane, with deep roots remaining in the ground all year long, consumes high vol umes of water. In some areas, 100 percent of water demand is provided by irrigation.
- Soil erosion: cane is often planted where runoff from water is a problem because of heavy rains or unsuitable sites. Cases of water-caused soil erosion are often due to the steep hills on which sugar is sometime planted. It is suggested that sugar be planted in areas with no more than an 8 percent slope, but extreme cases of 20 to 30 percent slopes exist and foster severe soil erosion. Soil “min ing” can also occur where more soil is lost to erosion and other practices than is replaced by ad ditional organic content.

- Soil compaction: this is a problem where mechanical harvesting is common because repeatedly driving heavy equipment over a field compresses the soil. This reduces water permeability and cre ates a tougher environment for the plant root system.

- Loss of biodiversity: Many sugarcane producing countries use high portions of their total land area to produce sugar on both newly converted land and land that has been in use for many decades. Where production expansion is taking place, it may be replacing tropical forests that have rich sys tems of biodiversity. Wetlands are commonly reclaimed, drained, and planted to sugar in order to

capitalize on nutrients and water supplies. Changes in soil structure and the overall environment may not only displace current species, but also prevent future growth of species within the ecosys tem.

- Field burning: 80 percent of harvesting uses some burning to reduce the amount of vegetation left on the cane. The smoke and ash generated are causes of severe air pollution, hazardous to human health and leading to higher levels of carbon and ozone in the atmosphere. Burning fields also adversely affects nutrient and chemical properties of the soil and decreases nitrogen levels.

Sugar Beet Growing

Sugar beets are a deep-rooted temperate region crop. Growing seasons as short as 100 days can produce commercially viable sugar beet crops. The sugar beet develops a large succulent root in its first year in which much reserve food is stored, and in the second year it reproduces if left in the ground. Thus, beets are normally farmed as an annual, planted in early spring and harvested in the fall of the same year. In warmer climates, sugar beets can be a winter crop, planted in the autumn and harvested in the spring.

Beets root to a depth of two meters and extract most of the available nitrogen from the topsoil and subsoil. Carefully timed nitrogen application is thus key to good yields. Sugar beets, like any field crop, also require use of herbicides to control weeds and pesticides to control pests, but use can be minimized. A glyphosate-tolerant variety of sugar beet has also been developed and will eventually be commercialized.

Sugar beet is important as a rotation crop (with winter wheat, barley, maize, oilseeds, etc.) in many of the areas where it is grown because its pests and diseases are different from those afflicting other crops and because plant residues (root and leaf fragments) from the sugar beet crop decompose over a long period of time. Sugar beet tops are either fed to cattle or plowed back into the soil.

Soil loss from harvesting, erosion, and compaction can be substantial, since planting is usually done on bare soil exposed to wind and water. Harvest of this root crop also results in soil being removed together with the root, although most of it is either returned to the land or used for other purposes. Mechanical harvesting also results in soil compaction.

Sugar Processing

A sugar factory can potentially generate significant amounts of pollution, regardless of whether it is processing cane or beet. This includes air pollution from chimneys, odor, noise, and dust. In beet plants where coal or oil is employed as fuel, NOx, and SOx are potential pollutants. Most sugarcane mills use bagasse, the residue from the milling of cane, to power their boilers. This produces particulate matter, nitrogen oxide, and sulphur, but often replaces other energy sources that would be equally if not more polluting. Efficient plants can also return electric power to the grid from their operations.

Water borne pollutants from sugar factories are for the most part degradable organic compounds that can be treated, but discharge quantities can be considerable. Both cane and beet are washed when they enter the mill, consuming large amounts of water. The boiling process to concentrate the sugar also uses large volumes of water, and water is released when mills are cleaned once or twice per year. In remote cane areas, disposal of molasses into waterways is sometimes a problem if there is no nearby market for it. Beet processing can use and recycle water and sugar syrups at many stages of this production process, but otherwise the waste would be released into local surface water, where it has a high biological oxygen demand.

Significant efforts have been made by some processors to recycle. After sugar is extracted, sugar beet residue is used as animal feed. Molasses is used as a feedstock by the fermentation industry or fed to livestock. In some countries, soil adhering to the sugar beet can be marketed to landscapers, architects, and farmers, and lime products produced as part of the purification process are sold for soil conditioning. British Sugar has used hot water and carbon dioxide from one of its plants to produce tomatoes, rather than releasing the CO2 into the atmosphere.

Sustainability Certification

Certification programs for foodstuffs have proliferated in recent years. National governments have always played a role in establishing grades and standards for a variety of food items. The International Standards Organization also has a plethora of programs that define how companies can certify that they follow environmental management practices. Certification programs for methods of production like "dolphin-safe" tuna, organic, and non-genetically modified, and for traceability of animal products back to the producer have evolved under both private and governmental auspices.

Environmental certification is the latest manifestation of consumers' desire to know more about what they are purchasing and companies' need to understand what they are sourcing. A program has existed for forest products and seafood for a number of years, and the World Wildlife Fund and other organizations are working to establish similar certification programs for palm oil, soybeans, sugar, and other food commodities. A program of this type for sugar would also contribute to limiting any adverse impacts of expansion of sugar crop production due to trade liberalization and demand for renewable fuels.

SECTION 5: A MATRIX APPROACH

We used a matrix as an analytical tool to assess and illustrate the environmental implications of changes in scale and location of agricultural production that could accompany agricultural trade reform. In one dimension the matrix lists relevant causal policy measures, and in the other the broad environmental (or social) indicators. The policy measures' effects on these indicators are characterized in the matrix as either neutral, positive, negative, or both positive and negative.
The matrix approach used in this paper originates from "Trade, Agriculture and the Environment," a paper co-authored by John A. Dixon and M. Ann Tutwiler, but differs in some respects in its treatment of implicit and explicit distortions.[8] A brief description of each category in the matrix follows.

Columns - Policy Measures, Explicit and Implicit Distortions

Fuel ethanol

Fuel ethanol is included as an explicit policy distortion because its development is being driven primarily by government policies that either mandate and/or subsidize its use, and sugar crops are one of the major raw materials. Since the scale of ethanol's impact in some countries is likely to be considerably larger than that of trade liberalization, it is important to keep this in mind as a background factor as one looks at the relative effects of the different components of trade liberalization or implicit distortions.

Tariffs and Quotas

In the agriculture context, high import duties and restrictive quotas are associated with either protected or value-added products. Protecting production through high tariffs – thus sidestepping market signals – may promote environmentally disruptive agricultural expansion. Facing a higher duty for processed products than for unprocessed ones (tariff escalation) can encourage production of basic raw commodities in exporting countries at the expense of processed ones, which may save on the environmental costs associated with a heavily polluting processing industry but may also cause environmental degradation if it encourages the use of non-sustainable farming practices to maximize volume. A few exporters have resorted to differential export taxes to offset importers' tariff escalation. Export taxes are legal under WTO rules, but when a country imposes a higher tax on raw materials than on finished products, it effectively subsidizes domestic processors and enables them to export at lower prices as well.

As noted in Section 3, should the Doha Round be concluded, it is expected to cut high tariffs more than low ones, thus reducing or eliminating tariff escalation., but developing countries will receive special and differential treatment that will most likely result in longer phase-out periods for tariffs and end rates of less than zero. "Sensitive" and "special" products may also remain protected. Tariff rates in the sugar sector are at the high end of the scale in comparison to other agricultural commodities.

Non-tariff barriers

Non-tariff barriers affect production and use of most agricultural commodities to some degree. Non-tariff barriers range from sanitary and phytosanitary regulations to import licensing to cumbersome customs and port handling procedures. In the sugar sector, however, they play a negligible role and warrant little discussion.

Domestic support measures

Domestic support measures linked to production (Amber Box) have been criticized as distorting price competition, stimulating uneconomic domestic production, limiting imports, and creating oversupply in world markets. Production-limiting compensation (Blue Box) by the US and the EU has also been criticized because of these countries' continued high levels of expenditure and impact on trade.[9] Some countries, in particular the G-20, have also argued that support not linked to production (Green Box) has an implicit impact on trade.

The United States and the European Union have maintained high levels of support for their farming sectors, of which the sugar sector has been a primary beneficiary. The Doha Round is expected to substantially reduce Amber Box payments, and Blue Box payments would likely be capped at some low percentage of the value of production. This would result in a relatively significant change for developed country sugar producers and would shift production to other crops. Green Box compensation may also offset sugar disciplines in other categories through support for ethanol and may even increase production of sugarcane in the United States and a few other countries.

Export Ssubsidies and Ttaxes

Export subsidies can affect the environment through the scale and composition of output and through changes in production technologies. However, eliminating export subsidies is part of the Doha agenda because of their price effect. By subsidizing production in the exporting country, these subsidies reduce the price in the importing country, sometimes below the cost of production. They also increase the use of fixed

factors of production, discourage agricultural diversification, result in over-grazing and the extension of farming to marginal land, and lead to intensive use of fertilizer and crop protection chemicals. By suppressing world prices, they reduce farm incomes in non-subsidized countries and stifle poverty-alleviation efforts in many developing countries.[11]

Export subsidies can also affect environmental conditions in a commodity-importing country when they are removed, by spurring rapid growth and investment that is environmentally damaging. Removing them can also cause the relative sizes of different sectors to change because they have insulated certain sectors from market signals. If polluting sectors grow when subsidies are removed, they can cause environmental damage. Removing subsidies can also contribute to changes in production methods that are less costly but more polluting. Export subsidies are expected to be eliminated by the Doha agreement by 2013, but the agreement will begin to rationalize production in response to market signals before then. Competitive producers will benefit, but if market signals result in an increase in productive capacity, this could be at the expense of the environment in sensitive areas unless corresponding policy measures act to discourage production there.

Externalities

This heading includes policy measures that are external to the cost of producing sugar, but highly relevant to national policies that affect the environment. These include, for the purpose of this study, enforcement of environmental regulations and well-defined property rights. Both can add to the cost and risk of production but are not directly included in the cost.

Relevant environmental regulations can include requirements to protect specifically identified land, retire land because of soil erosion, air quality regulations pertaining to airborne dust, regulations prohibiting wetlands loss, requirements for water quality/impairment from nutrients, regulations governing wildlife habitat loss, and environmental liability regimes. Obviously there is great opportunity for variations in enforcement of these regulations between countries, areas within countries, and kinds of producers. It can generally be assumed that environmental performance standards are lower where enforcement of environmental regulations is lax or nonexistent, but there may be exceptions for some areas where private certification schemes can effectively take the place of state intervention. Environmental enforcement is generally more effective with respect to processing industries than with respect to production of agricultural commodities.[12]

Undefined property rights and lack of environmental enforcement can also deter investment in a sector and ultimately lead to creation of environmental problems when land is abandoned or otherwise not used productively. It is well-accepted by economic and developmental experts that markets for environmental (and all other) goods fail to work well when property rights are undefined, are poorly defined, or cost too much to enforce.[13] Property rights issues may arise in the sugar sector in countries where agricultural expansion is taking place. As such, they are implicitly distorting and can lead either to an inability to use available resources or to uncontrolled exploitation unregulated by rule of law.

Non-pollution environmental externalities

In this paper, non-pollution externalities are the physical conditions in producing countries that have an effect on the countries' ability to realize gains from trade reforms focused on agricultural production or processing. These include soil quality, existing biodiversity, and geographical conditions like access to ports. For example, a country may not be able to expand production to take advantage of increased market access if it has no land available. Conversely, it may be possible for producers to further exploit already-

degraded, cheap, and available land for quick gains enabled by new market access opportunities. Non-pollution spatial externalities like soil erosion and biodiversity loss are therefore implicitly distorting and can act as barriers or incentives to exports. The Doha agenda will not change any of these parameters, but a producing country's policy response to them will be influenced by the Doha results.

Pollution Externalities

Like non-pollution spatial externalities, pollution externalities can act in some cases as barriers and in other cases as incentives to unregulated production and exports, depending on the terms of trade. Some examples of pollution externalities relevant to sugarcane and sugar beet production might include chemical residues in soil or water, air pollution caused by cane field burning, surface transportation or polluting processing facilities, or water pollution caused by fertilizer runoff. Policies relevant to pollution externalities might include becoming a signatory to environmental treaties or initiating programs to combat adverse environmental conditions.

Rows - Environmental Effects

The rows of the matrix assess effects relative to a set of environmental indicators. Environmental indicators were much discussed in the 1990s. The OECD Ministers adopted a set of environmental indicators in May 2001. Of the OECD indicators, which include a range of indicators from climate change to fishery resources, several are particularly relevant to environmental conditions prevailing in sugar-producing countries. These include soil erosion/organic content, groundwater contamination, loss of habitat/biodiversity resulting from forest conversion or improper land use, loss of other productive use, and deleterious human health impacts. As relevant as these basic indicators are, each will not be equally relevant to sugar production in each producing country. The OECD indicators do not include soil health, for instance, which is a key component of sustainable agricultural production.

The World Bank and other development institutions have also used environmental indicators extensively in their evaluations of projects for environmental and social impacts. Most recently the 2005 Environmental Sustainability Index (ESI)[14] ranked countries on criteria that include overall environmental stewardship in several categories. They include not only soil, air, and water quality and quantity, but also include environmental governance, reducing ecosystem and population stress, reducing transboundary environmental stress, and a number of other criteria. This paper includes their rankings in the country sections where relevant. The study is interesting not only because it is exhaustive for a variety of indicators, each of which is based on multiple data sets, but also because it attempts to correlate them to both GDP and growth competitiveness, and because it illustrates the complexity and multi-dimensionality of environmental sustainability.

In comparison, this effort uses a much broader and simpler approach to arrive at results that are more indicative than they are definitive. It is based on work undertaken on environmental effects of agriculture[15] and focuses on:

- soil factors (expressed as soil erosion and quality);
- air quality (intended to encompass air pollution/haze from forest conversion, particulate and other emissions from processing and harvesting activity, and gross emissions of greenhouse gases from

agriculture);
- water quality (including kinds of use, contamination by crop protection chemicals, and scarcity);
- loss of habitat and biodiversity; and
- social impacts, intended to reflect both disruption of rural communities and indigenous people and jobs added to the rural economy.

SECTION 6: COUNTRY MATRICES

6.1 Brazil

The CARD study referenced earlier projected that Brazilian sugar production would average 17 percent higher over the ten years following liberalization as a result of a successful Doha Round. As Table 5 indicated, that would require an additional 350,000 hectares of land to be planted to sugarcane. However, that study worked from 2001/02 base period and Brazil's sugar production has expanded by about a third since that year. Currently about half of Brazil's 5.6 million hectares of sugarcane are used for sugar production. Therefore, a 17 percent increase in the 2.8 million hectares now being harvested for sugar would be about 475,000 hectares. Cane area expansion for production of fuel ethanol is expected to exceed that by a considerable margin, as discussed below.

6.1.1 Economy and Trade

Currently, Brazil is the world's leading sugarcane producer and largest sugar exporter, producing an estimated 385 million metric tons of sugarcane and exporting 17 million tons of raw and refined sugar in 2005/06. Brazil is also among a select few countries producing significant quantities of ethanol from sugarcane. It has been the world's largest producer of ethanol, producing 35 percent of the worldwide total in 2005 and is considered the only supplier capable of meeting the huge rise in import demand for ethanol expected in the near future.

More generally, Brazil is one of the world's leading agricultural producers, and sugarcane has been one of the country's most important crops, accounting for about 10 percent of the total value of crop production in 2004. During that year, Brazil had 9.4 million hectares planted to perennial crops like coffee and citrus, and 56.7 million hectares planted to annual crops, including 5.6 million in sugarcane. Cane production is concentrated in the Center-South region, and in particular the state of Sao Paulo, where it accounts for just over half the 5.5 million hectares in annual crops. Two other states in which sugarcane represents a high share of planted area are Alagoas (67 percent) and Rio de Janeiro (81 percent). In most other states, cane is a comparatively minor crop.

Brazil's 2005/06 crops in both the Northeast and Center-South were adversely affected by dry weather. USDA's Foreign Agricultural Service projects that the combination of a rebound to normal yields and a 300,000 hectare increase in planted area will push cane production up by 35 million tons in 2006/07 to 420 million tons.[16]

This is only the early stage of a massive expansion of the sugarcane sector in Brazil stimulated by both sugar and ethanol demand. Throughout early 2006, various press reports quoting the agriculture minister, the Sao Paulo sugarcane industry association, and Datagro, a leading consulting firm, pointed to the anticipated investment of about $10 billion in ninety-two new mills by 2012/13, at which point total cane milled would exceed 600 million tons. That would require a 40-50 percent increase in area planted, i.e. an additional 2.5-3.0 million hectares.

Presumably the expected effects of trade liberalization are encompassed in that number, since it is 5 to 6 times the 475,000 hectare estimate derived from the Elobeid and Beghin model. To get an increase of 2.5-3.0 million hectares, land would have to be taken out of other crops in addition to bringing new land into production. In the Center-South, where most expansion is expected to occur, that land would come out of grains and oilseeds, cattle grazing, and perennial crops like citrus or coffee. But much of the new planting will necessarily occur in non-traditional areas.

Government Policies

The Brazilian Government has recognized the potential for sugarcane expansion and has assisted with investments into infrastructure and research. As a result, the sugar sector in Brazil has become quite organized and efficient. Transportation routes and loading facilities have been improved and new varieties of sugarcane developed, increasing both yields and the capacity to export both sugar and ethanol.

Historically, government assistance to the sugar sector has been mostly in the form of subsidized credit and policies related to ethanol. Brazil has had a high rate of inflation in most years and commercial interest rates have been correspondingly high. Rural credit programs with subsidized fixed rates totaled over $13 billion for 2004/05 according to USDA.[17] There has also been a long history of debt forgiveness in the sugar and alcohol sectors.

Direct policy measures on sugar are rather limited. The domestic sugar market is more or less at world price levels, although there is an import duty of 17.5 percent on both raw and refined sugar that can provide some protection at times. Exports are not controlled and have been determined on a mostly commercial basis.

Historically sugar and ethanol prices moved in tandem in Brazil because most mills had the choice of shifting from one to the other. Sugar prices determined ethanol prices. That may be beginning to change due to the rise in world petroleum prices, which could affect both ethanol and sugar prices.

Brazil is the world's largest and most efficient producer and exporter of ethanol. With production costs far lower than those of its leading competitors, Brazil is projected to produce upwards of 17,000 million liters for 2006/07. About half the Brazilian sugarcane is used to make refined, crystallized, and raw sugar and the other half is used for ethanol production. With installed and planned processing capacity, the balance between sugar and ethanol can be shifted by a few percentage points in either direction in response to relative prices. For a map of sugarcane production in Brazil, see Appendix A.

The interchangeability of the Brazilian sugar crop between consumable sugar and ethanol allows its producers a great deal of flexibility in world markets, and how production is balanced between ethanol and sugar can have significant impacts on world prices. It also offers sugarcane producers an extraordinary capacity for growth, including export growth if market access is assured.

6.1.2 Environment

ESI Rating[18]

The ESI gave Brazil a somewhat negative rating on air quality, a slightly positive score on greenhouse gas emissions, an almost neutral one on biodiversity (slightly better than the neutral rating for its peer group), a good score on land, a slightly positive score on water quality (but very good on water quantity), a slightly

positive score on reducing air pollution, and a neutral score on environmental governance.

Environmental Policies Relevant to Sugarcane Expansion

Expanded world demand for both sugar and biofuels, and increased cane planting to meet this demand, promises great increases in acreage planted to cane in Brazil. Depending on where this takes place, this could have adverse environmental and social consequences.

Deforestation and the destruction of habitat that conversion requires have been a principal source of environmental concern for Brazil, Paraguay, and other countries in the region. However, other environmental effects associated with large-scale production of almost any commodity, which include large-volume water use, soil erosion due to cultivation techniques, and pesticide residues in water and soil, are also likely to occur. The accompanying social effects of large-scale agricultural production, including loss of livelihood of large numbers of small producers and poor working conditions, land rights and tenure, and the environmental effects of processing facilities, have also become issues of concern in the region and beyond.

As infrastructure is developed to service the production of sugarcane (and soy) in the west, the possibility of expansion into the more environmentally sensitive Amazonian regions is also enhanced. Growth in demand will almost certainly increase production, and the soy infrastructure corridors could foster sugarcane expansion into the Amazon. However, Brazil also has many abandoned farms that could be converted to use and therefore has an opportunity to encourage production on less environmentally sensitive sites.

Expansion of sugarcane and soy will both likely take place due to biofuels demand. To some extent they can substitute for each other and are likely to demand space in the same areas. However, sugarcane is the more environmentally challenging crop because, in addition to the large-scale production effects on the environment, sugarcane is also burned prior to harvest and the side-effects of producing ethanol with low technology methods – e.g., burning cane in the field and burning of bagasse without appropriate filtration – have clear environmental and social deficits. A positive link has been made between cane burning and deleterious health effects in exposed populations.[19]

Nevertheless, because of its renewability, its zero balance in terms of CO2 production and its less toxic emissions, ethanol has generally had a positive reception in Brazil, and Brazilian technology has increased both its productivity and energy yield. Future technological improvements, such as harvesting of green cane, are expected to contribute to both.

In addition, in January 1999, Brazil's Congress implemented an environmental pollution law that fines polluters for environmental standards violations. Industrial polluters had five years to come into compliance with the new law, after which they can be fined between $50 and $50 million for violations.[20]

Environmental Externalities

Externalities like poorly defined property rights and lax environmental enforcement are associated with the ongoing year-by-year expansion in Brazil's booming agriculture sector. That being said, Brazil receives high marks compared to other developing countries for longer-term environmental sustainability. Its land and water resources are generally good, it has invested years of expertise in agronomic research and energy production from biomass, and it has a large and capable workforce willing to expand its already significant export potential.

The right to a healthy environment and its priority over private property rights and economic development are established in Brazil's 1988 constitution. A 1998 environmental crimes law holds corporate CEOs criminally responsible for environmental crimes and also has hefty administrative penalties. However, Brazil's environmental regime is generally characterized by lack of resources to implement too many laws and a lack of coordination among the many agencies responsible for them.[21] Most observers of Brazil's environmental regime concur that it is sophisticated and strict – on paper – but difficult to enforce and therefore weak, especially in the face of demand-driven pressure to engage in biofuels production.

Much of the land recently converted to agriculture has been planted to soy. This could change if sugar makes inroads into those areas and forces soy further into protected areas. The problems with soy cultivation are well-known and have been described in an earlier IPC paper. They involve lack of enforcement of the Brazilian Forest Code, planting rules that cause fragmented development, and uncontrolled incursion into reserved forest lands.

Recent studies have shown an 85 percent reduction in Cerrado vegetation in the regions of Franca, Araraquara, Ribeirao Preto, and Sao Carlos. Similarly, clearing of new areas in the State of Alagoas has resulted in deforestation so complete that it is estimated that only 3 percent of the original rain forest cover remains.

Because it is a grass, sugarcane can be grown in more fragile or marginal areas where other conventional crops are likely to fail or are too difficult to farm – such as on steep slopes or in riparian areas or wetlands. These often harbor greater concentrations of biodiversity. At this time, there appears to be no effective state or private sector mechanism in Brazil to discourage planting in such areas, which are also likely to be less profitable because they require more fertilizer and other inputs to deliver reasonably good yields.

Brazil's undeveloped land area in the Cerrado is larger than the total production area of the United States, and another 20 million hectares are expected to be developed over the next ten years. Advocates of controlled expansion argue that abandoned farms and marginally profitable ranches should be opened first to cultivation because many of them have worker housing, power generation, and basic infrastructure for internal access to fields and because soils have permitted the return of native grasses.

Effective incentives for utilization of already-cleared land, and for cropping methods that retain soil quality, could be paramount for sustainable expansion in the Cerrado, as would productivity increases more generally. In short, Brazil's resource base, including for sugarcane, is excellent, and there is no reason in the long term that it should not be managed and developed sustainably.

Social Externalities

Like many other rapidly urbanizing countries, Brazil's rural sector is currently experiencing extensive social change, as small farmers move to urban and marginal areas and indigenous communities are dispersed or destroyed by development pressure. A landless workers' movement has been active for many years and has taken on new momentum since 2000. Sugar has historically been grown by large landholders. It is estimated that barely 20 percent of the sugarcane produced in Brazil comes from small or medium-sized properties. This, plus other factors, contributes to migration out of, and between, rural areas.

As is the case with other agricultural producing countries, exploitative conditions are alleged to be present in sugarcane regions of Brazil, involving indentured labor, poor living conditions, poor wages, and lack of freedom to associate. Sugar production in Brazil has stimulated support among workers and in rural areas for social movements dedicated to improving social conditions, from allocating land to the poor to eliminating exploitative and child labor. Brazil's costs of production are said to be among the lowest in the world, so there may well be scope for improving some of these conditions without hurting the industry's international competitiveness.[22]

The Matrix for Brazil

	Explicit Distortions/Policy Measures					Implicit Distortions		
Environmental Effects	Ethanol	Market Access – Tariffs/ Quotas	Non-tariff Barriers	Domestic Support	Export Subsidies	Externalities (e.g., envtl. enforcement, defined property rights)	Non-pollution Externalities: environmental	Pollution Externalities
Soil Erosion/Quality	-	-		-	-	-		
Air Quality	+ -	-		-	-	-		+ -
Water Quality	-	-		-	-	-		
Loss of Habitat/ Biodiversity	-					-		
Social Impacts	+ -	+		+	+	-		

Because Brazil is an important user and exporter of ethanol, much of its expansion in planted area will be ethanol related. The resulting increase in sugarcane monoculture will therefore have a net negative effect on soil quality and water use, perhaps more negative for water than soil, because sugar is a "thirsty" crop. Brazil's score on air quality, however, would be a minus for burning cane and processing activity, but a net plus in the same category because ethanol replaces fuels that contribute more to air quality degradation and carbon emissions. Although sugar cane will not likely reduce biodiversity in protected areas, it may displace other crops which in turn may advance into protected or biodiverse areas, resulting in a net loss of habitat. On the plus side, increases in sugarcane planting would lead to some additional seasonal rural employment.

The removal of the explicit distortions that now characterize the world sugar market would benefit Brazil in terms of its ability to export both sugar and ethanol. The resulting increased cropland devoted to sugarcane culture would therefore result in negative impacts on soil, water, and air quality, but relatively few effects on biodiversity. This is the case for market access and domestic support in the matrix. The non-tariff barrier category has been left blank in all cases because nothing being negotiated in the current agenda for reduction of non-tariff barriers appears likely to affect trade in sugar. Removal of EU export subsidies will have a larger effect on Brazil's ability to export sugar than reforms in market access and domestic support. Social impacts received a plus for additional rural employment.

Brazil's good environmental legislation but pronounced lack of enforcement capability, combined with the likelihood that increased sugarcane acreage will be widely dispersed in non-traditional areas, leads to a minus across most environmental categories. Brazil was scored as a neutral in terms of how it chooses to deal with its non-pollution environmental externalities. It has land capable of absorbing all the projected expansion, but whether it uses already-converted and abandoned farmland or converts new acreage to sugar cane, and whether it manages the water needs of the crop compatibly with other uses, will determine the final outcome. Pollution externalities will also depend on the extent to which Brazil manages effects on soil,

water use, and air quality. Burning of cane is a net minus. Likewise, on the social side, increased employment is a net plus but poor working conditions in the sector a definite minus.

If and when cellulosic conversion technology becomes commercialized, Brazil will be able to also convert bagasse to ethanol and may be able to devote less land to sugarcane production. This would limit some of the potential adverse environmental impacts discussed above.

6.2 Indonesia

6.2.1 Economy and Trade

Indonesia's economy recently has been achieving annual GDP growth of about 5 percent, benefiting from the broader upswing in the world economy over the last few years. However, the rise in world energy prices is posing a challenge to the country's economy. According to the Office of the US Trade Representative, lack of contract enforceability, discriminatory taxation, the absence of a transparent and predictable regulatory environment, and arbitrary and inconsistent interpretation and enforcement of laws further contribute to problems for the business community and foreign investment.[23]

Political reforms designed to address corruption in central government bodies have decentralized fiscal powers to provincial and local governments, and this has potential implications for business and investment, as well as environmental policy. Weak regional governance and administration is a major challenge, given that there are some 353 districts and thirty provinces now responsible for key public services.

Labor-intensive agriculture and resource extraction still characterize Indonesia's economy, with regulatory controls varying by sector. Regulatory controls and export restrictions, for example, have done little to address the forestry sector's problems, including over-exploitation.

Trade Policies

Indonesia has liberalized tariffs beyond its multilateral commitments. Many of its bound rates, however, remain considerably higher than the applied duties, especially in agriculture, where 1,341 tariff lines have bindings at or above 40 percent.[24] Pronounced escalation is also apparent for semi-processed products in the food, beverage, and tobacco industries, among others. In the Doha negotiations, Indonesia has been advocating special products exemptions from tariff reductions for rice, sugar, soybeans, and corn.

Indonesia also maintains a number of import barriers to food products and raw materials, including import licensing, de facto quotas and prohibitions, and food labelling requirements. In 2004 the government temporarily banned imports of rice, sugar, and salt to prop up prices for domestic producers. Only designated private companies and the National Logistics Agency (Bulog) are permitted to import sugar and certain other basic commodities. The five companies currently designated for sugar are also told how much they are allowed to import.

Sugar in Indonesia

Indonesia has been a net importer of sugar since the 1960s and in recent years has imported 40-50 percent of its needs. Consumption in 2005/06 was estimated at just under 4 million tons. In 2003 the government initiated a program to become self-sufficient in sugar because consumption double the rate of production was expending costly foreign exchange earnings. The target date at this time is 2009, and there has been some progress toward meeting that target.

According to USDA, there are about 375,000 hectares of sugarcane currently under cultivation. The Elobeid and Beghin model implies an increase of about 126,000 hectares due to trade liberalization, i.e. about a one-third increase from today's levels.

Most sugar is currently produced in Java, with the rest cultivated in Sumatra, Kalimantan, and Sulawesi. More than half of Java's sugarcane was irrigated in the mid-80s, but other crops, livestock, and urbanization have replaced sugar in some areas. There has therefore been a shift in the cultivation of sugarcane to non-irrigated areas and to poorer lands. Rice is the major competitor with sugar in Java. Future expansion of sugarcane cultivation will most likely take place outside Java for these reasons. Where plantations still rely on rainfall for their water supply, they face water shortage problems during the dry season.
Sugarcane is cultivated in Indonesia primarily by small and medium-sized farmers, although they are typically organized in groups responsible for at least twenty hectares of land. Production has been relatively inefficient, as has been government policy, which is split among four different ministries: Agriculture, Trade, Industry, and Finance. Indonesia's inefficiencies in the sugar sector are attributed to the dominance of extended ratoon cropping, suboptimal input use, and inefficient harvesting and transport systems. Palm sugar, made from the sap of the sugar palmyra palm, has been proposed as an alternative to sugarcane. However, while this could potentially lead to some use of currently unused oil palm land allocations, it is not seen as having high-volume production potential.

6.2.2 Environment

ESI Rating

The ESI gave Indonesia a very bad rating on air quality, a slightly bad score on greenhouse gas emissions, a slightly lower than neutral one on biodiversity (worse than the neutral rating for its peer group), a moderately good score on land, an extremely negative score on water quality, an almost neutral score on reducing air pollution, and a negative score on environmental governance.

Expansion in Sugarcane Acreage

The sugar sector has been a troubled one in Indonesia for some time, but so far it has not encountered charges that it is a mass polluter. However, with the challenge of meeting Indonesia's own needs, and with biomass energy production an increasingly important possibility for Indonesia and the rest of the world, expansion of cane planting is a real possibility. Sugar production is attracting some new investment, and expanded acreage could become a reality in the next decade. One investment advisor is quoted as estimating that "Vast areas are available for sugarcane plantations in Indonesia's eastern region such as in Buru Island, Seram, and Papua. At least 1 million hectares of land suitable for sugarcane plantations are available in Merauke alone."[25]

This raises the issue of whether expansion of plantings on a large scale can be handled in a sustainable manner. There is certainly no question that Indonesia has a lot of available land, but land that was not in crops was probably not in crops for a reason. In 2005, the Ministry of Agriculture identified 286,000 hect-

ares of land in Lampung (Sumatra) and Merauke (Papua province) as adequate to develop cane fields and establish sugar factories. This is more than double the model increase of 126,000 hectares. In March 2006, the Jakarta Post reported that the provincial administration of West Java plans to open an 18,000-hectare sugarcane plantation and create some 20,000 jobs in the Garut regency. Planting was expected in 2006, with the first harvest in 2007.

Processing Expansion

The Indonesian government's sugar self-sufficiency program, which includes the replanting of fields, updating of the state-owned factories, and developing cane plantations and establishing sugar mills outside Java, also carries with it some potential for spreading adverse environmental effects of sugar processing facilities. Important as well is the proposal to move the industry from densely populated and land-scarce Java to other areas. Currently, only twelve mills are located outside Java, compared to forty-six in Java.

Regulatory Structure and Enforcement

Weak environmental enforcement, in part due to government restructuring, and lack of well-defined property rights are major problems that will likely contribute to continuing loss of habitat and biodiversity, and to lower soil, air, and water quality in the absence of effective policies designed to reverse these trends. In the matrix, Indonesia is marked down in these categories.

However, sugar expansion has not yet been the proximate cause of the conversion of forest lands that have led to biodiversity loss and soil and water degradation. Continuation of illegal logging, which has been taking place for some time, has exacerbated these problems.

Decentralization, reliance on private sector largesse and voluntary compliance, lack of regulatory infrastructure, and multiple regulatory layers all appear to be factors in Indonesia's weak environmental governance. Although Indonesia is a party to numerous international or regional environmental treaties, including the Kyoto Protocol, it continues to face major environmental problems that include rapid deforestation, air pollution (caused by motor vehicles), water pollution, and carbon emissions.

As noted above, implementation of Indonesia's environmental policy is constrained by fragmentation of information; various Ministries, such as Mines and Energy, Agriculture, Forestry, and Public Works collect data, but these are not cross-referenced. Lack of enforcement power is another constraint. The Environmental Impact Management Agency (BAPEDAL) has no enforcement powers, but relies on voluntary compliance by industry with its environmental programs (e.g., Clean River Program, Blue Sky Program, Cleaner Production Program).[26]

Indonesia's problems of enforcement are most apparent in its inability to adequately control wildfires. A ban on burning practices by the government in 1997 has been relatively ineffective, and fires that burn in Indonesia regularly have been known to blanket the country and its neighbors in haze.

Social Impacts

Sugar production in Indonesia was a welcome source of jobs when the sector was strong, but cutbacks to the sector in the reforms following the Asian economic crisis provoked massive discontent among farmers

suddenly exposed to competition at world sugar price levels. The resulting downsizing of the sugar industry in Java angered farmers and caused them to switch to other crops.[27] Labor unrest has also been a problem in recent years, with allegations of union-busting and other unfair labor practices at sugar mills. However, the sector could still be an important source of jobs in rural areas where jobs are scarce, and increased domestic production would be welcome in terms of meeting consumption requirements.

The Matrix for Indonesia

	Explicit Distortions/Policy Measures					Implicit Distortions		
Environmental Effects	Ethanol	Market Access – Tariffs/ Quotas	Non-tariff Barriers	Domestic Support	Export Subsidies	Externalities (e.g., envtl. enforcement, defined property rights)	Non-pollution Externalities: environmental	Pollution Externalities
Soil Erosion/Quality	-	-		-	-	-		
Air Quality	-	-		-	-	-		-
Water Quality	-	-		-	-	-		
Loss of Habitat/ Biodiversity	-	-		-	-	-	-	
Social Impacts	+	+		+	+	-	-	-

Indonesia is a comparatively high cost producer of both sugar and ethanol. Therefore, while trade liberalization and growth in fuel ethanol production will affect the world sugar price, Indonesia will mostly focus on becoming more self-sufficient and sugar production will very likely increase. The degree to which this will affect sugarcane planting for ethanol likely depends on whether world sugar and oil prices continue to be linked, and continue to rise. Indonesia's net contribution to biofuels will most likely continue to be through palm oil, for which plantings are already increasing. Indonesia therefore rates a minus across all the environmental categories, including biodiversity, for its projected increase in sugarcane acreage, even though it will for the most part not be for ethanol production.

Indonesia will also not be a likely sugar exporter in the near term even if distortions in the international sugar market are significantly eliminated. But acreage will increase, with a consequent minus for air quality, because of burning of cane residue, and for biodiversity, because new plantings will likely be on outer islands rather than Java, and a plus for increased employment.

Indonesia's notable lack of environmental enforcement capability and its eagerness for foreign direct investment to expand agricultural production warrant an emphatic minus in most of the environmental categories. However, the social impact will be mitigated by increased employment. In terms of its non-pollution environmental externalities, the geophysical properties of Indonesia environmentally support sugarcane cultivation, but the manner in which it is conducted will likely lead to some deterioration of the physical environment. Internal distribution system problems (producing on other islands for transport to Java) would also discourage production. This may well be a plus environmentally, but a social negative. Indonesia's pollution externalities are potentially very high for air quality and if large amounts of cane are burned this will add to the problem. Likewise, sugar processing will add pressure to ecosystems already under stress.

6.3 China

6.3.1 Economy and Trade

China does not have a specific sugar support program or market price objective, but it does intervene in the market in a variety of ways to influence supply and demand. Historically the central government controlled imports directly. As one of the conditions of admission to the World Trade Organization in 2001, China agreed to a tariff rate quota for sugar. For the first year, the quota was 1.764 million metric tons, with an in-quota duty of 20 percent and an over-quota duty of 75 percent. As of 2006, the TRQ is 1.945 million tons with an in-quota duty of 15 percent. Sugar outside the quota is subject to a 50 percent duty.
Much of China's sugar market remains controlled by state trading companies. In 2003, LMC International estimated that they accounted for 70 percent of domestic sugar sales, that private traders accounted for 20 percent, and that direct sales by factories to end users accounted for the remaining 10 percent. State trading companies are also assigned the majority of the import quotas, currently 70 percent. Whether and when they can use those quotas is also subject to government influence. And some of that sugar is just imported as raw sugar, processed, and re-exported as refined sugar, with no net impact on the domestic market.

The central government also maintains strategic reserves of sugar which it releases to the market to counter rising prices. It did so in 2001 and again used that tool in 2006, auctioning 184,000 tons in January and an additional 368,000 tons in April and May.

China's main sugarcane producing provinces are Guangxi, Yunnan, and Guangdong. Although China also has sugar beet production in the northeastern and northwestern regions, it is not as significant, amounting to less than 10 percent of sugar production. Beet production has also diminished over the past decade as other crops have brought higher returns. These include corn, soybeans, cotton, and tomatoes. As the price of sugar increases in the domestic and international markets, however, sugar production in China is likely to increase in both cane and beet growing regions. Like farmers everywhere, those in China respond quite quickly to market signals. For a map of sugarcane growing areas in China, see Appendix B. For a map of sugarbeet growing areas, see Appendix C.

Sugar production is already increasing in China. A survey conducted by China's National Bureau of Statistics in more than 800 counties at the end of February 2006, showed that the country's sugar-cropping areas will reach 1.65 million hectares (ha) in 2006, 5.8 percent or 90,000 ha more than in 2005, of which sugarcane-growing areas will expand by 66,670 ha, up 5.2 percent over 2005 and beet-growing areas will increase by 20,000 ha, up 9.5 percent.[28] The agricultural department of south China's Guangxi Zhuang Autonomous Region predicted that the regional sugarcane-growing areas will reach 796,670 ha in 2006, up 10 per cent or 72,400 ha more than in 2005.

Recent price increases for sugar have enhanced its viability as a crop, especially in marginal areas. In Guangxi, the local agricultural department estimates that 90 percent of the sugarcane is planted on hilly land not suitable for rice production.[29] But when prices are high, farmers use irrigated rice paddies for cane, doubling yield over non-irrigated land to up to 165 MT/ha.

The Elobeid and Beghin study implied a 176,000 hectare increase in sugarcane in China as a result of trade liberalization (assuming all the impact is on cane rather than beet). This would be almost a 10 percent increase on top of this year's estimated area and would undoubtedly push cultivation on to marginal and less suited land.

Whether sugar crop production in China will be directly affected by fuel ethanol markets remains to be seen. China has subsidized ethanol production from maize for several years in an effort to address air pollution problems in urban areas that will be hosting the Olympics in 2008. The economics of using sugarcane for this purpose are less favorable but not insuperable. China's beet and cane sugar industries stayed in business during 2002 and 2003 when wholesale sugar prices were only about US $0.15 per pound, although production did decline. Wholesale prices have since doubled, but countries that can produce white sugar for $0.15 per pound can also competitively produce fuel ethanol if the right government policies are in place.

6.3.2 Environment

ESI Rating[30]

The 2005 ESI Report gave China a very poor rating on air quality, almost neutral on biodiversity, positive on land use, and somewhat negative on water quality and quantity. Natural resource management was rated as somewhat poor, as was environmental governance. China got its worst score on reducing transboundary environmental pressures.

Agricultural Pollution in China

Agriculture does not rank as high as manufacturing as a polluter in China, but environmental consequences of intensive agriculture include serious impacts on biodiversity, soil erosion, water pollution, and pesticide pollution and widespread use of poor quality fertilizers and poor waste management. China's agricultural development in recent years has emphasized food self-sufficiency and intensive, target-related production without incentives for sustainable production practices. This has increased the intensity of resource use and the intensity and scale of its environmental problems. Combined with rising affluence and a shift of food preferences to those that are less efficient in terms of resource management (e.g., livestock, swine, and poultry), continued development of the agriculture sector will lead to further pressure on China's environment as its population grows. Indeed, China's environmental problems in the agriculture sector are severe enough that they are considered capable of curtailing much of this development potential.

People's Daily Online reported in 2000 that more than 130,000 hectares of farmland have been damaged by industrial solid waste, over 5.3 million hectares of land are affected by air pollution, 7.3 percent of the country's irrigated farmland has been harmed by polluted water and 93 million hectares of farmland have been contaminated by pesticides. Desertification is also taking place on grassland, now estimated at 2.62 million square kilometers and expanding at more than 2,400 square kilometers per year.

Water use is an urgent problem for agriculture. China has experienced serious water shortages over the past two decades. According to the Worldwatch Institute, average annual flows in the Yellow, Huai, and Hai Rivers have dropped by 10-40 percent. Declining water quality is leading to reduced supply as well, even in water-rich areas. According to a recent report on the country's current status of water resources funded by the Chinese Ministry of Science and Technology, water shortages in China cause direct economic losses averaging 280 billion yuan (US$35 billion) each year, 2.5 times more than the figure caused by floods. Social unrest over pollution, including both pollution from agricultural industries and pollution affecting agriculture, is increasingly common, as residents become better informed about environmental pollution and hopeful that protest will help to resolve problems stemming from it.

Environmental Projections

As China is already the world's fourth largest sugar producer, the environmental effects of increased cane production in China could be significant. Sugarcane remains the most reliable income for some farmers, particularly those on marginal lands unsuitable for fruit and vegetable planting. Most important to sugar production, China's per capita water resources are only 22 percent of the world average. Increased sugar production, therefore, has the potential to make serious inroads on sustainable use of water in China.

In 2004, according to the Worldwatch Institute[31], agricultural uses totaled almost 359 billion cubic meters of water in China, 65 percent of total national use. Of this, some 323 billion cubic meters, or 90 percent, went to farmland irrigation, according to China's Ministry of Water Resources. Most of China's fields use flood irrigation methods that can result in significant waste, with one hectare of farmland typically requiring 20,000–30,000 cubic meters of water a year.

Agricultural and Environmental Regulatory Structure

The transition of China's economy from a centrally planned system largely closed to international trade to a more market-oriented economy with a rapidly growing private sector has made it a hugely influential player in the global economy, particularly with respect to its increased need for natural resources. The agriculture sector reflects all of these changes. Since collectivized agriculture was phased out in the late 1970s, China has also liberalized prices, decentralized finance, increased autonomy for state enterprises, founded a diversified banking system, developed stock markets, grown its private sector, and opened its economy to foreign trade and investment. This has resulted in economic development that has generally been more rapid in coastal provinces than in the interior, and in large disparities in per capita income between rural and urban regions. China is at present challenged to sustain adequate job growth for millions of workers no longer needed by state-owned enterprises, for rural migrants to urban centers, and for new entrants to the work force. There is also a need to control the corruption accompanying widespread economic change and contain the associated environmental damage while maintaining social control.

China's agricultural and environmental policies are centrally controlled, but regionally and locally administered. This has led to a host of conflicting and unfunded mandates at local level, ranging from disproportionately high rates of taxation on rural farmers to lack of enforcement of sanitary and phytosanitary and environmental regulations. In addition, the vagueness and lack of transparency of some mandates, an inconsistent judicial system, and inadequately trained judges, some unwilling to confront state authorities, make enforcement at provincial level inconsistent and sometimes non-existent. However, efforts to combat the worst environmental and social effects of pollution are ongoing and a host of recent initiatives have been launched to enlarge and modernize the framework of China's environmental regulatory system and to ensure that it is enforced at the local level.

Environmental and Social Law Enforcement

China's constitution assigns to the state the duty to protect and improve the living environment, prevent and control pollution and other public hazards, and ensure the rational use of natural resources. China's recent environmental efforts date from 1992, when the Chinese National Congress adopted environmental protection goals in tandem with economic development strategies. China now has many environmental laws on the books, including a Marine Protection Law, Forestry Law, Mineral Resource Law, Water Pollution Control Law, and Air Pollution Control Law. The basic law is the Environmental Protection Law of 1989, which creates a framework for environmental regulation and gives citizens the right to sue polluters. The Environmental Impact Assessment Law of 2005 requires the government to conduct environmental reviews

of major development projects and hold public hearings. These laws are administered by China's Environmental Protection Agency (SEPA), which was elevated to Ministerial rank in 1998.

China has recently promulgated a host of other laws and regulations, including a Protected Areas Law to cover the protected areas now accounting for 15 percent of China's territory, and a new regulation on water management that updates the system of use permits and stipulates charges for water consumption in agriculture. This is expected to enforce water-saving measures in irrigation and motivate farmers to economize on water use. The regulation was to take effect in April 2006. According to the Worldwatch Institute, the new regulation could affect agricultural production by imposing extra costs on farmers, but use within a certain quota is also not charged, which will exempt a large number of individual producers.[32]
Finally, China has issued a call to conserve energy resources. The new five-year plan calls for a 20 percent reduction in energy consumption per unit of GDP by 2010 and an estimated 45 percent increase in GDP by 2010. The plan states that conserving resources and protecting the environment are basic goals, but does not include details on the policies and reforms necessary to achieve these goals.

Social Changes

It was estimated in 2004[33] that from 100 to 150 million surplus rural workers in China were adrift between the villages and the cities, many subsisting through part-time, low-paying jobs. Other statistics include a 4.2 percent official registered unemployment rate in urban areas in 2004 and substantial unemployment and underemployment in rural areas. An official Chinese journal estimated the overall unemployment rate (including rural areas) for 2003 at 20 percent. It is also estimated that because of its "one child" policy, China could demographically become one of the most rapidly aging countries in the world.

China's most pressing social problem is the rural economy. A survey on "2004-2005 Social Situation Analysis and Prediction" made by the China Academy of Social Sciences (CASS), as reported in the Peoples' Daily, identified the following as the seven most important social problems:

- Aggravating social contradictions due to loss of farmland (40 million farmers have lost their land in the country);
- Income gap further widened (highest earning incomes almost ten times the lowest);
- Long-term employment outlook (twenty-four million urban people need to work, including 740,000 university graduates who cannot find jobs, with only 9 million new job opportunities);
- Need for poverty-relief work (current rural absolute poverty standard is below 625 yuan per year for each farmer in China, well below the 900-yuan standard of the UN international poverty standard);
- Corruption (China must perfect the anti-corruption system);
- Sustainable development is seriously hampered by resources, energy and environment (pollution of water and atmosphere in some river valleys and cities is very serious with aggravating ecological destruction and land desertification in some regions); and
- Attention should be paid to social and psychological changes in the fast-economic growth period (low-income people are disaffected by increases in basic food prices to 50-60 percent of income and the increasing gap between rich and poor).

Added to this are China's human rights record, as perceived by the international community, and a recent series of rural revolts against state authorities on environmental issues. The latter are a result of the lack of enforcement of environmental laws and regulations, local autonomy and corruption, and the relative lack of a mechanism for private citizens and organizations to seek enforcement of environmental statutes.[34]

Ethanol affects the world price of sugar. However, China is currently making ethanol from corn, subsidizing

The Matrix for China

	Explicit Distortions/Policy Measures					Implicit Distortions		
Environmental Effects	Ethanol	Market Access – Tariffs/ Quotas	Non-tariff Barriers	Domestic Support	Export Subsidies	Externalities (e.g., envtl. enforcement, defined property rights)	Non-pollution Externalities: environmental	Pollution Externalities
Soil Erosion/Quality		-		-	-	-	-	-
Air Quality		-		-	-	-		-
Water Quality	-	-		-	-	-	-	-
Loss of Habitat/ Biodiversity						-		
Social Impacts		+ -		+ -	+ -	-		

production in part because of its intention to show reduced air pollution in urban areas for the Olympics. Sugarcane acreage is increasing in response to higher sugar prices, but there is apparently no plan to use cane for ethanol. China's production costs are mid-range. It therefore rated one negative for water quality because of increased ethanol demand, but other environmental effects were seen as unlikely.

China's sugar sector will not be strongly affected by trade liberalization, except as a result of other exporters' increased access to other markets. Market prices will therefore be the primary drivers for China. China thus netted the same general marks across the three environmental categories but got an extra minus for water use because any increase in cane or beet planting is likely to increase pressure on this resource. Biodiversity was not seen as likely to be influenced by market forces, but increased acreage in sugarcane was seen as a net minus for social impacts because of the human health implications of water shortages. However, a higher price for sugar may keep marginal farmers in business and enhance their ability to remain in rural areas.
It is also possible that as rural incomes rise in China, there will be more environmental awareness and governments at various levels will be able to devote more resources to safeguarding the environment. This has already happened to some degree in urban areas of China.

6.4 Turkey

6.4.1 Economy and Trade

According to World Bank data, agriculture accounts for about 13 percent of Turkey's GDP and half of the nation's land area is classified as agricultural. Turkey experienced a financial crisis and a recession in 2001, but the economy has since rebounded and both economic growth and inflation are at acceptable levels, although unemployment is still high.

Turkey's agriculture has always been highly protected, with a high degree of state ownership, and as the government has begun to pursue admission to the European Union, it has tended to align its agricultural programs with those in the EU. This has been something of a moving target though, as the EU has gone through a series of reforms in various commodity sectors over the past decade. Agricultural exports and imports are about equal at roughly $6 billion in each case. The main exports, which mostly go to the European Union, are fresh and dried fruits, vegetables, tree nuts, wheat flour, pasta, olive oil, tobacco and tomato paste.

Turkey's sugar beet processing industry was once fully owned by the Turkish Sugar Corporation (TSC), a state-controlled entity. As part of a broader privatization process imposed by the International Monetary Fund, Turkey has gradually been moving these beet factories into private hands. Currently TSC still owns twenty-two of the thirty-three beet factories, but their average size is small and TSC only accounts for slightly less than half of the total national sugar production of 2.2 million tons. Five, including one newly constructed, are owned by the Central Union of Sugar Beet Producers Cooperatives (PANKOBIRLIK). The rest are in other private hands.

The objective of Turkey's sugar policy has been self-sufficiency, and this has been achieved through a high level of price support and import barriers. The tariff on sugar is 135 percent, and that is reinforced by an import licensing system that almost never issues an import license.

Sugar policy was legislatively redefined in 2001 to meet IMF obligations. The law established a Sugar Board responsible for establishing production quotas and minimum prices for sugar and sweeteners and a Sugar Authority to administer them. The Board is comprised of four government officials and one representative each from TSC, PANKOBIRLIK, and the starch-based sweetener (SBS) industry. There are seven SBS companies with eight plants. For 2006/07 the production quota for sugar is 2.34 million tons, and it is expected that the SBS quota will again be 351,150 tons. The latter is well below reported capacity of 900,000 tons.

Sugar beets are produced by smallholders in Turkey. According to the Sugar Authority, 336,000 hectares were harvested by 348,000 farmers in 2005/06. Thus the average beet area per farm is less than one hectare. Beets are grown under irrigated conditions in Turkey. It is mostly flood irrigation with four to six applications totaling about 500 mm.[35]

For 2006/07 the Sugar Board announced a procurement price for sugar beet of YTL 89.90 per ton of beets with 16 percent sugar content (about $67). This is 10 percent below the prior season, and it is expected that Turkey will have to eventually match the 36 percent price reduction that the EU is beginning to implement this year as part of its reform of the sugar regime. Official ex-factory prices for sugar in 50-kilo bags are the equivalent of about $0.57 per pound but there has been significant discounting, by as much as 20 percent, due to excessive stock levels. Retail prices are the equivalent of $0.67-0.77 per pound.[36]
Five sugar factories have associated ethanol production capacity, and there is one fuel ethanol plant in the investment stage. Any larger-scale production of fuel ethanol from sugar beets would require a high degree of subsidization given Turkey's beet production costs.

6.4.2 Environment

ESI Rating[37]

The ESI gave Turkey rather negative ratings on water quantity and quality, a neutral one on biodiversity, and weak positives for land use and air quality. Turkey received a strong negative on reducing water stress and weak negatives on managing natural resources and reducing transboundary environmental pressure. On the positive side, Turkey received a very good rating for international collaborative efforts and lesser positive ratings for reducing population stress.

Turkey's Environment

Turkey's environment is characterized by highly diverse ecoregions, four of which are coastal zones, and high rates of endemism in plant species (native plants in many of Turkey's ecoregions grow nowhere else in the world). It has a young population and a high rate of internal migration to non-agriculturally oriented cities, creating major environmental changes as rich agricultural land becomes urbanized. These include salinization, soil erosion, and pollution of surface waters.

Turkey's privatization policies have contributed to environmental problems in some areas where factory closures have also resulted in high unemployment rates. The main state-owned enterprises, of which many are food and agriculture-related (including sugar processing) are said to be some of the country's biggest polluters.[38] Turkey is also a natural energy bridge between the Middle East and Europe, making it an important transit hub for energy supplies via the Bosporus and oil and gas pipelines, and has ratified the Kyoto Protocol on global climate change. It presently uses poor-quality coal for some of its power generation, but is moving toward cleaner energy sources.

The 2002 REC Environmental Report on Turkey's Environment estimated that 83 percent of Turkey's agricultural production suffers from environmental problems, of which soil erosion is perhaps the worst, affecting 81 percent of the total land surface in Turkey.[39] In addition, lack of coordinated management capability has seriously affected Turkey's ability to protect sensitive places, such as the Konya Closed Basin,[40] from the challenges to effective water management posed by intensive agriculture, including the cultivation of sugar beet.

Regulatory Structure

Turkey began to address environmental concerns in the late 1970s, but in 1991 strengthened its ability to coordinate environmental regulation by establishing a Ministry of Environment. This Ministry oversees the Environmental Law of 1982, which governs prevention of pollution and land and natural resource management, and is based on a Constitutional provision giving the state and the citizens responsibility to protect the environment. Regulations issued under this law include those governing air quality, water pollution, noise control, solid waste, medical waste, hazardous waste, environmental impact assessment, and toxic substances and products.

Turkey is in the process of harmonizing its standards with those of the European Union in preparation for accession. This will result in adoption of the Community "acquis" or body of law. The progress of the negotiations will depend on Turkey's ability to effectively administer its new obligations.

Turkey's laws are administered at the provincial level by appointed governors of 81 provinces, all affiliated with the Ministry of Interior Affairs. Provincial special administrations, municipalities (numbering 3,228 and elected by popular vote every five years), and villages also complete the administrative picture.

Environmental and Social Law Enforcement

Poor control of soil and water contamination and lack of infrastructure for sewage and waste treatment is cited as a problem in Turkey's administration of its environmental laws. In addition, Turkey's forested areas (estimated in 2002 at 27 percent of its land area) are shrinking due to illegal cutting and clearing, illegal settlement and grazing, fires, and pests. Pastures are also declining because of urbanization and poor management, and biodiversity is likewise suffering from rapid development of urban areas, major investment projects (hydropower and power plants), and tourism projects.

It is clear that in terms of both infrastructure and enforcement, improvements are needed. The recommendations of the 2002 REC Review included enhanced enforcement capability, including fines and penalties for non-compliance, clearer definition of law enforcement responsibility, and better environmental information and monitoring.

Turkey's environmental commitments have been receiving substantial attention in the context of its accession to the European Union. The accession instrument provides that "In all areas of the acquis, Turkey must bring its institutions, management capacity, and administrative and judicial systems up to Union standards, both at national and regional level, with a view to implementing the acquis effectively or, as the case may be, being able to implement it effectively in good time before accession. At the general level, this requires a well-functioning and stable public administration built on an efficient and impartial civil service, and an independent and efficient judicial system."
Considerable assistance is in process to enable Turkey to meet these commitments. This includes training in environmental management, environmental information, and work on sustainable agriculture and tourism, waste management, ecosystem and environmental protection, and development of renewable energy sources.

The Matrix for Turkey

	Explicit Distortions/Policy Measures					**Implicit Distortions**		
Environmental Effects	Ethanol	Market Access – Tariffs/ Quotas	Non-tariff Barriers	Domestic Support	Export Subsidies	Externalities (e.g., envtl. enforcement, defined property rights)	Non-pollution Externalities: environmental	Pollution Externalities
Soil Erosion/Quality								
Air Quality								
Water Quality		+		+	+			
Loss of Habitat/ Biodiversity								
Social Impacts		-		-	-			

Since sugar production is likely to decline in Turkey as a result of trade liberalization, and since the cost of producing fuel ethanol from beet in Turkey is comparatively high, area planted to sugar beets will decline. The question, then, is whether the environmental impacts of other crops in the current rotation, like corn, wheat, and sunflower, are better or worse than those from beets. The main difference is probably the volume of irrigation required, so from that perspective a decline in beet area is an environmental plus because of its comparatively high water requirement. A decline in the number of beet factories would also have positive environmental impacts, but these would be offset to some degree by processing associated with increased output of other crops.

Sugar beet is comparatively labor intensive and is also a cash crop with a payment guaranteed by the factory. Loss of that economic option for farmers would have adverse social impacts.

6.5 Conclusions

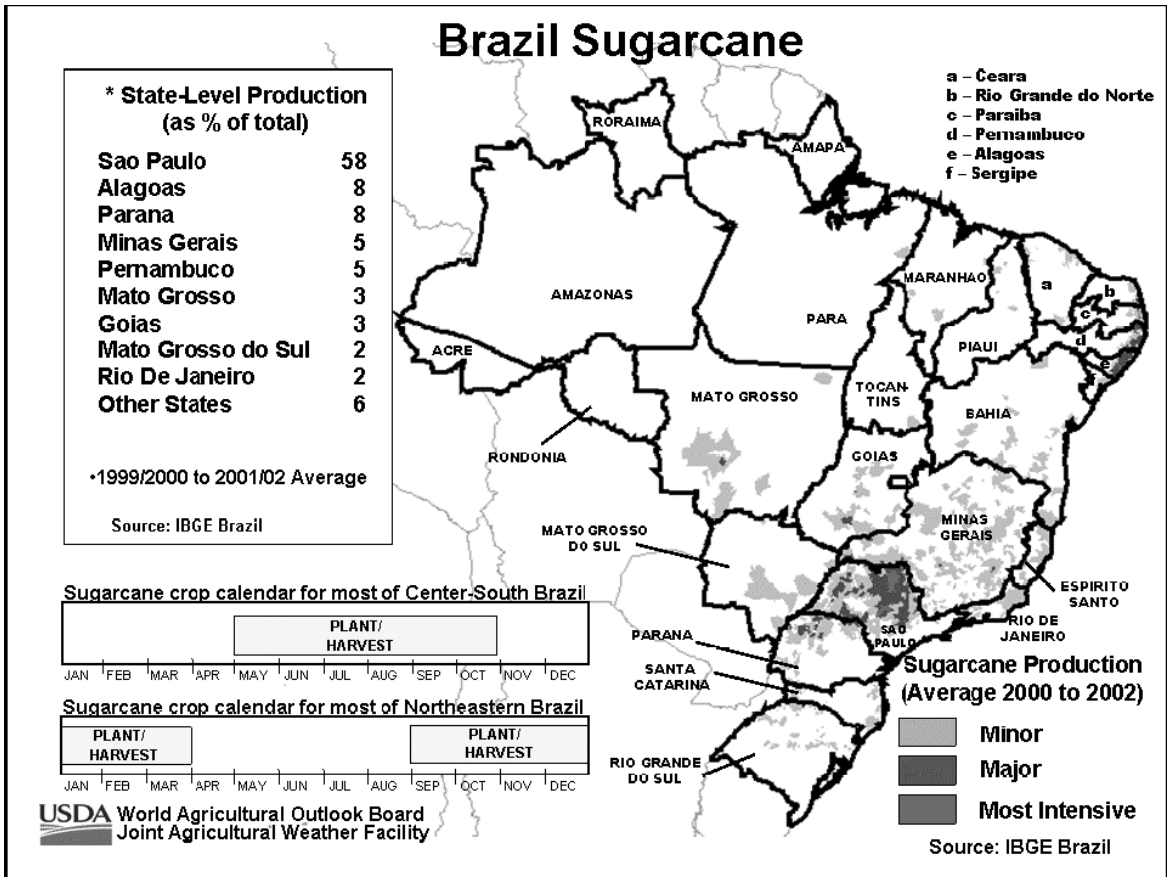
As in the case of oilseeds, the effects of trade liberalization on production of sugar crops, and thereby on the environment, are likely to be overwhelmingly influenced by developments in energy markets. High demand for renewable biofuels like ethanol is expected to sharply increase production of sugarcane and might also modestly affect production of sugar beets.

The matrix approach used in this paper to assess the environmental impacts of sugar trade liberalization and rising demand for energy crops is not a fine-edged tool. This makes it difficult to compare results for the few countries reviewed as case studies. Nevertheless, some common themes do emerge:

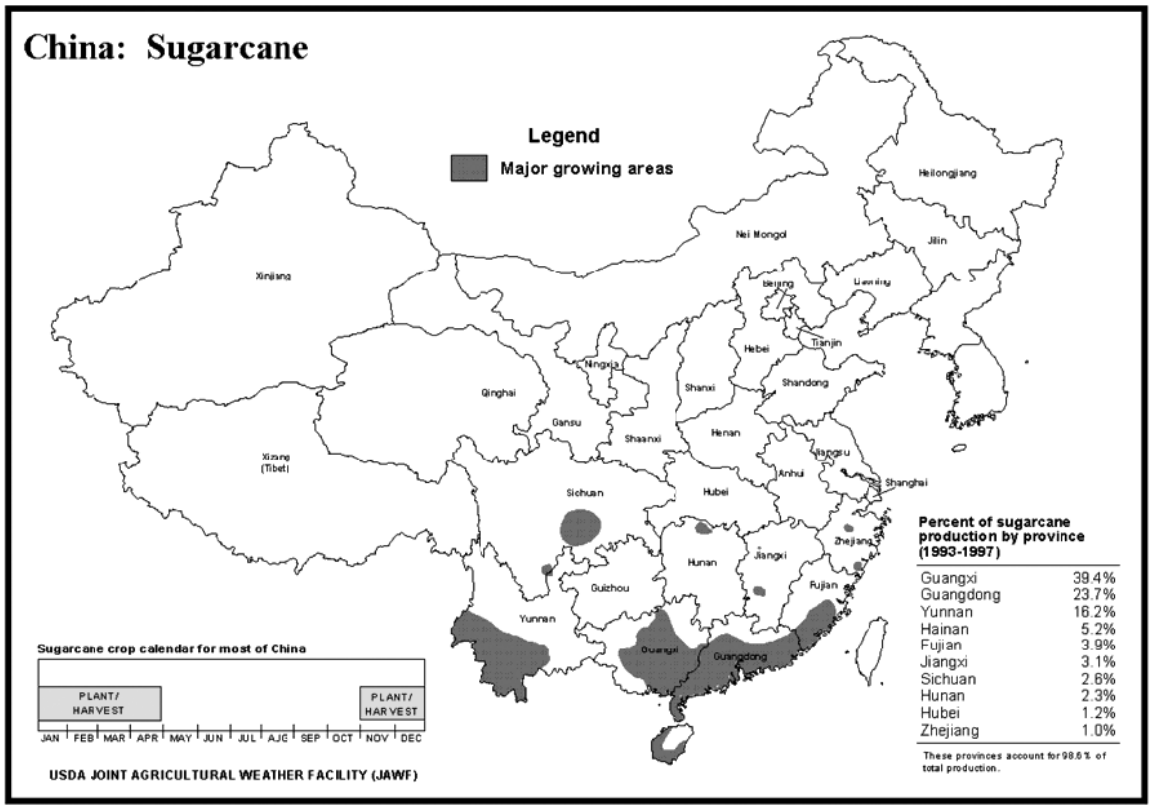
- **This will mostly be a sugarcane issue** because sugar beets generally have a higher cost of pro duction that limits their fuel ethanol potential, and trade liberalization will reduce subsidized produc tion of sugar beets in industrial countries.
- **Resource endowments are of critical importance** for assessing environmental outcomes. The availability of suitable land and an adequate water supply is the key to expansion of sustainable sugarcane production. Of the three cane countries discussed, Brazil is best endowed and China is least.
- **Enforcement of existing environmental laws and regulations is needed**; such action is more important than developing new environmental rules. Enforcement is weak in all three cane coun tries, and unless that changes, the environmental impacts of expanded sugarcane production could be worse than we have portrayed.
- **Technological advances could ameliorate some of the anticipated adverse environmental impacts**.
- **The net effect of biofuel production is uncertain**, considering the potential environmental conse quences analyzed in this paper. In other words, the trade-off of the net positive effect on air qual ity of substituting ethanol for petroleum transportation fuels, for the net negative effect of expanded crop production is an uncertain calculation.
- **The social pluses of increased employment probably more than offset any social negatives** from displacement of indigenous populations and a shift from diversified cropping to sugarcane monoculture.
- **Improved economic prospects in developing countries may lead to more environmental awareness** and increased public and private activity to safeguard the environment.

It will be important to monitor the shifting production patterns of sugar crops and their environmental im-pacts over the next few years. This is a task that both governmental and non-governmental organizations can share.

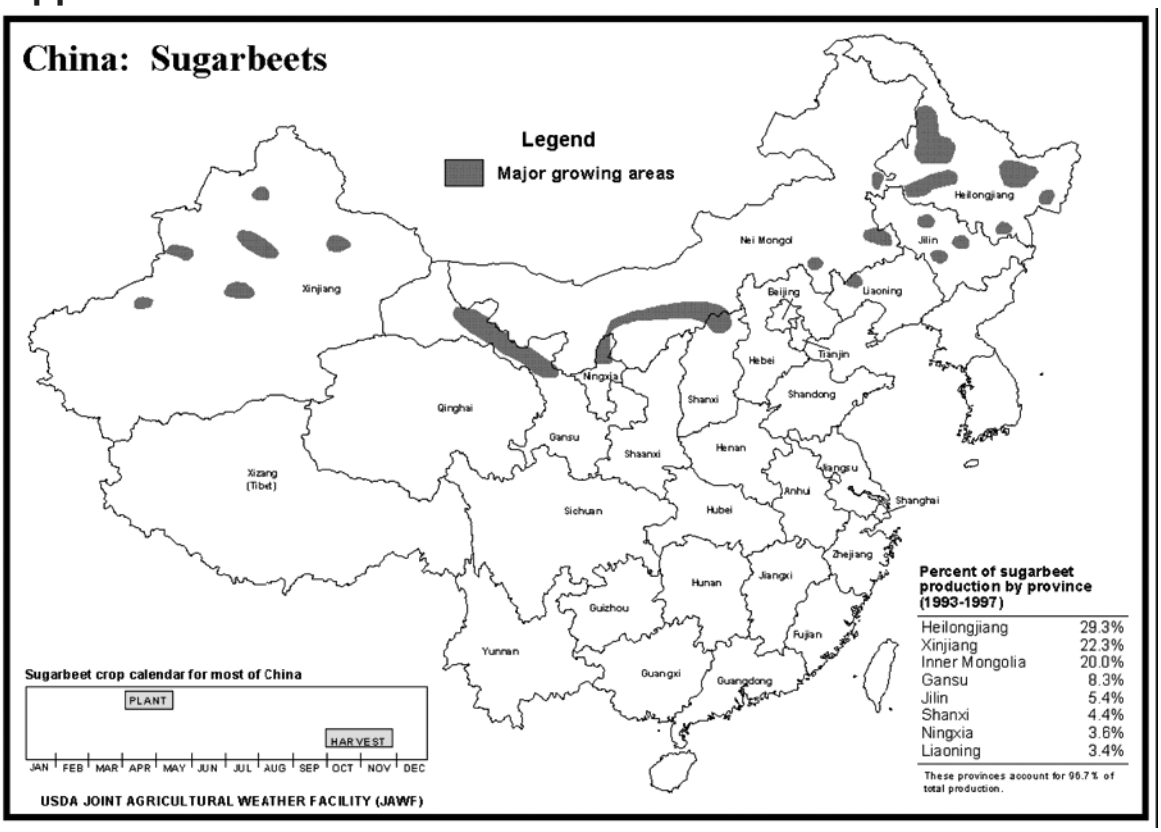
Appendix A


Brazil Sugarcane
* State-Level Production
(as % of total)
Sao Paulo 58
Alagoas 8
Parana 8
Minas Gerais 5
Pernambuco 5
Mato Grosso 3
Goias 3
Mato Grosso do Sul 2
Rio De Janeiro 2
Other States 6
•1999/2000 to 2001/02 Average
Source: IBGE Brazil
a – Ceara
b – Rio Grande do Norte
c – Paraiba
d – Pernambuco
e – Alagoas
f – Sergipe
RORAIMA
AMAPA
AMAZONAS
PARA
MARANHAO
PIAUI
ACRE
MATO GROSSO
TOCAN-TINS
BAHIA
RONDONIA
GOIAS
MINAS GERAIS
MATO GROSSO DO SUL
ESPIRITO SANTO
RIO DE JANEIRO
SAO PAULO
PARANA
SANTA CATARINA
RIO GRANDE DO SUL
Sugarcane Production
(Average 2000 to 2002)
Minor
Major
Most Intensive
Source: IBGE Brazil
Sugarcane crop calendar for most of Center-South Brazil
PLANT/ HARVEST
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
Sugarcane crop calendar for most of Northeastern Brazil
PLANT/ HARVEST
PLANT/ HARVEST
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
USDA World Agricultural Outlook Board
Joint Agricultural Weather Facility

Appendix B


China: Sugarcane
Legend
Major growing areas
Heilongjiang
Nei Mongol
Jilin
Xinjiang
Liaoning
Beijing
Tianjin
Hebei
Ningxia
Qinghai
Shanxi
Shandong
Gansu
Shaanxi
Henan
Xizang (Tibet)
Jiangsu
Anhui
Shanghai
Sichuan
Hubei
Zhejiang
Hunan
Jiangxi
Guizhou
Fujian
Yunnan
Guangxi
Guangdong
Sugarcane crop calendar for most of China
PLANT/ HARVEST
PLANT/ HARVEST
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
USDA JOINT AGRICULTURAL WEATHER FACILITY (JAWF)
Percent of sugarcane production by province (1993-1997)
Guangxi 39.4%
Guangdong 23.7%
Yunnan 16.2%
Hainan 5.2%
Fujian 3.9%
Jiangxi 3.1%
Sichuan 2.6%
Hunan 2.3%
Hubei 1.2%
Zhejiang 1.0%
These provinces account for 98.6% of total production.

Appendix C


China: Sugarbeets
Legend
Major growing areas
Heilongjiang
Nei Mongol
Jilin
Xinjiang
Beijing
Liaoning
Tianjin
Hebei
Ningxia
Shanxi
Shandong
Qinghai
Gansu
Shaanxi
Henan
Jiangsu
Xizang (Tibet)
Anhui
Shanghai
Sichuan
Hubei
Zhejiang
Hunan
Jiangxi
Guizhou
Fujian
Yunnan
Guangxi
Guangdong
Sugarbeet crop calendar for most of China
PLANT
HARVEST
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
USDA JOINT AGRICULTURAL WEATHER FACILITY (JAWF)
Percent of sugarbeet production by province (1993-1997)
Heilongjiang 29.3%
Xinjiang 22.3%
Inner Mongolia 20.0%
Gansu 8.3%
Jilin 5.4%
Shanxi 4.4%
Ningxia 3.6%
Liaoning 3.4%
These provinces account for 96.7% of total production.

Endnotes

[1] Jane Earley, Thomas Earley and Matthew Straub "Specific Environmental Effects of Trade Liberalization: Oilseeds", IPC Issue Brief No. 16, Washington, DC: International Food & Agricultural Trade Policy Council, October 2005.

[2] For industrial purposes, ethyl alcohol is mainly used in solvent applications (toiletries and cosmetics, paints, lacquer thinners, print ing inks, dyes, detergents and disinfectants, and pharmaceuticals) and as a chemical raw material for the production of ethyl acry late, glycol ethers, ethylamines, ethyl acetate and acetaldehyde. Denatured ethyl alcohol accounts for over 90 percent of the industrial alcohol produced in the US and is available in synthetic and fermentation grades. In the US, most industrial uses of alcohol are mature with demand growth projected at minimal rates. The use of alcohol for solvent purposes faces continued regulation as a volatile organic solvent or VOC.

[3] MTBE is methyl tertiary butyl ester, a widely used oxygenate that has now beet withdrawn because it accumulates in and contaminates groundwater supplies.

[4] UNICA, "Brazil's Sugar and Ethanol: Energy and Environment Commodities," May 2004.

[5] Ibid, page 48.

[6] "Sugar: the impact of reforms to sugar sector policies, a guide to contemporary analyses", FAO Trade Policy Technical Note No. 6 on issues related to the WTO negotiations on agriculture, undated.

[7] Amani Elobeid and John Beghin, "Multilateral Trade and Agricultural Policy Reforms in Sugar Markets", Working Paper 04-WP 356, Center for Agricultural and Rural Development, Iowa State University, September 2005 (Revised).

[8] Dixon, J.A., and M.A. Tutwiler. "Trade, Agriculture and the Environment: The sustainability of free and more open markets." Wash ington, International Food & Agricultural Trade Policy Council Discussion Paper, 2004.

[9] Malunga observes that "after six years of reductions on Amber box subsidies as per the Uruguay Round decisions, developed countries still retained about 80 percent of their original domestic support and export subsidies. The 3 boxes are extensively used by countries with high domestic support, and rather than true reductions, support is often shuffled or redefined so as to fit into boxes that are not subject to reductions."The Impact of Export Subsidies on the Environment, Vincent G. Malunga for the Interna tional Center for Trade and Sustainable Development, at http://www.ictsd.org/dlogue/1999-02-10/MALUNGA.pdf.

[10] Idem.

[11] Comments by New Zealand, as reported in WTO, Trade and Environment News Bulletin, May, 1996 available at http://www.wto.org/english/tratop_e/envir_e/te009_e.htm.

[12] CUTS briefing paper, "Tariff Escalation, A Tax on Sustainability," Dr Basudeb Guha - Khasnobis, Assistant Professor, Indira Gandhi Institute of Development Research, Bombay, INDIA, January 1998, Number 1, at http://www.cuts-international.org/1998-1.htm.

[13] Property Rights and Environmental Remedies, Richard O. Zerbe, Jr., Professor of Public Affairs and Adjunct Professor of Law, University of Washington, Washington Policy Briefs, March, 1999, at http://www.wips.org/Environment/PBMisfeldtEnvironmentSalmon.html.

[14] 2005 Environmental Sustainability Index, Benchmarking National Environmental Stewardship, Yale Center for Environmental Law and Policy, Yale University, available at www.yale.edu/esi.

[15] Jason Clay, "World Agriculture and the Environment, A Commodity by Commodity Guide to Impacts and Practices", Island Press, 2004.

[16] USDA Foreign Agricultural Service, "Brazil Sugar Annual 2006", April 10, 2006.

[17] http://www.ers.usda.gov/Briefing/Brazil/domsupport.htm on March 29, 2006.

[18] "Environmental Sustainability Index (ESI): Benchmarking National Environmental Stewardship." Esty, D.C., M. Levy, T. Srebotnjak, and A. de Sherbinin, eds. New Haven: Yale Center for Environmental Law & Policy, 2005.

[19] Assessment of the Effects of Sugar Cane Plantation Burning on Daily Counts of Inhalation Therapy, http://www.awma.org/Journal/ShowAbstract.asp?Year=&PaperID=250.

[20] http://www.law.du.edu/elliot/sfeinle/.

[21] http://www.inece.org/newsletter/10/regional_americas.html.

[22] Idem.

[23] USTR. "2005 National Trade Estimate Report on Foreign Trade Barriers." USTR, 2005. Available at http://www.ustr.gov/Document_Library/Reports_Publications/2005/2005_NTE_Report/Section_Index.html.

[24] USTR. "2005 National Trade Estimate Report on Foreign Trade Barriers." USTR, 2005. Available at http://www.ustr.gov/Document_Library/Reports_Publications/2005/2005_NTE_Report/Section_Index.html.

[25] Asia in Focus, http://www.dprin.go.id/ENG/Publication/IndReview/2006/20061302.htm.

[26] This program contains written guidelines for specific industries, such as textiles, electroplating, tapioca, tanning, pulp and paper, palm oil, and gold mining.

[27] http://www.atimes.com/atimes/Southeast_Asia/DI26Ae01.html.

[28] http://news.tradingcharts.com/futures/5/7/77558675.html.

[29] GAIN Report CH5031, Foreign Agricultural Service, U.S. Department of Agriculture, April 10, 2005.

[30] "Environmental Sustainability Index (ESI): Benchmarking National Environmental Stewardship." Esty, D.C., M. Levy, T. Srebotnjak, and A. de Sherbinin, eds. New Haven: Yale Center for Environmental Law & Policy, 2005.

[31] Worldwatch Institute http://www.worldwatch.org/features/chinawatch/stories/20060314-1.

[32] Worldwatch Institute http://www.worldwatch.org/node/3892.

[33] http://www.odci.gov/cia/publications/factbook/geos/ch.html#Govt.
[34] http://www.oycf.org/Perspectives/8_103100/downside_of_growth.htm.
[35] European Commission MOCA study, Agriculture and Fisheries Unit of the Joint Research Centre (DG-JRC EC) at http://mars.jrc.it/marsstat/Crop_Yield_Forecasting/MOCA/16030900.HTM.
[36] USDA Foreign Agricultural Service, Turkey Sugar Annual 2006, GAIN Report TU6017, 4/18/2006.
[37] "Environmental Sustainability Index (ESI): Benchmarking National Environmental Stewardship." Esty, D.C., M. Levy, T. Srebotnjak, and A. de Sherbinin, eds. New Haven: Yale Center for Environmental Law & Policy, 2005.
[38] "Turkey's Environment, A Review and Evaluation of Turkey's Environment and its Stakeholders," Regional Environmental Center for Central and Eastern Europe, edited by Kerem Okumus, Szentendre, Hungary, May 2002.
[39] Ibid.
[40] Plans for construction of dams and irrigation projects for sugar beet production could irreversibly change the hydrology of the Basin, according to WWF.
[41] http://www.deltur.cec.eu.int/default.asp?pId=4&lang=1&fId=2&prnId=4&hnd=1&docId=672&fop=0.

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The International Food & Agricultural Trade Policy Council (IPC) convenes high-ranking government officials, farm leaders, agribusiness executives and agricultural trade experts from around the world and throughout the food chain to build consensus on practical solutions to food and agricultural trade problems.

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