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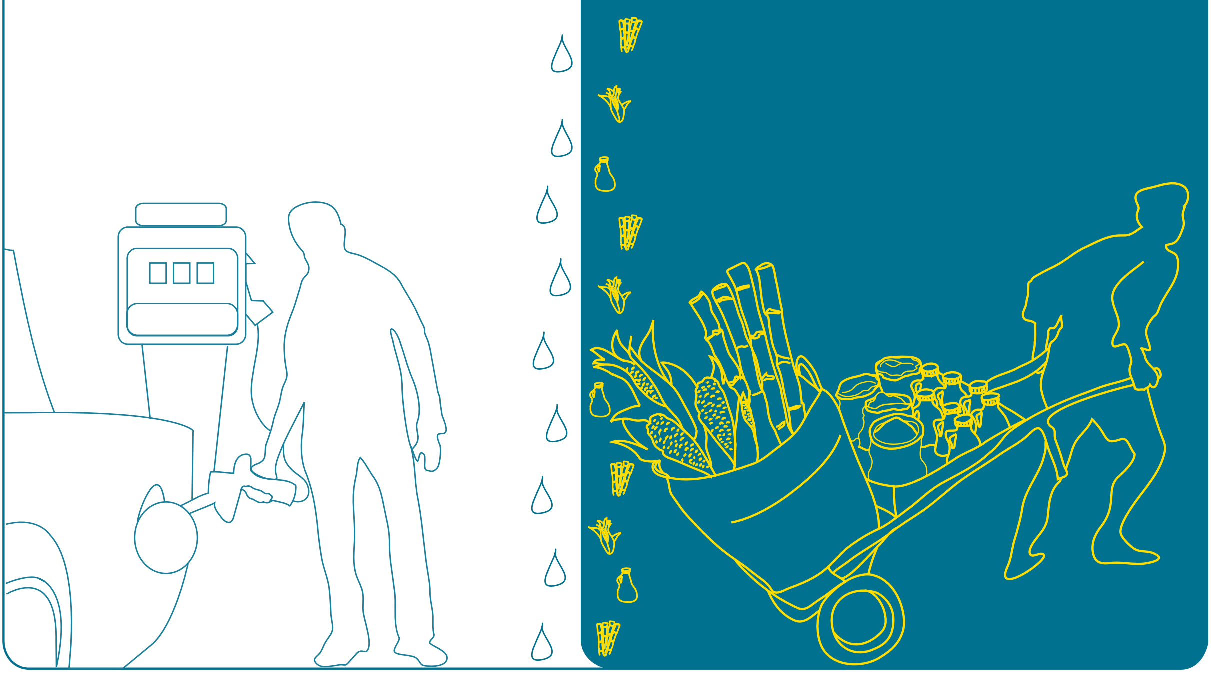
# *The Promises and Challenges of Biofuels for the Poor in Developing Countries*

Joachim von Braun and R. K. Pachauri



## INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

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# The Promises and Challenges of Biofuels for the Poor in Developing Countries

Joachim von Braun and R. K. Pachauri

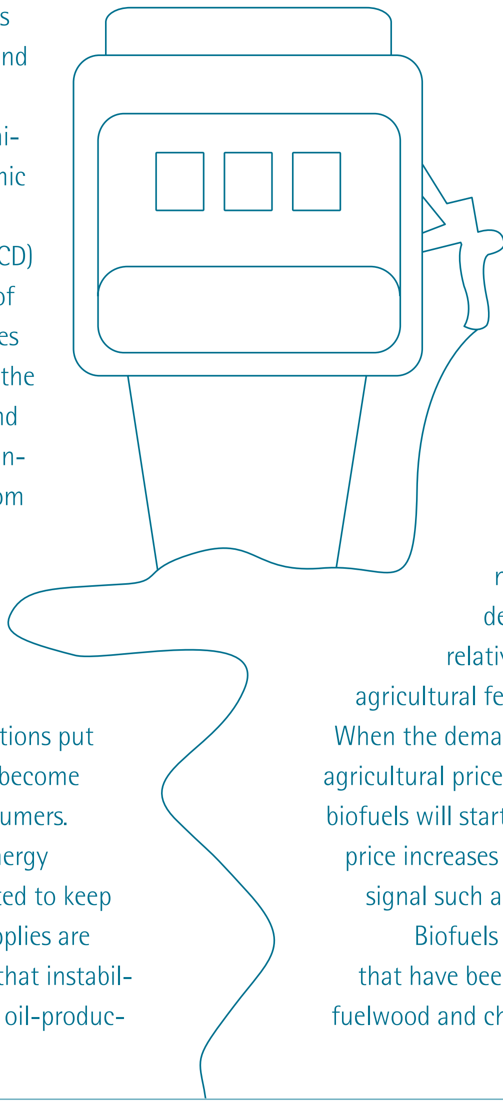
In the past several years the changing world energy situation has generated intensive discussion about biofuels, much of it promising a source of environment-friendly energy that would also be a boon to the world's farmers. At the same time skeptics argue that biofuel production will threaten food supplies for the poor and fail to achieve the environmental benefits claimed. Based on the analyses below, we conclude that in order to make a difference in the lives of poor people as both energy producers and consumers, and to make strong environmental and economic contributions, biofuel technology needs further advancement, and investments and policies facilitating agricultural innovation and trade will have to be considered.

## Biofuels

### Why Now?

One reason that biofuels have achieved such a high place on the global agenda is that demand for energy is rising and is certain to continue to rise in the coming decades. Energy use is predicted to jump in many parts of the developing world, where use of marketed energy has been very low until now. Indeed, some 2 billion people still have little or no access to modern energy.

According to the U.S. Energy Information Administration's 2006 *International Energy Outlook*, global consumption of marketed energy is projected to rise by 71 percent between 2003 and 2030, from 421 quadrillion British thermal units (Btu) to 722 quadrillion Btu. Three-quarters of the increase will come from developing countries. In fact, the report projects that energy demand in the countries outside the Organization for Economic Cooperation and Development (OECD) will surpass that of the OECD countries in 2015. Much of the increase in demand in developing countries will come from Asia, including China and India, whose fast economic growth and enormous populations put them on track to become large energy consumers.



Given that energy demand is projected to keep rising, that oil supplies are constrained, and that instability in some major oil-producing countries shows no sign of abating, oil prices seem unlikely to fall much in the near future—if ever. With oil prices in 2006 between US$60 and US$70 a barrel and agricultural commodity prices increasing less than prices of other raw materials, biofuels have become competitive with petroleum in many developing countries' farm systems, even with today's technologies. The International Energy Agency projected that biofuels would be competitive with petroleum at petroleum prices of between US$60 and US$100 a barrel. That point has been reached, and markets seem to be internalizing expectations of unstable and perhaps rising future oil prices. The competitiveness of biofuels, however, depends heavily on the relative prices of oil and of agricultural feedstock for biofuels. When the demand for biofuels increases agricultural prices, the competitiveness of biofuels will start to decline, and recent price increases for cereals in 2006 may signal such a trend.

Biofuels include fuel sources that have been used for millennia, like fuelwood and charcoal, as well as newer sources like ethanol, biodiesel, and biogas. These new sources depend on natural vegetation, crops grown specifically for energy, or agricultural or other forms of wastes and residues. Processing makes these biofuels cleaner and more efficient than traditional forms of biofuel, and if they are produced in a way that reduces net carbon emissions, they could contribute to mitigating global climate change.

Ethanol, for instance, can be made from sugars (like sugar beets and sugarcane), grains (like maize and wheat), cellulose (grass or wood), and waste products (like crop waste or municipal waste). Up to 10 percent ethanol can be blended with gasoline and used in standard vehicles, whereas specially made flexible-fuel vehicles can use any proportion of ethanol and gasoline. Ethanol accounts for 40 percent of nondiesel fuel in Brazil, which produces nearly half the world's total production (16.5 billion liters of ethanol in 2005). Biodiesel, which can be blended with petroleum diesel, is made from oilseed crops, as well as from waste oils and greases. Biodiesel production is more land-intensive than ethanol production, and so far represents only a fraction of ethanol production. The European Union accounted for 89 percent of the world's biodiesel production in 2005.

## Will Farmers Produce the Energy of the Future?

The growing potential of biofuels appears to create a substantial opportunity for the world's farmers. Can small-scale farmers and poor people in developing countries take advantage of this opportunity?

Energy crops could provide farmers with an important source of demand for their products. About 80 developing countries, for instance, grow and process sugarcane, a high-yielding crop in terms of photosynthesis efficiency that can also be used to produce ethanol. With international sugar prices moving generally downward until recently, partly owing to protectionist sugar policies in some OECD countries, sugarcane production for ethanol has become a more attractive option for developing-country farmers. Other energy crops include maize, soybeans, rapeseed, and oil palm, and

# Lessons from Brazil's Ethanol Program

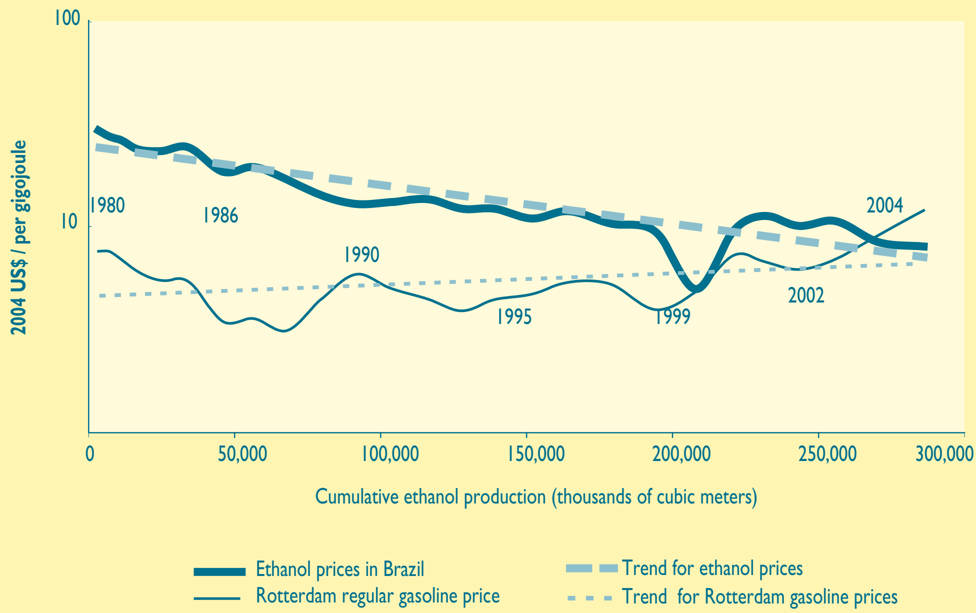
**José Roberto Moreira**

Brazil, the world's largest producer of ethanol, undertook a major ethanol production program based on sugarcane beginning in the mid-1970s. During periods of low oil prices, Brazil's program was criticized as being uneconomic, but today the ethanol industry is recognized as an efficient sector that brings substantial benefits to the Brazilian economy.

What are the factors in Brazil's success with ethanol? First, Brazil has abundant agricultural land and an appropriate climate for sugarcane.

Second, almost all sugar mills in Brazil can produce both ethanol and sugar. International sugar prices have been both highly volatile and on a general downward trend. When sugar prices fall, Brazilian mills are able to shift to ethanol production to some extent.

**Brazil's Ethanol Prices at Sugar Mill Gate Compared with International Gasoline Prices, 1980–2005**




Source: J. Goldemberg et al., "Ethanol Learning Curve: The Brazilian Experience," *Biomass and Bioenergy* 26 (2004): 301–304.

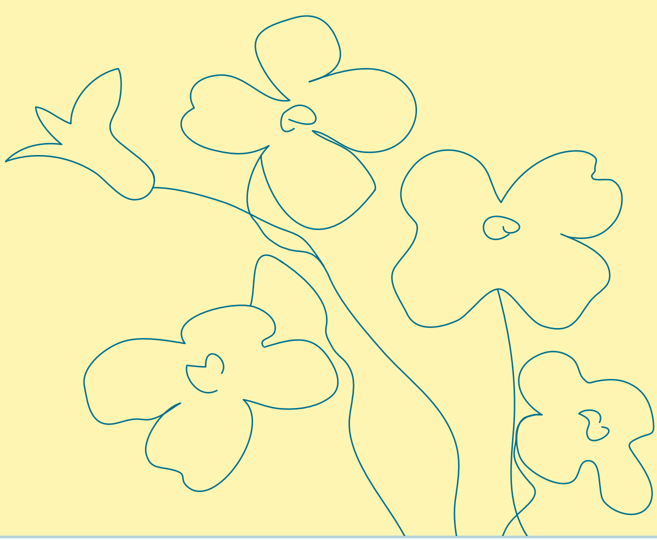
Third, Brazil has achieved significant improvements in sugar production and ethanol processing. Between 1975 and 2000, sugarcane yields in the São Paulo region rose by 33 percent, ethanol production per unit of sucrose rose by 14 percent, and the productivity of the fermentation process rose by 130 percent. Thus, as oil prices have risen, Brazil's ethanol production costs have fallen (see figure).

Fourth, Brazil has taken advantage of synergies with electricity and heat production. At present, cogeneration of heat and electricity from bagasse (residues from the sugar-manufacturing process) supplies most of the energy needs of the biofuel production process itself, and also allows an increasing amount of electricity to be exported to the grid.

Fifth, the Brazilian government provided crucial institutional support to get the ethanol industry off the ground. Consumers are afraid to buy cars that use a new fuel that may be difficult to find, and service station owners are not interested in investing in a parallel fuel distribution system since the number of potential users is usually very small. Therefore the Brazilian government provided incentives, set technical standards, supported technologies for ethanol production and use, and ensured appropriate market conditions.

Brazil's experience offers some relevant policy lessons. Among the policies most important to Brazil's success were its requirement that the auto industry produce cars using neat or blended biofuels; subsidies for biofuels during initial market development; the opening of the electricity market to renewable energy–based independent power producers in competition with traditional utilities; support for private ownership of sugar mills, which helps guarantee efficient operations; and stimulation of rural activities based on biomass energy to increase employment in rural areas.

**Adapted from José Roberto Moreira, "Brazil's Experience with Bioenergy," brief in** ***Bioenergy and Agriculture: Promises and Challenges,*** **2020 Focus 14 (Washington, D.C.: IFPRI, 2006). José Roberto Moreira is president of the Executive Council of the Brazilian Reference Center on Biomass, Institute of Electrotechnology and Energy, University of São Paulo.**

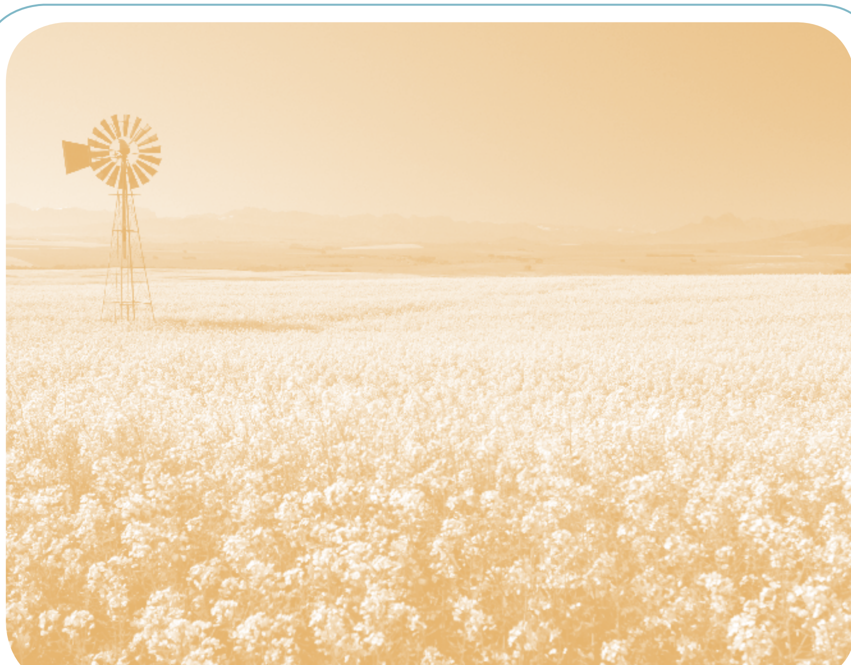


many developing countries already grow or could grow these and other potential energy crops.

A modern biofuels industry could also provide developing-country farmers with a use for crop residues like stalks and leaves, which can be converted into ethanol or electricity. Emerging new technologies that convert cellulose to energy might lead to a much higher valuation of "residues," and may in fact make "residues" history in agriculture.

In some cases farmers can grow energy crops on degraded or marginal land not suitable for food production. An oil-bearing crop called *Jatropha curcas*, for example, produces a seed that can be converted into non-polluting biodiesel. The crop is of special interest because it grows in infertile soil, even in drought conditions, and animals do not graze on it. India has 60 million hectares of waste land, of which it is estimated that half might be used for *Jatropha* cultivation. The cost of producing biodiesel from *Jatropha* is just Rs. 20–25 (US$0.43–US$0.54) per liter. The Energy and Resources Institute (TERI) of India announced in February 2006 that it is undertaking a 10-year project, in conjunction with BP, to cultivate 8,000 hectares of wasteland with *Jatropha* and install the equipment necessary to produce 9 million liters of biodiesel a year. The project will include a complete analysis of the social and environmental impacts of the approach.

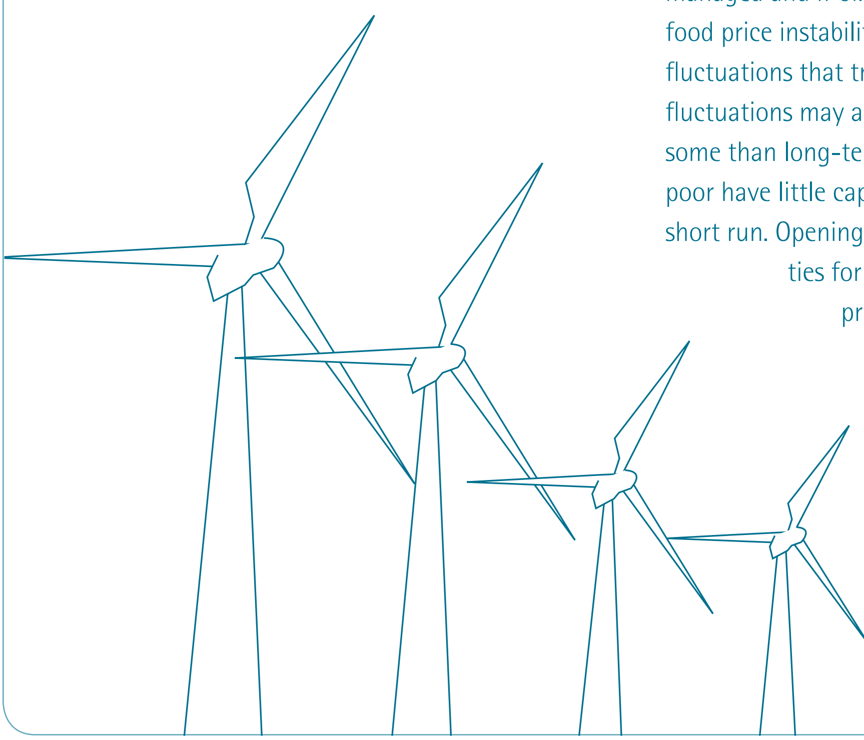
Because biofuel production is as labor intensive as agriculture, it may be a boon to rural areas with abundant labor. In Brazil, one study showed that in 1997 the ethanol sector employed about 1 million people. Thirty-five percent of these jobs were temporary harvesting jobs employing many poor migrant laborers from the Northeast, but 65 percent were permanent. Moreover, the



number of jobs in manufacturing and other sectors in Brazil created indirectly by the ethanol sector was estimated at 300,000. Many of the jobs created are unskilled, and this situation offers an opportunity for increased income to poor rural people. And small farmers are not left out: some 60,000 small farmers produce about 30 percent of the sugarcane in Brazil (see Box 1 for more information on Brazil's experience with biofuels).

Will crop production for biofuels compete with and drive out food production, thereby increasing food insecurity? This question remains controversial. We conclude that energy crop production does not need to lead to increased food insecurity, for a couple of reasons. First, new ways of combining food production with energy production have been developed. Food crop residues like rice and wheat straw, maize husks, and sugarcane bagasse (a fibrous residue) can be converted into biogas, ethanol, and electricity. In other cases energy crops can be targeted to more marginal lands, while food crops can be grown on more favorable lands. In addition, farmers can rotate food and energy crops. Brazilian farmers are increasingly growing sugarcane in rotation with tomatoes, soya, peanuts, and other food crops. Finally, research can—and must—help enhance overall crop productivity, and this is a prime task for the Consultative Group on International Agricultural Research (CGIAR). (See Box 2 for scenarios of future food and fuel production.)

Second, it is now well understood that food insecurity is a result not simply of a lack of food availability, but poverty. Food-insecure people do not have the income to buy the food that is available. If increased production of biofuels can raise the incomes of small farmers and rural laborers in developing countries, it may in fact improve food security. Still, risks for food security remain, particularly if the biofuel sector is not well managed and if oil price instabilities drive food price instability. Destabilizing oil price fluctuations that translate into food price fluctuations may actually be more worrisome than long-term price effects, as the poor have little capacity to adjust in the short run. Opening up trade opportunities for biofuels can dampen price fluctuations. Thus the effects of biofuel expansion on food security depend heavily on policies related to technology and trade.



BOX 2

# A Closer Look at the Food-versus-Fuel Debate

**Mark W. Rosegrant, Siwa Msangi, Timothy Sulser, and Rowena Valmonte-Santos**

Will aggressive growth in bioenergy production in developing countries crowd out production of food crops, creating a tension between the need for energy and the need for food and feed? The future of biofuels in the context of world agriculture and the world energy sector is hard to assess. Rather than aiming to "predict" such a future, IFPRI researchers looked into a set of scenarios of alternative policies and their outcomes (using IFPRI's International Model for Policy Analysis of Agricultural Commodities and Trade [IMPACT]) to determine how a scenario of aggressive growth in biofuel production could affect food availability and consumption at global and regional levels. The scenario assumes very rapid growth in demand for bioethanol across all regions and for biodiesel in Europe, together with continued high oil prices and rapid breakthroughs in biofuel technology to support expansion of supply to meet the demand growth, but it holds projected productivity increases for yields at baseline projection levels. It considers major potential feedstock crops for bioethanol (maize, sugarcane, sugar beet, cassava, and wheat) and for biodiesel (various oilseeds plus soybean). In this "aggressive biofuel growth" scenario, biofuels account for 10 percent of transport fuel production by 2010, 15 percent by 2015, and 20 percent by 2020 throughout most of the world, except for adjustments in line with other projections for Brazil, the European Union, and the United States. (The projections for biodiesel were limited to Europe, because the EU-15 countries represent almost 90 percent of the world's production volume of biodiesel.)

The researchers also considered the case where second-generation cellulosic conversion technologies come on line for large-scale production by 2015. In this "cellulosic biofuel" scenario, they held the volume of biofuel feedstock demand constant starting in 2015, in order to represent the relaxation in the demand for food-based feedstock crops created by the rise of the new technologies that convert nonfood grasses and forest products. Crop productivity changes are still held to baseline, except for short-term, price-induced input use effects.

Finally, the researchers considered an aggressive biofuel growth scenario that includes, in addition to second-generation technologies, the effect of increased investments in crop technology that would lead to increased productivity over time, in order to better support the expansion of feedstock supply in response to growth in biofuel demand.

The first "aggressive biofuel growth" scenario for large-scale bioethanol and biodiesel production shows significant increases in world prices for the various feedstock crops used (see table). If cassava were to be used aggressively as a feedstock for bioethanol, cassava prices would rise significantly,

**Percentage Changes in World Prices of Feedstock Crops under Scenarios, Compared with Baseline**

| Feedstock crop | Aggressive biofuel growth scenario without technology improvements[a] | | Cellulosic biofuel scenario | Aggressive biofuel growth scenario with productivity change as well as cellulosic conversion |
|---|---|---|---|---|
| | 2010 | 2020 | 2020 | 2020 |
| Cassava | 33 | 135 | 89 | 54 |
| Maize | 20 | 41 | 29 | 23 |
| Oilseeds | 26 | 76 | 45 | 43 |
| Sugar beets | 7 | 25 | 14 | 10 |
| Sugarcane | 26 | 66 | 49 | 43 |
| Wheat | 11 | 30 | 21 | 16 |

**Source:** IFPRI, IMPACT results, 2006.

[a]Assumptions based on stated plans for biofuel production in Brazil, China, Europe, India, and the United States, and on a scenario of aggressive biofuel growth in Africa (for details see M. W. Rosegrant et al., "Bioenergy and the Global Food Balance," brief in *Bioenergy and Agriculture: Promises and Challenges*, 2020 Focus 14 [Washington, D.C.: IFPRI, 2006]).

causing sizable welfare losses to the major consumers of this crop in Sub-Saharan Africa. It should be noted that past experiments with cassava-based biofuels in Brazil were not promising.

The importance of cellulosic biofuel technologies is also shown in the table. If these technologies, which rely on by-products of food and feed production and feedstock produced on nonfood-producing marginal lands, become commercially viable and widely adopted in about a decade, the impact on markets and food systems could be significantly mitigated.

The third scenario illustrates the importance of crop technology innovation at the farm production level and shows a further softening of price impacts. This third scenario, in particular, shows how investments in the biofuel industry and the agricultural sector can be combined to produce a more favorable outcome, which can mitigate the consumer-level impacts. Moreover, this scenario seems the most plausible of the three, as neither national governments nor fuel producers would want to engage in a large-scale expansion of production without the necessary investments in place to ensure a reliable supply of feedstock material at a reasonable cost, both for producers and for consumers of food and feed commodities.

The results show a food-versus-fuel trade-off in cases where innovations and technology investments are largely absent and where trade and subsidies are flawed. The situation changes considerably when technological advances in biofuel and crop production are considered.

**Adapted from Mark W. Rosegrant, Siwa Msangi, Timothy Sulser, and Rowena Valmonte-Santos, "Bioenergy and the Global Food Balance," brief in *Bioenergy and Agriculture: Promises and Challenges*, 2020 Focus 14 (Washington, D.C.: IFPRI, 2006). Mark W. Rosegrant is director of the Environment and Production Technology Division (EPTD) at IFPRI. Siwa Msangi is a postdoctoral fellow and Timothy Sulser and Rowena Valmonte-Santos are research analysts in EPTD at IFPRI.**

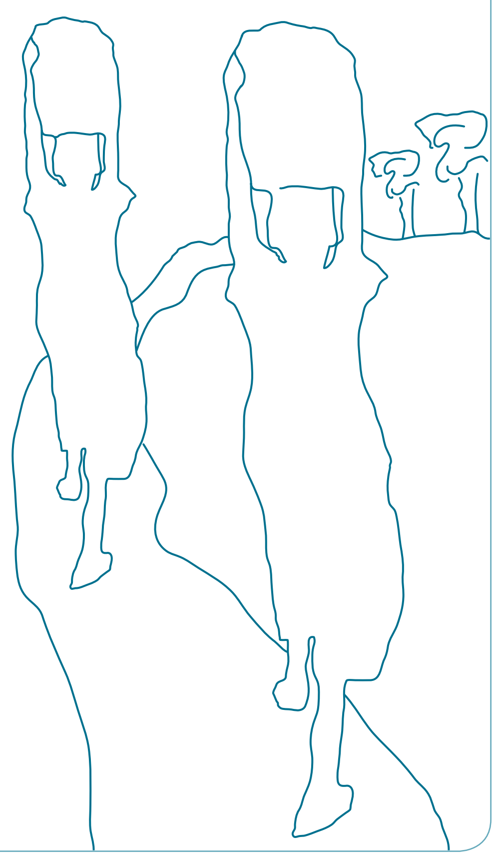
# What Are the Challenges in Creating a Biofuel Industry That Benefits Small Farmers and Poor People?

The high demand for energy and the apparent enormous potential of biofuels are no guarantee that small farmers and poor people in developing countries will receive the benefits. Creating an industry that helps the neediest people improve their lives and livelihoods will require careful management at all levels. This management includes taking the necessary steps to develop a global market and trade regime with transparent standards for biofuels.

One of the arguments in favor of biofuels is their potential to serve as an environmentally sustainable source of energy. That added social benefit might even justify some level of subsidy and regulation, given that these external benefits are not internalized by the markets. But several environmental aspects of biofuels require attention.

First, biofuels must be produced in a way that results in an output of energy greater than the amount of energy used to produce them—that is, they should have a highly positive energy balance. Maize ethanol, of which the United States is currently the largest producer, has been controversial because until recently it had a negative energy balance. In 2002, however, the U.S. Department of Agriculture stated that maize ethanol had achieved an energy output-input ratio of 1.34:1, thanks to more efficient cultivation and processing practices. Brazil's large ethanol industry based on sugarcane is well established as a net energy producer.

Second, biofuel production must be managed in a way that substantially reduces greenhouse gases compared with petroleum. Maize ethanol produced in the United States may reduce emissions by 10 to 30 percent compared with petroleum, whereas ethanol produced from sugar or cellulose could reduce them by 90 percent or even more. Farmers can contribute to greenhouse gas reductions by adopting cultivation practices that use less petroleum-based fertilizer and fuel and that sequester more carbon in the soil. The greatest potential for reducing greenhouse gases lies in successfully converting cellulosic and



lignocellulosic feedstocks—derived from, for instance, trees, grasses, crop residues, and municipal waste—into ethanol. These feedstocks are, however, more difficult to process than starch or sugar crops. A major R&D effort is needed to develop cellulosic ethanol, which could contribute to a much greater expansion in biofuels without adverse consequences.

There are other challenges as well. Like any innovation, increased production of energy crops has the potential to exacerbate socioeconomic inequalities by concentrating benefits on the well-off. It can lead to deforestation, a loss of biodiversity, and excessive use of fertilizers and pesticides, thereby degrading the land and water that poor people depend on. Policymakers must take care to ensure that biofuel production is managed and regulated in a way that avoids these pitfalls. These risks are speculative at present. With improved access to finance and sound policies for support of cooperation and for contract security, most innovations in agriculture can be scale neutral. Under the assumptions of an aggressive biofuel growth scenario—which is not, it must be noted, a prediction—significant price increases for some food crops could emerge in the long run (135 percent for cassava, 76 percent for oilseeds, and 41 percent for maize by 2020) unless new technologies are developed that increase efficiency and productivity in crop production and biofuel processing (see Box 2). Without technologies to improve productivity, the prices changes would adversely affect poor, net-food-purchasing households and would probably exceed the possible income gains by many small farm households.

In addition, in many low-income developing countries, farmers are unaware of the opportunities presented by biofuel production and thus risk missing out on the potential benefits. Public-private partnerships could help raise awareness of these opportunities among farmers in low-income countries.

To develop a biofuels sector that is sustainable and pro-poor, actors at the international, national, and local levels have crucial roles to play. International institutions must help transfer knowledge and technology on developing an efficient and sustainable biofuels industry to poor countries. The international community must also create a level playing field for trade in biofuels. By subsidizing their domestic agriculture and their biofuels industries, the OECD countries are raising the price of grains and feedstock in their own countries and are distorting the opportunities for biofuel production and trade in developing countries. At the national level, policymakers must take steps to create a well-functioning market for biofuels, to promote investment in associated areas like flexible-fuel vehicles and fueling stations, and to regulate land use in line with socio-economic and environmental goals. They must also provide farmers who wish to grow energy crops with the same kinds of support needed for other forms of agriculture, such as research and extension services, credit, and infrastructure. Finally, local institutions must participate in designing and managing projects to develop biofuels so that poor people and small farmers can gain benefits as both biofuel producers and consumers.

In response to concerns about energy supplies and prices, a number of countries have set standards or targets for biofuels use. The European Union has set a goal of 5.75 percent of motor fuel use from biofuels by 2010. The United States has mandated the use of 28.4 billion liters of biofuels for transportation by 2012. Brazil will require that all diesel contain 2 percent biodiesel by 2008 and 5 percent by 2013, and Thailand will require 10 percent ethanol in all gasoline starting in 2007. India mandates a 5 percent ethanol blend in nine states, and China is requiring a 10 percent ethanol blend in five provinces. Many other countries are taking similar steps.

As countries move to strengthen their energy security by increasing their use of biofuels, they should also work to ensure poor people's and small farmers' participation in the creation of a more sustainable global energy system. With sound technology and trade policies, win-win solutions—that is, positive outcomes for the poor as well as for energy efficiency—are possible with biofuels in developing countries.

**Joachim von Braun** is director general of IFPRI, and **R. K. Pachauri** is director general of The Energy and Resources Institute (TERI) in New Delhi, India.

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