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Re-fueling the WTO Development Round: Enhancing the Development Synergism Between Agriculture and Energy

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Re-fueling the WTO Development Round: Enhancing the Development Synergism Between Agriculture and Energy

By Daniel G. De La Torre Ugarte*

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Introduction

Higher and more stable agricultural commodity prices are a necessary condition for the agriculture sector to become an effective force in the socioeconomic growth of the less and least developed countries. Higher and stable crop prices are therefore a necessary condition for the success of other development efforts such as export promotion, diversification, and the production of value added goods. It is evident that the current strategy of trade liberalization—in and of itself—cannot deliver higher commodity prices. Contrary to some conventional thinking, this policy failure is not only the result of the agricultural policies of OECD member states, but more importantly one of the fundamental structural characteristics of agriculture.

The main characteristic of agricultural production is that aggregate demand for agricultural commodities does not vary greatly according to price – people must consume food no matter how high the price, and there is only so much a person can eat, no matter how cheap food becomes. At the same time, total agricultural supply does not significantly respond–in the short term—to lower prices because cropland in major producing countries cannot easily be moved in and out of production and has few alternative uses. Furthermore, growth in supply tends to outpace the growth in demand due to investments in productivity. This combination of factors, in a free market environment, tends to produce results characterized by structural oversupply and decreasing commodity prices (Ray, De La Torre Ugarte, and Tiller).

An effective contribution of OECD countries to find a solution to chronic over-supply and the resulting low world prices for crops is to reduce the amount of cropland planted with food and feed crops. In this context, the processing of crops into energy and other bio-products offers an unparalleled opportunity to address this imbalance. The shift of cropland currently used in the production of food to produce bio-energy and bio-products from dedicated crops would reduce the gap between the capacity to produce food and what the market can absorb at reasonable prices. The US and the EU spend over 20 billion dollars a year in direct support to their farmers. Introducing incentive mechanisms to promote the growth of energy-dedicated crops could reduce production of traditional crops, increase their price and reduce or eliminate the need to subsidize them; farmers would rely mostly on income from the market as the main source of support.

The concept of using agriculture to produce energy is not a new concept. In fact, humans have used agriculturally related practices to create power for centuries; “agriculture is essentially an energy conversion process – the transformation of solar

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energy, fossil fuel products and electricity into food and fiber for human beings" (Peart and Brook). As late as the 1950s, many farms ran mostly on sunlight, relying on draft horses and using crop rotations for soil fertility instead of commercial fertilizers. Nowadays however, agriculture uses far more energy in the form of farm inputs. Traditionally, up to 60 percent of cropland was devoted to energy production in the form of feed and green manures (Stanhill, 1984). But even today, biomass feedstock continues to be the most important source of energy–especially heat—in many developing countries (Smil, 2003). With the advent of the petroleum age, farmers could purchase energy more cheaply from fossil-fuel derived sources such as fertilizers, tractors and fuel. This allowed crop production to increase at the cost of reduced energy efficiency. Today, we are once again looking to our agricultural lands to become producers of energy.

One of the biggest advantages of the utilization of biomass for energy is its good fit with the current distribution infrastructure of liquid fuels, and with the use in internal combustion engines. When co-fired with coal or other sources, it is also a good fit to the current electric distribution infrastructure. The growing overcapacity in agricultural production reduces concerns of dramatically affecting the food supply. Moreover, well managed biomass production based on native grasses offers environmental gains when compared with the current monoculture and high input use of cropland in food and feed production in the US and EU.

The goal is to reduce agricultural supply of traditional food and feed crops from the US and the EU primarily to drive commodity prices to increase to allow less developed countries to energize their national agricultural productive capacity, which would increase rural employment, enhance national food security and possibly result in increased foreign exchange, both from decreased import dependence and potentially from increased agricultural exports. For the US and EU, the benefits would be reduced fossil fuel dependence, production of environmental goods (e.g. cleaner air) and higher prices within a more market-oriented, less taxpayer dependent production and trading system. While a strong price for agricultural commodities is not the only condition to ensure the development of the countries of the South, higher prices are a precondition for the success of domestic policy reforms, such as tax reforms, to direct some export revenues to rural development programs.

1. Limits of Trade Liberalization in Agriculture

While it could be productive to engage in a discussion of what policy instruments do belong to the amber or green boxes, the reality is that as long as agricultural production does not significantly adjust in response to lower prices or income, the chances to benefit the developing world are very slim. So, rather than discussing the color of a specific agricultural policy, it seems more productive to focus on the ability of free markets to deal with the uniqueness of agriculture.

1.1. The Natural Distribution of Resources

Notwithstanding the importance of economic and political institutions, recent studies on the relationship between geography and economic development provide evidence of the relevance of geographic analysis for economic development.

Landlocked economies may be particularly disadvantaged by their lack of access to the sea or navigable waterways because of high transportation costs and access to international markets (Hausmann). Costal regions and regions linked to the coast by navigable waterways are strongly favored in development relative to the hinterland. In addition, tropical regions are hindered in development relative to temperate regions because of the greater burden of disease and limitations on agricultural productivity (Gallup and Sachs).

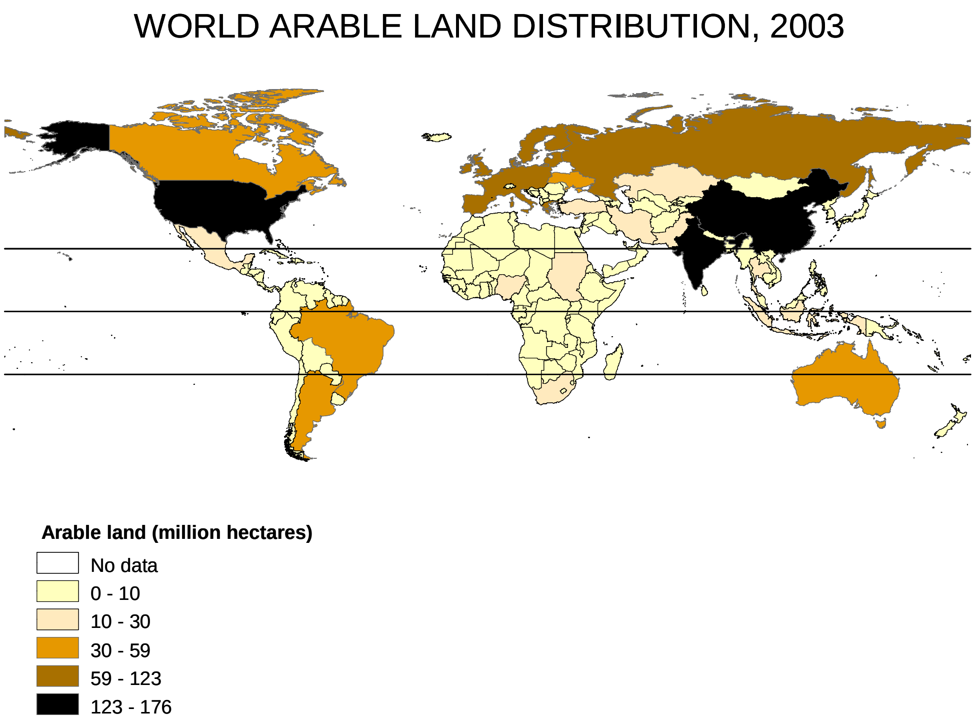
As an activity integrated into the natural environment, for agriculture the geographic factors are central. Soil type and abundance, water availability and seasonality, temperature, and sunlight are just a few of the elements that farmers of all times faced when making planting and management decisions in their fields. The environmental inputs play a key role in influencing which crops can be grown, and when and where they can be grown. The consequences derived from these relationships are often ignored in the discussion and analysis of macroeconomic and international trade issues relating to agriculture.

This does not mean that nature is the single determining factor in agricultural production and trade; human intervention can to an extent selectively breed seeds and modify agronomic practices to allow crops to be grown in areas beyond their native ecosystem. The purpose of this study is to emphasize the role that the natural elements of the ecosystem have played in agriculture and ultimately in the culture and the development of nations (Landes 1998).

The map in Figure 1 presents the world distribution of arable land. Of the 226 countries in the world, just 20 countries contain 84 percent of the world's arable land. From Table 1 it is clear that in 2002 the major agricultural countries–Argentina, Australia, Brazil, Canada, European Union, and United States—accounted together for 33 percent of the land, with China and India adding up to 22 percent, while the more than two hundred countries of the rest of the world, including most developing countries, accounted for 45 percent. When compared to 1961, the rest of the world lost three percentage points in the amount of global arable land.

The same Table 1 displays some information on the land per capita, and here the disparities are obvious. The land per capita in the major agricultural countries is twice what it is in the rest of the world and five times that of the China and India combined. Obviously, population has or will soon outgrow the increase in arable land, which is fixed and nearly maxed out. Only Brazil has a significant potential for expansion.

Figure 1



Source: FAOSTAT

Table 1. Distribution of Arable Land

	Arable Land (in 1000Has.)				Arable Land per capita	
	1961		2002		1962	2002
	1000 Ha	%	1000 Ha	%		
Major Ag	410,038	32	465,452	33	0.61	0.46
China, India	259,203	20	304,336	22	0.14	0.09
Rest of World	607,316	48	634,342	45	0.47	0.22
Total	1,276,557	100	1,404,130	100	0.41	0.23

Source: FAOSTAT

1.2. Enhancing the Advantages Provided by the Natural Endowment

It is evident that the natural ecosystem has significant impacts on the geographic distribution of agriculture, but nature is not the single determinant factor. There are ways in which the effects of nature on crops can be managed, and that is precisely one of the major roles of research and development (R & D) through technology.

Technology can effectively modify the adaptation of crop varieties to ecosystems beyond the production capacity of the natural endowments of their native ecosystems.

Technology is also important, because it results in new factors—practices, implements, machinery, fertilizers, pesticides, herbicides—that have an impact on the physical yield as well as the economic return of the crops. Therefore, to an extent, R&D has the potential to equalize the distributional unfairness of the natural resource endowment.

Existing data published provides a very good understanding of the distribution and evolution of research expenditures. Tables 2 and 3 show data on total public investment in research as well as on the intensity of this research. While Table 2 provides an idea of the dominance of R& D expenditure in agriculture in developed countries, it also indicates the significant increase in R&D spending in Brazil, China and India and even in developing countries. However, when these absolute numbers are converted into intensity ratios, it is clear that the overwhelming concentration of research investment lays in the major agricultural countries.

When considering the economic value of agricultural production, a very important factor that needs to be taken into account is the infrastructure of distribution and transportation. Investment in distribution and transportation networks can enhance or overcome the advantages or disadvantages given by the natural topography and the location of the production areas. A well developed transportation network is a necessary condition for a country to derive full benefits from sound trade and macroeconomic policies (Hamilton 2000).

According to World Bank data, in 2000 the major agricultural countries accounted for more than 56 percent of the world roadways, while the share of India and China was 17 percent. These two groups share 71 percent of the world railways, and also represent 90 percent of the new railroad expansion for the period 1990 to 2000. African's surface represents 20 percent of the world area, but the continent has less than 6 percent of the roadways and only 7 percent of the railways of the world. Africa also represents just 7 percent of the new railroad expansion for the last decade, keeping its share of global roadway infrastructure merely constant, but failing to increase.

Technology, one of the most important equalizers in terms of agricultural production and of balancing the lack of natural resources for agriculture is also largely concentrated in the six major agricultural countries increasing their relative advantage already biased in their favor by their endowment of natural resources. The same can be said about investment in infrastructure and transportation. In summary, human intervention has deepened the natural advantage that the countries had in agriculture as a result of their natural endowment.

Table 2. Global public agricultural research expenditures in millions of 1993 international dollars

	1976	1985	1995
Developed Countries	7,099	8,748	10,215
Brazil, China, India	1,658	3,070	5,050
Developing Countries	3,080	4,606	6,427
TOTAL	11,837	16,424	21,692

Source:Pardey and Beintema (2001)

Table 3. Selected public research intensity ratios, 1976-95

	Expenditures as % of GDP			Expenditures per capita			Expenditures per economically active agricultural population		
	1976	1985	1995	1976	1985	1995	1976	1985	1995
	(percent)			(1993 International dollars)					
Developing Countries	0.44	0.53	0.62	1.5	2	2.5	4.6	6.5	8.5
Sub-Saharan Africa	0.91	0.95	0.85	3.5	3	2.4	11.3	10.6	9.4
China	0.41	0.42	0.43	0.7	1.3	1.7	1.8	3.1	4.1
Other Asia	0.31	0.44	0.63	1.1	1.7	2.6	3.8	6.1	10.2
Latin America	0.55	0.72	0.98	3.4	4	4.6	26	36	45.9
Developed Countries	1.53	2.13	2.64	9.6	11	12	238.5	371	594.1
TOTAL	0.83	0.95	1.04	3.3	3.8	4.2	12.9	15.3	17.7

Sources: Pardey and Beintema (2001)

1.3. Response to Market Signals

The overriding problem is that agricultural markets do not self-correct (Ray, De La Torre Ugarte and Tiller). The self-correction issue is so important in the case of crop agriculture, because market disruptions occur so frequently. Weather-based fluctuations in yields are an obvious market shock. A longer term, more predictable force that affects agricultural markets is that productivity growth tends to outstrip the traditionally slower growth in food demand. Domestic demand for agricultural products in a country like the US grows with population but, unlike the demand for cars, houses, clothes and most other product categories, doubling a consumer's income will have a minor impact on his demand for food. Likewise, the rate of growth in export demand over time has been disappointing, especially in the case of grains. If the growth in demand for agricultural products kept up with production, low farm prices and incomes would be much less of an issue.

In the agricultural sector, productivity-enhancing technologies are quickly adopted, increasing supplies and putting downward pressure on prices. The lower prices, in turn, become further incentives to adopt more cost-reducing technologies, and prices continue their slide. In this way, production agriculture is under constant price pressure, with periods of brief reprieve generally the result of disasters or other random events. Given that food is essential for life, it is urgent that the productive capacity of agriculture continue to stay well ahead of immediate needs. Most agree that this important part of agricultural and food policy should be continued, despite its severe downward pull on farm prices. The mere presence of low prices is not the problem. What matters is how consumers respond in terms of the amount they are willing to buy and how producers respond in terms of the amount they are willing to produce next season. If consumers bought more of the lower priced goods and producers cut their production, excess inventories would quickly vanish and prices would arrive at profitable levels once again.

If this adjustment could take place in the agricultural sector, there would be no fundamental price and income problem. This is exactly the way it works in most product-producing industries: consumers buy more and producers provide less in response to a drop in prices or increase in inventories or a drop in sales. Prices rise and profitability re-appears. But neither the quantity of crops demanded nor the quantity supplied is significantly responsive to changes in price, so timely market self-correction does not take place. Total annual output remains relatively constant irrespective of prices, the level of subsidies, or other sources of revenue.

Even when individual farmers go bankrupt, total output changes very little. In contrast to other industries, where a plant closure means a reduction in industry size because the land and other assets are often sold to a different industry, crop acreage typically remains in production. It is merely tilled by someone else. A farm sale does not typically reduce the size of the agricultural industry. In fact, output per acre may actually increase, because the new owner is a better manager or is better capitalized.

The bottom line is this: regardless of the cause of decline in revenue, total crop output declines very little in response. Self-correction works no better on the demand side than on the supply side. To establish an agricultural policy based on the assumption that free market adjustments will occur within a reasonable time is not only naïve and ill-advised, it simply will not work**.**

1.4. Implications for Agricultural Trade

The original agricultural advantage in the six major agricultural countries in the world, based first in their privileged endowment with natural resources, has been enhanced by the concentration of investment in research, transportation and infrastructure. In addition, during most of the 1900's, massive investment in agricultural public support programs has allowed the development and consolidation of tremendous production capacity in the agricultural sector. All of this has resulted in a growing concentration in the production and export of temperate products in the major agricultural countries as well as in China and India, as it is shown in Table 4 using the cases of corn and wheat. In the case of rice, a sub- tropical product, there have been some progress in the rest of the world, but the overwhelming growth has come in the countries of China and India.

It is clear that the existing production capacity and the increase in this capacity in the major agricultural countries –mostly in Brazil—as well as in China and India continues to tilt the playing field in favor of these two groups. Moreover, change in production and trade flows in favor of the developing countries resulting from trade liberalization will not bear fruits unless significant investment in technology and infrastructure precedes it. The largest share of the benefits from trade will continue to accumulate in the countries in which the production capacity already exists, but as important as that, it will accumulate where the ability to market that production exists.

Table 4. Distribution of the production and export of selected commodities

CORN	Production 1961	Production 2003	Exports 1961	Exports 2003
North	57%	58%	66%	64%
China	9%	18%	0%	19%
India	2%	2%	0%	1%
Others	32%	22%	33%	26%

WHEAT	Production 1961	Production 2003	Exports 1961	Exports 2003
North	42%	47%	50%	52%
China	6%	16%	0%	1%
India	5%	12%	0%	4%
Others	47%	25%	50%	43%

RICE	Production 1961	Production 2003	Exports 1961	Exports 2003
North	4%	2%	12%	14%
China	26%	31%	13%	8%
India	25%	20%	0%	12%
Others	45%	47%	75%	66%

Source: FAOSTAT

Overcoming the advantages of the six major agricultural countries and of China and India will take a two-phased process. The first step is the reduction in the use of the production capacity of those countries, so as to allow prices, production and trade flows to shift in favor of the developing countries. The second step is to start a significant process of investment in infrastructure and research in developing countries.

2. The Role of Bioenergy in a New Energy Paradigm

Biomass is a widely available energy resource that is receiving increased consideration as a renewable substitute for fossil fuels. Developed in a sustainable manner 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.

Paragraph 31(iii) of the Doha Ministerial Declaration encourages negotiations on 'the reduction or, as appropriate, elimination of tariff and non-tariff barriers to environmental goods and services' (EGS). Bioenergy fuels derived from sustainable agricultural practices have many attributes that qualify them as EGS. They can also play a major role in economic development strategies. Modern energy services—heat , electricity and transportation fuel—are essential for economic advancement and for breaking the cycle of poverty, thus constituting a key element toward the achievement of the Millennium Development Goals (MDGs), particularly with oil prices hovering around 60 US dollars per barrel. The Kyoto Protocol's Clean Development

Mechanism (CDM) offers an additional economic incentive for development of bioenergy services in developing countries. All these elements are pointing to a new era in which the energy paradigm, environmental sustainability, and poverty alleviation all should be mutually supportive endeavors – and demand international policy coherence.

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 de-carbonize 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 percent 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 can be as high as 80 percent (UNDP, 2000).

The potential contribution of modern biomass energy services to a new energy paradigm is indeed significant. The world consumes about 400 EJ (exajoules) 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 size of bioenergy's ultimate contribution, however, is conditional on the use of sustainable agricultural practices, on land use consistent with the food needs of local and global populations, and on the technically and economically efficient distribution and conversion of feedstock into energy. However, bioenergy has to be viewed not as a replacement for oil, but as one element of a wider portfolio of renewable sources of energy.

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. The results are bioenergy products that provide multiple energy services: cooking fuels, heat, electricity and transportation fuels.

It is this very diversity that holds the potential of a win-win-win development path for the environment, social and economic development, and energy security. 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.

3. Synergism Between Bioenergy and Agricultural Development

3.1. The Role of Agriculture in Developing Countries

Over the last five decades, the world's agricultural population increased from 1.5 billion to 2.5 billion, currently constituting 40 percent of the world's population. Africa showed the highest percentage increase in agricultural population, from 222 million to 460 million. In 2005, some 54 percent of the population in African countries is 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 percent of the jobs, and represents on average 15 percent of the gross domestic product (the average participation of agriculture in the GDP is 30 percent for 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 to 52 million people, declining from 8 to less than 2 percent of the world's agricultural population. Thus, in fact, just 2 percent of the world's agricultural population have access to more than 34 percent 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 (Gollin et al.). Agriculture is important because it employs a large portion of the labor 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). Agriculture also has the capacity to exploit productivity-increasing technological innovations that make large net additions to national income and consequently to aggregate demand.

3.2. Bioenergy in the North as a Mean to Induce Agricultural Development

The degree of concentration of the conditions of natural ecosystems required for agriculture in only a few countries of the North, and also the concentration of the investment in agricultural research and infrastructure in these same countries, significantly affects the ability of free trade to re-allocate the trade flows of agricultural commodities between North and South.

Since market mechanisms alone are unable to induce a significant adjustment in the agricultural production in, and consequently agricultural exports from developing countries, for developing countries to benefit from the World Trade Organization's (WTO) Agreement on Agriculture (AoA) what needs to happen is the implementation of policies in the North that would result in an effective and significant reduction in their exports of agricultural commodities. In brief, policy mechanisms need to be put in place that would transfer the production of agricultural commodities from agriculturally developed countries to developing countries, especially least developed countries.

One way to do this is to find other non-food uses for commodities. If the support to farmers in the North were to be shifted towards the production of energy-dedicated crops, an unparalleled set of opportunities would arise to address the imbalance in ecosystem endowments and research expenditures between North and South described earlier. The shift of cropland currently used in the production of food to produce bio-energy/bio-products dedicated crops[†] would reduce the gap between the capacity to produce food and what the market can absorb at reasonable prices. Moreover, the land used to grow grasses and grains for energy production could be shifted back into food production with relative ease as, and when, an increased food supply is required.

In the case of many agricultural commodities, especially temperate climate commodities, production and/or export is highly concentrated in a few countries in the North and some countries in the South with more advanced economic development. If the above strategy is properly implemented in a few appropriate countries, the potential exists to transfer significant resources from these countries to less and least developed countries in which agriculture plays a key role as a source of employment, income, and foreign exchange. While price is not the only condition to ensure the development of the countries of the South, higher prices are a precondition for the success of domestic reforms. The latter would be required to ensure that these higher prices would be transferred to most farmers and populations dependant on agriculture. It is important to note that higher commodity prices also have the potential to increase the price of food and the cost of living, especially for the urban segment. While this is an important factor to take into consideration, the positive impacts would likely outweigh the negative impacts in economies where a larger share of the population depends on agriculture. In this case, the challenge would be to devise compensatory mechanisms for the urban poor.

In summary, the increased use of agricultural products for energy could facilitate a transition away from traditional agricultural support programs in highly industrialized countries (De La Torre Ugarte and Hellwinkel, 2004; Fulton, 2004). At the same time, coherent and mutually supportive environmental and economic policies may be needed to encourage the emergence of a globally dispersed bioenergy industry that will pursue a path of sustainable development and achieve win-win outcomes for the environment and economic development.

3.3. The Potential Contribution of the U.S.A.

Agriculture is well positioned to become an important component in the strategy to develop and use alternative energy sources. The corn-based ethanol industry in the United States was practically born as a result of the energy policy objective. It grew from non-existent in 1970 to 1.9 billion gallons in 2001. The growth resulted from the combination of national security concerns, new gasoline standards, and government incentives. Use of corn for ethanol was estimated to represent 7.1 percent of total domestic use in the year 2001 (USDA). Several studies have documented the contribution of the ethanol industry to agriculture in the form of a higher corn price and higher farm incomes, as savings in government expenditures and also the potential gains if the growth of this industry speeds up as a consequence

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[†] Bioenergy/bioproducts dedicated crops are those which main use is their transformation into energy/bioproducts. Examples are switchgrass, hybrid poplars and willows, jatropha, and other products with little food and feed value, and are produce for the purpose of transforming them into energy or bioproducts.

of banning environmentally harmful fuel additives such as MBTE as a fuel component.

The engine behind the growth of the use of corn for ethanol has been environmental regulations as well as tax breaks supporting the use of ethanol as a cleaner fuel in order to help with national compliance of the Clean Air Act. The increased use of agricultural commodities (such as corn, others) and their by-products for energy production results in moving away from feed and food production. However, agricultural input and output prices will respond to the changes in use, and consequently generate new levels of returns, income and government expenditures in the agricultural sector, without distinguishing the origin of the change, whether it be energy or food and feed markets. The energy sector competes through the production of ethanol with the feed and food market for the use of the same commodity, f.ex. corn. Because of this direct competition for corn use, changes in the feed market would directly affect the price of corn, and consequently the demand for ethanol, and vice versa; hence, more or less, the price variability of one market will be directly transferred to the other.

The link between the energy and agricultural sector takes a new dimension in the case of a dedicated energy crop, such as switchgrass. In contrast to the conversion of conventional crops into biofuels, energy dedicated 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 corn and the major crops, switchgrass is a perennial crop. This reinforces the fact that short run events in the agricultural sector are less likely to impact the dedicated energy crop market. Finally, switchgrass is a perennial, which "has important implications for stabilizing agricultural soils, reducing erosion, and improving water quality" (McLaughlin). Annual row cropping causes soil erosion and chemical runoff, whereas energy dedicated crops grow for many years thereby significantly reducing these effects. Furthermore, these crops also provide a habitat for wildlife. In summary, there are three basic advantages of switchgrass for conversion into biofuels such as ethanol over rival annual feedstocks: i) It competes for land with traditional crops thereby raising prices and reducing government payments; ii) it does not compete for final product use of traditional crops, and iii) it is perennial and therefore lessens soil erosion

The results of a recent analysis (De La Torre Ugarte and Hellwinkel, 2004) indicate that national switchgrass acreage could reach 26.9 million acres by 2013 at the upper-limit price of $50 per dry ton (dt). As switchgrass plantings are increased, the price of other commodities increase and government payments decrease.

The analysis included switchgrass prices ranging from $20 to $50 per dry ton. At all prices above $25, switchgrass production would steadily increase up to the final year of the analysis, 2013. Switchgrass does not come into production until the price reaches $25 per dt. At this price, 6.4 million acres are planted by 2013. Table 5 shows that switchgrass acreage increases as price increases up to 26.9 million acres at a price of $50 per dt. Nationally, wheat, soybeans and hay lose the most acreage, decreasing by 5.8, or 7.5 and 7.2 million acres respectively. Corn acreage only loses 1.7 million acres and rice does not loss any acreage.

As acreage shifts into switchgrass production, the price of the other commodities increases. The greatest increases are seen in wheat and soybeans with a $0.86 and $1.25 rise in prices respectively at the highest switchgrass price scenario. Although corn did not lose much acreage, its price increased significantly by $0.53 per bushel. Hay lost considerable acreage and the effect carries over to its price, which sees an increase from $91.14 per ton to $102.66 per ton. Table 6 gives the price changes for the other switchgrass price levels in 2013.

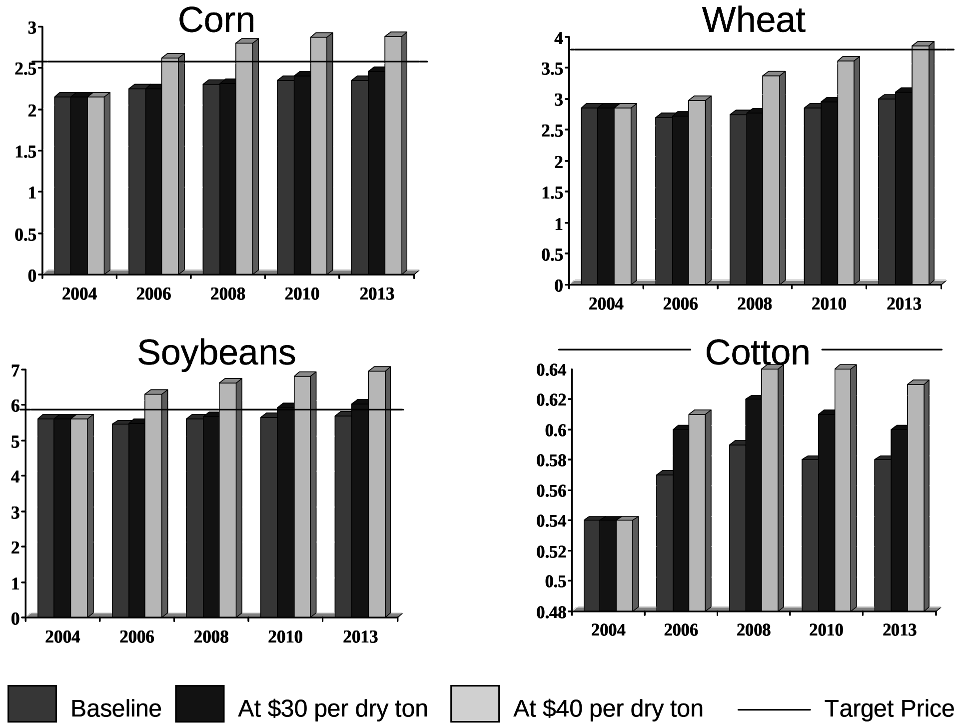
At each unique switchgrass price level, the transition of acres out of traditional crops is steady, and likewise, the price of traditional crops also steadily increases over the 10 year study period. Figure 2 shows the progress of prices upward over the simulation period in 3 different scenarios; the baseline, $30 per dt, and $40 per dt. Note that the relative price increase above baseline prices for corn and cotton are mostly realized by 2006; whereas wheat and soybean prices continue to rise relative to the baseline throughout the study period. Figure 2 also has a line indicating the target rates of the crops. At $30 per dt, only soybean prices reach above the target rate. But at the $40 per dt rate, corn, wheat and soybeans reach above the target prices indicating greater government savings in payments to traditional commodities. Cotton target prices are never reached, and therefore cotton continues to receive government payments in all scenarios.

The development of the switchgrass supply curve shows the optimal switchgrass price and production where marginal government savings are maximized. By plotting the final year data on price and quantity of switchgrass at increasing prices, an approximation of the supply curve is illustrated in figure 2. Starting from $20 a dry ton, where no switchgrass is produced, switchgrass quantities increase as its price increases. Expectedly, the slope of the curve increases at higher prices (above $60 per dt); this is due to inelastic demand constraints on food commodities which cause increased competitiveness for land resources. Figure 2 also illustrates falling government payments as the quantity of switchgrass increases. Government payments drop the quickest when switchgrass production is between 45 and 80 million dry tons. This corresponds to switchgrass prices between $25 and $40 per dt. If these savings in government payments were to subsidize switchgrass production, the result would be a shift in the supply curve out to the line defined as 'Net Cost Supply Curve'—meaning the supply curve resulting from the net of using the revenue saved in reduced payments to other crops to fund switchgrass production. The greatest distance between the supply curve and the net cost supply curve occurs at 81 million tons of switchgrass production, or at the $40 per dt price level. Here, $20 of government savings per ton of switchgrass produced is realized. If government savings were to subsidize switchgrass at this point, the nation's agricultural lands could produce 81 million tons of switchgrass at an additional cost (above baseline total government payments) of only $20 per dt.

This re-allocation of cropland from food and feed crops into a bioenergy crop reduces the production level of those crops, and consequently also reduces the exports from the US of commodities like corn, soybeans, wheat, rice, and cotton.

Consequently, developing countries may benefit not only from the higher prices resulting from the decreased US production, but also from the supply response that those higher prices will trigger domestically.

Figure 2: Crop Price Changes at different Switchgrass Prices.



The extent of the supply response in a developing country will be a function of the ability of the domestic marketing system to transfer a significant share of the price increase to the producers. Higher prices of these commodities, for farmers in developing countries, would also generate a positive supply response in the production of agricultural products that would have been previously displaced by cheap commodities from the international markets. In the developing countries, price increases would provide the necessary resources to invest in new practices and the introduction of modern inputs.

If similar bioenergy strategies could be implemented across the most agriculturally developed countries, then enough momentum would be created to expect that the increases in commodity prices would be sustainable in the long term. To date, Brazil is not only the most important producer of ethanol from sugar, but also continues to invest in expanding the bioenergy sector. The European Union also has established a target for renewable fuels. So the prospects for wide-spread impacts in agriculture are present.

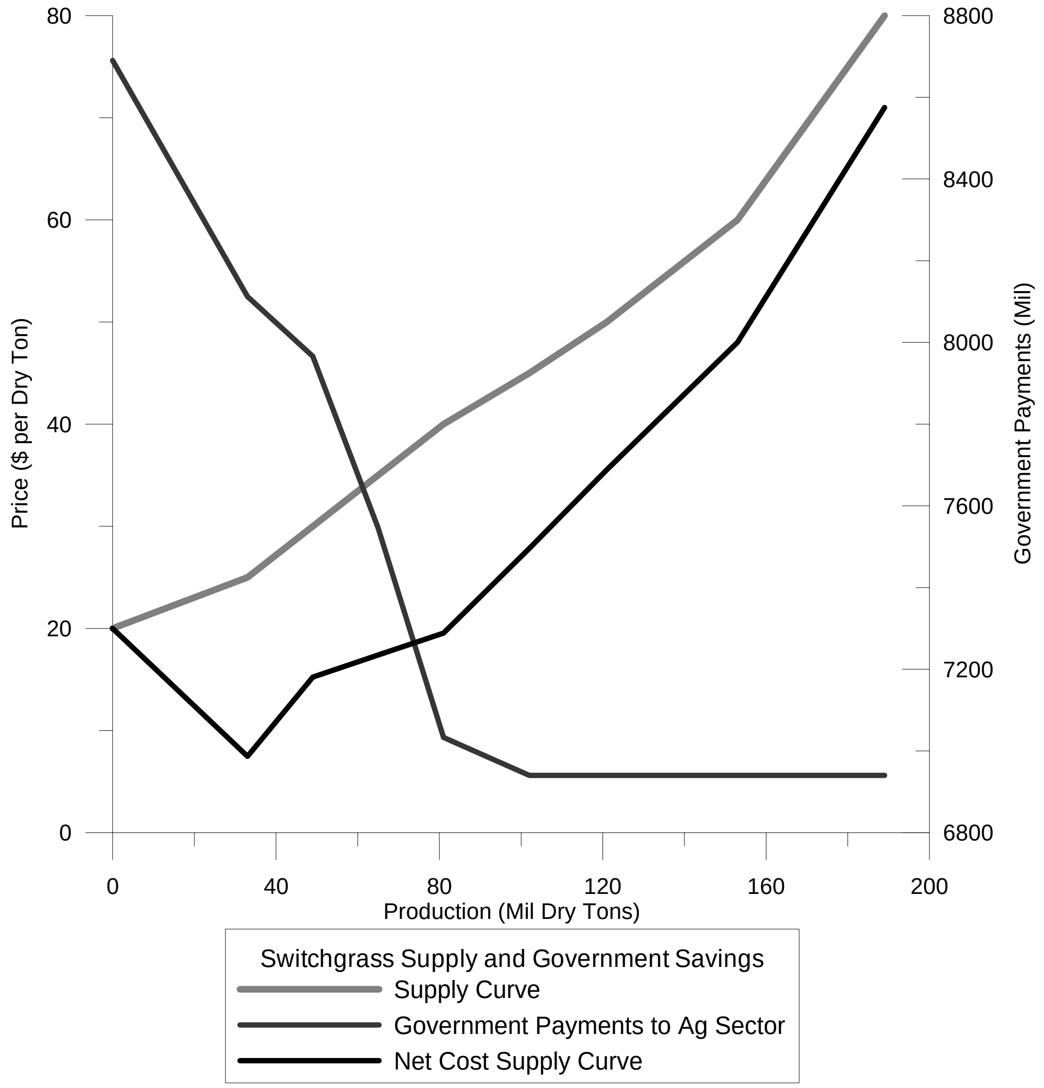
Table 5: Acreage Changes as Switchgrass Price Increases, 2013.

Price ($/dt)	Corn	sorghum	Oats	Barley	Wheat	Soybeans	Cotton	Rice	*Switchgrass*	Hay
0	73.8	7.5	1.9	4.3	51.1	71.2	12.6	3.1	*0.0*	62.4
20	73.8	7.5	1.9	4.3	51.1	71.2	12.6	3.1	*0.0*	62.4
25	73.4	7.5	1.9	4.2	50.8	70.3	11.6	3.1	*6.4*	58.8
30	73.3	7.3	1.8	4.3	50.5	70.0	11.8	2.7	*9.9*	56.6
35	73.0	7.2	1.8	4.3	49.4	69.6	11.4	2.7	*14.1*	55.6
40	70.3	7.1	1.7	4.0	48.3	71.0	11.0	3.0	*17.6*	55.3
45	72.9	6.9	1.7	3.9	46.7	65.8	10.8	3.1	*22.6*	55.4
50	72.1	6.9	1.6	3.8	45.3	64.1	10.7	3.1	*26.9*	55.2

Table 6: Price Changes as Switchgrass Price Increases, 2013.

price	Corn	sorghum	Oats	Barley	Wheat	Soybeans	Cotton	Rice	*Switchgrass*	Hay
0	2.35	2.10	1.35	2.55	3.00	5.70	0.58	7.22	*0.00*	91.14
20	2.35	2.10	1.35	2.55	3.00	5.70	0.58	7.22	*20.00*	91.14
25	2.42	2.18	1.38	2.61	3.07	5.91	0.61	7.24	*25.00*	96.74
30	2.46	2.27	1.39	2.64	3.11	6.02	0.60	8.26	*30.00*	100.63
35	2.52	2.40	1.44	2.69	3.23	6.19	0.61	8.30	*35.00*	102.66
40	2.90	2.69	1.57	3.01	3.40	5.68	0.62	7.54	*40.00*	104.71
45	2.62	2.54	1.50	2.89	3.58	6.61	0.63	7.41	*45.00*	102.64
50	2.88	2.67	1.57	3.06	3.86	6.95	0.63	7.22	*50.00*	102.66

Figure 3: Switchgrass Supply Curve, Government Payments and Switchgrass Supply Curve after government savings.



3.4. Contribution of Bioenergy to Development in the South

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: environmental benefits from the reduction of greenhouse gases (GHG) and the recuperation of soil productivity and degraded land; economic benefits from the increased activity resulting from improving access to and quality of energy services; and international benefits derived from the development of sustainable bioenergy trade.

The Brazilian experience in biofuels, dating back to the Alcohol Programme of 1980, shows that it is possible to achieve a sustainable and economic ethanol production. Ethanol production in Brazil is economically viable without any government support at oil prices above 35 US dollar per barrel (Cohelo, 2005); this experience based on the use of sugarcane is transferable to other countries. Biofuels based on corn or other feedstock is maturing rapidly and reaching the point that ethanol prices would cover the cost of production.

There is a clear link between access to energy services and poverty alleviation and development. The first set of critical energy needs are 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 are those that provide energy for income-generating activities that help break the cycle of poverty.

As was mentioned before, the poor rely heavily on biomass as a source 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, 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 in the development of biofuels is to diversify energy resources; however, the opportunities for rural development need also 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 bioenergy 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.

Because bioenergy production facilities need to be located in rural areas, close to where the feedstock is grown, 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 produced will also benefit rural areas.

Additionally, since certain energy crops like trees and grasses require fewer inputs, they sometimes can be grown on land 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.

The CDM of the Kyoto Protocol allows polluting countries or enterprises to purchase environmental goods from developing countries. This is an example of an instrument that offers the opportunity to export environmental goods and services (EGS) from developing to developed countries, or even within a South-South framework. The CDM also furthers sustainable development in the countries providing the environmental benefits.

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

3.5. Contribution of Bioenergy to Food Security

There is a wide consensus that the world produces, and has the capacity to produce 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 that would allow 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 the distribution of it. 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 to food 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 exploitation and the creation of international and domestic mechanisms that contribute to keeping poor people poor. Often food producers are the poor.

The overemphasis on trade and efficiency encourages farmers to shift production from local foods to cash crops such as coffee, cocoa, tea, wine, spices, fruits, and other agricultural products demanded by the developed world. This is done at the cost of reducing local food production for the community and the domestic market. 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.

Given this framework, the potential contribution of energy production in poverty reduction and food security lays in the sustainable use of the local resources to produce food and to complementary produce energy to support the economic diversification of the household and the community. The use of agricultural residues as energy feedstock is a first phase in the search for the synergism between food and energy production. But the utilization of bioenergy dedicated crops can also provide the means to recuperate degraded soils.

The contribution of bioenergy in the fight against poverty and in improving food security could be multiple. Shifting land use in developed countries towards energy uses would reduce the dumping in the commodity markets and provide access to higher prices for farmers in developing countries. In developing countries, the production of energy in concert with a sustainable food production and the sustainable use of local resources could also result in higher incomes for farmers and added energy services for the community, all of which would enhance the community's ability to develop economic activity designed to reduce poverty and enhance food security.

4. 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; this feedstock 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 biofuel sector 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 the crushing of the sugar stalks (Fulton, 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 fiber) like 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, like 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 EGS.

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. A further expansion towards the use of energy dedicated crops would more than likely 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 et. al, De La Torre Ugarte; De La Torre Ugarte and Walsh) between 15 to 30 million acres in the US can shift towards energy dedicated crops and generate a significant reduction in the food and feed production and export surpluses. Given the weight of the US 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 and feed towards 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.

Given the low density of 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.

There is a great gap between countries at the forefront of development of their biofuels industries, such as Brazil, the Philippines, and the US, 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 owe their progress to a set of economic incentives and domestic policies that have fostered the development of a bioenergy industry (Coelho). 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 that bioenergy could play in their economies and in the economies of countries that could be markets for bioenergy services, such as Japan, as well as opportunities that tradable environmental goods may have for their economies.

An international bioenergy trading system will be supported best 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 expand the biofuel market.

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 a large production potential, like Brazil and Thailand, to take advantage of their economies of size by promoting mechanisms that expand the production and use of bioenergy as well as international trade of energy services. At the same time, these international rules should support conditions to generate investment in countries with a smaller volume potential, but which are capable of taking advantage of domestic resources suitable to their resource base.

The nexus of energy development, poverty alleviation and economic development, and environmental protection offers a unique opportunity for international development, 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.

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