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ENVIRONMENT AND FOOD SECURITY AT RISK*

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Introduction

BIOFUELS were hailed in the first half of the decade as a green solution to reliance on imported petroleum, and a savior to farmers seeking higher prices for commodities in surplus. But in the second half, biofuels have emerged as real and imminent threats to both environmental quality and food security while being a costly and ill-conceived response to energy concerns. Agriculture and energy ministers will meet at a high level conference at the Food and Agriculture Organization (FAO) in Rome in June 2008. Their meeting is dedicated to world food security and the challenges of climate change and bioenergy. It is thus useful and timely to take stock of the escalating disenchantment with biofuels. This disenchantment revolves around three issues: impacts on the global environment, threats posed to food security in poor nations, and its high-cost path to energy security.

This paper first provides background on the growth and development of the biofuels sector, with emphasis on policies in the U.S., Brazil and the EU—the main producers of ethanol and biodiesel fuels. Many developing countries are also launching their own production capabilities. The conduct of the "big three," and their research and evaluation of biofuel impacts and alternatives, will therefore loom large in determining the industry's future. The second section assesses the impacts of biofuels on:

- Food prices and food security in poor households, especially in food-importing developing countries.
- Economic distortions and unintended consequences of subsidies and mandates to biofuels.
- Environmental and ecological impacts on land use, air and water quality, water quantity, and greenhouse gas (GHG) emissions related to climate change.

The third section considers a variety of responses, and poses the dilemmas of moving from biofuels based on food crops to those based on cellulosic feedstocks with more benign environmental and food security consequences.

Growth and Development of the Biofuels Sector

Investments in biofuels have grown rapidly since 2000, accelerating especially in OECD countries and Brazil after 2003, when oil prices began to climb above $25/barrel to approach $120/barrel in April, 2008. Between 2001 and 2007, world production of ethanol tripled from 18.5 billion liters to almost 60 billion liters, while biodiesel rose from 1 billion liters to 9 billion liters, almost ten-fold. Steenblik (2007) estimated U.S. corn-based ethanol production at roughly 18 billion liters in 2006 followed by Brazil at 17 billion liters of ethanol from sugar cane, and the EU at 1.6 billion liters. Biodiesel, the other major biofuel, is produced mainly in the EU, with 4.8 billion liters of production in 2006, compared with 850 million liters in the U.S.1 World production of ethanol and biodiesel in 2006 was 51 billion liters and 6.5 billion liters, respectively. A growing list of developing countries are beginning to invest in feedstocks for the production of ethanol and biodiesel and are watching both the progress and pitfalls of Brazil, the EU and U.S.

These developments are set against a background of rapid changes in the rural sectors of developing countries driven by urbanization and increasing rural labor shortages, trade integration, and a reversal of secular declines in world grain and oilseed prices. These prices have risen rapidly since 2005 due to growing demands from countries such as India and China and the diversion of food stocks to biofuel use. Rising food and feed prices have been a boon to surplus producers of these commodities. But the combined effect of rising oil and food prices has stressed many developing economies and poor households. Moreover, most of

[1] Ethanol from corn is mainly processed from dried grain to produce denatured alcohol, dried distillers feed grains with solubles (DDGS) and CO_2. Sugar cane-based ethanol converts juice from cane to ethanol and CO_2, using cane residues to heat and distill the ethanol in a process that is half the cost per liter or less than corn-based fuel. Biodiesel fuels involve different technologies which convert oils or fats from soybeans, rapeseed, sunflowers, oil palm, or rendered grease into additives that can be blended with petroleum diesel. These oils are reacted with methanol and potassium chloride to separate the glycerine molecules, which can be sold separately for use in soap or cosmetics.

the 82 FAO low-income food-deficit countries are also net oil importers (Runge and Senauer, 2007). In addition to these trends, growing attention to climate change, greenhouse gas (GHG) emissions, land-use changes and other environmental impacts have focused attention on whether biofuels are a clean and green technology, or seem increasingly brown, contributing to a variety of environmental problems.

The outlook for food, agriculture, and energy suggests that the substantial sums spent in OECD countries to subsidize the biofuels sector are encouraging rapid investments that are consuming a growing share of feedgrains, oilseeds and other crops. In the U.S., which was once a reliable supplier of exported grain and oilseeds for food, biofuels are projected to consume more than 25 percent of record corn harvests in 2007 and as much as 50 percent or more by 2015 even as export demand remains strong, driving prices further upward. In the EU, ethanol and biodiesel are projected to increase oilseed, corn and wheat usage from negligible levels in 2004 to roughly 21, 17 and 5 million tons, respectively, in 2016 (OECD-FAO, 2007).

Government support undergirding the biofuels industry has also grown rapidly; it is fair to say that until oil prices began rising rapidly after 2004, biofuels would have been unprofitable without these subsidies, which in 2006 totaled more than 11 billion dollars in the OECD countries (de Gorter and Just, 2008; Steenblik, 2007). The U.S. leads this list, with over 6 billion U.S. dollars in annual support, followed by the EU with about 4.8 billion U.S. dollars. Brazil has also based its sugar cane-based industry on a variety of indirect subsidies, which have declined in recent years. OECD biofuel supports have expanded since 2005, notwithstanding the rise in oil prices which has had the effect of allowing biofuels to better compete for a share of the energy market.

Five main policy instruments support the biofuels industry in the OECD, apart from the crop price supports that encourage production of feedstocks. The first of these are mandates (sometimes described as "renewable fuels standards"). In the U.S., 2007 energy legislation raised mandated production of biofuels to 36 billion gallons by 2022. The EU set targets for biofuels at 2 percent of liquid motor fuel demand in 2005, and at 5.75 percent by 2010, accompanied by mandatory blending requirements in nine Member States. As a prelude to new mandatory requirements, in January 2007 the European Commission announced new pollution standards for motor fuels based on developing methods to measure the carbon output of different fuels and certification of life-cycle carbon emissions, in recognition of growing concerns over the GHG implications of the biofuels industry.

The second main set of instruments is direct biofuel production subsidies, which also raise feedstock prices. In the United States, blenders are paid a 51-cent per gallon (the subsidy was reduced to 45 cents in farm and energy legislation passed in June 2008) "blender's credit" for ethanol and a $1.00 credit for plant-based biodiesel. These are topped off by additional volumetric credits in many U.S. states. The U.S. corn-based ethanol subsidy was conceived in an atmosphere of $25 per barrel oil and burdensome surplus corn stocks. Today, oil prices are four times higher, and corn surpluses have disappeared, but the policy has not been modulated to reflect these changed circumstances. As a result, the blender's tax credit is not creating new demand but rather paying the equivalent of more than $200 per acre to divert scarce corn from food/feed channels into fuel tanks. India's finance minister recently labeled this policy a "crime against humanity." The EU pays subsidies to turn surplus low-grade wine into alcohol fuel as part of its "crisis distillation" policy.

The third main policy instrument is a tariff on imported biofuel to protect domestic production from competition, such as the 54-cent per gallon U.S. tariff on imported ethanol, designed especially to prevent Brazilian cane-based ethanol (which can be produced at less than half the cost of U.S. ethanol from corn) from entering U.S. markets. The U.S. thus now converts over 30 percent of its feed corn, in which it has a distinct comparative advantage, to ethanol, which the 54-cent per gallon tariff demonstrates has a clear comparative disadvantage vis-à-vis Brazil. The EU's tariff on denatured ethyl alcohol adds 50 percent to the cost of imported ethanol.

Fourth are subsidies for the distribution, storage and transport of biofuels. Ethanol requires distribution, transport and storage to be separate from petroleum fuels because it contains water and is corrosive to petroleum facilities. In order to encourage the construction of biofuels facilities, the U.S. applies a 30 percent "fuel property tax credit" for installing E85 facilities. It also subsidizes flexible fuel vehicles by exempting them from fuel-economy (CAFE) standards. Since the 1970s, Brazil has invested substantial public funds in developing an ethanol distribution network, as well as regulating and encouraging vehicle manufacturers to build ethanol-using engines.

A final set of subsidies to the industry involves public grants to support

R&D into better conversion technologies, notably "second generation" cellulosic biofuels. The U.S. Department of Energy has paid six "pilot" cellulosic plants a total of 385 million dollars to subsidize cellulosic ethanol, a measure of its current lack of competitiveness. It is important to note that despite the 21 billion gallon U.S. cellulosic mandate (part of the 36 billion gallon mandate for 2022), not a single drop of cellulosic ethanol has yet been produced in the U.S. on competitive commercial terms. Since the useful life of most existing or planned corn-based ethanol plants is 15-20 years (U.S. capacity is expected to nearly double due to new plant construction in the next year to close to 14 billion gallons), the incentive to make ethanol from cellulosic feedstocks such as switchgrass largely awaits the corn-based plants vintage end-date, which will occur after the 2022 mandate comes due. And, unless production of U.S. ethanol shifts significantly away from the U.S. cornbelt, the incentive to grow and supply any feedstock but corn (now priced at highs in excess of $6.25/bushel) will be extremely limited.

The combined effect of these subsidies, especially in the U.S. and EU, together with the rapid increases in the price of oil (for which biofuels are a substitute) has been to encourage further expansion of ethanol and biodiesel production capacity. The result: ethanol producers can pay higher and higher prices for feedstocks, illustrated by the record 2008 levels of corn, soybean and wheat prices. While these prices may return to their trend levels at some point (if yield increases and hectares opened to new plantings occur) projections suggest they may go 30-50 percent higher in the short-run, even assuming normal weather and yields.

In developing countries, meanwhile, the ability to pay comparable subsidies to biofuels does not exist. Still, many developing countries such as Angola, Malaysia and Thailand are encouraging ethanol and biodiesel production from sugar cane, oil palm, and cassava. Many more are considering how they can be part of the biofuels boom, and examining whether the employment and rural development opportunities are worth land conversion to supply feedstocks and produce biofuels. In Malaysia and Indonesia, for example, substantial land-clearing is underway to plant oil-palm for biodiesel. Burning tropical forest land to clear it for palm oil production has moved Indonesia to be the third largest carbon emitter, after the United States and China, according to a study presented at a 2006 UN climate change conference.

Biofuels' Untoward Impacts

The impacts of current biofuels trends are playing out against a backdrop in which global climate change is challenging governments to develop plans to mitigate GHG emissions and sequester carbon that would otherwise be released into the atmosphere. For many years, biofuels appeared to offer a cleaner, greener alternative to fossil fuels, and subsidies to the sector were rationalized in part on this basis. However, three potential impacts are sowing doubts over whether negative effects cancel any benefits biofuels may bring.

Careful assessment of these trends has given rise to criticisms from economists, ecologists, NGOs and international organizations, who point to gaps in our state of knowledge and call for additional analysis of biofuels' effects. These involve three main impact areas: (1) food prices and food security in poor households, especially in food-importing developing countries; (2) economic distortions and unintended consequences of OECD subsidies; and (3) environmental and ecological impacts on land-use, air and water quality, water quantity, and global GHG emissions related to climate change.

(1) FOOD PRICES AND FOOD SECURITY IN POOR HOUSEHOLDS

The rapid increase in grain and oilseed prices due to biofuels expansion represents a shock to food prices worldwide. In the OECD countries, the effect has been felt especially in relation to animal agriculture—the beef, pork, poultry, eggs and milk resulting from corn and soybean-derived feeds. In the U.S., the consumer price index for food calculated by USDA increased in 2007 by 4 percent, the highest annual increase since 1990, and is projected to rise in 2008 by another 3.0–4.0 percent. The index of meat prices rose in 2006–2007 by 3.3 percent, poultry by 5.2 percent, eggs 29.2 percent, and dairy products by 7.4 percent.

Price effects were also felt in the processed food sector, where corn, wheat and soybean-derived products are prominent. Food manufacturers including canned and frozen vegetable producers have also felt the transmission effects of these food price shocks. As farmland was diverted from other crops to grow corn (U.S. corn acres expanded by 15 percent in 2007, mainly drawing land away from soybeans and land conservation programs such as the Conservation Reserve Program [CRP]), vegetable processing firms raised the premiums paid to contract growers to keep them from turning to corn. These cost increases will eventually appear in prices for canned and frozen vegetables. In 2008, early planting intentions reports suggest a shift from corn back to soybeans, but also indicate that a larger number of farmers will withdraw land from the CRP.

From 2005 to January 2008, the global price of wheat increased 143 percent, corn by 105 percent, rice by 154 percent, sugar by 118 percent, and oilseeds by 197 percent (Senauer, 2008). In 2006-2007, this rate of increase accelerated, according to the USDA (2008, p. 2) "due to continued demand for biofuels and drought in major producing countries."

In rich, already overfed countries such as the U.S., these shifts fell most heavily on the poorest, who consumed disproportionate shares of processed foods and spent a higher percentage of disposable income on food in general. But it is in poor countries that the price increases posed direct threats to disposable income and food security. There, the run-up in food prices (which the OECD in its ten-year outlook of 2006-2015 identified as a fundamental structural shift) had a double edge. For those producers of corn, soybeans, wheat or cassava with surpluses to sell, higher prices offered new hope and opportunity. But for the over one billion of the world's poor who are chronically food-insecure, they foretold deepening poverty and hunger (Runge, et al., 2003). These are poor farmers in countries such as Bangladesh who can barely support a household on a subsistence basis, and who have little if any surplus production. They are also poor slum-dwellers in Lagos, Calcutta, Manila or Mexico City who produce no food at all. They are net consumers of food, not producers, who spend as much as 90 percent of their meager household incomes just to eat. Food price-induced riots have now occurred in Egypt, Guinea, Haiti, Indonesia, Mauritania, Mexico, Morocco, Senegal, the Philippines and Yemen (FAO, 2007).

Hence, with respect to food security, there is every reason for serious reservations over the current effects of biofuels. The high food prices of 2006 increased the food import bill of the developing countries by 10 percent over 2005. But by the end of 2007, the annual rate of increase was estimated at 28 percent. Because the increase in prices has ocurred mainly in grains, those countries most dependent on grains for their diets have been hardest hit. The USDA (2008) reports that in low-income Asia, grains account for 63 percent of the diet, and in North Africa and the former Soviet republics, 60 percent. In sub-Saharan Africa, the world's most food-insecure region, grains account for 50 percent of the diet, while in low-income Latin America the share is 43 percent. Some countries stand out for their vulnerability to price increases: Bangladesh diets are 80 percent grain-dependent, while in Eritrea and Ethiopia, the share is 70 percent.

The USDA Economic Research Service's Food Security Assessment model of 70 low-income countries estimates the "food gap," which is the "amount of food needed to raise consumption of all income groups to the nutritional requirement of roughly 2,100 calories per person" (USDA, 2008, p. 4). A baseline scenario of the food gap in 2016 assumed a one percent annual food price increase from 2007-2016, resulting in a food gap of 25.2 million tons by 2016. But if the estimated 28 percent grain price increase actually occurring in 2007 is used, followed by a return to the assumed to one percent annual increases thereafter, the shock raises the food gap by eight percent in one year to 27.2 million tons. When broken down by region, Latin America and the Caribbean experience a 24 percent increase, while Asia's increase is 9 percent and sub-Saharan Africa's is 6 percent. Certain countries, such as Guatemala, Honduras and Peru, see food gap increases of more than 20 percent.

The consequences of such a shock, which has already occurred, are also noteworthy in relation to available food aid. Even given the unrealistic assumption that a 28 percent food price increase in 2007 will be followed by a return to one percent increases from 2008-2016, the quantity of food aid donations, which averaged 7.5 million tons a year from 2004-2006, falls to 5 million tons by 2016 with constant spending, covering only 17 percent of the projected food gap, compared with 25 percent coverage in 2006. To maintain the 2006 level of food aid at eight million tons, food aid budgets will need to rise by 35 percent over the next decade (USDA, 2008, p. 6).

If food security and energy security are regarded as analogous efforts to assure a reliable supply, data on the variability of both over the period 1960-2005 suggest that deviations from trends measured by standard statistical indicators offer little reassurance that substituting biofuels for gasoline will result in enhanced energy security. Eaves and Eaves (2007) report that over the 45 years from 1960 to 2005, the standard deviation of U.S. corn yields was 11.9, while the standard deviation of petroleum imports was 6.7, despite the fact that the time period included the Six-Day War, the Arab oil embargo, the Iranian revolution, and the Iran-Iraq war. The data suggest that in one out of 20 years, corn yields will decline by as much as 31.8 percent, while oil imports will decline only 14.9 percent. They conclude: "based on history, by displacing gasoline with ethanol we exchange geo-political risk with yield risk, and history suggests that yield risk is about twice as high" (p. 26-27).

(2) ECONOMIC DISTORTIONS OF BIOFUELS SUBSIDIES

As one set of subsidies for biofuels has been layered on pre-existing ones, and as national subsidies have been joined by state and sub-national supports, their effects are often complex and contradictory. For example, the U.S. credit of 51-cents per gallon is often argued to be offset by the 54-cent per gallon tariff (largely by ethanol producers themselves, who suggest, erroneously, a sort of budget neutrality). The U.S. mandates provided under 2005 and 2007 legislation were laid on top of the blenders credit and tariff and are likely to be joined by further subsidies if new federal farm legislation is approved in 2008.

It is clear that without at least some of these subsidies, ethanol production in the U.S. would not have been viable. But their combined effects, especially the U.S. 36 billion gallon mandate by 2022, have encouraged new construction of ethanol plants. These may be thought less risky than is in fact the case, especially as rising corn prices (the feedstock of 95 percent of U.S. plants) also raise primary input costs (as well as the cost of soybeans, the indirect feedstock for soy-biodiesel). Even with mandates and blenders credits, rising feedstock prices, combined with logistical problems in the delivery of ethanol due to lack of infrastructure, have created gluts and soft ethanol prices. Ethanol investors may also face shortages of capital as the mortgage-lending crisis spills into credit markets generally. A recent analysis by de Gorter and Just (2008) illustrates the substantial losses in welfare resulting from the combined effect of blenders' credits and mandates, and argues that the ironic result is to subsidize U.S. gasoline consumption, exactly the opposite of ethanol's purported intent of reducing reliance on petroleum fuels.

Ethanol also is a very high-cost path to enhanced energy security. First, it consumes fossil fuels in its production, processing and distribution, so its net oil replacement value is only about 30 percent. The exception granted flexible fuel vehicles to encourage E85 usage has probably resulted in a net increase of one billion gallons per year in gasoline use, and its lower energy content drives vehicles fewer miles. Subtracting all of these attributes means that ethanol is actually replacing only about one-tenth of the gasoline implied in the fuel mandates. Moreover, it is a strategy dependent on oil prices remaining high and ethanol subsidies—federal operating subsidies and state and local job-creation subsidies—remaining generous.

The idea of energy independence, even if it were not so heavily subsidized, is also ill-conceived. Just like food security, energy security through self-sufficiency is a very high-cost strategy. National yield fluctuations are much larger than global ones. Alternative energy can be produced more cheaply elsewhere, as evidenced by the 54-cent per gallon import duty. And the energy market is global, requiring global rather than local solutions.

Biofuels policies in the OECD, reliant on both high domestic subsidies and border protection through tariffs, also contradict the goals of the Doha Round to reduce domestic subsidies and expand market access to developing countries. In this respect, they mirror the most distorting aspects of domestic support and protectionist border measures in the farm sector, and discourage developing countries from investing in biofuels as an export-promotion strategy.

(3) ENVIRONMENTAL AND ECOLOGICAL IMPACTS

Perhaps the most salient set of recent criticisms of biofuels policy relates to their local, national and global impacts on the natural environment. At the local level in the U.S., water shortages due to the huge volumes necessary to process grains or sugar into ethanol are not uncommon, and are amplified if these crops are irrigated. Growing corn to produce ethanol, according to a recent study by the U.S. National Academy of Sciences (2007), consumes 200 times more water than the water used to process corn into ethanol, which involves about 4 liters of water per liter of ethanol, compared with 1.5 liters of water per liter of gasoline. The situation is even more ironic in Nebraska, which annually produces over one billion gallons of ethanol. The corn for that production is irrigated from the Ogallala aquifer, which, because of its very low recharge rate, represents "fossil water" the supply of which is steadily diminishing. Local complaints over odors and particulate pollution are also prevalent.

In well-watered areas, such as the cornbelt of the upper midwest U.S., another more serious problem may arise. Corn plantings, which expanded by over 15 percent in 2007 in response to ethanol demands, required extensive fertilization, adding to nitrogen (N) and phosphorus (P) loadings that run off into lakes and streams and eventually enter the Mississippi watershed. This runoff is aggravated by systems of subterranean tiles and drains (98 percent of Iowa's arable fields are tiled) which accelerates field drainage into ditches and local watersheds (Petrolia, 2005). As a result, loadings of N and P into the Mississippi, and hence the Gulf of Mexico, encourage algae growth and eutrophication, starving water bodies in the Mississippi watershed and eventually the Gulf of oxygen needed by aquatic life and enlarging the hypoxic "dead zone." Using data from the U.S. Geological Service, which keeps track of the dead zone, scientists predicted in 2007 that it would expand in 2007-2008 to 22,127 km^2—25 percent higher than the year before and its largest extent since measurements began in 1985 (Turner and Rabalais, 2007).

While Brazil reports ample water supplies for its ethanol industry, and sufficient suitable land to allow continued expansion of cane, land-use pressures elsewhere appear less neutral. In a recent evaluation of forest cover and land use, Righaleto and Spracklen (2007) note that to substitute ethanol and biodiesel for petrol and diesel by 10 percent in the U.S. would require 43 percent of current U.S. cropland for biofuel feedstocks (whether first or second generation). The EU would need to commit 38 percent of its cropland base. Otherwise, new lands will need to be brought into cultivation, drawn disproportionately from those more vulnerable to environmental damages.

Two recent studies focused on the question of carbon loadings and GHG emissions due to land-use shifts resulting from biofuels. Fargione, et al. (2008) argued that if land is converted from rainforests, peatlands, savannas or grasslands to produce biofuels, it will immediately incur a "carbon debt." Estimating the savings on greenhouse gas emissions from biofuels compared to fossil fuels, the authors calculate the time in years necessary to repay this debt. In the case of corn for ethanol, this time is 93 years (48 years if grown on "abandoned" cropland); for soybean biodiesel from rainforest it is 319 years; for palm oil biodiesel 423 years if grown on peatland rainforest. In light of the urgency of actions to confront global warming, this long "payback" to biofuels is disappointing, suggesting that other measures would be far more effective in facing GHG challenges.

Searchinger, et al. (2008) examined how land-use changes for biofuels feedstocks may displace crops previously grown to new areas which then require further land-use conversions. Using a worldwide agricultural model to estimate emissions from these land-use changes, corn-based ethanol nearly doubles greenhouse emissions over 30 years, and increases greenhouse gases for 167 years. Biofuels from switchgrass, if they force crops onto other land, may increase greenhouse gas emissions by 50 percent.

A third study emphasizes the links from the heavy applications of nitrogen needed to grow expanded feedstocks of corn and rapeseed (Crutzen, et al., 2007). The nitrogen necessary to grow corn and rapeseed releases N_2O into the atmosphere, a greenhouse gas 296 times more damaging than CO_2. The impact of this effect on global warming outweighs the greenhouse gas reductions achieved through the use of biofuels, making them net greenhouse gas negative. These results do not even include the fossil fuels used on farms or for fertilizer and pesticide production.

Models of climate change continue to analyze the impacts of biofuels to determine whether certain feedstocks are negative, neutral or positive in their effects on GHG emissions. The models clearly point to the conclusion that the use of cellulosic feedstocks in second generation biofuels can achieve positive or neutral effects, underscoring the need to move rapidly in this direction. Unfortunately, the current economics of cellulose do not yet allow it. Cellulosic ethanol costs 2–3 times more than ethanol from corn, which is nearly twice as expensive as ethanol from sugar cane. Nor is it clear that political lobbies associated with first generation feedstocks, such as corn and soybean growers, will happily abandon them in favor of cellulosic alternatives.

Analysis and Policy Responses

It is increasingly urgent that governments recognize threats to food security posed by run-ups in commodities prices, especially in countries most vulnerable to grain price increases and in most need of food aid to alleviate the food gap. Initiatives to evaluate potential biofuel production opportunities, followed by analysis of impacts on food security, should reverse their emphasis—looking first at food insecurity as a warning against diversion of resources from food to fuel.

Second, economic distortions and their unintended consequences merit detailed analysis of known and thus far unknown and unstudied interactions between policy instruments. Both de Gorter and Just (2007, 2008) and Steenblik (2007) have pointed to some of the unintended consequences of "subsidy stacking," which will only become worse if new U.S. farm legislation approves a variety of new biofuels subsidies in 2008.

Third, environmental and ecological impacts require further assessments at all levels—regional, national and international. At the subnational level, monitoring of water resource quantity and quality, including groundwater depletion and surface water pollution from nitrogen and phosphorus loadings, will be critical. At the national and international level, ocean pollution (such as the dead zone in the Gulf of Mexico) must also be monitored. Finally, the GHG emissions resulting from biofuels require full life-cycle assessments of land and forest clearing, alternative feedstocks, and the use of fossil fuels and fertilizers to grow them.

Taken together, these issues suggest a matrix, constructed for each country (and perhaps agro-ecological subzones), to evaluate different feedstock alternatives, their cost-per-unit energy produced, and their impacts on water quantity and quality, nitrogen loadings, land use changes and GHG emissions as shown schematically below.

	Feedstock					
Impacts	**Corn**	**Soybeans**	**Wheat**	**Switchgrass**	**Sugar**	**Other**
Cost per unit energy						
Water quantity per unit energy						
Water quality impacts						
Nitrogen loadings						
Land use changes						
Current price						
GHG emissions						

EXAMPLE MATRIX WITHOUT DATA

In addition to the responses noted above, a number of policy responses to biofuels trends are urgently needed. First, governments should undertake the analysis noted above respecting food insecurity, "subsidy stacking," and the environmental impacts of biofuels expansion. Especially where assessments are global or transboundary in nature, multilateral review by FAO/OECD, WTO and other groups such as UNEP is needed. These reviews and assessments do not require the creation of a separate multilateral agreement or entity; in fact, FAO/OECD seem very well placed to undertake them under current authority. However, it would be useful for FAO/OECD to develop some type of globally-based information and data clearinghouse on biofuels and the issues and challenges they pose.

Conclusions

The main conclusions of this assessment are:

- Rapid increases in biofuel production, especially in Brazil, the EU and U.S., have important implications for global food security and environmental impacts, including climate change.
- These developments are set against rapid changes in the rural sectors of developing countries driven by urbanization and increasing labor shortages, trade integration, and reversals in secular declines in world grain and oilseed prices.
- Most of the world's food-insecure countries are also net oil importers, caught between rising petroleum and food prices.
- Rapid increases in biofuels production in Brazil and the OECD are supported both by escalating oil prices (for which biofuels are a substitute) and by expanding subsidies and mandates.
- Biofulels are also subject to border protections, distribution, storage and transport subsidies, state and local job-creation and development subsidies and sponsored R&D into conversion technologies for cellulosic or "second generation" biofuels.
- Many developing countries, which cannot afford such subsidies, are considering how they can benefit from the biofuels boom, and whether the employment and rural development opportunities are worth land conversion to supply feedstocks and produce biofuels.
- These trends have given rise to criticisms from economists, ecologists, and NGOs, who point to gaps in our state of knowledge and call for additional analysis of biofuel's effects in three main impact areas: (1) food prices and food security in poor households, especially in food-importing developing countries; (2) economic distortions and unintended consequences of OECD subsidies; (3) environmental and ecological impacts on land-use, air and water quality, water quantity, and global GHG emissions related to climate change.

- Analyses of these issues is necessary, both by national governments and multilateral agencies such as FAO/OECD in all three impact areas, including a matrix evaluating costs and environmental impacts of various biofuel feedstocks in different countries and agro-ecological subzones.
- Policy responses are also urgently needed, in which the analysis above informs policy reforms built around reducing the negative impacts of biofuels on food security, energy security and environmental stewardship that can reap the benefits and minimize the harms of converting biomass to fuel.

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