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Opportunities and challenges of biofuels for the agricultural sector and the food security of developing countries

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NOTE

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1. Background

Over the last five decades, the world's agricultural population has increased from 1.5 billion to 2.5 billion, currently constituting 40 per cent of the world's population. Africa showed the highest relative increase, from 222 million to 460 million. In 2005, some 54 per cent of the population in African countries was involved in agriculturally-related activities. Agriculture remains the main source of employment in Africa and in most of the rest of the developing world; it generates over 50 per cent of the jobs and represents on average 15 per cent of the gross domestic product (GDP), 30 per cent of the GDP in sub-Saharan Africa. In those regions, agriculture consists of small, family-owned plots, many of which have been cultivated for generations.

During this same period, the agricultural population of the North decreased from 126 million to 52 million, declining from 8 per cent to less than 2 per cent of the world's agricultural population. In fact, just 2 per cent of the world's agricultural population has access to more than 34 per cent of the world's arable land.

The agricultural sector has been the cornerstone of the industrial and economic development of most nations. Improvements in agricultural productivity can hasten the start of industrialization, and hence have large effects on a country's relative income (Golan et al., 2002). Agriculture is important because it employs a large portion of the labour force in the early stages of a country's development, and increasing farm incomes will expand the demand for products by the rural sector, generating an additional dynamic impact in rural economies (Mellor, 1966). Agriculture also has the capacity to take advantage of productivity-increasing technological innovations that make large net additions to national income and consequently to aggregate demand.

There is a wide consensus that the world produces enough food to feed everyone. Still, there are more than 800 million food-insecure people. That is, 800 million people today are not able to consume the quantity and quality of food to meet a diet allows them to have an active and healthy life.

The obstacles to sufficient nutrition have become more visible and in most cases lay not in production, but in distribution. Other important contributing elements to food insecurity are drought, disease, poor soils, war, failing or failed Governments and poverty. There is a strong interrelation between food distribution/access and the other contributing factors just mentioned. For many development experts, poverty reduction is a central piece in improving food security.

Poverty is a major cause of hunger. The process of increased economic globalization generates benefits and costs and, consequently, winners and losers. It is important to focus on the contribution and expectations of trade liberalization to avoid the creation of international and domestic mechanisms that keep poor people poor. Often, food producers are the poor.

Biomass is a widely available energy resource that is receiving increased consideration as a renewable substitute for fossil fuels. Developed sustainably and used efficiently, it has the potential to create jobs and economic growth in developing countries, reduce demand for costly oil imports, and address environmental problems ranging from desertification to climate change. Moreover, it potentially provides a growing market for additional investment in technology and productivity in developing countries.

The notion of a new energy paradigm may conjure images of automobiles propelled by fantastic hydrogen-powered engines and solar panels illuminating houses and streets. Many experts believe that the world is at least 50 years from this vision. Others predict that the world will have to decarbonize the world's energy systems to protect the global climate system. In any case, the world is likely to move towards utilization of multiple sources of energy (Smil, 2003), and the question we must ask is how best to use the renewable energy portfolio – wind, solar, biomass, thermal, ocean tides – available today.

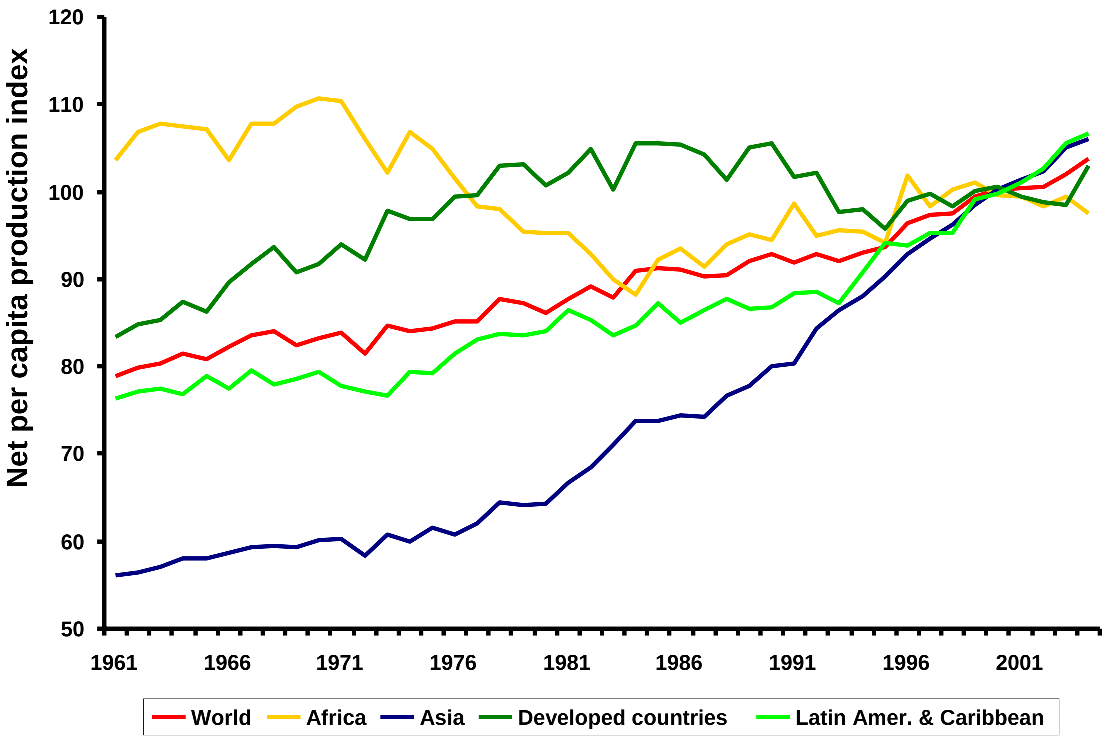
Biomass was the world's primary source of energy until the late 1920s. Today, about 10 per cent of the world's energy use is still derived from biomass; however, this average masks the far greater importance of bioenergy in less developed countries in Africa, Asia and Latin America, where its share is as high as 80 per cent (UNDP, 2000).

2. Selected trends in agriculture and food security

In order to proceed with the analysis, it would be useful to review the trends of some key variables that are important in the analysis of the impacts of biofuels in the agricultural sector and in food security. Among the variables to consider are agricultural production, nutrition, prices, land use and agricultural research.

Regarding agricultural production, the variable chosen is the per capita agricultural production. The data in figure 1 indicates that worldwide there has been an increase in agricultural production; however, this increase has not been uniform across regions, and much less among countries. Agricultural production has actually declined in Africa for much of the period through the 1980s; since then, it has shown a steady recovery, but without reaching the level of the 1960s. Asia and Latin America are experiencing a more dynamic and steady growth. Overall production in developed countries, while increased, scaled down in the last few years of the period.

Figure 1. Net per-capita production index for selected country groups, 1961–2004

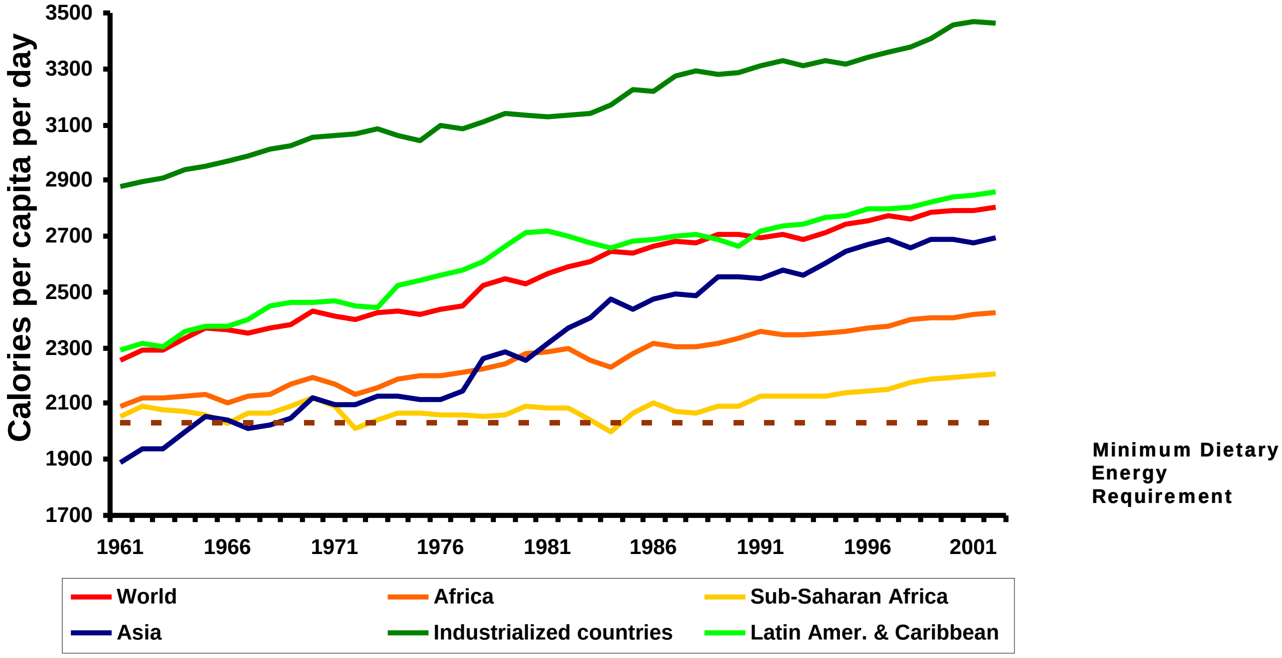


Source: FAOSTAT 2005.

The corresponding variable to the behaviour of production should be the evolution of the nutritional levels. Figure 2 indicates how the supply of calories per capita per day indicator has behaved in the last 45 years. The dotted line in the figure indicates the most up-to-date and maximum level for any country of the minimum dietary energy requirement.

Two clear conclusions can be drawn from the analysis of the data. One is the steady increase in the caloric supply across the board for the selected regions. It is clear the difference is the starting point in 1961, and once again Asia is the best performer. The second conclusion is that the caloric supply has steadily been above the maximum minimum requirement for the last 45 years. This corroborates the fact that malnutrition is more a distribution and access problem than a limitation of the food availability. Nonetheless, the differences between the country groups are very clear.

Figure 2. Evolution of the caloric supply for selected country groups, 1961–2004



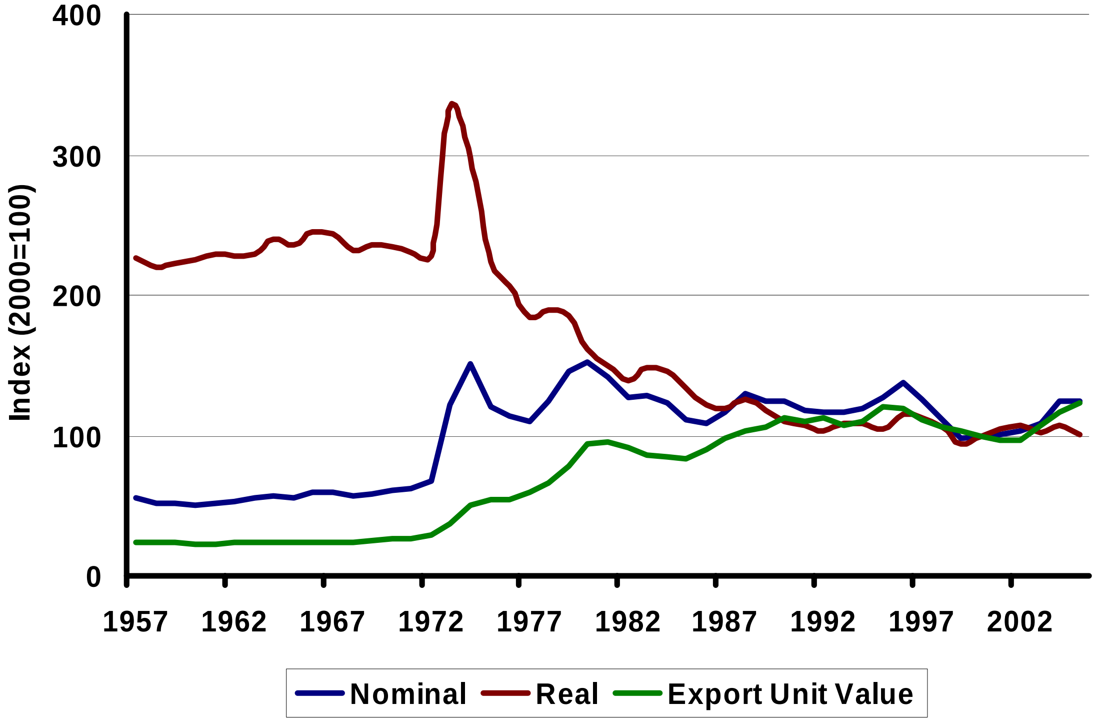
Source: FAOSTAT 2005.

If one considers the per capita agricultural production as a proxy for agricultural supply, and the minimum dietary energy requirement of calories per capita per day as a simplified indicator for demand, as food is a necessity more than a price driven good, one may infer that there has been a steady excess supply. This excess supply would manifest itself as a steady decline in the price for agricultural commodities.

The behaviour of agricultural commodity prices from 1957 to 2005 is presented in figure 3. A simple observation of the behaviour of the indicator for real prices shows a steady decline. This decline in real agricultural prices has been a constant challenge in the viability of the farm sector in many countries. The constant increase in the production capacity resulting from investments in research, infrastructure, and/or domestic support has resulted in the expansion of the supply curve further than demand expanded. This gap is one of the potential areas than biofuels can fill and therefore break the steady tendency for agricultural commodity prices to decline.

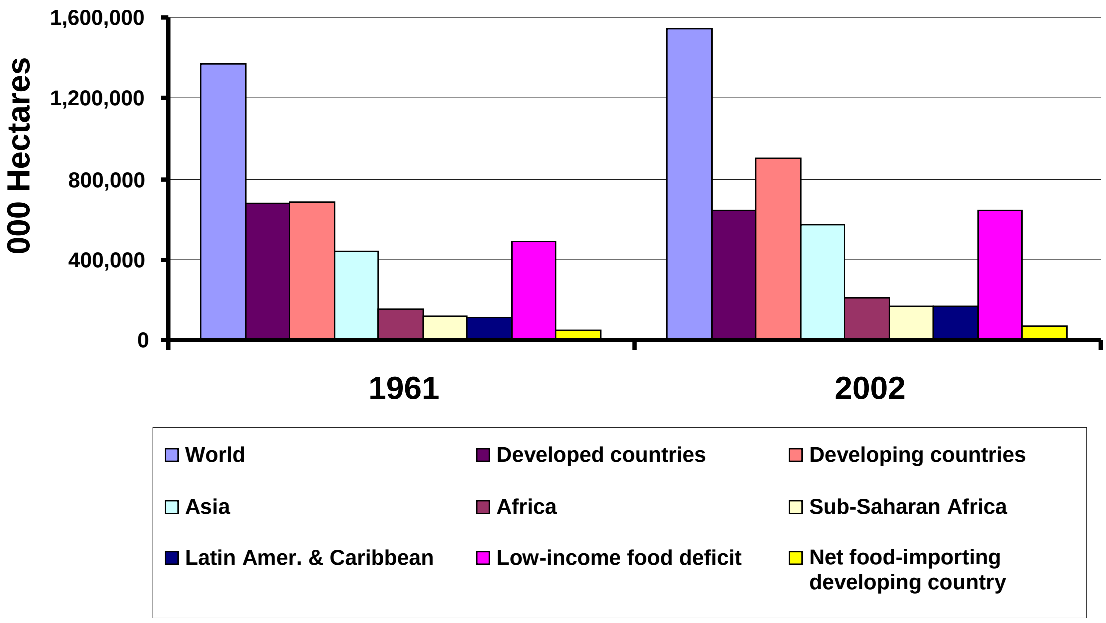
It is also important to consider the distribution of the arable land which, together with water, is the most important resource for agricultural production. The land availability by country groups is presented in figure 4. The data indicates that there has been an increase of arable land in developing countries since 1961. But it also indicates that the arable land in sub-Saharan Africa and Latin America are similar in magnitude. It also confirms that net-food-importing developing countries are the group with the least land resources. However, the low-income food deficit countries do have a significant availability of arable land.

Figure 3. Agricultural commodity prices index, 1957-2005



Source: IMF.

Figure 4. Total arable land in crops for selected country groups, 1961 and 2002

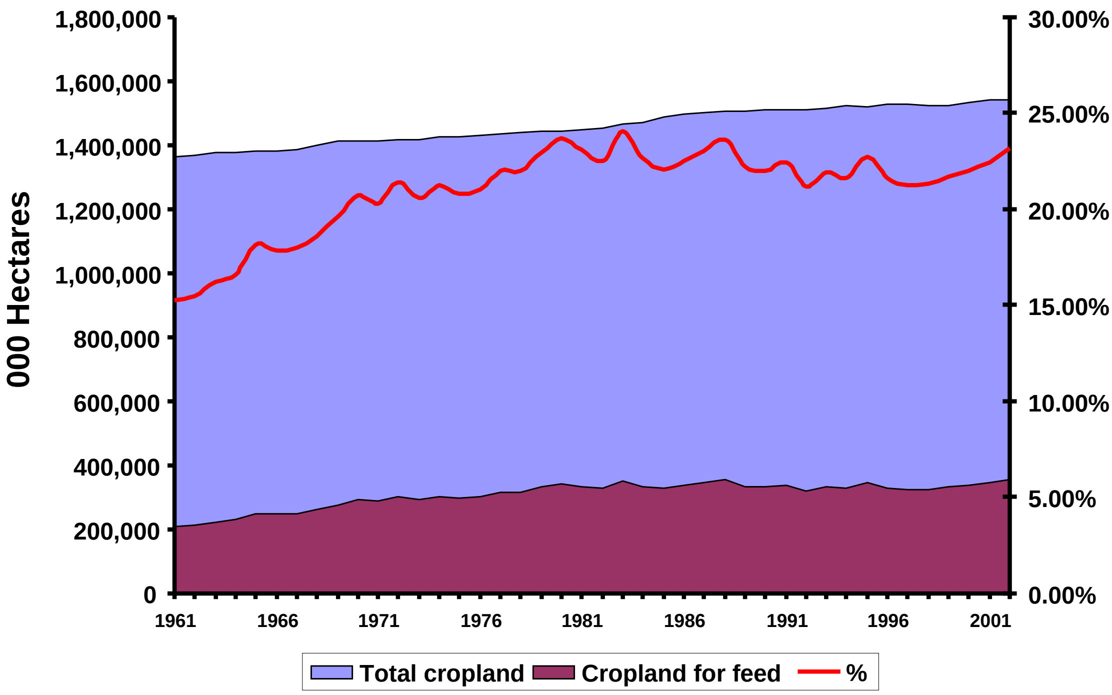


Source: FAOSTAT 2005.

According to data from the Food and Agricultural Organization of the United Nations (FAO), land planted with cereals represents the largest use of arable land. Within this group, a significant portion of the production is dedicated to animal feed. In fact, figure 5 indicates that there has been a steady increase of the cropland dedicated to animal feed. By 2002, almost one of every four hectares in production was dedicated to animal feed, up from one in six in 1961. This is an indication that there has been an animal population explosion.

This indicator is significant because, as will be seen later in this publication, this land use is the one that bioenergy crops would compete with first. In addition, it provides an idea of the importance of developing a biomass- and livestock-integrated system that would reduce the hectares dedicated to animal feed and increase their contribution to energy production.

Figure 5. Total arable cropland and cropland for animal feed use, 1961–2002



Source: FAOSTAT 2005.

Technology can effectively modify crop varieties to adapt to non-native ecosystems, and provide yields above natural production capacity. Technology is also important because it results in new agricultural dynamics – practices, implementations, machinery, fertilizers, pesticides, herbicides – that have an impact on the physical yield as well as the economic return of the crops. Therefore, to some extent, research and development has the potential to moderate or exacerbate the distributional inequality of natural resource endowments.

Since the elimination of the International Service for National Agricultural Research, a former member of the Consultative Group on International Agricultural Research, consistent and current data on investment in agricultural research is not easy to find. However, existing published data provide a very good indication of the distribution and evolution of these expenditures. Tables 1 and 2 have data on total public investment in research and on the intensity of this research. While table 2 provides an idea of the dominance of developed countries, it also indicates a significant increase in Brazil, China and India, and even in developing countries. However, when the absolute numbers are converted into intensity ratios, there is a clear and overwhelming advantage of research investment concentrated in the developed countries.

This advantage is even grater than it appears, since private research expenditures in the North have accelerated in the last 20 years. This concentration of investment means that technology – one of the most important equalizers in terms of agricultural production and balancing the lack of natural resources for agriculture – is also largely concentrated in the North. This increases the relative advantage already biased in their favor by the endowment of natural resources.

Table 1. Total public agricultural research expenditures by region, 1981, 1991 and 2000 (2000 dollars)

	1981	1991	2000
High-income countries	8,293	10,534	10,191
Brazil, China, India	2,272	3,737	6,028
Developing countries	4,632	5,721	6,791
Total	15,197	19,992	23,010

Source: Pardey et al., 2006.

Table 2. Selected public agricultural research intensities, 1981, 1991 and 2000

	Expenditures per capita			Expenditures per economically active agricultural population		
	1981	1991	2001	1981	1991	2000
	(2000 dollars)					
Asia-Pacific	1.31	1.73	2.35	3.84	5.23	7.57
L. America-Caribbean	5.43	4.94	4.96	45.10	50.54	60.11
Sub-Saharan Africa	3.14	2.69	2.28	9.79	9.04	8.22
Middle East-N. Africa	3.24	3.63	3.66	19.15	27.30	30.24
Developing countries	2.09	2.34	2.72	6.91	8.14	10.19
High-income countries	10.91	13.04	11.92	316.52	528.30	691.63
Total	3.75	4.12	4.13	14.83	16.92	18.08

Source: Pardey et al., 2006.

3. Development opportunities from bioenergy

The potential contribution of modern biomass energy services to a new energy paradigm is indeed significant. The world consumes about 400 exajoules (EJ) of energy per year. However, the world annually generates the equivalent of about 100 EJ of largely unused crop residues (Woods and Hall, 1994), and could produce an additional 180 EJ from energy dedicated grasses and trees (IPCC, 1996). The objective should not be to replace fossil fuels with biomass based sources of energy. The size of bioenergy's ultimate contribution, however, is conditional upon the use of sustainable agricultural practices, land use consistent with the food needs of local and global populations, and the technically and economically efficient distribution and conversion of feedstock into energy. Bioenergy has to be viewed not as the replacement for oil, but as one element of a portfolio of renewable sources of energy.

The current participation of biofuels in the transportation fuel market is still of little significance, 3 per cent of the gasoline consumption and less that 0.2 per cent of the consumption of transportation diesel. The international trade of biofuels is still of little significance relative to the size of the fuels market. In this context, the opportunity presented by the development of a bioenergy industry is to be a player in a market of almost unlimited dimension.

The production of energy from biomass involves a range of technologies that includes solid combustion, gasification and fermentation, among others. These technologies produce liquid and gas fuels from a diverse set of biological resources – traditional crops (sugar cane, corn, oilseeds), crop residues and waste (corn stover, wheat straw, rice hulls, cotton waste), energy-dedicated crops (grasses and trees), dung and the organic component of urban waste. Figures 6 and 7 present the different sources of renewable energy and the role of biomass in that set, and also the diversity of feedstock and uses that biomass offers. The results are bioenergy products that provide multiple energy services: cooking fuel, heat, electricity and transportation fuels.

It is this very diversity that holds a win-win-win development path potential for the environment, and social and economic development. The opportunity at hand is to develop an international trade framework that, together with domestic policy instruments, will enhance the role of bioenergy as part of a successful development strategy.

Bioenergy derived from sustainable agricultural practices provides an opportunity for developing countries to utilize their resources and attract the necessary investment to accelerate their sustainable development process. Some of the potential benefits include (a) environmental benefits from the reduction of greenhouse gases and the recuperation of soil productivity and degraded land; (b) economic benefits from the increased activity resulting from improving access to and quality of energy services; and (c) international benefits derived from the development of sustainable bioenergy trade.

Figure 6. Sources of renewable energy

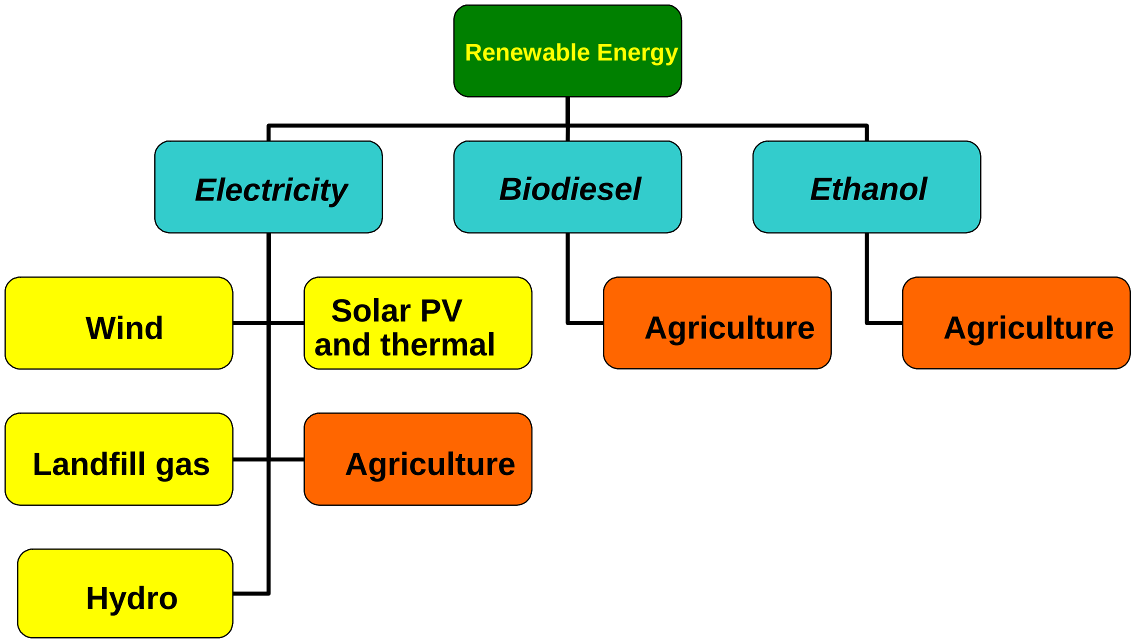
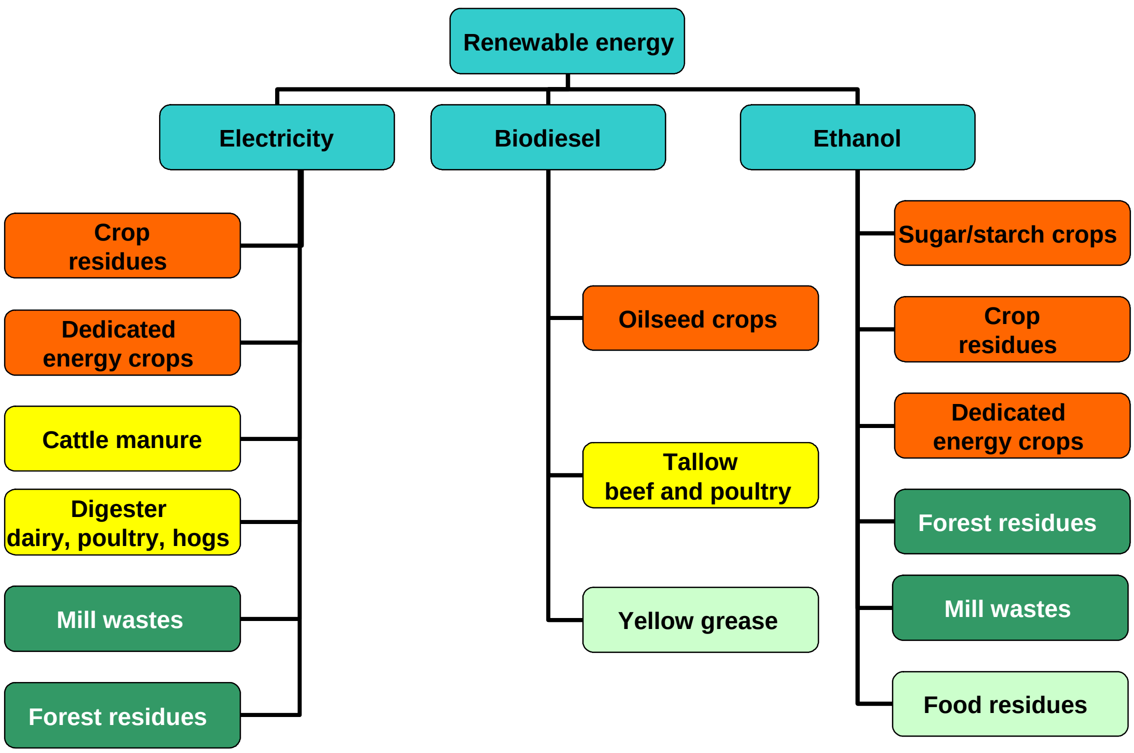


Figure 7. Biomass feedstock and energy products



There is a clear link between access to energy services and poverty alleviation and development. The first set of critical energy needs includes those that satisfy basic human needs: fuel for cooking and heating, energy for pumping water, and electricity for health and education services. The second set of critical energy needs includes those that provide energy for income-generating activities that help break the cycle of poverty.

The Brazilian experience in biofuels, dating to the Alcohol Programme of 1980, shows that it is possible to achieve sustainable and economic ethanol production. Ethanol production in Brazil is economically viable without any government support with oil prices above $35 per barrel (Coelho, 2005); this experience based on the use of sugarcane is transferable to other countries. While sugars-based biofuels provide for the launching pad of the industry, their contribution may not be enough for a global takeoff. Biofuels technology based on cellulosic feedstock is maturing rapidly and reaching the point of commercial implementation.

The poor rely heavily on traditional sources of biomass as sources of energy. In this context, traditional bioenergy is mainly derived from the combustion of wood and agricultural residues. The negative impacts of burning such substances are severe. First, when combusted in confined spaces, they produce significant indoor pollution to which women and children are primarily exposed. This creates severe health consequences, including respiratory illnesses and premature death. Secondly, this use puts immense pressure on local natural resources, especially as communities must satisfy increasing demands for energy services (Kartha and Leach, 2001).

The benefits of moving from the use of traditional biofuels – direct burning of wood for cooking and heat – toward modern biofuels (electricity, ethanol) cannot be overlooked. It has the potential to directly impact the quality of life of 2 billion people by improving indoor air quality, providing additional energy services for development activities, and allowing for sustainable management of natural resources.

For many countries, a key motivation to develop biofuels is to diversify energy resources; however, the opportunities for rural development also need to be a key priority. Rural development benefits from a dynamic bioenergy sector begin with feedstock production. As agricultural production in many developing countries is characterized by labor-intensive activity, additional demand for agricultural products will increase employment and wages in the agricultural sector. Furthermore, the additional personal income generated has the potential to induce significant multiplicative impacts as it is spent by the rural population.

The production of bioenergy-dedicated crops, as well as use of residues from the production of food and feed grains, would not only provide the foundation to build a domestic energy industry, but would also directly support and enhance the production of crops that increase the food security of a region or country. The satisfaction of basic needs for both food and energy could lead to a more efficient use of land and rural resources when the complementarities between these two are recognized.

The sugar and corn experience in Brazil and the United States indicates that the transformation infrastructure from feedstock into bioenergy is likely to be located in rural areas, close to where the feedstock is grown. In this case, construction and operation of those facilities will generate additional economic activity in rural areas. Transportation of the feedstock to the plant and distribution of the fuels could likely crowd out rural roads and other rural transportation infrastructure; the needed attention to the additional infrastructure demands would also benefit rural areas and the marketing of rural products.

Since certain energy crops like trees and grasses require fewer inputs, they sometimes can be grown in cropland too marginal for food crops. These energy crops have the potential to extend the land base available for agricultural activities and also create new markets for farmers.

Given the low density of most biomass feedstocks, it will be necessary to locate conversion facilities in the same rural area where the production of feedstocks occurs. This fact emphasizes the close link between the biofuels sector and rural development.

The convergence of environmental, development and trade concerns under a bioenergy framework can be attributed to the flexibility of biomass itself – almost any type of feedstock can be used, multiple energy services can be produced, projects can be developed on a variety of scales based on resource availability, and many development goals present in the Doha Declaration and the Kyoto Protocol can be utilized.

These positive impacts in the dynamics of the rural economy could have a substantial role in reducing the historic exodus towards the urban areas, helping to create the critical mass required to invest in education, health and other public infrastructure.

4. Strategies for improving food security

"A household is food secure when it has access to the food required for a healthy life for all its members (adequate in terms of quality, quantity, and cultural acceptance), and when is not at risk of losing such access" (ACC/SCN, 1991: 6).

This conceptualization of food security often divides the challenges to food security into two categories, acquirement and utilization. The first element, acquirement, has to do with the size of the food supply and the resources available to the household to acquire food directly through production and/or through exchange in the marketplace.

The second element, utilization, has to do with the quality of food acquired and its utilization within the household. This includes preparation and storage. Given the key role women play in food preparation in rural areas, the more time dedicated to food preparation, and away from other economic and cultural household activities, the higher level of food utilization is achieved. The same can be said in terms of women's health. The higher degree of food utilization a household can achieve, the healthier women are. The household ability to store food through the lean season also plays a key role. The reduction of food losses resulting from inadequate storage facilities is also important.

Given this framework, energy production's contribution to food security starts from expanding the demand for the resources available in rural areas: land and labour, and creating a new economic dynamic that will integrate the rural areas to a new engine for economic growth. This new dynamic should result in improvements in poverty reduction and food security, which must be based on the sustainable use of local resources to produce food and energy to support economic diversification at the household and community levels.

Growth in domestic food production can improve food security through increasing food availability and increasing farmers' incomes (FAO, 1996e; Stevens, et al., 2000). Mellor stresses that domestic agriculture is the main source of economic growth and rural employment in countries with high agricultural population ratios (Mellor, 1966). Hazell and Ramasamy (1991), using the example of the green revolution, point out that appropriate technological innovation in food production can reduce production costs, create employment among poor farmers, and thus improve food security for poor farmers. In addition to the promotion of employment, FAO stresses that growth of food supplies also reduces food prices and benefits food-purchasing households in rural and urban areas (FAO, 1996c).

Many studies link food insecurity with insufficient government support for domestic agriculture. For many developing countries, especially in Africa, the political influence of the agricultural sector on governmental policy has historically been weak (Mellor, 1986; Platteau, 1995). In many African countries, the agricultural sector is commonly taxed while being excluded from representation in governance (Rooyen and Sigwele, 1998). A large part of the investments in most of the least developed countries has been directed toward urban development, shifting resources away from agricultural production (Lipton, 1975). Policies in these countries consequently become unfavourable to agricultural production development, and result in insufficient "reinvestments in the agricultural and rural sectors through infrastructure, institution development, and human capital development" (Rooyen and Sigwele, 1998).

Many countries with food insecurity may not be highly connected with the world food market. Paarlberg (2000) concludes that a country's food security may rely heavily on the domestic food production level, as indicated by a weak relationship between the international grain market and food security in many developing countries.

Economic growth can improve food security by either increasing domestic food production or enhancing demand for food. According to the FAO (1996d), "…economic growth can enhance food security by increasing the individual's command over resources and thus their access to food…". A study by the United States Agency for International Development (USAID) concludes that stunted economic growth in several African countries has been the "root cause[s] ... [of both] inadequate food production and low capacity to import foodstuffs" (USAID, 1994). Economic and income growth generally increase food demand for both domestic and international food markets. Income growth for food producers allows them to introduce and apply new technologies with higher productivity. Economic growth therefore contributes toward both growth in domestic food production and increase in food importability.

The impact of economic growth on food security improvement can be negative. Historically, economic growth policies, often based on capital-intensive strategies (Mellor, 1988b), have tended to shrink public investment in agriculture and thus food production (FAO, 1996d; Fleuret and Fleuret, 1991). One study estimates that 90 per cent of the potential future drops in crop production in South Asian countries will be caused by the reduction in public research investment, while the impact of slow economic growth will account for only 10 per cent (Agcaoili-Sombilla and Rosegrant., 1996). Market-based economic growth may not strengthen food security if markets are not functioning effectively, even though market-based economic growth is "a critical element in … food security" (Poulton and Dorward, 2002). On the other hand, malnutrition can be significantly reduced through national public action, even with a low national per capita income level (FAO, 1996c).

According to FAO, agriculturally-driven economic growth could have a strong positive impact in reducing poverty and hunger. The increase in farm employment and income not only increases the ability to improve food consumption, it also has a very significant role in stimulating demand for non-agricultural goods and services, providing a boost to non-farm rural industries and incomes as well (FAO, 2003a).

Trade liberalization can lead a country to allocate resources into specific industries or commodities for which the country has a comparative advantage (FAO, 1996d). Food security can be improved "even in countries where agriculture remains a major contributor to GDP, by shifting resources into the production of non-food export crops and importing staple food requirements" (FAO, 2003a).

One of the desired goals of trade liberalization is trade balance surplus, which is available for importing food. FAO states that "holding foreign exchange reserves is the best guarantee that food consumption levels can be maintained…for countries relying on trade for food security" (FAO, 1996d). A study from the United States Department of Agriculture (USDA) suggests that a 1.3 to 2 per cent increase in foreign exchange availability is associated with 1 per cent growth in food imports (USDA, 1999).

Facilitation of food imports from food surplus countries plays a critical role in alleviating food deficits in developing countries (Mellor et al., 1986). Mellor et al. also stress that food imports are almost inevitable, especially in countries experiencing high economic and population growth, leading to rapidly increasing food demands.

Increasing stability of prices in domestic markets and the supply of food is another benefit of trade liberalization. Diaz-Bonilla et al. (2000) state that "food trade, along with stocks, helped reduce the variability of food consumption in developing countries to one-third to one-fifth of that of food production". One study shows that rice imports from India to Bangladesh had significantly made up the food deficit in Bangladesh, which was mainly caused by the flood-induced drop in Bangladesh's rice production, and also stabilized the price of rice in Bangladesh (Dorosh, 2001). According to Timmer (1989), food price stability contributes to increased household investment in productive activities rather than in stockholdings. Trade liberalization may therefore weaken the impact of domestic food production growth.

Trade liberalization can, however, aggravate food security, especially for low-income small farmers in less developed countries (FAO, 1996a; Ballenger and Mabbs-Zeno, 1992). Trade liberalization is generally associated with a decline in the domestic food price, and thus trade liberalization can harm food security if many of the poorest households are dependent on agricultural production (FAO, 2003b; Mellor et al., 1986).

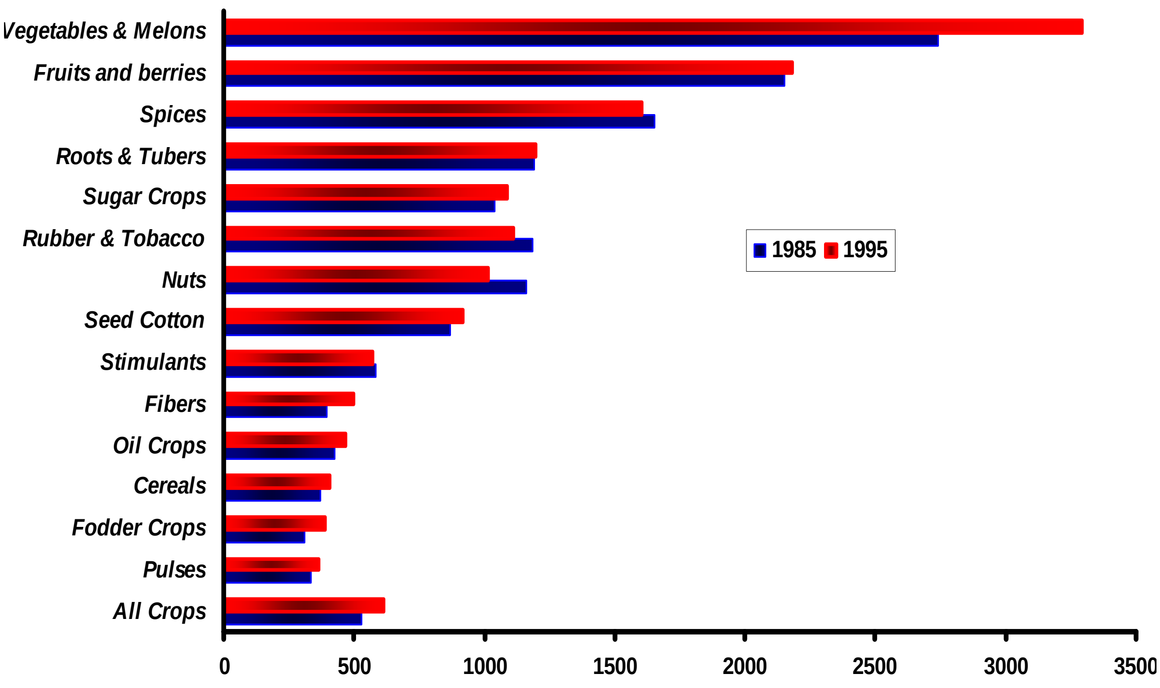
Policies aimed at creating a trade surplus may not always improve food security. Cheru (1992) points out that the policy of generating a foreign exchange reserve "often conflict[s] with long-term development needs" and "the needs of small farmers … and food security [is] ignored". Sarris (1980) concludes that a country with food deficits and constrained foreign exchange can improve its food security by driving "toward self-sufficiency, by reducing variability of grain requirements with help […] of domestic buffer stocks and by improving the domestic crop information system".

The overemphasis on trade and efficiency encourages farmers to shift land use from local foods and to specialize in production of very few cash crops such as coffee, cocoa, tea, wine, spices, fruits and other agricultural products demanded by the developed world. This specialization is done at the cost of reducing local food production for the community, and increasing the risk of food security. The degree of food security is then wholly dependant on the performance of an international market which is highly concentrated and dominated by a few traders and processors.

It is essential, then, to establish a clear link between the development of a bioenergy industry and the impacts in food production. The contribution of bioenergy in the fight against poverty and in improving food security could be multiple.

It is important to understand that to obtain cost-competitive biofuels, the production of energy feedstocks should compete first and mostly with the acreage planted with less productive crops. To illustrate this, figure 8 presents the value of the yield of a hectare planted in several crop categories. From the data in figure 8, it is possible to identify that land in cereals and fodder rank at the bottom of the yield scale, and are at the same time the crops with the largest planted area.

Figure 8. Yield per hectare of world crops – dollars per hectare



Source: FAO.

The shift in land use in agriculturally-developed countries towards energy uses would reduce dumping in traditional commodity markets and provide access to higher prices for farmers in developing countries. Farmers – in developing countries and elsewhere – should react to these higher world prices either by increasing the production of those traditional crops and/or by increasing the production of local food crops, previously displaced by cheap import prices. This supply response will depend on several factors: (a) the ability of the marketing system to transfer the higher world prices into farm gate price increases; (b) investment of the additional resources created by the price increase in increasing the production ability of farmers via recuperation of degraded lands, investment in infrastructure and technology, and/or improvement in management practices; and (iii) the availability of incorporating additional cropland sustainably.

The development of local bioenergy industry would provide additional value added through the utilization of crop residues. These additional resources in turn could also be invested in increasing the production capacity of the sector.

In developing countries, the production of energy in concert with sustainable food production and sustainable use of local resources could also result in higher incomes for farmers and added energy services for the community. This would enhance the community's ability to develop economic activity designed to reduce poverty and enhance food security.

But the existence or lack of food security must ultimately be measured at the household level, since aggregate availability of food does not ensure the reduction/elimination of hunger at the household or individual level.

5. Development of a bioenergy industry

There are three major feedstock sources in agriculture that can be efficiently transformed into liquid fuels: traditional food and/or feed crops, crop residues and energy-dedicated crops. These feedstocks can be processed into ethanol or other alcohol to be either blended or directly used in direct combustion engines.

Thus far, the preferred path for bioenergy use in the transportation sector has been the conversion of traditional crops, like sugar cane and corn, into ethanol either to be blended or directly used in internal combustion engines. Soybeans, jatropha, and other oilseed crops also can be converted to bio-diesel fuel and used to extend or substitute for fossil-derived diesel fuel. This path offers many developing countries that produce these crops a well-tested opportunity to build their biofuels sectors and reduce their need for costly imported fossil fuel.

For many countries – including those in the Caribbean Basin, Europe and Asia – the conversion of sugar cane and sugar beets provides an opportunity to build on their longstanding investment in production technology and infrastructure for sugar and adapt it to the production of bioenergy. South Africa offers a clear example of linking the sugar industry with bioenergy production through electricity generation from co-firing bagasse, a by-product from crushing the sugar stalks (Fulton et al., 2004).

For the development of the cellulosic ethanol industry – industrial transformation of cellulose fiber rather than sugars into ethanol – a sensible path begins with existing feedstocks, namely crop residues, followed by dedicated energy crops as the industry expands. The utilization of cellulosic crop residues for energy is severely limited by the need to protect soils from the impacts of water and wind erosion, and maintain and/or improve long-term productivity. New technological advances focus on the conversion of feedstocks rich in cellulose (plant fibre) such as crop residues/waste, and bioenergy-dedicated crops (grasses and trees) into a family of fuels that include ethanol, gas and solid fuels (for the production of electricity or heat). Industrial gasification plants (such as those based on coal in China) could convert an even wider variety of waste materials, including urban solid waste, to fuels, chemicals and plastics (UNDP, 2000).

The supply of cellulosic feedstock will depend on the agricultural production methods employed. The availability of crop residues for energy can be increased by introducing agricultural practices, such as cover cropping, that protect soils from the impacts of water and wind erosion, and maintain or improve long-term productivity. These practices tend to increase the volume of crop residues left on the ground and, consequently, the potential supply for energy conversion. Such practices are a necessary element for a sustainable development strategy, as well as a major component in the production of environmental goods and services.

For most developing countries, one may expect to follow a similar process, which is to base the growth of the bioenergy industry on the use of crop residues. Further expansion towards the use of energy-dedicated crops would depend on the agricultural resources of the country and the local food balance. One major element that would impact the path in a developing country is the pace at which cropland use in developed countries shifts from food and feed towards energy. According to existing research (De La Torre Ugarte and Hellwinckel, 2004; English et al., 2006), between 15 million and 50 million hectares in the United States can shift towards energy-dedicated crops and consequently generate a significant reduction in the food and feed production and export surpluses.

Given the weight of the United States in world markets, it is likely that world prices would also increase. The agriculture of developing countries may benefit from the higher prices and by expanding production of food and feed crops. This would also increase the availability of crop residues in developing countries, and the bioenergy industry could gain additional strength based on this additional energy feedstock.

Should cropland use in developed countries shift from food/feed to energy, farmers in developing countries may benefit from higher prices and expanded production of food and feed crops. This would also increase the availability of crop residues, and the bioenergy industry could gain additional strength, enabling a shift towards the use of energy-dedicated crops.

There is a great gap between countries at the forefront of development of their biofuels industries – such as Brazil, the Philippines and the United States – and countries which, despite relying on biomass for a large share of their energy, have further to go. These countries require a new approach to their production and use of bioenergy, not only to increase energy efficiency but also to develop a modern energy industry capable of generating environmental and rural development benefits.

The most advanced countries in biofuels production and utilization owe their progress to a set of economic incentives and domestic policies that have fostered the development of a bioenergy industry (Coelho, 2005). These policies, however, do not have to be protectionist in nature, but rather can spur market growth by setting national production targets or blending volumes. Many countries are now discovering the potential role bioenergy could play in their economies, as well as in the economies of potential importers, such as Japan, in addition to the opportunities that tradable environmental goods may have for their economies.

An international bioenergy trading system will be best supported by a diverse set of producers. Thus, trade could be seriously hampered if the development gap is not recognized. While trade rules should promote the expansion of biofuels markets by reducing tariffs to biofuels trade, they should also allow for coherent domestic policy mechanisms oriented towards sustainable development, particularly in the South. For example, countries implementing a renewable fuels standard to promote the use of biofuels should be allowed to balance their own rural and industrial development goals with their potential contribution to biofuel market expansion.

To take full advantage of the opportunities that a sustainable bioenergy sector offers, an institutional framework of mutually-supportive environmental and economic policies should be the concern of local and international bodies. The Doha Ministerial Declaration already provides a guiding principle by encouraging negotiations on environmental goods and services. These rules of trade – within the domain of the World Trade Organization (WTO) – should be flexible enough to encourage countries with large production potential, such as Brazil and Thailand, to take advantage of their economies of size by promoting mechanisms that expand the use of bioenergy. At the same time, these international rules should support investment in countries that have smaller volume potential but are capable of taking advantage of domestic resources suitable to their resource base.

The nexus of environmental protection with energy development, poverty alleviation and economic development offers a unique opportunity for international development, and for financial and trade organizations to develop a coherent framework for cooperation and trade to achieve a higher goal: the sustainability of both the environment and economic development.

6. An illustration of a biofuels strategy with global impacts on agriculture

According to the International Energy Agency, in 2005 the world consumed about 21 million barrels a day of gasoline and nearly another 21 million barrels a day of diesel. In the transportation fuel market, ethanol represents only 3 per cent of gasoline consumption, and biodiesel represents less that 0.2 per cent of the consumption of transportation diesel.

Hypothetically, if biofuels were to replace all oil-based transportation fuels, it would translate into about 30 million barrels of ethanol and 23 million barrels of biodiesel demanded per day. For illustration purposes only, if this demand were translated into hectares of sugar cane or corn, the two major feedstock for ethanol currently in use, it would be the equivalent of 300 million hectares of sugar cane (assuming Brazil’s yields), or 590 million hectares of corn (assuming United States yields). This is about 15 and 5 times respectively of the current world plantings to those crops. In the case of biodiesel, the potential demand would be equivalent to 225 million hectares of palm, or 20 times the current world plantings. The opportunities and challenges to attend to this massive feedstock demand in a sustainable manner should be at the center of the development discussion.

In order to have significant global impacts, biofuels should develop into a mainstream transportation source globally or in at least one of the largest consumers of fuels, such as the United Sates, European Union, Japan or China. The political discussion in the United States, driven primarily by national security and energy independence issues, is developing very aggressive goals for the use of renewables coming from both the public and private sectors. A specific implementation of one of these efforts will be used to illustrate the potential global impacts of developing a major bioenergy industry.

The energy goal incorporated into this illustrative analysis is to achieve of 29.43 quads of renewable energy by the year 2025 where agricultural (non-wind) resources would provide over 17.3 quads of energy through the production of 86.9 billion gallons of ethanol (7.35 quads), 1.1 billion gallons of biodiesel (0.15 quads) and 962 billion kilowatt hours (kWh) of electricity (7.95 quads). This implies that 27 per cent of the transportation fuels and 15 per cent of the electricity in the year 2025 would be produced using agricultural feedstocks. The period 2010–2015 corresponds to the time in which the cellulosic-to-ethanol conversion is expected to be introduced, and consequently reflects the period of steepest relative growth.

Table 3. Projected bioenergy production for the years 2007, 2010, 2015, 2020 and 2025

Energy scenario and renewable fuel type	Units	Projected for the year:				
		2007	**2010**	**2015**	**2020**	**2025**
Ethanol	Billion gallons	5.83	8.09	30.41	57.97	86.86
Biodiesel	Billion Gallons	0.16	0.22	0.45	0.72	1.10
Electricity	Billion kWh	87.00	89.00	379	698	962
Total energy	Quads	**1.23**	**1.45**	**5.77**	**10.77**	**15.45**

Source: English et al., 2006.

The results from the analysis indicate that reaching the energy goal is a plausible target if, in addition to current level of cropland, additional land from pasture and/or forestland is available to farmers for traditional uses and energy production. To meet the energy demands placed on renewable energy by 2025, additional land resources are required. In this analysis, of the 182.7 million hectares of pasture/rangeland available for alternative production, 70 million hectares are converted, with 40 million hectares converted to hay and 30 million hectares to dedicated crops. In addition, because of a shift in land use, another 13.7 million hectares are planted to dedicated energy crops, such as switchgrass.

For agriculture to attain this goal, it is imperative that the conversion of cellulosic feedstock – crop residues, switchgrass and wood residues – to ethanol be commercially available. It is evident that these goals can be reached at a much lower impact on agricultural prices when yields of traditional crops increase at a rate greater than that reflected in the baseline. Given current yield trends, continued investment in research and expected advancements in technology, yields could substantially increase above the trend line.

Bioenergy production is derived from several feedstocks. Corn for grain, in the initial years of the scenario, provides the foundation of the bioenergy industry. Even after the introduction of the cellulosic-to-ethanol conversion technology, corn is projected to continue to play a key role in the overall supply of feedstock, but mostly in the form of corn residues.

Attaining the goal is also dependent on the successful introduction of bioenergy-dedicated crops such as switchgrass and conversion of wood to ethanol. By 2025, the contribution of bioenergy-dedicated crops will be over 50 per cent of the total feedstock required by the bioenergy industry (figure 9). Other sources of cellulosic feedstock contributing to overall supply are wheat straw and wood and forest residues.

To support the level of feedstock reported above, significant changes in land use were projected to be necessary. Use of agricultural cropland changes when compared to the baseline, as agriculture attempts to meet the goal (figure 10). Dedicated energy crops such as switchgrass will likely become a major crop in United States agriculture, with 42.8 million hectares planted. Significant shifts from current uses (2007) are projected simultaneously.

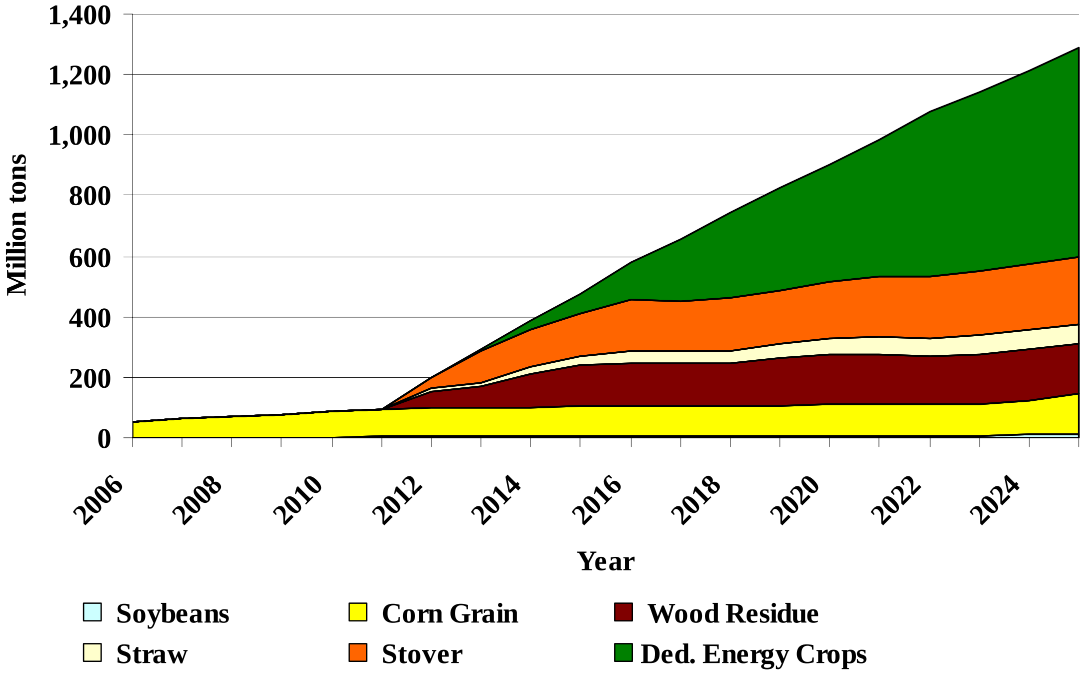
For instance, about 9 million hectares of soybeans would slowly shift into dedicated energy crops, along with 3.7 million hectares of wheat. In the case of corn, during the last five years of the analysis period, a shift of about 1.8 million hectares would occur, as acreage becomes constraining and more energy per acre is required to achieve the target.

Perhaps the most significant projected change is the shift of pastureland/rangeland and cropland in pasture, hereafter referred to as pastureland, towards the production of energy under the assumption that the feed value of the converted pastureland is replaced through hay production. An assumption of the study is that all pasture was already in use by the livestock industry.

A share of the shift of 70 million pasture hectares (40 million hectares) was used to produce more intensive grasses for animal feed, and the remaining pasture in cropland and the non-cropland grassland are projected to experience an increase in their management intensity, as it is well recognized that pasture and grassland are significantly underutilized. Consequently, this increase in management intensity is likely to occur at a very low additional cost, and while causing changes in the livestock industry, would not likely jeopardize the welfare of the livestock industry. This finding suggests that as information about energy dedicated crops expands, and a bioenergy cellulosic-based industry expands and becomes part of the agricultural sector, the hectares of pasture will shift into dedicated energy crops.

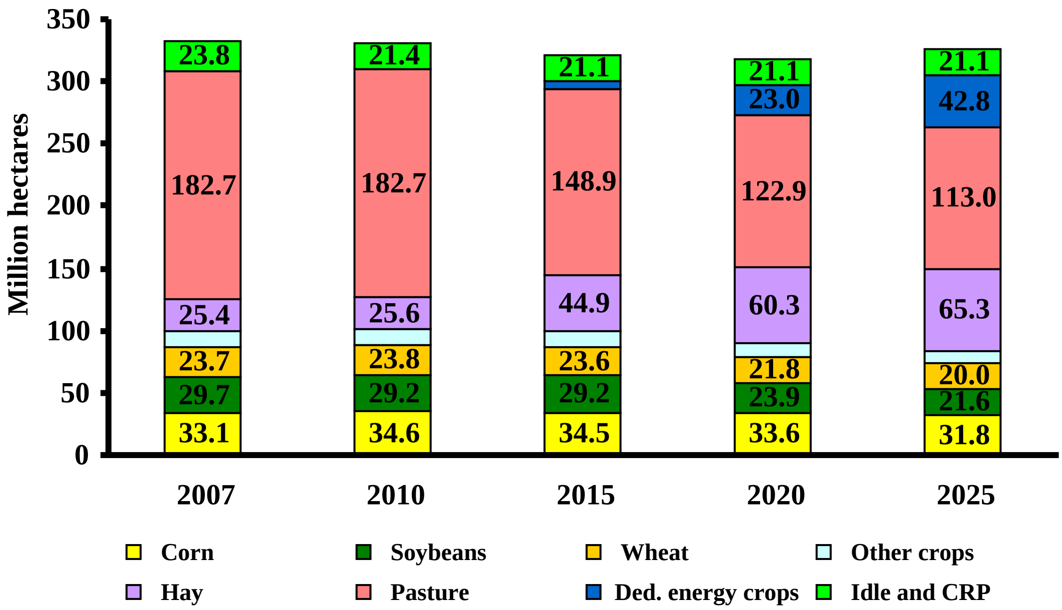
With a dramatic shift in land use toward energy crops, a corresponding change in average crop prices is anticipated. Therefore, as most major crops have some acreage shifted to energy-dedicated crops, an overall increase in commodity prices is projected (table 4).

Figure 9. Total energy feedstock quantity used



Source: English et al., 2006.

Figure 10. Changes in land use for selected simulated years



Source: English et al., 2006.

Notably, when compared with baseline prices, the crops that experience larger increases in price have the largest acreage decreases, as is the case of soybeans and wheat. However, the price increases are within price ranges experienced in the last decade.

Yield increases for both traditional and energy crops would dampen price increases as a result of acreage conversion to energy crops. An alternative scenario without the higher yields resulted in higher crop price impacts, and well-above-average market prices experienced in a number of years, especially for corn, wheat and soybeans. This is an indication that an expansion of a biofuels industry has to be accompanied not only by investments in bioenergy related elements of the supply chain, but also continue investments in traditional crops. This will increase the likelihood of success of the bioenergy industry growth, and keep agricultural commodity price increases at a reasonable level.

Consequently, biofuels have the potential to inject a significant demand into the agricultural sector and generate new economic activity in rural areas. Depending on how fast and to what level demand and production of biofuels increases, there will be increased pressure for a fixed amount of land. After current excess resources are brought into production, feedstock and crop prices will increase, making both biofuels and agricultural products relatively more expensive. Also, as the use of biofuels increases, there will be a relative drop in the price of oil, improving the relative price of oil vs. biofuels and consequently slowing down the adoption of biofuels.

Table 4. Impact on the average crop price for selected simulated years

	Projected for the year:				
Crop and scenario	2007	2010	2015	2020	2025
	$/MT				
Corn:					
Bioenergy goals	77.3	100.2	95.1	96.9	115.1
Baseline	79.9	94.4	94.4	91.1	89.3
Wheat:					
Bioenergy goals	115.6	118.3	125.4	144.7	148.9
Baseline	117.1	122.8	134.1	132.2	130.7
Soybeans:					
Bioenergy goals	206.1	233.9	248.6	257.3	271.6
Baseline	203.4	224.1	229.8	220.4	214.3
Cotton:					
Bioenergy goals	1143.4	1143.4	1390.0	1412.5	1412.5
Baseline	1143.4	1143.4	1277.9	1277.9	1300.4
Energy dedicated crops:	$/dry ton				
Bioenergy goals	0.0	0.0	46.85	60.90	81.85
Baseline	0	0	0	0	0

Source: English et al., 2006.

7. Impacts on developing countries from the global biofuels industry

In this process, the potential exists for significant resources to move into agriculture and rural areas, creating a unique opportunity for development. Developing countries with a sizeable feedstock potential (e.g. Thailand, Malaysia, the Philippines, India and the Dominican Republic) could potentially benefit, following the example of Brazil, not only from the increase in agricultural activity, but also from the establishment of a new, domestic energy sector with export opportunities.

Agricultural-based countries, even if they do not have major potential for feedstock production, would benefit from higher agricultural prices generated by diverting some of the land in the major feedstock producers from food/feed to energy. As higher world prices increase, local crop production will present opportunities to use residues or others crops as feedstock in local or regional areas of the country. By taking advantage of these opportunities to generate a local energy industry, rural areas would benefit directly.

Lower energy prices are another way in which developing countries may benefit. Lower energy prices may result from lower biofuel costs, especially during the first years of adoption, in which land for feedstock production is still readily available. Also, if biofuels become a significant element of the global energy market, the increases in biofuels availability and the corresponding displacement of oil-based fuels, could result in lower prices for oil products, too. Consequently, developing countries would also benefit from the additional supply of global transportation fuel markets.

The increased use of agricultural products for energy could also facilitate a transition away from agricultural support programmes in highly industrialized countries (De La Torre Ugarte and Hellwinckel, 2004; Fulton et al., 2004). At the same time, coherent and mutually-supportive environmental and economic policies are needed to encourage a globally-dispersed bioenergy industry that values sustainable development.

There are several factors that would influence biofuel's benefits and costs for developing countries. Among them are the rate at which biofuels demand, especially policy-induced demand, increases in the major energy consumers such as the United States, European Union, Japan, China and India. Another factor is the current availability of land in which feedstocks can be produced without competing with current agricultural uses. A third element is the rate of increase in agricultural yields. A fourth factor is the improvements in the efficiency of feedstock conversion to biofuels and the increase of acceptable feedstock diversity. The future trends in oil prices are a key element to biofuels adoption. Finally, a brief discussion on the opportunities for net food importing countries and low-income food deficit countries is presented. The following sections will attempt to address these factors.

7.1. Rate of increase in the demand of biofuels and the role of international trade

The use of biofuels is driven by both market and policy factors. Increases in the price of oil and resulting increases in the economic competitiveness of biofuels are the primary market factors. The establishment of renewable portfolio standards and/or renewable production targets constitutes the dominant policy-induced demand. These policy-induced factors are, to a large extent, a response to environmental and/or security concerns in developed countries. A third objective in developing countries is the opportunity to foster a domestic energy sector alongside rural development goals.

At the global level, there are several implications for various speeds of increasing biofuels demand. If the demand for biofuels grows rapidly, higher global biofuels prices would probably result, in turn increasing the rate of investment in biofuels and the production of feedstock. Higher biofuel prices would quickly bring feedstocks for which technology is readily available (e.g. sugar, corn, palm oil, soybeans) into production and conversion. This would result in quick price increases for these crops, exerting pressure on the expansion of their cultivated areas. At the same time, alternative crops such as jatropha and grasses would be viewed as more attractive feedstocks, increasing the resources dedicated to their development.

If use of global biofuels rapidly increases, potential increases in exports would become the driving force for developing countries to establish a bioenergy sector. The major beneficiaries would be countries poised to expand their biofuels and feedstock production. Countries with a large production of conventional feedstocks would likely be able to attract sizeable investments to jump-start their bioenergy sectors. For countries with a less substantial agricultural base, the high prices of biofuels could provide enough market protection to develop a domestic energy sector focused on rural development and their domestic market.

A much slower increase in demand would not result in significant price increases to biofuels nor price increases to feedstocks. However, this low pressure in feedstock prices could provide enough incentive to start a local bioenergy industry. In such a situation, the domestic market could be the initial focus and the export market would help achieve economies of scale until the local infrastructure and fleet could adapt to expand the domestic market.

The rate of demand increase in larger economies (i.e. the United States, European Union, Japan, China and India) as well as the degree of import openness will determine the size of the international markets. If agricultural producers in major energy-consuming countries reallocate their land use towards biofuels production when the size of the international markets is small, it will open trade opportunities in agricultural commodities for which production was reduced as a result of the reallocation of land use.

For small and medium-sized developing countries with potential to develop relatively sizeable biofuels industries, such as the Dominican Republic or Mozambique, the role of international trade is critical. The domestic energy market for biofuels is small, not only because the size of the economy, but also because their current transportation fleet may not be able to absorb biofuels at blend levels beyond 5 to 7 per cent. It will take 10 to 15 years to renew the fleet and develop the demand for their domestic biofuels market. The transition to biodiesel may be easier because vehicles are more readily adaptable to it than ethanol.

In order to achieve economies of scale, small and medium-size developing countries will initially have to rely on an international biofuels market. Depending on the supply response of biofuels and oil prices, countries with large biofuels expansion potential, such as Brazil and Malaysia, could potentially not crowd out the market. This would reduce the participation possibilities for other developing countries which depend on access to the international trading system.

A major word of caution needs to be emphasized in the case of international trade of biofuels. Given the potential size of the international biofuels market, unregulated trade has the potential to drive massive land resources into the production of feedstock. Countries with a low level of institutional development and enforcement mechanisms could experience significant environmental and social losses. These same impacts could occur in developed countries, where strong economic and political interests could drive biofuels to an unsustainable path.

The fact that within the context of the energy market, the international trade of biofuels is not yet significant opens up the possibility to develop adequate rules that would foster the sustainable development of the industry. There are few occasions in which decision makers are faced with this possibility.

7.2. Available land resources: competition between energy and food/feed sector

Ecological resources, especially land, are not equally or “fairly” distributed. From the 226 countries that currently exist in the world, 20 of them represent 84 per cent of the world’s arable land. This percentage remained consistent from 1961 to 2002.

The four major arable landholding countries (CR4 countries) include the United States (176 million hectares), India (162 million hectares), China (143 million hectares) and Russia (123 million hectares). They represent 44 per cent of the world’s arable land, followed by 25 countries of the European Union, the “EU-25” (100 million hectares), Brazil (69 million hectares), Australia (48 million hectares) and Canada (46 million hectares). The aggregate of these last four countries with the CR4 countries amounts to approximately 61 per cent of the world’s arable land in 8 countries. Following them are Argentina (34 million hectares), Ukraine (33 million hectares), Nigeria (30 million hectares), Turkey (26 million hectares), Mexico (25 million hectares), Kazakhstan (22 million hectares), Indonesia (21 million hectares) and Pakistan (21 million hectares). These account for an additional 15 per cent, leaving the 206 remaining countries with 24 per cent of the entire world’s arable land.

One key question is, “Which countries have the potential to bring additional arable land into production?” In this regard, Brazil needs to be highlighted because of its potential for expansion. In the last four decades, Brazilian arable land has increased an average of 3.7 per cent per year. According to the Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA), Brazil has the potential to bring up to 100 million hectares of additional land into cultivation from the “Cerrado” area without affecting the Amazon region. That means Brazil could add an additional 7 per cent to the world’s arable land, most of it highly suited for soybean production.

Table 5. Potential arable land available for production

	Increase of arable land 1961–2003	Arable land that could be brought back	Potential arable land that could be added
United States		14,000,000	
European Union		6,000,000	
Canada	4,800,000		
Australia	2,600,000		
Brazil	37,000,000		100,000,000
Argentina	6,400,000		
China	39,000,000		
India	5,900,000		
Former Soviet Union		33,000,000	
Others	31,873,000		
Total increase	127,573,000	53,000,000	

Source: FAOSTAT 2005.

From the 20 major landholding countries, only the United States, the European Union, Australia, Kazakhstan, the Russian Federation and Ukraine have the potential to bring arable land into production. The United States can reincorporate 14 million hectares, the European Union 6 million hectares in set-asides, Australia 5 million hectares, and 33 million hectares from Kazakhstan, Russia, and Ukraine. That represents a total area of 58 million hectares; therefore 4 per cent additional arable lands that can be potentially be back into production.

In summary, about 158 million hectares could be added to the current availability of arable land in production. In addition, there is an unknown number of hectares that may be recuperated in minor agricultural countries through the production improvements and/or through planting energy crops such as native grasses and jatropha that would enhance their productivity.

While this amount of arable lands falls short of replacing all oil-based transportation fuels, it is probably abundant enough to support the food requirements of a growing population and biofuels industry, both at reasonable prices. This statement is even more powerful when recognizing that there is additional feedstock available when crop residues, forest residues, and urban waste are taken into account.

Given the potential size of the biofuels demand, an increase in the competition for land resources between energy and food/feed uses is inevitable, even desirable. As explained above, there is some room for land availability expansion at the global level to accommodate this increased pressure without seriously distorting agricultural commodity prices. Only an extremely accelerated increase in global biofuels demand could overturn the ability to respond to the challenge at reasonable prices.

A sizeable increase in global biofuels demand would spur higher feedstock prices. The reallocation of land to energy crops would also result in higher commodity prices. This process will make feedstocks and, consequently, biofuels more expensive. In turn, this may slow down the global demand for biofuels, reducing the pressure over the land resources.

As agricultural commodity prices remain depressed, the increased demand for agricultural land would provide opportunity for sustained increase in agricultural commodity prices. This may result in significant resource transfers to rural areas in developing countries, bringing opportunities for standards of living and food security improvements.

As overall agricultural prices increase, developed countries that currently subsidize and overprotect their agricultural sectors may change their domestic policy instruments into mechanisms that do not dampen world markets. Therefore, one of the indirect contributions of biofuels is its potential to facilitate more equitable trade in agricultural markets.

There is another land allocation issue that is going on at a much more local level in each country. As with many other attempts at rural development, the potential exists for rural communities that traditionally produced their own staples to allocate a significant area to energy crops, reducing its access to food. For communities faced with that decision, it is clearly important to balance new opportunities from biofuels with their local production of food.

The increases in commodity prices also provide an opportunity to resume production of local traditional foods which were previously displaced by agricultural products coming from international markets at dumped prices. This will add to the diversity of the agricultural product mix, reduce the risk of income loss, and improve household food security.

7.3. Agricultural and feedstock yield increases

To a large extent, hunger and malnutrition are problems related to food access rather than the overall availability of food. This is due not only to increases of arable land in production but mostly by significant yield increases. This yield growth is presumed to be a result of productivity investment (crop genetics, fertilizer and farmer education) as well as other technological improvements.

During the last four decades, crop production has undergone major improvements. Worldwide production of rice, corn and wheat has grown due to yield increases of 77, 80, and 96 per cent respectively. The remaining increase can be attributed to land expansion. Sorghum, cotton and barley production is driven by yield improvements of above 93 per cent. However, soybeans and cassava are low compared with the other crops, at 36 and 26 per cent respectively.

For sugar, a key tropical product and major feedstock for ethanol, 60 per cent of the increase in production can be explained by increases in cultivated land, while 40 per cent is the result of yield improvements. For palm, a major feedstock for biodiesel production, the situation is not that different; 56 per cent of the increase in palm production is the result of additional land, and 44 per cent from yield improvements.

The divergence in agricultural productivity between the developing and developed world is grounded in dramatically different research and development capabilities and government investments. Advanced economies spend up to five times more (as a percentage of total agricultural production) on agricultural-related research and development than their counterparts in developing countries. Rich nations also benefit from the expenditures of private agricultural producers, a source of funding that is virtually non-existent in developing nations. (Hausmann, 2001).

Since climate changes little with longitude, countries of temperate zones – the United States, Europe, Canada, Australia and Argentina – can share technology advancements. Climate changes rapidly with latitude and therefore tropical countries are left outside of much of this transfer of technologies, due to the need of plant varieties to adapt to local conditions and climate. Tropical crops such as cocoa, coffee and cassava are left out of these technology transfers from countries of the North. In many countries of the South, there is also little yield improvements of major staple crops such as corn, wheat, sorghum and millet, possibly due to low local technology investment.

China has increased its yield of corn by almost 500 per cent during the last four decades, from approximately 1 to 5 tons per hectare (the world average yield during 2004 was 4.9 tons per hectare and the United States yield was 10 tons per hectare). According to Zhao Jiuran, director of the Corn Research Center under the Beijing Academy of Agriculture and Forest, the centre developed new species of maize with per hectare yields up to 13,500 kg in 2004. It also forecast that China could spread the “super corn” species over 2.66 million hectares of farmland, turning out an additional 6 billion kg of corn annually. This will significantly boost China’s food grain production, which occupies 26 million hectares, compared to 30 million in the United States.

Brazil’s main public research organization, EMBRAPA, recently released results for one of its soybeans varieties, BRS 232, indicating that it yielded 3,800 kg/ha. This yield is about 40 to 50 per cent above current commercial varieties, including Monsanto’s GMO. Brazil has shown significant success in achieving yield increases in soybeans, sugar, cotton, coffee and other cereals. The significance of increased tropical product yields offers opportunities for South–South cooperation, as crop varieties and production practices could be transferred to tropical areas of Africa and Asia.

Investment in technology has the potential to increase the availability of agricultural production for both food and energy markets. Higher agricultural prices and, in turn, higher returns for agriculture, would fuel investments in the sector, ultimately resulting in higher yields.

7.4. Conversion efficiency and feedstock diversification

A key element in the biofuels production chain is the means in which feedstocks are transformed into energy. These efficiency improvements have two impacts: firstly, to reduce the per-unit conversion cost, and secondly to broaden the set of feedstocks that can be converted in a single plant. While conversion technologies for sugar and corn are mature enough to produce significant breakthroughs, the marginal contribution of extracting fuels from their residues augment the profitability of the process.

Regarding ethanol, the major breakthrough would be the transformation of cellulosic material, the residues from traditional crops and grasses, into ethanol. This process would bring additional high-energy materials into the set of acceptable feedstocks, reducing the pressure on traditional crops and increasing the energy yields per hectare.

Another significant breakthrough is the development of commercial processes to gasify feedstock before they are transformed into bio-products. The advantage of the syngas process is its ability to utilize a diverse set of feedstock, because the first major stage of the process is to convert the feedstock into gas through heat. Once the feedstock is converted into a gas, it can be transformed into ethanol, bio-fertilizers, bio-polymers, or directly into a power source. This process will not only reduce the need for highly concentrated monoculture agricultural activity, but also open up the doors to the concept of bio-refinery.

The extent to which residues or new crops will impact the biofuels market will ultimately depend on the price of the biofuels and the price of the feedstock. An increase in the demand for jatropha will eventually spur a significant increase in feedstock price that could slow down its use in biofuels. This phenomenon could occur with any feedstock. The point at which the expansion of biofuels would result in a pure price increase would depend not only on the speed of adoption, the cost of feedstock production and the conversion technology, but also on the price of oil and environmental impacts.

The link between the energy and agricultural sectors takes a new dimension in the case of a dedicated energy crop such as native grasses or jatropha. In contrast to the conversion of conventional crops into biofuels, dedicated energy crops do not compete with conventional crops for final product use. The competition between the two sectors occurs at the fixed resource use level which is the allocation of cropland. Since dedicated energy crops have a very low value for the feed and food market, there is no competition on its final use. Instead, the competition is transferred to the land allocation process.

Short-run events in agricultural markets are less likely to impact the energy industry built on dedicated energy crops. In addition, unlike conventional crops, grasses and jatropha are perennial crops. This reinforces the fact that short-run events in the agricultural sector are less likely to impact the dedicated energy crop market.

7.5. Price of oil and feedback effect from increased biofuels production

A key variable influencing the rate of adoption or demand increase for biofuels is the price of oil. As it remains at current levels, incentives for feedstock transformation into energy already exist. An even further increase will bring new volumes and types of feedstocks into the market. On the other hand, if the price of oil drops significantly, the set of feedstocks will reduce until technological breakthroughs increase their profitability.

Current estimates state that ethanol from Brazilian sugar can be competitive at $30–35 dollars per barrel of oil. Also, ethanol from corn in the United States can be competitive with gasoline at oil prices above $50.

Once again, the level of global biofuel demand will play a significant role. As the utilization of biofuels increases significantly, it will displace the use of oil-based fuels and will eventually contribute to a reduction in the price of oil fuels. This reduction provides another mechanism through which biofuels could benefit developing countries, whether or not they are biofuels or agricultural producers.

7.6. Net food-importing developing countries and low-income food-deficit countries

One of the basic advantages of biofuels production is the diversity of feedstock that could be used. For these two country groups, biofuels opportunities should be sought in the utilization of crop residues and food waste. Especially for countries with a small agricultural base, the possibility to participate in regional multinational bioenergy industries should be considered.

Managing increased commodity practices has to begin by enhancing the production capacity and performance of the domestic agricultural sector. Local farmers should be encouraged to invest in productivity and infrastructure in order to expand domestic production and generate dynamic economic benefits for the whole country.

The expansion of the biofuels industry should ultimately lead to lower energy prices. Hence, this would be a direct benefit for net food-importing developing countries and for low-income food deficit countries.

Basically, these countries face challenges no different than the ones addressed in the Marrakesh Ministerial Decision, where a series of preferential treatment and exclusions of certain WTO obligations where approved for net food-importing developing countries and least developed countries.

8. Conclusions: impacts on poverty reduction

A dynamic biofuels industry has the potential to reduce poverty by injecting new economic activity in rural areas. The development of agricultural feedstock, the biofuels conversion process and the increase in farm gate prices are the mechanisms to revitalize rural development. Moreover, the development of a bioenergy industry would most likely imply new road and infrastructure projects in rural areas.

While the increase in agricultural prices could potentially benefit 2.5 billion people whose livelihood depends on the agricultural sector. Small landholders, rural landless workers and the urban poor could be at significant risk, at least in the short term. Implementation rules and temporary compensation measures may need to be considered.

Firstly, Government should continue to invest in distribution infrastructure to reduce the transaction costs between farmers and the end market. Price increases could be captured mostly by the marketing system, and be of little consequence for rural areas if the reduction in marketing costs is not addressed.

The reduction in food transaction costs would also help reduce the impact on the food bill of the urban poor. So increase efficiency in the marketing system also includes the process products and imported food.

In the case of small landholders, the absence of clear property rights and enforcement mechanisms could lead to their displacement by large and powerful interests. The size of the potential gains in agriculture would open the door to behaviour already known in many countries.

It is necessary that a significant share of new value added generated reaches farmers and rural areas, because that would open up the economic opportunities in other economic sectors. This must be a critical piece to reduce rural poverty among farmers and landless workers.

Enhanced opportunities for local ownership and the emphasis on sustainable development are key elements to ensure the participation of rural entrepreneurs. Government incentives, if implemented, should be biased in favour of ownership and scale that benefits rural communities.

Finally, the implementation of a biofuels strategy should contemplate sustainable development as a key benefit of international trade. There are few opportunities in which trade rules can be developed and put in place before any significant amount of trade occurs.

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