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SAG's

Study on Regional Evidence Generation and Policy and Institutional Mapping on Food and Bioenergy:

Latin America and Caribbean-LAC



Paper prepared on behalf of FORAGRO/PROCITROPICOS/IICA

– Version 1.0 –



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***Study on Regional Evidence Generation
and Policy and Institutional Mapping on
Food and Bioenergy:***

Latin America and Caribbean-LAC

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Paper prepared on behalf of FORAGRO/PROCITROPICOS/IICA

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List of Acronyms

BANADESA	Banco Nacional de Desarrollo Agrícola (Honduras)
BNDES	Banco Nacional de Desenvolvimento Econômico e Social (Brasil)
CDM	Clean Development Mechanism
CEDRSSA	Centro de Estudios para el Desarrollo Rural Sustentable y la Soberanía Alimentaria (México)
CEPAL	see ECLAC
CMM	Centro Mario Molina (México)
CNE	Comisión Nacional de Energía (Chile)
CNG	Compressed Natural Gas
ECLAC	UN Economic Commission for Latin America and the Caribbean
EISA	Energy Independence and Security Act (EE.UU.)
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuária
ERA/ARD	European Research Area / Agricultural Research for Development
ET	Evapotranspiration
EtOH	Ethanol
FAO	Food and Agriculture Organization of the United Nations
FAPRI	Food and Agricultural Policy Research Institute
FOB	Free On Board
FORAGRO	Foro de las Américas para Investigación Agrícola y Desarrollo Tecnológico / Forum for the Americas on Agricultural Research and Technical Development
GHG	Greenhouse Gases
IICA	Instituto Interamericano de Cooperación para la Agricultura
Kbep	Kilo barrels equivalent of petrol
LAC	Latin America and the Caribbean
LPG	Liquified Petroleum Gas
MAPA	Ministério da Agricultura, Pecuária e Abastecimento (Brasil)
MDA/SAG	Ministério de Desenvolvimento Agrário / Secretaria de Agricultura Familiar (Brasil)
OLADE	Organización Latinoamericana de Energía
PNPB	Programa Nacional de Producción y Uso de Biodiesel (Brasil)
PróAlcool	Programa Nacional do Alcool (Brasil)/National Alcohol Program (Brazil)
SAG	Southern Advisory Group
SAGARPA	Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación (México)
SENER	Secretaría de Energía (México)
SNV	Servicio Holandés de Cooperación al Desarrollo
UNICA	União da Indústria de Cana-de-Açúcar (Brasil)
UPME	Unidad de Planeación Minero Energética Ministerio de Minas y Energía (Colombia)
UWET	Unified Wood Energy Terminology
ZAE	Agro-ecological Zoning for Sugarcane in Brazil (Zoneamiento Agroecológico de la Caña de Azúcar)

1. Introduction: General outlook

Indications for the twenty-first century point towards an increase in the global demand for food, fiber and energy. Tropical countries that are rich in land, water and solar energy will thus have a unique opportunity to play an essential role. At the same time, due to a new environmental awareness that focuses on the sustainability of production systems, there is a call to shift production patterns by adopting measures aimed at slowing down the depletion of natural resources and reducing greenhouse gases in order to diminish their effects on climate change.

Among the different measures possible to achieve this, the use of renewable energy instead of fossil fuels (oil and coal) shows great potential for the utilization of renewable energy, particularly what is produced from biomass. Raw materials used for the production of biofuels may be obtained by growing high energy density specimens, or through the exploitation of organic refuse and waste.

Most countries in Latin America and the Caribbean have been, or are currently, implementing policies or programs that provide incentives for producing biofuels. However, although they represent an important opportunity for agriculture in the region, biofuels can only be optimized if progress is made towards the achievement of the regulatory goals that will allow their insertion in the countries' energy matrixes. The importance of clear regulatory goals stems mainly from the fact that, in their absence, a market cannot be created. Without a market, there are no investments and without investors the region may lose all comparative advantages it currently has over others with regard to biofuel production.

Another positive impact of renewable energy production is the redistribution of the income generated, since it requires a large raw material production base prior to processing and transportation. Employment and income supply are thus expanded, thereby helping to strengthen economic development in those countries.

According to the UWET (2001)¹ biofuels may be classified in three groups: (a) wood fuels, which are directly or indirectly derived from trees and bushes that grow in or outside forests; (b) agrofuels, that derive mainly from biomass resulting from crops grown for fuel, and from agricultural, agro-industrial and animal byproducts; and (c) municipal byproducts from biomass waste generated by the urban population in cities and villages that can be either solid or liquid/gas.

Other classification criteria for biofuels take into account their physical state, origin, end use, or conversion process. This study will focus mainly on liquid biofuels generated from agricultural raw materials (agrofuels), or those whose end use is transportation (bioethanol and biodiesel).

There are currently mounting concerns about the actual sustainability of biofuel production. Discussions on this subject focus principally on maintaining the available land fit for cultivation for growing high energy density specimens, or for the organic waste and residue exploitation necessary for biofuels, in such a way so as not to compete with food production and security.

The production of biofuels may indeed have an adverse effect on agricultural markets. Much has been said about how the increase in the demand for biofuels could result in a greater concentration of production and land ownership. Although this is not out of the question, a good biofuel policy can serve to guide agricultural and social development in regions where agriculture is no longer a competitive activity.

¹ Unified Wood Energy Terminology UWET". FAO (2001a). Departamento de Montes de FAO. 2001. Disponible en <http://www.fao.org/docrep/008/j0926s/j0926s00.htm>

There are no clear-cut rules to be followed for biofuel policies, namely because each country must define its goals based on its own geographical, social and environmental realities. Nor is it necessary to reinvent the wheel, as a number of country profiles are readily available, including their experiences on the subject.

A great deal of information can also be found in the literature on the conflicts that biofuel production may cause with regard to food security, although analyses on the subject are often unilateral. From the point of view of land competition, any agricultural activity that does not directly target food generation is competing with food security. Likewise, other agricultural activities such as silviculture, or flower or tobacco growing, currently practiced for income diversification in rural areas, would be equally condemned, just like the production of biofuels.

A thorough study of land-use potential prior to creating regulatory goals, and the use of techniques such as crop rotation or no-till systems, would make the production of raw materials possible, both for biofuel or food, minimizing food security risks while increasing energy security.

According to the Food and Agriculture Organization of the United Nations (FAO)², the different countries in Latin America and the Caribbean (LAC) can be classified according to their availability of arable land for agricultural expansion. They are thus divided into three major groups: (a) little availability, i.e. less than 1 million ha, such as Chile, Dominican Republic, El Salvador, Haiti, Jamaica, Honduras, Trinidad and Tobago, Costa Rica, Belize, Guatemala and Panama; (b) average availability, between 1 and 5 million ha, such as Cuba, Nicaragua and French Guyana; and (c) great availability, between 6 and 340 million ha, such as Ecuador, Surinam, Guyana, Paraguay, Uruguay, Mexico, Peru, Venezuela, Colombia, Bolivia, Argentina and Brazil. For the last group, the expansion of any kind of agriculture, even for supplying other countries with food and biofuels, would not compete with food security.

In light of such diversity, it was decided that this paper should analyze the 12 countries considered to be more representative of LAC in more depth, i.e. Argentina, Bolivia, Brazil, Colombia, Costa Rica, Ecuador, Honduras, Mexico, Paraguay, Peru, Dominican Republic and Uruguay, particularly over the last decade.

Another important consideration regarding biofuels is that one must differentiate between ethanol and biodiesel policies. Sugarcane is used as a raw material for ethanol, particularly in Latin America and the Caribbean. A crop that has been in the region for many years, sugarcane has been highly successful in virtually all of the countries. On other hand, with regard to raw materials for biodiesel, very few countries other than Argentina, Brazil, Paraguay and Colombia are among the top producers of oleaginous crops.

Although Brazil is the world's top sugarcane producer, the greatest agricultural productivity is in Colombia, with over 100 ton/ha, which can generate over 8,000 liters/ha of ethanol. In the case of biodiesel, agricultural productivity is quite a bit smaller, at less than 4,000 liters/ha even in the best conditions when using palm oil as a raw material, or 3,000 liters/ha when using jatropha. Such differences in agricultural productivity directly influence policy development, since biodiesel is usually more expensive than diesel, and ethanol is cheaper than gasoline. The general perception is that biodiesel policies have a social development characteristic that is far more important than that of energy security, while with ethanol there are more obvious energy and environmental objectives.

² Bot, AJ; Nachtergaele, FO; Young, A. 2008. Land Resource Potential and Constraints at Regional and Country Levels. Rome, IT, Land and Water Development Division, FAO. World Soil Resources Report 90.

For purposes of this study, preference was given to those crop alternatives that can be used for human consumption as well as for biofuels, and that currently constitute the main raw materials, such as corn and sugarcane (bioethanol), and soy bean and African palm (biodiesel). These products occupy a distinguished position in the food pyramid (vegetable oils and sugar are placed higher in the pyramid). In fact, as in the case of soy beans, agrofuels are obtained from the byproducts of the agro-industrial process, thus making better use of crops while increasing economic viability. Biofuel production can positively impact agriculture by generating a secure income arising from a promising market, as long as it is done in a rational and planned manner.

Lastly, this document is part of the regional component for LAC under the responsibility of the Forum for the Americas on Agricultural Research and Technological Development (FORAGRO), of the “Global Study on Regional Evidence Generation and Policy and Institutional Mapping on Food and Bioenergy Production”, proposed by the Southern Advisory Group (SAG), of the European Research Area (ERA) / Agricultural Research for Development (ARD), whose objectives are to analyze the status of biofuel production and its possible implications for the production of food and food security on the different continents.

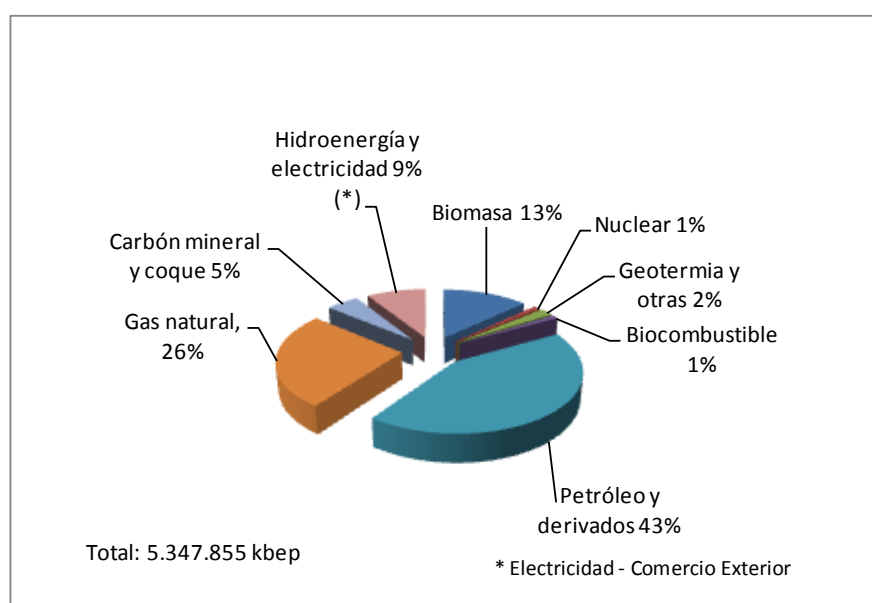
2. Current situation of biofuels in Latin America and the Caribbean (LAC)

2.1. Energy mix in Latin America

Latin America has approximately 13% of the world's viable oil reserves, which are concentrated in just three countries: Venezuela, Mexico and Brazil. Together they account for 94% of the reserves and 81% of the production in the region. Although they are among the group of 20 nations with the highest viable oil reserves, most countries in the region are facing a critical situation with regard to current and projected energy security, given their considerable dependence on oil imports and/or the low quantities of reserves over time.

Energy vulnerability is particularly important in Central America (except for Guatemala), the Caribbean (except for Trinidad and Tobago), Paraguay, Uruguay and Chile. Those nations normally import 100% of what they consume, as they do not have any reserves. Other countries, however, are either oil producers, although not enough to be self-sufficient (as is the case of Peru), or net exporters, but with declining production. Given their reserve horizon, the trend is for them to become net importers in the medium to long term (as is the case of Argentina).

Figure 2.1: Energy Demand 2007 - Latin America and the Caribbean

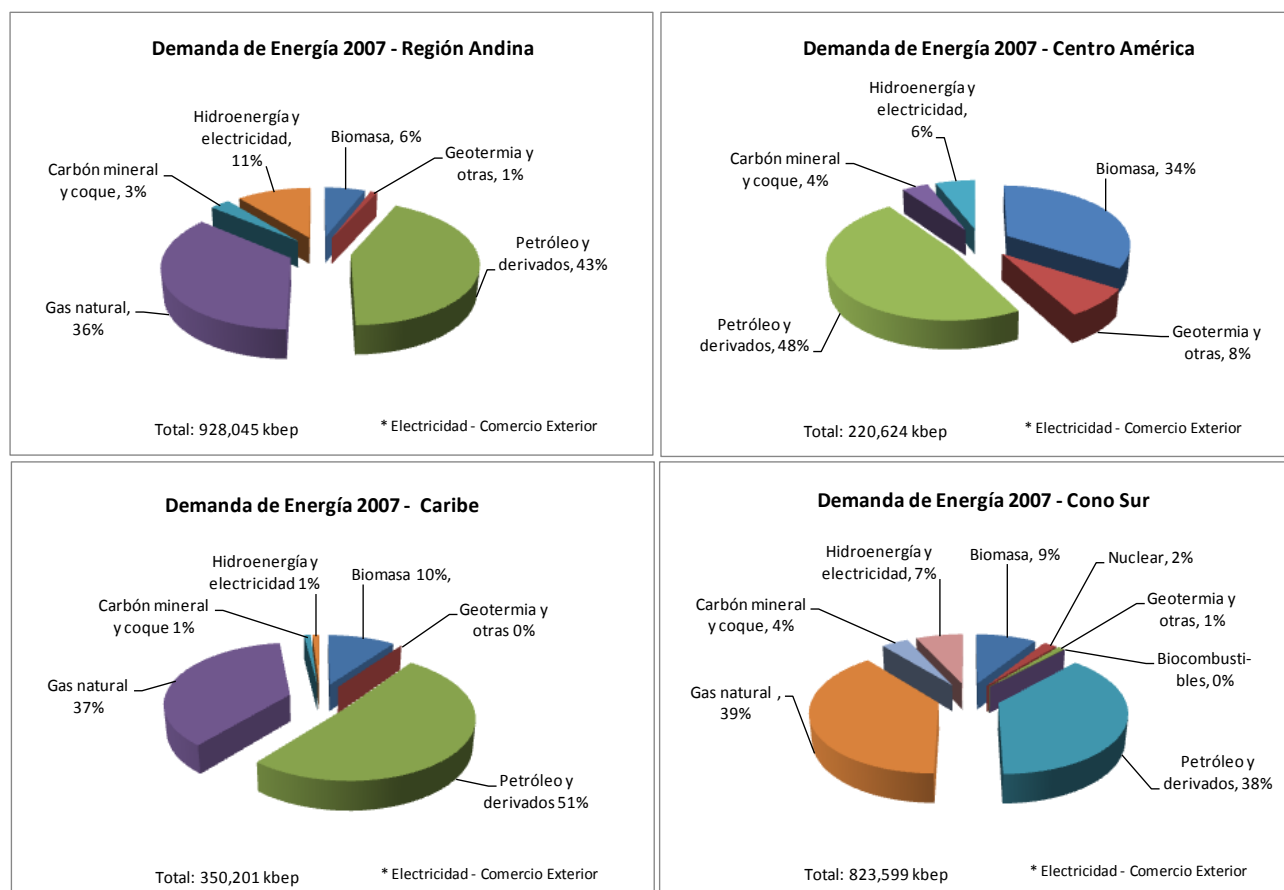


Source: Prepared by IICA based on energy statistics (OLADE, 2007, ECLAC, 2008) and official national sources.

On the demand side, energy use in the region is highly concentrated in fossil fuels (74% of total consumption), both in the aggregate amount and by sub-region. Central America is an exception, with a significant participation of biomass and hydropower. Brazil is an individual exception, with a 44% share of renewables in its energy mix (Figures 2.2 to 2.5). The country, which is considered to be a global reference in the use of renewable energy, traditionally obtains electricity from water sources. It has had an aggressive program to replace gasoline with ethanol (PROALCOOL) since 1974, and a program to replace diesel

with biodiesel since 2005, in addition to generating bioelectricity from biomass. As shown in Figure 2.1, the share of biofuels in the regional energy mix is still marginal (1% of energy consumption in 2007). Brazil is the country that has had the greatest percentage of biofuels in terms of energy consumption thus far (3% in 2007).

Figures 2.2 to 2.5: Energy Demand 2007 – Sub-regions of Latin America and the Caribbean



Source: Prepared by IICA based on energy statistics (OLADE, 2007, ECLAC, 2008) and official national sources

Table 2.1 presents a set of energy indicators, detailing the specific situation of each country in the region and classifying information according to their status as net importers or exporters of oil.

The Latin American transport sector is highly dependent on oil. In aggregate amounts this represents about 95% of the fuel consumption required to move its fleet, including land, water and air vehicles. As shown in Table 2.1, almost all of the countries in the region have a deficit of fossil fuels. With the exception of Venezuela and Trinidad and Tobago, all of them are net importers of diesel oil, even important oil-producing countries such as Mexico and Brazil. The only net exporters of gasoline in the region are Venezuela, Argentina, Trinidad and Tobago, Brazil, Colombia and Uruguay, while Bolivia is self-sufficient.

Table 2.1: Energy indicators for Latin America and the Caribbean – 2007

Indicadores energéticos de América Latina y el Caribe - 2007								
Países importadores netos de petróleo y derivados	Reservas probadas de petróleo	Alcance de las reservas de petróleo	Alcance de las reservas de gas natural	Consumo final energético	Participación de la biomasa en el consumo final energético	Participación del petróleo en el consumo final energético	Participación del petróleo importado en la oferta total de petróleo	Importaciones netas de petróleo
	Gbbl	años	años	kbep	%	%	%	kbep
Barbados	0,002	4,2	1,6	3.120	7	87	100%	s/d
Chile	0,03	30,1	20,7	220.221	17	50	103%	74.378
Costa Rica	0	0	0	34.487	15	48	96%	5.179
Cuba	0,05	2,8	38,4	100.099	8	82	65%	34.544
El Salvador	0	0	0	33.856	32	43	100%	6.230
Grenada	0	0	0	638	8	92	100%	s/d
Guyana	0	0	0	6.935	47	53	100%	s/d
Haití	0	0	0	19.476	72	26	100%	s/d
Honduras	0	0	0	34.150	41	51	100%	s/d
Jamaica	0	0	0	31.734	7	93	101%	7.491
Nicaragua	0	0	0	26.920	43	40	100%	5.779
Panamá	0	0	0	28.630	14	74	100%	s/d
Paraguay	0	0	0	39.524	38	24	96%	s/d
Perú	0,39	13,8	49,3	106.330	17	34	69%	30.160
República Dominicana	0	0	0	57.205	10	71	103%	12.963
Uruguay	0	0	0	23.409	14	58	94%	11.152
Países exportadores netos de petróleo y derivados	Reservas probadas de petróleo	Alcance de las reservas de petróleo	Alcance de las reservas de gas natural	Consumo final energético	Participación de la biomasa en el consumo final energético	Participación del petróleo en el consumo final energético	Participación del petróleo exportado en la producción de petróleo	Exportaciones netas de petróleo
	Gbbl	años	años	kbep	%	%	%	kbep
Argentina	2,35	9,9	7,8	540.445	3	33	9%	20.761
Bolivia	0,39	22,4	45,5	36.659	14	40	29%	5.141
Brasil	20,38	31,9	33,7	1.713.531	25	38	24%	6.053
Colombia	1,36	7,0	15,0	219.716	10	43	43%	79.861
Ecuador	4,00	21,5	2,4	88.391	7	79	66%	124.081
Guatemala	0,48	85,1	0,0	62.582	48	40	86%	4.791
México	31,21	27,7	24,7	1.311.583	5	47	55%	653.218
Surinam	0,10	21,0		7.273	5	80	14%	693
Trinidad y Tobago	0,61	13,8	11,4	123.721	0	7	67%	-9.085
Venezuela	99,38	89,0	152,1	476.950	0	41	68%	840.026
Total América Latina y Caribe	161	44	38	5.347.855	13	43	51%	1.538.029

Fuente: Elaborado por IICA en base a Informe de Estadísticas Energéticas: OLADE 2007 y CEPAL (2008)

Gasoline, naphtha and alcohol (ethyl or methyl), comprise 48% of the aggregate consumption of the transport sector in the region, while diesel oil accounts for 40%. The remaining 60% consists of kerosene and turbo, CNG and LPG.

It should be noted that the participation and importance of each of these fuels in the final demand from the transportation sector varies significantly from country to country, as can be seen in Table 2.2. Thus, in Venezuela, Mexico, Barbados and Grenada, gasoline represents 65% to 80% of this particular consumption, while Paraguay, Uruguay, Peru, Honduras and Argentina are characterized by a high incidence of diesel oil, between 56% and 79%. Argentina and Bolivia consume a fair amount of CNG. In absolute terms, Brazil is also a big CNG consumer, as is Colombia, although to a lesser extent.

Table 2.2: Fuel consumption in Latin America and the Caribbean - 2007

Consumo de combustibles en América Latina - 2007										
Países importadores netos de petróleo y derivados	Consumo de energía del sector transporte	Consumo de gasolinas / alcohol para transporte	Participación de gasolinas / alcohol en transporte	Consumo de diesel oil para transporte	Participación de diesel oil en transporte	Consumo de GNC o GNV para transporte	Consumo de GLP para transporte	Consumo de diesel oil para agricultura, ganadería y pesca	Balance de comercio exterior en diesel oil	Balance de comercio exterior en gasolinas / alcohol
	kbep	kbep	%	kbep	%	kbep	kbep	kbep	kbep	kbep
Barbados	960	740	77	220	23			4	-593	-740
Chile	59.103	17.155	29	25.873	44	162	27		-31.895	-173
Costa Rica	11.493	4.877	42	5.282	46		51	264	-5.734	-3.756
Cuba	3.541	454	13	1.569	44	18	3	1.086	-8.556	-
El Salvador	7.245	3.057	42	3.630	50				-3.421	-2.314
Grenada	268	206	77	20	7			15	-272	-218
Guyana	1.117	700	63	324	29			580	-1.936	-759
Haití	3.035	1.689	56	1.163	38				-2.387	-1.689
Honduras	7.540	2.981	40	4.521	60				-5.016	-3.057
Jamaica	9.095	3.965	44	2.868	32			850	-4.042	-2.960
Nicaragua	3.950	1.587	40	2.167	55			41	-2.485	-1.069
Panamá	7.358	1.605	22	3.736	51		32	67	-5.686	-1.961
Paraguay	8.416	1.493	18	6.640	79		119		-6.641	-1.440
Perú	27.202	5.761	21	18.449	68	388	1.219	2.330	-6.085	7.379
República Dominicana	15.594	6.093	39	4.159	27		2.687		-7.372	-4.025
Uruguay	6.022	1.823	30	4.186	70			1.247	-2.069	949

Países exportadores netos de petróleo y derivados	Consumo del sector transporte	Consumo de gasolinas / alcohol para transporte	Participación de gasolinas / alcohol en transporte	Consumo de diesel oil para transporte	Participación de diesel oil en transporte	Consumo de GNC o GNV para transporte	Consumo de GLP para transporte	Consumo de diesel oil para agricultura, ganadería y pesca	Balance de comercio exterior en diesel oil	Balance de comercio exterior en gasolinas / alcohol
	kbep	kbep	%	kbep	%	kbep	kbep	kbep	kbep	kbep
Argentina	86.849	14.302	16	48.694	56	17.091		21.685	-4.972	22.131
Bolivia	9.327	3.268	35	3.922	42	1.132		2.232	-2.761	77
Brasil	411.340	163.225	40	206.464	50	16.186		38.347	-20.088	7.697
Colombia	61.433	32.190	52	24.830	40	3.095		3.412	-2.123	2.733
Ecuador	33.947	14.172	42	17.176	51			269	-11.862	-5.834
Guatemala	15.429	6.694	43	8.512	55		19		-9.484	-7.225
México	371.599	240.302	65	98.827	27	112	7.598	17.384	-15.609	-75.299
Surinam	1.045	572	55	296	28			281	-1.040	-647
Trinidad y Tobago	5.826	3.192	55	2.019	35				10.211	7.578
Venezuela	111.852	89.786	80	20.812	19	54			48.264	38.548

	Consumo del sector transporte	Consumo de gasolinas / alcohol para transporte	Participación de gasolinas / alcohol en transporte	Consumo de diesel oil para transporte	Participación de diesel oil en transporte	Consumo de GNC o GNV para transporte	Consumo de GLP para transporte	Consumo de diesel oil para agricultura, ganadería y pesca	Balance de comercio exterior en diesel oil	Balance de comercio exterior en gasolinas / alcohol
	kbep	kbep	%	kbep	%	kbep	kbep	kbep	kbep	kbep
Total América Latina y Caribe	1.284.323	621.889	48	516.357	40	38.239	11.756	90.093	-103.654	-26.073

Fuente: Elaborado por IICA en base a Informe de Estadísticas Energéticas: OLADE 2007

Although no aggregate statistics on the share of biofuels in the vehicle fuel mix are available for the region, there are some specific situations that are worth noting, together with historical experiences. In the case of Brazil, which has been using ethanol as a fuel since the mid-70s, and biodiesel since 2005, the use of biofuels reached 25.1% in vehicle fuel consumption (anhydrous ethanol: 7.6%; hydrated ethanol: 16.2%; and biodiesel: 1.34%) in 2008. In 2006, Paraguay, which uses alcohol fuel since 1999, recorded a 4.6% share in the automotive fuel mix for this biofuel. Current and expected required blends will be presented in the following chapter.

Table 2.2 also shows statistics for the agricultural sector's diesel oil consumption, which is particularly significant in Brazil, Argentina, Mexico, and to a lesser extent, Colombia, Peru and Bolivia. Diesel oil is a major component in agricultural production costs. Together

with fertilizers, pesticides and transportation costs, it is an important mechanism for passing increases in oil prices onto the cost of food production. In this sense, the end of an era of cheap and abundant oil would mean more expensive food due to the impact on production costs, both in primary production and in the food and beverage industry. Rising energy prices also pose a threat to rural development by reducing access to energy services, a prerequisite for raising household incomes, and by absorbing increasing amounts of capital from rural areas.

2.2. Public support measures and policies for the production of biofuels

2.2.1. Political mapping

According to ECLAC (2008) there are three factors behind biofuel policies in the global agenda:³

a. Energy factors:

The increase in the global demand for oil is mainly the result of the growth in consumption for transportation, given the limited duration of viable global reserves and their maximum production capacity. Consequently, energy-related efforts to boost biofuel programs are mainly geared towards ensuring the security of supply, reducing dependence on imported oil and mitigating the impacts of international price volatility and uncertainty concerning price evolution.

Moreover, considering the volumes of fossil fuels consumed in countries with high and rising levels of energy consumption per capita (high level = "developed" countries: U.S.A., Europe, Japan, etc.; increasing level = emerging economies: China, India), and the dwindling availability of land for competitive crops, a potential market for an international biofuel trade is open, raising the hopes of some countries with favorable conditions (tropical climate, availability of land and water, etc.) to develop an export product (*commodity*). This is especially true for some larger countries in Latin America, although ECLAC (2008) concluded that exporting is only a sustainable option for a few countries⁴.

b. Environmental factors:

Environmental factors are basically related to the need to reduce greenhouse gas emissions (GHGs), which would have a favorable impact on the environment, both globally and locally, especially in big cities. Thus, replacing fossil fuels with biofuels in the transportation sector is in line with commitments made under the Kyoto Protocol to the extent that it would contribute to reducing GHG emissions.

However, the net effect of biofuels on the environment is still being widely discussed, given the ensuing impacts throughout the entire chain of production, including their possible polluting effects on natural resources (soil, water), and the degree of responsibility for deforestation or the decline in biodiversity. Another issue, whose complexity has not been examined as thoroughly as it should be by the scientific world, and has therefore almost

³ CEPAL: Aporte de los biocombustibles a la sustentabilidad del desarrollo en América Latina y el Caribe: Elementos para la formulación de políticas públicas. Santiago de Chile 2008.

⁴ CEPAL, 2009: Biocombustibles y Comercio Internacional: Una perspectiva Latinoamericana. See also Chapter 2.3.2 and footnote nº 12.

been overlooked in policy design, is the GHG emissions resulting from land-use change and the ensuing debt in the balance (*carbon debt*).

c. Factors related to agricultural development:

Biofuels create new opportunities for agricultural development. Producers and exporters in tropical developing countries with the potential to produce biofuels from competitive crops, relative to oil prices, can take advantage of raw material price improvements to promote biofuels and thereby reduce imports and increase exports. However, risks related to land degradation, water use, land-use changes that could affect food supply, concentration of ownership and exclusion of small and medium-scale producers must be seriously considered, as well as the negative impact on biodiversity.

In addition to their positive impact on energy supply and the reduction of negative effects on the environment associated with fossil fuels, biofuels allow for a redistribution of the income generated in a given country whereas value chains of fossil fuels are highly concentrated. Agro-energy, on the other hand, needs an extensive production base of raw materials before the processing and transport stages. This implies extending the offer of employment and income and strengthening national economic development, especially in rural areas (IICA/Gazzoni 2009).⁵

In order for this redistribution to have a greater impact, policies and support measures for implementing projects geared towards the production and use of biofuels, an increase in capital investments, operational resources, management skills and production scales are needed. Moreover, the scenario for the implementation of support policies must be suitable in terms of legal security and contract enforcement, political and economic stability and an acceptable level of risk to the supply of foreign credit, foreign direct investment or even ownership interest.

The biofuel industry has been expanding since the 1970s. However, it is only now, out of necessity, and due to increased environmental concern, that a number of governments have begun to regulate their production, distribution and large-scale use. The leading ethanol-producing countries, such as Brazil, Colombia, Argentina and Mexico have a regulatory framework for the production, use and management of ethanol, and have established rates for the gasoline/ethanol blend. They also award incentives to producers. Some countries in Latin America and the Caribbean have yet to formulate a regulatory framework, while others already have bills that will be sent to Congress or are being reviewed by lawmakers.

Legislative proposals have been developed according to each country's specific interest in this alternative type of energy. Over 20 countries in Latin America and the Caribbean have laws or bioenergy-related decrees currently in force, most of which have been developed or updated in the last decade:

- Argentina, Bolivia, Brazil, Colombia, Costa Rica, Guatemala, Honduras, Paraguay, Panama, Peru, Dominican Republic, Ecuador, Mexico, Jamaica and Uruguay.

In the following countries they are up for revision/updating or preparation:

- Chile, Cuba, El Salvador, Guatemala, Honduras, Panama and Venezuela.

⁵ Gazzoni, Decio Luiz. Biocombustibles y alimentos en América Latina y el Caribe. San José, C.R.: IICA, 2009.

2.2.2. Overview of existing legislation

The information presented below is mainly from the following agencies, in addition to official national sources: OLADE, IICA, SNV, CEDRSSA and CMM ⁶.

The summary that follows aims to provide an overview of the legal situation in Latin America and the Caribbean (LAC), given the regular structure of laws on biofuels. In order to show the measures and actions set out in each country to encourage the production and consumption of biofuels, and to present the main guidelines and regulations on the topic, a political map was organized according to the following themes:

- a. Legal: Purpose of Law - Statement of National Interest - objectives of corresponding laws.
- b. Institutional: Law enforcement authorities and their functions - advisory body and other officials involved.
- c. Obligation: Blend of biofuels and fossil fuels - scope and targets (percentages currently valid and planned for bioethanol and biodiesel blends).
- d. Incentives: Promoting the production and use of biofuels - national programs.
- e. Research and technological innovation: Production of raw materials and developing technologies to produce biofuels.

The countries that have been taken into account are:

Argentina	Honduras
Bolivia	Mexico
Brazil	Paraguay
Colombia	Peru
Costa Rica	Dominican Republic
Ecuador	Uruguay

- a. Legal: Purpose of Law - Statement of National Interest – Objectives of corresponding laws

Table 2.3 presents the main aims and objectives outlined in the corresponding laws. In some cases they are quite unequivocal, while in others they are tacit, numerous and rather extensive, as in the case of Brazil. In yet other countries they are more limited, as in the case of Paraguay.

The most common denominator between the laws in LAC is energy security: reducing reliance on fossil fuels and increasing energy self-sufficiency (see Table 2.3).

⁶ - Organización Latinoamericana de Energía: Legislación de Biocombustibles en América Latina y el Caribe: <http://www.olade.org/legislacionBio.html> , 2009.
 - IICA, “Atlas de la agroenergía y los biocombustibles en las Américas: 1. Etanol”; San José, Costa Rica, 2007.
 - IICA, “Atlas de Biodiesel”, Edición Revisada octubre de 2009; San José, Costa Rica, 2007.
 - SNV (Servicio Holandés de Cooperación al Desarrollo): “Estudio Comparativo de La Legislación Latinoamericana sobre Biocombustibles”, Tegucigalpa Honduras – Julio 2008.
 - Centro de Estudios para el Desarrollo Rural Sustentable y la Soberanía Alimentaria – CEDRSSA: “Legislación sobre el Uso de Biocombustibles en América Latina y el Mundo”, México, 2007.
 - Centro Mario Molina: “Normatividad de biocombustibles en el mundo”, México, 2008.

Some of the most frequently mentioned objectives of these instruments are: contributing to the country's sustainable development, facilitating the implementation of projects under the Clean Development Mechanism - CDM (Argentina, Costa Rica, Ecuador, Mexico, Paraguay) and reducing environmental pollution (Colombia, Costa Rica, Honduras, Mexico, Peru) by encouraging the production and use of biofuels. Colombia, Peru and Honduras are also interested in creating jobs. Countries like Peru and Colombia have established a link to job generation in the development of the biofuel market through the promotion of farming and agribusiness activities, making that one of the objectives of the law. Another objective in Peru is to provide an alternative market to illicit crops, as part of the battle against drugs.

Laws in Argentina and Bolivia are not specific about their purposes, but judging from the spirit of the legal instruments, it would appear that these countries are aiming towards sustainable development and the reduction of dependence on fossil fuels.

Table 2.3: General Interest Statement - Purpose of the Law

	Countries											
	AR	BO	BR	CO	CR	EC	HN	ME	PA	PE	DR	UR
Introduce biofuels into the national energy mix			X					X			X	X
Contribute to sustainable development and facilitate implementation of CDM	X				X	X		X	X			
Energy security: Reduce reliance on fossil fuels and increase energy self-sufficiency	X	X	X	X			X	X			X	X
Contribute to employment and income generation			X	X			X			X		
Mitigate negative environmental impacts of fossil fuel energy operations		X		X	X		X	X		X	X	
Provide alternative markets for illicit crops										X		

Source: Adapted from SNV, 2008 and completed by authors based on official sources

- b. **Institutional:** Law enforcement authorities and their functions - advisory body and other officials involved.

i. Law enforcement authorities

Due to the numerous goals and objectives associated with the production and use of biofuels and the horizontal nature of the value chain, different authorities have become responsible for enforcing biofuel-related laws. In almost every country, the authorities involved are linked to Mines and Energy; Natural Resources and Environment; Agriculture, Livestock and Fishing and/or Industry, Economy and Trade.

The following departments tend to be more involved in the principal phases of the production chain *upstream* (consisting exclusively of the agricultural stage) and *downstream* (covering the whole production chain after the agricultural stage):

- Ministry of Agriculture, Livestock and Rural Development:
Upstream section: promotion of sustainable production of biofuel supplies from agricultural and forestry activities, algae, biotechnological and enzymatic processes, technical assistance and research, innovation and technology transfer for the production of raw material.
- Ministry of Mines, Hydrocarbons and Energy:
Downstream section: registration and control of biofuel production, blends and other issues, definition of technical specifications and standards, registration and monitoring of the biofuel trade.

The different ministries responsible for enforcing this specific legislation in the respective countries are: the Ministry of Environment and Natural Resources (Colombia, Ecuador, Honduras, Uruguay); Economy, Industry, Trade and Production (Argentina, Bolivia, Honduras, Paraguay); Planning and Finance (Argentina, Uruguay); and/or Science and Technology (Argentina, Paraguay).

Table 2.4: Law enforcement authorities

Authority	Countries											
	AR	BO	BR	CO	CR	EC	HN	ME	PA	PE	DR	UR
Agriculture, Livestock and Rural Development	X	X	X	X	X	X	X		X	X		X
Mining, Hydrocarbons and Energy		X	X	X	X	X				X		X
Electricity and Renewable Energy						X		X			X	
Environment and Natural Resources				X		X	X					X
Economy, Industry, Trade and Production	X	X					X		X			
Planning and Investment	X											X
Science and Technology	X								X			
Others (Drug Control)										X		
Agency, Commission or National Council	X		X	X	X	X		X		X	X	X

Source: Adapted from SNV, 2008 and completed by authors based on official sources

It is important to note that a number of responsibilities are normally involved in the development and conceptualization of bills. In Brazil, for example, over 10 federal ministries were involved in the manifold aspects of the process of designing and developing the National Program of Biodiesel Production and Use in 2004-2005.

ii. Advisory body or other officials involved

Because laws on biofuels address the different issues of public and private sectors and in order to provide consistency and comprehensiveness in the application of the law, in some countries, one of the first steps in the process is to form technical or advisory bodies whose purpose is to support the different authorities in law enforcement and implementation.

In some countries, these are highly public and cross-sectoral (Argentina, Brazil, Colombia, Costa Rica, Mexico), while in others, while others count on the participation of private sector entities and the scientific community (Ecuador, Honduras, Peru).

National biofuels commissions (or agencies with similar names), are responsible for developing and establishing the general guidelines needed for the production, handling, processing and marketing of biofuels, among other functions. They are also in charge of proposing and recommending standards and complementary provisions for the law, and/or proposing an action plan to ministries with strategies for the short, medium and long-term implementation of the use of biofuels, as well as follow-up and control actions, determining who will be in charge and a time frame.

iii. Functions of the enforcement authorities

The relevant authorities are generally in charge of promoting and monitoring the production of biofuels and raw materials; establishing quality standards, requirements and the necessary conditions for the manufacturing plants; certifying investment-related and industrial activities; preparing regulations and technical standards; designing and implementing policies applicable to the sector; monitoring and supervising the production of raw materials; processing and production of biofuels and other environmental issues associated with biofuel production.

Table 2.5: Functions of law enforcement authorities

Main functions of the law enforcement authority
To promote and control the production of biofuels and raw materials: to promote the sustainable production of inputs for bioenergy from agricultural activities, forestry, algae, enzymatic and biotechnological processes and enhance their marketing, increasing competitiveness and profitability by means of scientific and technological development without jeopardizing food security and sovereignty;
Establish quality standards, requirements and necessary conditions for manufacturing plants;
Certify investment-related and industrial activities;
Prepare technical and security standards and regulations;
Design and implement policies applicable to the sector; define the scope of general incentives for the production and use of renewable energies such as tax incentives;
Monitor and supervise the production of raw materials, processing and production of biofuels and other environmental issues associated to biofuel production;
Seek to reduce air pollutant emissions and greenhouse gases (GHGs);
Coordinate actions among federal, state (if any), and municipal governments, as well as the private and social sectors.

Source: Adapted from SNV, 2008 and completed by authors based on official sources

- c. Obligation: Blend of biofuels and fossil fuels - scope and targets (percentages currently valid and planned for bioethanol and biodiesel blends)

The most constant element in the policy designed to increase biofuel production in the region is the guarantee to producers that there will be domestic demand, since it is mandatory to gradually blend gasoline with ethanol or fossil diesel with biodiesel. In some countries, this measure is accompanied by production incentives and by a domestic price control of ethanol, to ensure greater benefit to producers with regard to opportunity costs (IICA, Atlas Ethanol, 2007)⁷.

Driven by the motivations described above, many countries have set targets for replacing gasoline with bioethanol and diesel oil with biodiesel. Table 2.6 presents a summary of the goals set by some countries in Latin America and the Caribbean. Given the sector's dynamism, some of these goals may change relatively quickly. In the case of Brazil, for example, B5 was supposed to be introduced in 2013 but was moved up to 01/2010 by a federal government decision in October 2009.

Emphasis is placed on the actual blend in regulations on biofuels, and is also closely linked to the objectives and purposes of the Law. Biodiesel must be produced and consumed if the objectives of the Law are truly aimed at decreasing reliance on fossil fuels, reducing local environmental pollution and increasing energy self-sufficiency. One mechanism used to ensure more domestic consumption is the definition of "mandatory minimum percentage blends" that each country seeks to achieve within a certain period of time. If the objectives include promoting domestic biofuel production and consumption, an important consideration is that compulsory consumption could ensure local demand and provide a favorable long-term outlook for producers. (Bioenergy Public-Private Committee, Chile).

Figures 2.6 and 2.7 show that when replacing gasoline with ethanol, short to medium-term targets differ widely from country to country according to their production capacity projections by area, crops, and available technological knowledge (see Chapters 2.1 onwards). On the other hand, when replacing fossil diesel with biodiesel, the national programs of most countries establish the goal of 5% (B5) in the short term, providing for the introduction of a mandatory blend of about 20% (B20) in the medium term.

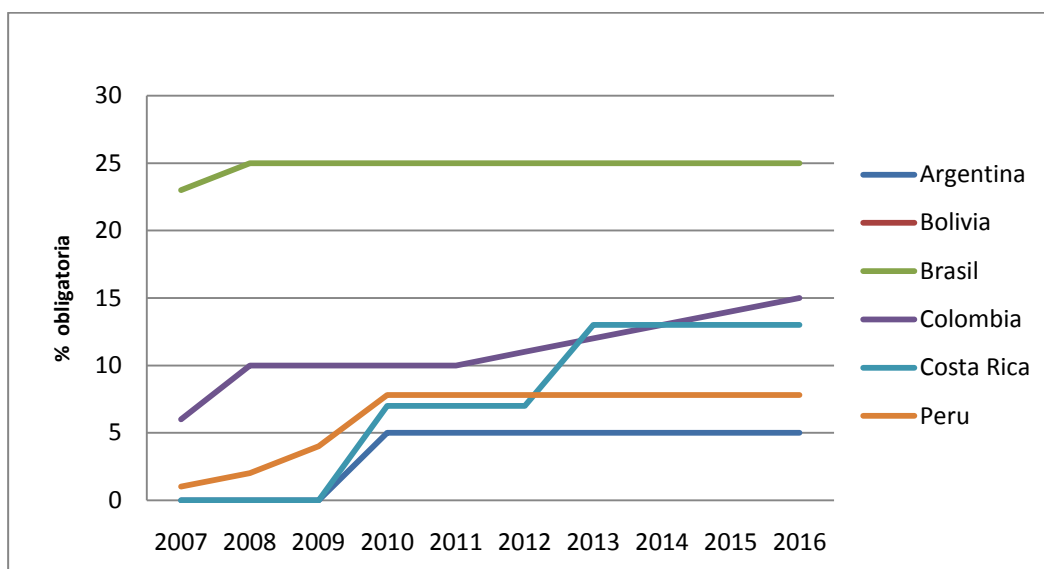
⁷ IICA, "Atlas de la agroenergía y los biocombustibles en las Américas: 1. Etanol"; San José, Costa Rica, 2007.

Table 2.6: Mandatory blending targets suggested for biofuels in 18 LAC countries

Country	Bioethanol	Biodiesel
1. Argentina	01/2010 → 5% on the final product	01/2010 → 5% on the final product
2. Bolivia		01/2007 → 2.5 % 2007-2015 → Increase gradually according to annual targets 01/2015 → 20.0%
3. Brazil	A long time ago (Established consumption) → 20.0% 10/2006 → 23.0% 07/2007 → 25.0%	01/2008 → 2% 01/2009 → 3% 07/2009 → 4% 01/2010 → 5% 01/2020 → 20%
4. Chile	5,7 %	
5. Colombia	2005 → 10 % in metropolitan areas = 60% of national consumption 2007 → 10.0% 2012-2016 → Increase gradually up to 15.0%	01/2008 → 5%
6. Costa Rica	01/2007 → 7.0% 01/2010 → 13.0%	01/2010 → 2.0% 01/2013 → 5.0% until 2026 → 10.0%
7. Ecuador	10.0%	proposes → 2.5 % Increase gradually according to annual targets 01/2020 → 20.0%
8. El Salvador	Central American Sustainable Energy Strategy sets a goal to replace 15% of fossil fuel consumption	
9. Guatemala	Currently → 5.0% In discussion → 10.0%	
10. Honduras		Up to 30 % The Biofuel Technical Unit will establish blends according to prevailing conditions
11. Jamaica	05/2009 → 10.0%	
12. Mexico	No goals. Tests performed between 2008 and 2010; nationwide distribution 2011-2014; Given the limited availability of biodiesel, only a few production centers could be used	
13. Nicaragua	Central American Sustainable Energy Strategy sets a goal to replace 15% of fossil fuel consumption	
14. Panama	01/2009 → 10.0% Central American Sustainable Energy Strategy sets a goal to replace 15% of fossil fuel consumption	Central American Sustainable Energy Strategy sets a goal to replace 15% of fossil fuel consumption
15. Paraguay	Blend established since 1982 Currently mandatory → 12.0% Currently authorized → 18.0% In discussion → 20.0% to 25.0%	Currently → 3.0% In discussion → 5.0%
16. Peru	2006 – 2010 → Increase gradually and progressively by region according to annual targets 01/2010 → 7.8%	01/2009 → 2.0% 01/2011 → 5.0%
17. Dominican Republic	01/2015 → 15.0%	01/2015 → 2.0%
18. Uruguay	Until 12/2015 → 5.0% (voluntary) 01/2015 → 5.0% (required)	Until 12/2008 → 2.0% (voluntary) 01/2009 → 2.0% (required) 02/2012 → 5.0%

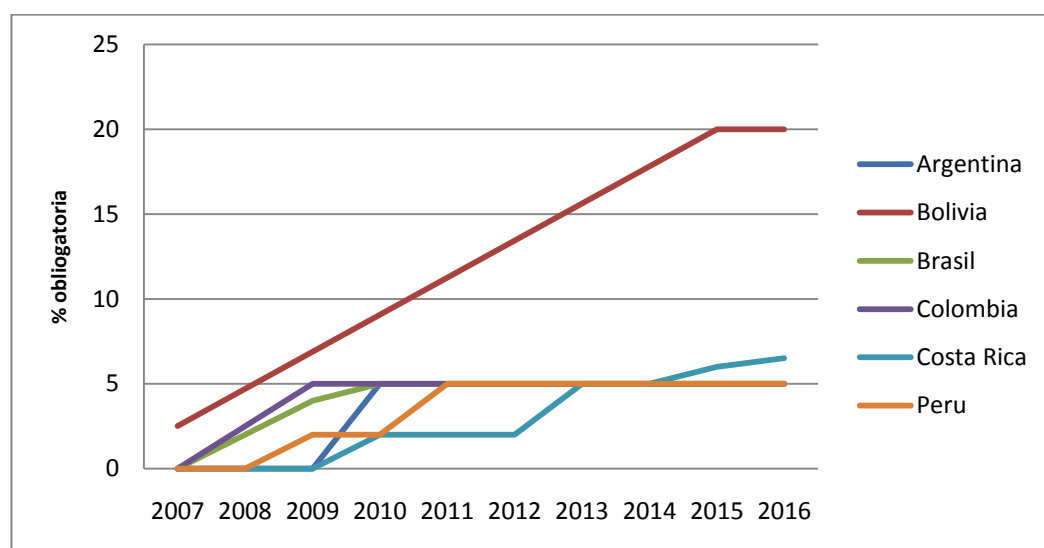
Source: based on 1) Latin American Energy Organization (www.olade.org), 2009; 2) IICA, Ethanol Atlas (2007), 3) IICA, Biodiesel Atlas (2009) and 4) official national documents

Figure 2.6: Required percentage for “gasoline-ethanol” blend in selected Latin American countries



Source: Based on official national documents

Figure 2.7: Required percentage for the “petrodiesel-biodiesel” blend in selected Latin American countries



Source: Based on official national documents

- d. **Incentives:** Promoting the production and use of biofuels – National incentive programs for the production and use of biofuels

The most significant incentive, implemented by almost all LAC countries that already have a biofuels policy, is tax exemption (Value Added Tax, Income Tax, Tax on Liquid Fuels and Natural Gas, etc.) for the various stages of the biofuel industry. Even though tax exemptions favor both, producers of raw materials (*upstream* section) and the industrial sector responsible for the production and marketing of biofuels (*downstream* section), most countries chose to establish much stronger and more consistent incentives for the *downstream* section (Table 2.7). The agricultural sector, as a supplier of raw material for biofuel producers, is expected to benefit from the steadfast and dynamic encouragement given to the industrial sector.

Table 2.7: Tax incentives and public support

Incentives	Countries											
	AR	BO	BR	CO	CR	EC	HN	ME	PA	PE	DR	UR
Incentives (tax and others) for the production of raw material (<i>upstream</i> section)			(x)	x		x			x	x	x	X
Technical assistance for the production of raw material	X		x	x	x	x		x	x			
Incentives (tax and others) for the industrial sector to implement investment projects (different technological routes), produce and trade biofuels (<i>downstream</i> section)	X	x	x	x		x	x		x	x	x	X
Technical assistance for the production of biofuels (different technological routes)	X		x	x			x	x				
Plan, strategy or national program for the development of the production and use of biofuels (see also Table 2.9)	X		x	x	x	x		x	x			X
Direct statement in the laws or official government priority for food security and regular food supply to the domestic market before developing biofuels		x	x					x				

(x) In Brazil, the law gives tax benefits to industrial producers who buy raw materials from smallholder producers (through special tax exemptions: those who incorporate raw material producers on a household scale pay lower taxes). Incentives therefore also indirectly benefit producers of raw material.

Source: Based on 1) IICA, Atlas Ethanol, 2007; 2) IICA, Atlas Biodiesel, 2009; 3) SNV, 2008 and 4) official sources.

Following the creation of an intersectoral technical advisory body (Table 2.4), many countries formulated a plan, a strategy or a program for the development of the production and use of biofuels (Table 2.7). The governments of these countries generally show a high degree of interest in developing biofuel production programs. Even countries that do not have a specific regulatory framework appear to be interested in promoting this type of program (IICA, Atlas Ethanol, 2007). The existence of a case-specific plan or program almost always coincides with a broader approach to the issue and the implementation of

complementary measures such as technical assistance for the production of raw materials and/or biofuels, and public and private efforts in research and technological innovation (Tables 2.7 and 2.9).

It is becoming increasingly common for biofuel production programs to be an integral part of rural development strategies aimed at mitigating poverty and strengthening food security. These programs are thus viewed as activities that can significantly contribute to achieving the objectives and goals of social and economic programs in these regions. The private sector, particularly sugar producers and distilleries, are investing or planning to invest in an effort to expand their installations to meet the growing demand for ethanol. The industry sees this as a great opportunity to revitalize agricultural activity while expanding the distillery business at the same time (IICA, Ethanol Atlas, 2007).

In line with the aims and objectives formulated, the priority areas and approaches for promoting the value chain of biofuels are: (i) the industry involved with biofuel production and marketing, (ii) producers and (iii) the focus on the country's available and established raw materials (Table 2.8).

Table 2.8: Priority Sector / Approach for promoting the value chain of biofuels

Approach	Countries											
	AR	BO	BR	CO	CR	EC	HN	ME	PA	PE	DR	UR
Household agriculture / small producers		X	X									X
Small and medium-sized businesses	X											X
Regional economies	X		X					X		X		
Farmers	X	X		X	X	X	X	X	X		X	
Industry (biofuel producers) and trade		X		X	X	X	X			X	X	X
Domestic raw material		X	X	X	X	X	X		X			X

Source: Adapted from SNV, 2008 and completed by IICA based on official sources

- e. Research and technological innovation: The production of raw materials and the development of technologies for the production of biofuels

In general, every country in the region has set up agricultural research centers, which are responsible for conducting research on the different aspects of the production of raw materials for biofuel. The private sector also plays an important role in these centers. However, research and innovations for producing ethanol from sugarcane are limited to only a few countries, including Brazil, Mexico, Colombia and Argentina. Other countries, such as those in Central America like Belize and Panama, need technical assistance from nations that have made more progress in this area (IICA, Atlas of Ethanol, 2007).

Countries that have traditionally been dedicated to sugarcane production have focused their research on aspects such as increasing production and agricultural productivity, and in some cases, on the ethanol production process itself, in order to expand their ability to supply the domestic market and to participate in the international market as well.

Table 2.9: Public and private investments in research, innovation and technology transfer for the production of raw materials and biofuels (different technological routes)

Investment		Countries											
		AR	BO	BR	CO	CR	EC	HN	ME	PA	PE	DR	UR
... in research, innovation and technology transfer for the production of raw material	Private	X		X	X		X	X	X	X	X		
	Public	X	X	X		X	X	X	X	X	X	X	X
... in research, innovation and technology transfer for 1. biofuel production (different technological routes) and/or 2. its use (developing and adapting engines, electricity generation, etc.)	Private	X		X	X		X			X			
	Public	X		X	X	X		X	X				

Source: Based on 1) IICA, Atlas Ethanol, 2007; 2) IICA, Atlas Biodiesel, 2009; 3) SNV, 2008 and 4) official sources.

All of these countries are interested in expanding and diversifying their raw material production base and finding crops that can replace corn and sugarcane as sources of ethanol, and soy bean and oil palm as sources of biodiesel. Such is the case for beetroot, cassava, sweet sorghum, dairy products and panela, for example, for the production of ethanol, and algae, cotton, palm, sunflower, jatropha, castor bean, peanut, canola, among others, for the production of biodiesel. Agricultural research on raw materials for biofuel production has focused on the development of different plant varieties, including high yield sugarcane.

The most important medium-term technological development thus far is ethanol production from cellulose. The progress that will be made in the next five to 10 years is expected to facilitate industrial production, which would significantly expand the primary product base. In that case, other crops (plants with high potential for cellulose production), waste from agricultural production, wood itself, and even solid waste generated by cities could become the basis for ethanol production. Countries like Chile, with a long tradition as a forest product exporter (11.6% of total exports), will have an industrially viable opportunity in the ethanol market.

Countries that traditionally grow sugarcane are investigating, among other options, the possibilities of increasing agricultural yields and improve ethanol production in order to improve their supply capacity. The most recent example is that of Agro-ecological Zoning for Sugarcane in Brazil, launched in September 2009 (see Box 3.2, page 55). They are also seeking to promote affordable technologies for producers at the same time. Countries where sugarcane is not a feasible option are exploring the possibility of tapping into other resources such as drawing on their geographical location for exporting, or using other crops or residues generated by these crops.

In the *upstream* section, the main areas covered in research, development and technology transfer programs are:

- (i) Breeding (plans to introduce different plant varieties and collections, germplasm conservation, procurement of local varieties, variety evaluation);

- (ii) Agronomy (spatial arrangement and variety, evaluation of cultivars on different sowing dates, precision agriculture, weed management, soil and fertilizers, pests, etc.);
- (iii) Technologies for the sustainable production of cereals and oilseeds in agricultural systems; rotations and tillage methods; high productivity sustainable agricultural systems; diagnosis, nutrient replacement and fertilizer technology; adaptability and stability of grain and oilseed cultivars in different environments; integrated pest, weed and disease management; different quality management methods for cereals and oilseeds, etc.

In the *downstream* section, research covers such topics as:

- (i) Designing, modeling, optimization of continuous and discontinuous (*batch*) chemical processes; reliable engineering with intelligent control and monitoring systems and processes for biodiesel and bioethanol; MSW biogas plant design, industrial and agricultural waste;
- (ii) Plant design and engine test bench. Performance and gas emissions of alternative fuels in combustion engines;
- (iii) Production of biodiesel with enzymes, heterogeneous catalysts and direct application of oil as a fuel oil; glycerol treatment. Biotechnology for the treatment of glycerol as a fuel;
- (iv) Fuel quality control, according to international and national standards.

2.3. Consumption of biofuels and production of raw materials

2.3.1. Current and forecasted consumption of biofuels

In 2008, the estimated gasoline market for Latin America and the Caribbean (LAC) was approximately 132 billion liters of gasoline and 101 billion liters of diesel (Tables 2.10 and 2.11). In terms of potential areas for expansion, countries with low land availability (Chile, Dominican Republic, El Salvador, Haiti, Jamaica, Honduras, Trinidad and Tobago, Costa Rica, Belize, Guatemala and Panama – see introduction) represent approximately 10% of regional diesel or gasoline consumption. Countries with higher consumption, such as Brazil, Mexico, Colombia and Venezuela, are also those with the greatest availability of land for agricultural expansion.⁸

Table 2.10: Gasoline consumption in Latin America and the Caribbean

Region / country	Millions of liters			
	1990	2000	2003	2008*
Central America and the Caribbean	29,991	35,536	39,302	62,883
South America	35,377	45,658	43,579	69,725
Total	65,368	81,194	80,602	132,608
Argentina	5,451	4,392	3,144	3,616
Bolivia	465	553	663	762
Brazil	9,061	16,439	15,389	24,500
Chile	1,783	3,091	2,702	3,107
Colombia	5,671	5,486	4,788	5,506
Costa Rica	250	710	788	906
Cuba	1,325	492	533	613
Dominican Republic	693	1,599	1,296	1,490
Ecuador	1,603	1,852	228	3
El Salvador	215	440	501	576
Guatemala	405	976	1,023	1,176
Haiti	78	128	138	159
Honduras	171	396	414	476
Jamaica	306	638	672	773
Mexico	25,601	28,906	32,601	37,491
Netherlands Antilles	110	123	158	182
Nicaragua	113	192	215	247
Panama	273	506	523	601
Paraguay	158	206	215	247
Peru	1,381	1,187	1,021	1,174
Trinidad and Tobago	450	430	440	506
Uruguay	274	372	245	282
Venezuela	9,531	12,080	13,131	15,101

* Estimated

Source: IICA, Gazzoni, 2009 en base al Instituto Mundial de Recursos

⁸ Gazzoni, Decio Luiz: "Biocombustibles y alimentos en América Latina y el Caribe", IICA, San José Costa Rica, 2009.

Table 2.11: Diesel consumption in Latin America and the Caribbean (LAC)

Region / country	Millions of liters			
	1990	2000	2003	2008*
Central America and the Caribbean	11,443	14,990	16,552	26,485
South America	29,874	46,398	47,018	75,229
Total	41,317	61,387	63,571	101,714
Argentina	4,522	7,915	6,637	10,619
Bolivia	269	370	463	741
Brazil	17,939	26,280	27,325	43,720
Chile	1,477	3,051	3,207	5,131
Colombia	925	1,830	2,058	3,293
Costa Rica	345	465	610	976
Cuba	442	262	245	392
Dominican Republic	351	871	682	1,091
Ecuador	887	1,730	1,931	3,090
El Salvador	262	514	519	830
Guatemala	274	601	753	1,205
Haiti	84	140	163	261
Honduras	211	346	457	731
Jamaica	109	143	167	267
Mexico	8,726	10,465	11,372	18,195
Netherlands Antilles	221	315	369	590
Nicaragua	163	346	352	563
Panama	179	307	643	1,029
Paraguay	424	795	986	1,578
Peru	1,157	2,147	2,213	3,541
Trinidad and Tobago	77	213	221	354
Uruguay	275	559	522	835
Venezuela	1,998	1,722	1,676	2,682

* Estimated.

Source: IICA, Gazzoni, 2009 en base al Instituto Mundial de Recursos.

Some of the comparative advantages of the LAC countries with regard to the production of biofuels are their natural resources such as the availability of agricultural land, suitable climate, extensive cultivation season and sufficient water supply for high productivity. At the same time, the technology supply, manpower, administrative capabilities and investment capital, among other things, are important differential factors for competition. The size of the internal market and the access to fossil fuel sources or other competitive differentiating factors linked to the energy production potential from other renewable sources are also basic elements in the establishment of sustainable biofuel production.

Consequently, most of the countries in the LAC have decided in favor of biofuels and have been fomenting their production and use in recent years (see Chapter 2.2). Based on the caloric value for the current consumption (2007) of fuel (Table 2.2), and considering the increase in consumption over the past few years (Tables 2.10 and 2.11) and the compulsory mixing proposed in the relevant laws, it is possible to predict biofuel consumption – bioethanol and biodiesel – in 18 LAC countries for the years 2010 and 2015 as presented in Tables 2.12 and 2.13.

Table 2.12: Forecast for bioethanol consumption in 18 countries within the region

Final consumption – 2007	Gasoline consumption in 2007 ⁽¹⁾ (in 1000 liters) ¹	Forecasted gasoline consumption for 2010 ² (in 1000 liters)	Compulsory mixing with bioethanol in 2010	Forecasted bioethanol consumption for 2010 (in 1000 liters)	Forecasted gasoline consumption for 2015 ² (in 1000 liters)	Compulsory mixing with bioethanol in 2015 (in 1000 liters)	Forecasted bioethanol consumption for 2015 (in 1000 liters)
Argentina	4,966,757	5,506,732	5%	275,337	6,540,270	5%	327,013
Bolivia (i)	550,800	610,682	10%	61,068	725,299	25%	181,325
Brazil (ii)	35,889,006	39,790,783	25% - 100% (flex-fuel vehicles)	28,000,000	47,258,968	25% - 100% (flex-fuel vehicles)	45,000,000
Chile (iii)	2,762,861	3,063,233	2%	61,265	3,638,160	2%	72,763
Colombia (iv)	5,288,330	5,863,266	10%	586,327	6,963,720	20%	1,392,744
Costa Rica	801,560	888,704	8%	71,096	1,055,501	8%	84,440
Ecuador (v)	2,394,855	2,655,219	5%	132,761	3,153,567	5%	157,678
El Salvador (vi)	507,799	563,006	10%	56,301	668,675	10%	66,867
Guatemala (vii)	1,105,627	1,225,829	10%	122,583	1,455,900	10%	145,590
Honduras	505,223	560,149	To be determined	-	665,282	To be determined	
Jamaica	638,574	707,999	10%	70,800	840,880	15%	126,132
Mexico (viii)	38,905,847	43,135,609	0%	-	51,231,571	6%	3,073,894
Nicaragua	278,138	308,377	To be determined	-	366,255	To be determined	
Panama	290,056	321,590	24%	77,182	381,948	24%	91,668
Paraguay (ix)	243,190	269,629	5%	13,481	320,234	5%	16,012
Peru	1,088,878	1,207,258	7.8%	94,166	1,433,844	7.8%	111,840
Dominican Republic	1,135,422	1,258,863	0%	-	1,495,134	15%	224,270
Uruguay (x)	306,483	339,804	5%	16,990	403,580	5%	20,179
Total	97,659,409	108,276,732		29,507,526	128,598,792		51,092,416

Notes:

- (i) Bolivia: The forecasted bioethanol consumption for Bolivia is based on the unlikely possibility of the regulation of the corresponding legislation which is frozen due to a decision from the current government.
- (ii) Brazil: MAPA's bioethanol consumption forecast was used since it takes into account both the mix of anhydrous bioethanol with gasoline and the consumption of hydrated bioethanol by flex-fuel automobiles.
- (iii) Chile: Mixing is not compulsory.
- (iv) Colombia: From 2012 on, compulsory mixing can be up to 85%. Reference is based on the UPME scenario of the Colombian Ministry of Mining and Energy considering an E20 mix for the years 2009 to 2025.
- (v) Ecuador: Bioethanol consumption forecasted for 2010 was calculated based on the Biofuels Pilot Plan E5 in Guayaquil (where gasoline consumption is officially estimated at 46,000 liters daily). Consumption forecasted for 2015 assumes that the Plan will be extended throughout the domestic territory.
- (vi) El Salvador: Forecasted bioethanol consumption in El Salvador is based on the assumption that the proposed legislation will be passed.
- (vii) Guatemala: Forecasted consumption for bioethanol is based on the assumption that the proposal from the Ministry of Mining and Energy will be implemented (Law for Incentives to the Development of Projects on Renewable Energies 2003, stagnant so far).
- (viii) Mexico: Forecasted consumption for bioethanol for Mexico in 2015 is based on the assumption that the Bioenergy Starter Program will be extended throughout the country. The Program will start in Guadalajara in 2011 and will include Monterrey Metropolitan Areas and Valle de Mexico Metropolitan Areas.
- (ix) Paraguay: The assumption was the usage of the maximum levels in the compulsory mix (E20-E24).
- (x) Uruguay: 5% optional in 2010, compulsory from 2015 on.

Source: Independent compilation based on 1). OLADE, except Argentina (Energy Secretariat) 2). An assumed annual cumulative growth rate of 3.5% was applied evenly to all countries.

Table 2.13: Forecast for biodiesel consumption in 18 countries within the region

Final Consumption – 2007	Biodiesel Consumption in 2007 ⁽¹⁾ (in 1000 liters) ¹	Forecasted Biodiesel Consumption for 2010 ⁽²⁾ (in 1000 liters)	Compulsory mixing with Biodiesel in 2010	Forecasted Biodiesel consumption for 2010 (in 1000 liters)	Forecasted Biodiesel Consumption for 2015 ² (in 1000 liters)	Compulsory mixing with Biodiesel in 2015 (in 1000 liters)	Forecasted Biodiesel consumption for 2015 (in 1000 liters))
Argentina	13,853,972	15,360,146	5%	768,007	18,243,036	5%	912,152
Bolivia (i)	1,038,791	1,151,726	2,5%	28,793	1,367,889	20%	273,578
Brazil	40,151,269	44,516,429	5%	2,225,821	52,871,554	5%	2,643,578
Chile (ii)	6,704,467	7,433,363	5%	371,668	8,828,503	5%	441,425
Colombia	5,277,217	5,850,945	10%	585,095	6,949,088	20%	1,389,817
Costa Rica	1,047,971	1,161,904	5%	58,095	1,379,977	5%	68,999
Ecuador	3,299,650	3,658,381	To be determined	-	4,345,009	To be determined	-
El Salvador (iii)	674,006	747,282	2%	14,946	887,537	2%	17,751
Guatemala	1,490,061	1,652,057	To be determined	-	1,962,125	To be determined	-
Honduras	882,086	977,985	To be determined	-	1,161,539	To be determined	-
Jamaica	726,670	805,672	5%	40,284	956,886	5%	47,844
Mexico (iv)	20,332,111	22,542,575	UBA Diesel Additive in Cadereyta	8,700	26,773,508	UBA Diesel Additive throughout the country	105,000
Nicaragua	570,610	632,646	To be determined	-	751,385	To be determined	-
Panama	902,701	1,000,841	To be determined	-	1,188,685	To be determined	-
Paraguay	1,069,391	1,185,652	3%	35,570	1,408,183	To be determined	-
Peru	3,646,396	4,042,825	2%	80,856	4,801,608	5%	240,080
Dominican Republic	898,836	996,555		-	1,183,595	2%	23,672
Uruguay	915,746	1,015,304	2%	20,306	1,205,863	5%	60,293
Total	103,481,950	114,732,288		4,238,141	136,265,967		6,224,189

Notes:

- (i) Bolivia: The forecasted biodiesel consumption for Bolivia is based on the unlikely possibility of the regulation of the corresponding legislation, currently frozen due to a decision from the present government.
- (ii) Chile: Mixing is not compulsory.
- (iii) El Salvador: Forecasted consumption of biodiesel in El Salvador is based on the assumption that the proposed legislation will be passed.
- (iv) Mexico: Forecasted projection corresponds to that of the SENER Bioenergy Starter Program that plans to incorporate biodiesel as a UBA Diesel Additive for 2009-2010. Ultra Bajo Azufre (UBA) Diesel is produced by the Cadereyta Refinery to comply with lubrication specifications. The intention is to extend biodiesel incorporation to all domestic UBA diesel production between 2011 and 2014.

Source: Independent compilation based on 1). OLADE, except Argentina (Energy Secretariat) 2). An assumed annual cumulative growth rate of 3.5% was applied evenly to all countries.

With regard to bioethanol, “Brazil is an emblematic case where the bioethanol experience should become a reference for developing countries and their increased opportunities in the world market. Its leadership in bioethanol and technologies associated with liquid fuels is undisputed. With over thirty years implementing a program with a strong government influence, its own technological developments and the ever-growing participation of biofuels in their transportation system make it a singular case among developing

countries.”⁹ As a result, with over 90% of the grand total, Brazil currently produces and consumes most of the bioethanol produced in the LAC. Even with the increase in consumption in other countries also predicted for 2015 (particularly Colombia and Mexico), Brazil will still be responsible for over 80% of bioethanol consumption within the LAC region.

A significant increase in the use of sugarcane for bioethanol production is expected in Brazil, the world’s second largest bioethanol producer, stimulated by the anticipated growth of the flex-fuel vehicle fleet, a sizeable increase in the installation capabilities assumed by the current investor wave in the sugar and alcohol segment and the escalation of external demand. According to projections from the Brazilian Ministry of Agriculture, bioethanol production will go from 18,900 million liters in 2007 to over 31,800 million liters in 2013 (with over 7,000 million liters in exports), and should reach 41,600 million liters by 2018, with a domestic consumption of 30.3 thousand million liters (exports would be in the range of 11,300 million liters)¹⁰.

The situation is slightly different for the projected consumption of biodiesel: while Brazil will be the largest biodiesel consumer in LAC by the year 2015, its consumption will represent less than a third of total consumption in the region. Countries such as Argentina, Bolivia, Chile, Colombia and Peru will also consume considerable amounts of biodiesel, and

Brazil and Argentina will become firmly established among the main worldwide producers and exporters of biodiesel, especially soy-based. The still growing production and processing capacities of their emerging biofuel industries (*downstream* and *upstream*), which - including plants already in construction or in the process of being regulated as well as a number of approved blueprints - will soon facilitate the production of over 5,600 million liters, foretells a significant increase in the use of oleaginous plants and vegetable oils over the next few years. On top of that, the also growing processing capabilities for bioethanol and biodiesel production in other Latin American and Caribbean countries will add to the ensuing demand for sugarcane, palm, soy bean and other raw materials.¹¹

2.3.2. Production of raw materials

Given the favorable situation in LAC regarding raw material production for biofuel, the region is expected to become a self-supplier, with biofuel-exporting potential in some cases (Brazil, Argentina).¹²

a. Raw materials for bioethanol production

Bioethanol can be obtained from three types of raw materials:

- Crops and products with a high sugar content such as sugarcane, beetroot, sweet sorghum and molasses.

⁹ CEPAL, 2008: Aporte de los biocombustibles a la sustentabilidad del desarrollo en América Latina y el Caribe: Elementos para la formulación de políticas públicas.

¹⁰ Ganduglia, F y Equipo de Proyectos de Biocombustibles (EPB) – ARPEL. Inédito. Guía ARPEL – IICA sobre Biocombustibles. Guía ARPEL REF No. 01-2009 – IICA REF No. 01-2009

¹¹ Ganduglia, F y Equipo de Proyectos de Biocombustibles (EPB) – ARPEL loc.cit

¹² CEPAL, 2009: Biocombustibles y Comercio Internacional: Una perspectiva Latinoamericana

“... There are few Latin American countries that currently have the potential to export biofuels... Being more specific, only Brazil and Argentina, which are currently the two greatest exporters of agricultural products in the region, display favorable conditions to the expansion of biofuel exports. In the other countries, biofuels have an important niche to fill, but it is within the domestic market.”

- Starch crops with high starch content such as those found in cereals (corn, grain sorghum, wheat and barley), roots and tubers (manioc, potato, sweet potato, etc.) or inulins (Jerusalem artichoke or topinambur, agave, yam, etc.).
- Raw materials and crops with high cellulose content (lignocelluloses), where carbohydrates are found in a more complex form (wood, agricultural and forestry residue, lignocelluloses crops, herbaceous material, etc.).¹³

Ganduglia et al. estimate that the production of raw materials that are most relevant for bioethanol in 10 South American countries¹⁴ amounted to almost 760 million tons in 2007 (Table 2.14). The crop with the greatest immediate availability in the region is sugarcane, which is grown in every country in South America except Chile, as well as throughout all of Central America and the Caribbean. Brazil, the world's main sugarcane producer, leads significantly in the regional production of this raw material. Following sugarcane are corn, whose South American production is concentrated in Argentina and Brazil¹⁵, cassava, sorghum, sweet beetroot and yam (Table 2.14). The main South American producers of raw materials used in the production of bioethanol are Brazil, followed by Argentina and Colombia.¹⁶

Table 2.14: Raw materials used for bioethanol production in 10 South American countries in 2007

Raw Materials	Total Production (in 1,000 tons)	Conversion to ethanol ¹⁾ (l/t) (b)	Potential of ethanol production (in billion l) (a) * (b)	Potential participation in total ethanol production (%)
Sugarcane	635,530	81	51,5	55,3 %
Corn	80,016	410	32,8	35,2 %
Manioc	36,495	180	6,6	7,1 %
Sorghum	5,362	402	2,2	2,3 %
Yam	619	n/d	n/d	n/d
Sweet Beetroot	1,833	32	0,1	01 %

Source: Ganduglia, F. et al ARPEL/IICA (unpublished): Guía ARPEL – IICA sobre Biocombustibles (based on official statistics from each country and FAOSTAT)¹⁾ Matt Johnston et al. 2009. Resetting global expectations from agricultural biofuels. Environmental. Research Letters. 4 (2009) 014004 (9pp): http://www.iop.org/EJ/article/1748-9326/4/1/014004/erl9_1_014004.pdf?request-id=f7eaac1d-97fb-4eee-bf7d-5e47648f07ea

Around 5 million ha were used for growing sugarcane in Brazil in the 90s and in the early part of this century. From 2003 on, with the advent of flex-fuel engines, and their widespread acceptance by consumers, the increase of hydrated bioethanol consumption resumed in the domestic market, paving the way for new perspectives for the expansion of the sugarcane agro-industry in Brazil. Since that time, the Brazilian agro-industry has expanded significantly (Chart 2.8). According to UNICA¹⁷ the area available for sugarcane harvesting increased to 5.83 million ha in 2007/08 and 6.75 million ha in 2008/09.

¹³ Ganduglia, F y Equipo de Proyectos de Biocombustibles (EPB) – ARPEL. Loc.cit.

¹⁴ Argentina, Bolivia, Brazil, Chile, Columbia, Ecuador, Peru, Paraguay, Uruguay, Venezuela.

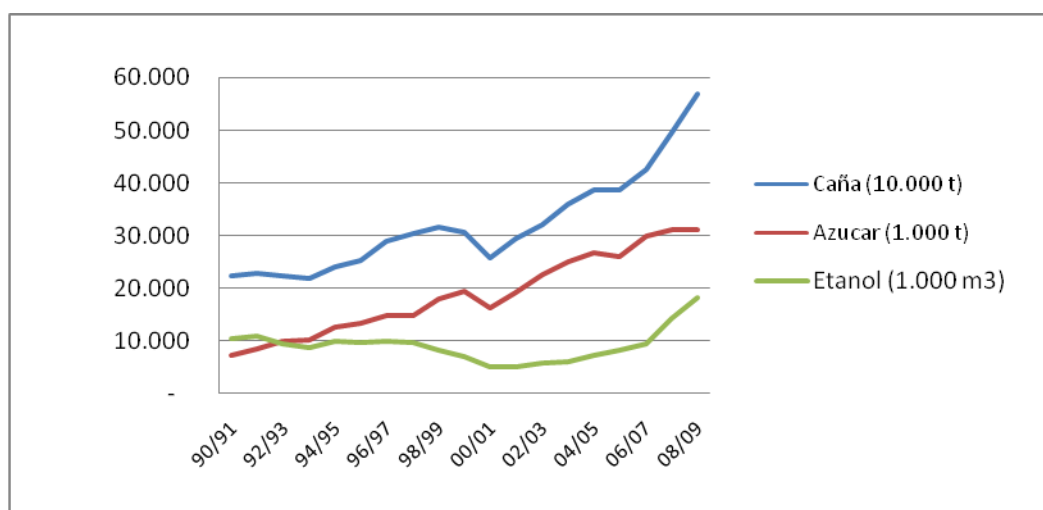
¹⁵ Another important corn producer is México (see Box No. 2.1)

¹⁶ Ganduglia, F y Equipo de Proyectos de Biocombustibles (EPB) – ARPEL. Loc.cit.

¹⁷ UNICA: "Avaliação da área de cana disponível para colheita na safra 2008/09", available at <http://www.unica.com.br/dadosCotacao/estatistica>

This, together with a continuous growth in crop productivity since the 1950s, ensures that Brazil has the conditions to meet the demands of both markets: for human consumption (sugar) and for biofuels (ethanol). In order to steer and organize the likely expansion of the sugarcane agro-industry, which will face even greater demands from the different markets in the future, the Brazilian Government recently put forth a proposal for the creation of agro-ecological zones for sugarcane, applying both ecological (environmental) and economic criteria (see Box N° 3.2, Chapter 3, page 55).

Figure 2.8: Evolution of sugarcane, bioethanol and sugar production in Brazil



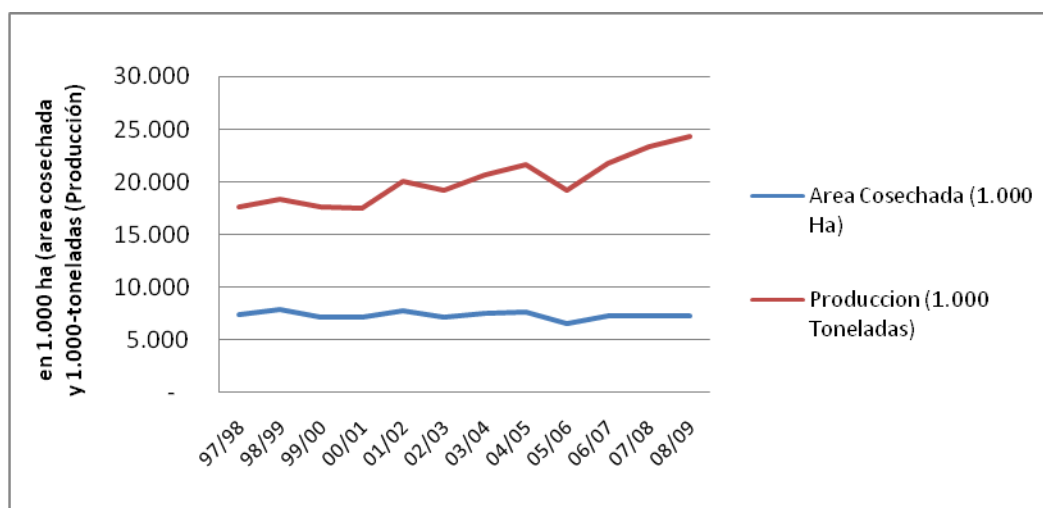
Source: Independent compilation based on data from União da Indústria de Cana-de-açúcar - UNICA, available at <http://www.unica.com.br/dadosCotacao/estatistica>

Box N° 2.1: Corn Production in Mexico

Corn is by far the most important agricultural crop in Mexico from the nutritional, industrial, political and social point of view. The country has two corn production cycles: spring-summer and autumn-winter, with very diverse agro-climatic conditions in terms of humidity, weather and irrigation. Mexico is a center of origin and diversity of corn, and recent studies reveal over 50 different types. In response to the importance of these crops, the Mexican government, through the Agricultural, Cattle Raising, Rural Development, Fishing and Food Secretariat (Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación – SAGRAP) maintains several programs to foment the growing and conservation of the different varieties of Creole corn.

Corn production increased 6.1 million tons between 1994 and 2008, reaching a production level of 24.4 million tons (Graph 2.10) in 2008. The area cultivated over the past 25 years, which ranged between approximately 7.5 and 9.2 million ha has shown a significant trend towards a 1% decrease per year over the last decade (from 9.13 million ha in 1997 down to 7.9 million ha in 2008; Graph 2.10). The continued increase in total production is thus due to an increase in yield from 1.8 t/ha (in the 80s) to 2.3 t/ha (in the 90s) to 2.6 t/ha (2000-05) to 3.3 t/ha in 2008. Production for 2008 was in excess of 68 billion pesos (approximately US\$ 5.3 billion), making Mexico the fourth largest corn producer in the world.

Figure 2.9: Harvested area and corn production in Mexico 1997 - 2008



Source: Independent compilation based on SAGARPA/SIAP (Servicio de Información Agroalimentaria y Pesquera), México, Available at: <http://w4.siap.gob.mx/artus/eis/loadstage.asp>

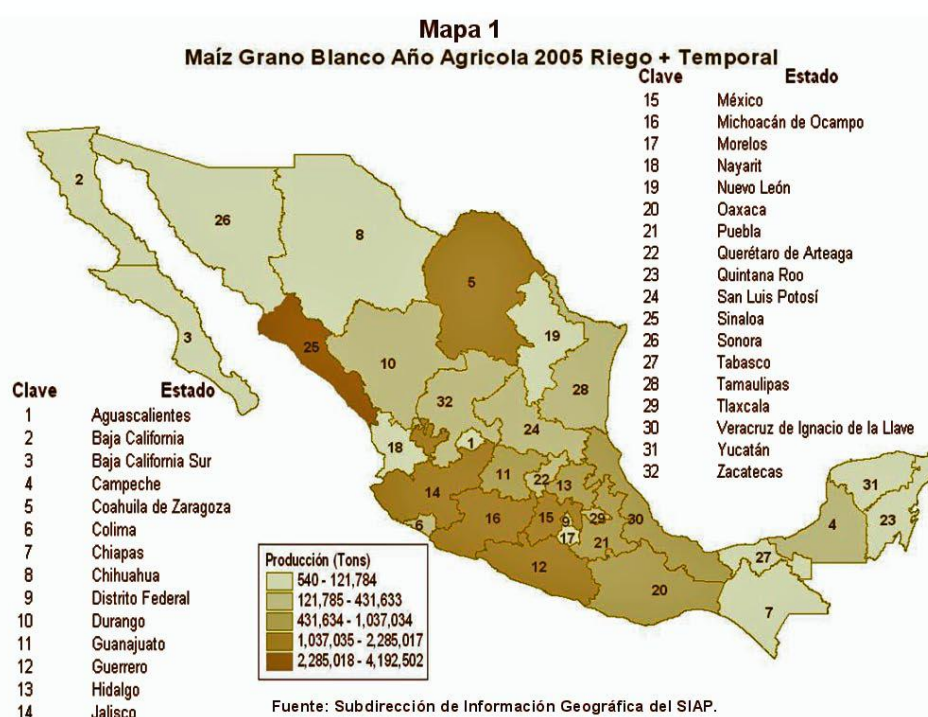
Corn contributes approximately 65% of total cereal production. A comparative analysis of corn with other cereals produced in Mexico (mainly wheat, sorghum, barley, rice and oats) with regard to the evolution of the volume of production, shows that corn increased an average of 2.0% per year between 1996 and 2006.

Domestically, corn crops occupy 38.5% of the total cultivated surface area. Approximately 2 million people grow corn as their main activity, a figure that represents 30% of the employed population in the primary sector of the country's economy. Smallholder properties predominate for corn production. Out of the 1.9 million registered producers, 85.1% of them own land with less than 5 ha, and 56% have production units smaller than 2 ha. Consequently, corn growing in Mexico allows the coexistence of production systems: the first is known as a subsistence system, where small-scale land owners make up the majority (85%) and a good part of what is obtained from those lands is used for self-consumption, constituting an important part of the income of families living in the rural sector. The second, the commercial production system, is targeted to comply with demands imposed by the agro-industry responsible for the multiple products derived from corn such as: corn meal, tortilla, cornflower, starches, cereals and animal feed.

Box N° 2.1 (cont.): Corn Production in Mexico

The observable domestic consumption of corn in 2008 was 33.6 million tons, divided between white and yellow corn and other varieties. Domestic production provides the white corn for human consumption and imports are mostly yellow corn. By breaking down the main corn varieties, one can see that the country is self-sufficient in white corn, while 74% of the yellow corn supply comes from imported grain. In 2008, 93% of the imports referred to yellow corn being used mainly for cattle-raising and starch industries. From 2006 to 2008, corn imports were reduced by 1.5 million tons, dropping from 10.7 to 9.2 million tons.

Figure 2.10 Distribution of white corn production by state in 2005



Source: SAGARPA/SIAP "Situación actual y Perspectivas del Maíz en México 1996-2012" (pdf) México, sin año.

Bioenergy in Mexico is responsible for 8% of the primary energy consumption, which is why ethanol production in Mexico is still embryonic. Sugarcane chaff is the material used for bioenergy production, and it is used for electric and or thermal energy in the sugar industry. The first ethanol industrial plant has just become operational. Ethanol is produced from corn and sorghum. The ethanol produced as a result of the process is destined for the U.S. market.

Sources: 1.) Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación – SAGRAP: "Producción de Maíz en México", PowerPoint Presentation, Septiembre 2009, sent by Coordinación General de Comunicación Social (comusoc@sagarpa.gob.mx)
2.) SAGARPA/SIAP "Descripción del Maíz" (pdf), Mexico, without year.
3.) SAGARPA/SIAP -Servicio de Información Agroalimentaria y Pesquera; México, available at <http://w4.siap.gob.mx/artus/eis/loadstage.asp>
4.) SAGARPA/SIAP "Situación actual y Perspectivas del Maíz en México 1996-2012" (pdf) México, without year.

b. Raw materials for biodiesel production

Biodiesel is obtained from the transesterification of vegetable oils or animal fats. Vegetable oils can be obtained from a wide variety of oleaginous seeds and fruit, as well as other alternative raw materials such as seaweed. Recycled cooking oils are also used¹⁸.

The crops that have the potential to increase the biodiesel supply in Latin America are the most widely grown oleaginous plants such as soy, African Palm, cotton, sunflower, peanut, etc., with soy in the forefront. In 2007, Ganduglia et al estimated the production of over 130 million tons of oleaginous seeds and fruit for the 10 countries in South America, resulting in around 17.3 million tons of vegetable oil (Table 2.15).¹⁹

Table 2.15: Raw material for biodiesel production (from oleaginous seeds and fruit) for 10 South American countries in 2007

Oleaginous	Total Production (in 1,000 tons)	Conversion to biodiesel ¹⁾ (l/t) (b)	Potential of biodiesel Production (in billion l) (a) * (b)	Potential participation in total biodiesel production (%)
Soy	112,473	183	20,6	83,9 %
African Palm	7,353	223	1,6	6,7 %
Cotton	4,749	103	0,5	2,0 %
Sunflower	4,043	418	1,7	6,9 %
Coconut	3,100	n/d	n/d	n/d
Peanut	908	n/d	n/d	n/d
Colza	195	392	0,1	0,3 %
Castor Oil	163	393	0,1	0,3 %
Sesame	115	n/d	n/d	n/d
Safflower	58	n/d	n/d	n/d
Flax	51	n/d	n/d	n/d
Tung	50	n/d	n/d	n/d

Source: Ganduglia, F. et al. ARPEL/IICA (Inédito): Guía ARPEL – IICA sobre Biocombustibles (en base a estadísticas oficiales de los países y FAOSTAT) 1/ Matt Johnston et al. 2009. Resetting global expectations from agricultural biofuels. Environmental. Research Letters. 4 (2009) 014004 (9pp). Available at: http://www.iop.org/EJ/article/1748-9326/4/1/014004/erl9_1_014004.pdf?request-id=f7eaac1d-97fb-4eee-bf7d-5e47648f07ea

Just as sugarcane is prevalent as a raw material in bioethanol production, soy appears to be the raw material of choice in the production of biodiesel. The production of this oleaginous plant was over 112 million tons in 2007, which is 87% of the total for oleaginous plants in the 10 countries. However, this output is mainly concentrated in the two large agro-exporting countries of the region, Brazil and Argentina. Soy is the most immediately available raw material, followed by the African Palm, cotton seeds and sunflower seeds (Table 2.15). The other important oleaginous crop is palm, which is mainly produced in Colombia and Ecuador in South America, and in Honduras, Costa Rica and Guatemala in Central America (Table 2.16). Palm is currently the crop with the greatest potential for vegetable oil production.

¹⁸ Ganduglia, F y Equipo de Proyectos de Biocombustibles (EPB) – ARPEL, loc. cit.

¹⁹ Argentina, Bolivia, Brazil, Chile, Columbia, Ecuador, Peru, Paraguay, Uruguay, Venezuela.

Other crops such as castor oil or jatropha still have no tradition in the region. In Brazil, for example, the government supports the development of these crops as raw materials for the production of biodiesel since they are more consistent with small properties and semi-arid zones in the rural areas of Brazil, home to the country's poorest populations. Nevertheless, harvest results are currently much lower than what was originally predicted.

Table 2.16: Most important soy and African Palm-producing countries in LAC (2007)

Country	Production (in tons)
Soy	
Argentina	40,467,100
Bolivia	1,619,000
Brazil	52,464,640
Paraguay	3,800,000
Uruguay	631,900
African Palm	
Brazil	590,000
Columbia	3,200,000
Costa Rica	790,000
Ecuador	2,000,000
Guatemala	605,000
Honduras	1,250,000
Mexico	309,582
Venezuela	307,403

Source: adapted from: CEPAL, 2009: Biocombustibles y Comercio Internacional: Una perspectiva Latinoamericana", en base de FAOSTAT.

Box No. 2.2: Strengthening family agriculture in the Brazilian Northeast through the National Program for the Production and Use of Biodiesel

The Brazilian Government created the National Program for the Production and Use of Biodiesel (Programa Nacional de Produção e Uso de Biodiesel - PNPB) as a self-sustaining energy program, taking into consideration the price, quality and security of the biodiesel supply. It offers development opportunities for Brazilian agriculture, especially for small-scale farmers in underprivileged and underdeveloped regions. The program's objective includes the market introduction, production and rational use of biodiesel, considering aspects of ecological and economic feasibility and sustainability, fostering social inclusion and sustainable regional development in rural areas through the generation of income and employment for the farmer's household.

How can family agriculture benefit from the improvement of biofuel production and the social inclusion of less favored rural sectors?

There are a number of crops from which oil can be extracted and transformed into biodiesel, and are specially suitable for family agriculture, such as Castor (*Ricinus communis*) and the Physic Nut (*Jatropha curcas*). They adapt to less demanding conditions and do not require large amounts of water or much agricultural care, allowing for cultivation with fewer investments. Another advantage of

these crops is that they can be used in mixed intercropping production systems with other crops such as beans, which provide valuable nutrition and fix nitrogen to the soil, improving its fertility²⁰. The Brazilian Northeast is characterized by a semi-arid climate with irregular rainfall and frequent drought, rendering agricultural practices more difficult as a result of the frequent loss of production. The region is also characterized by a low human development index (HDI), socio-economic inequality, demographic pressure, rural poverty and a lack of opportunities and perspectives for family agriculture.

Castor is considered to be the main oleaginous crop in the Northeast for supply of raw material for the PNPB, as it has the following characteristics: i) it is adapted to the soil and climate conditions of the Northeast; ii) it has a high oil content (48%); iii) it has a short production cycle; iv) it can be cultivated in association with other (food) crops; v) it grows in degraded soils; vi) agro-ecological zoning for the crop has been done for over 725 departments in the Northeast and vii) farmers acquainted with the crop know the cultivation process (especially in the State of Bahia).

Consequently, the Brazilian Government is promoting the cultivation of castor. Of the approximately 900,000 km² of Brazil's semi-arid northeast region, more than 15,000,000 hectares meet the necessary climate, soil and elevation requirements (from 300 to 1500 above sea level) for its cultivation (SUDENE, 1989)²¹. Considering the limitations due to soil and climate, and the requirements of rain-fed agriculture, the Empresa Brasileira de Pesquisa Agropecuária [Brazilian Agricultural Research Corporation] (Embrapa) has developed stable and profitable production systems in combination with beans. Castor is being intercropped with different bean species (*Vigna unguiculata* L., *Phaseolus vulgaris* L.), which are the most important source of proteins for the rural population of the Northeast, or with peanuts (*Arachis hypogaeae* L.), sorghum (*Sorghum bicolor* L.) or pearl millet (*Pennisetum glaucum* L. or *Pennisetum americanum* L. Leeke)²². Small-scale farmers implement the mixed cropping systems in small areas (2–6 ha), quite often on degraded soils. The cultivation of castor is considered an opportunity for small-scale producers in the region to diversify production, putting at their disposal a complementary cash crop, increasing revenues and decreasing agricultural risks (Table 2.17). Among other advantages, harvesting of castor occurs at a different season of the year than the associated crops, allowing a net income during the months that are deemed less profitable.

Another advantage relates to the support of the state/government not only through technical assistance and rural development services, but also with the formalization of the biodiesel production chain, based on raw material from family agriculture. Through the so-called Social Biofuel Seal, the government has established tax benefits for biodiesel producers, assuring the commercialization of production originating from family agriculture and consequently guaranteeing a reliable income for small-scale producers and the economic stability of the productive chain.



Obtaining the Social Biofuel Seal brings the following advantages to biodiesel production companies: i) tax benefits, including tax reduction; ii) better financing conditions via the BNDES; iii) participation in all biofuel auctions organized by the National Petrol Agency of ANP, which is the body that regulates the activities of the oil, natural gas and biofuel industry in Brazil; iv) benefitting from marketing campaigns organized and financed by the government. In order to obtain the Social Biofuel Seal and comply with counterpart obligations, biodiesel producers agree to:

- Acquire a certain percentage of raw material from family agriculture (50% in the Northeast, 10% in the Northern and the Midwest regions, and 30% in the Southwest and Southern regions).
- Sign and fulfill long-term supply contracts with family producers (or cooperatives) defining minimum prices, approved by the Federal Union of Rural Workers and recognized by the government.

²⁰ Preguntas y respuestas más frecuentes sobre Biocombustibles. IICA. – San Jose, Costa Rica: IICA, 2007.

²¹ SUDENE. Programa Nacional de Incentivos à Cultura da Mamona - PROIMA. Recife, PE, Brasil, 1989.

²² Consórcio Mamona + Amendoim: Opção para a Agricultura Familiar. Circular Técnico No. 104, Embrapa Algodão, Campina Grande, Brazil 2006.

- Provide proper technical assistance: certified seeds, rural technicians, good agricultural practices etc

Table 2.17: Socio-economic analyses of the "Ricinus communis – Bean Consortium"^{a)} and results from the demonstration area at Inhamuns/Crateús, State of Ceara^{b)}.

Description	Unit	Potential Production ^{a)}	Actual average production in the Northeast ^{a)}	Producer A. de Melo, Parambu, Crateus, Ceara ^{b)}
Average productivity of <i>ricinus communis</i>	(kg/ha)	1,500	1,000	1,600
Average productivity of beans	(kg/ha)	400	300	480
Income from <i>ricinus communis</i> production	(R\$ ¹⁾ /ha)	1,125	400	1,920
Income from bean production	(R\$ ¹⁾ /ha)	600	750	638
Gross Income	(R\$ ¹⁾ /ha)	1,725	450	2,558
Production costs	(R\$ ¹⁾ /ha)	600	1,200	1,350
Net Income	(R\$ ¹⁾ /ha)	1,125	800	1,228

Note: 1) 1 R\$ = aprox. 0.55 US\$, December 2009.

Sources: a) "Módulo de Produção de Matéria Prima na Agricultura Familiar - Resultado baseado na análise sócio-econômica do consórcio mamona x feijão (COOPPE/UFRJ e Embrapa)", José Renato Cortez Bezerra, Embrapa Algodão; Taller "Produção de Biodiesel Através da Agricultura Familiar" Campinas, 09.03.2008.
b) "Relatório de Implantação da Unidade Técnica Demonstrativa: Agricultor Antonio de Melo Neto, Município Parambu, Polo de produção Inhamuns/Crateús, estado de Ceara. Responsible Technician : Uires Amorim Loiola, 11.19. 2009. By the Agricultural Development Ministry (MDA), farm-household Secretary (SAF), Brazil.

In addition to complementing traditional food crops, other aspects of the economic feasibility of castor production in family agriculture include the establishment of production hubs, the possibility of organizing production in cooperatives and, eventually, the verticalization of production and added value by organizing oil extraction at the cooperative level. The joining together of several small-scale producers would suffice for the acquisition of a small facility for the production of biofuel to meet local power needs, or to find new business opportunities for the product²³. With the obligation of establishing direct contracts between biofuel producers and raw material producers, the production chain has been shortened and the dependence of small-scale producers on intermediaries has been reduced²⁴.

The program's political feasibility is defined by the participation of family agriculture, and positive environmental, economic, and social impacts are essential to justify the continuity of the public policy of supporting the inclusion of family agriculture in the biofuel chain. Once more, without the participation of family agriculture, the production of biofuel will remain in the hands of large-scale producers and in mono-cultivation. An unpublished evaluation of the program's performance, however, indicates that the production of basic grains in the region, especially beans, has increased since the onset of the program due to the promotion of mixed cropping systems²⁵.

²³ Preguntas y respuestas más frecuentes sobre Biocombustibles. IICA. – San José, Costa Rica: IICA, 2007.

²⁴ Verbal communication, December 2009. Ministério de Desenvolvimento Agrário (MDA), Secretaria de Agricultura Familiar (SAF), Brazil.

²⁵ Comunicação Verbal communication, December 2009. Ministério de Desenvolvimento Agrário (MDA), Secretaria de Agricultura Familiar (SAF), Brazil.

Box no 2.3: Production of raw material - The case of HONDUPALMA²⁶, Honduras

Although the tropical climate of Honduras favors the production of a variety of commercial crops, the country continues to import the bulk of its agricultural products. However, the government has promoted the cultivation of the African Palm, established years ago along the country's northern coast as an agricultural cash crop. The action is part of a strategy to reduce poverty and generate jobs and income, while at the same time helping to resolve the energy issue of the country through the production of biofuels for the national transportation sector.

The government strategy for the production of biofuels focused on expanding palm plantations in the hope that the crop and its products - vegetable oil and biodiesel - would reduce total dependency on imported fossil fuel. This would contribute to the government's investments in initiatives to develop the national economy: creating new jobs and income-generating alternatives within a dynamic economic sector with growth potential; promoting agricultural development in rural areas often characterized by weak economic structures; reducing Greenhouse Gas emissions (GHG) and generating additional income under the Clean Development Mechanism (CDM) and the United Nations Framework Convention on Climate Change (UNFCCC).

In terms of environmental administration, the country has some of the largest tropical forests and biodiversity reserves of Central America. The development and expansion of agricultural production in Honduras for food and bioenergy thus requires the timely and thorough consideration of any negative impact - environmental or social - that might result from such expansion.

Current status of the African Palm in Honduras²⁷:

The first commercial plantations were established in the 1940s. From 1971 onwards, palm cultivation was strongly promoted as part of the agrarian reform process, which included the establishment of rural cooperatives in the departments of Colon and Yoro. Later on, these cooperatives formed larger organizations that are still functioning today, called COAPALMA (14 cooperatives) and HONDUPALMA (30 cooperatives and other grassroots organizations).

The African Palm cultivation area in Honduras has more than doubled, from approximately 40,000 hectares in the 1990s to 82,000 hectares in 2005. This increase was achieved as a result of record prices for palm oil, in addition to facilitated access to private financing and technical assistance for producers who are already involved in or getting started in the African Palm industry. In 2007, the total planted area was 96,000 hectares, and it is expected to reach 120,000 hectares by 2010. For the palm-producing region on the country's northern coast, approximately 800 new producers have been registered in the departments of Atlántida, Cortés, Colón and Yoro, which offer the most favorable production conditions for that crop (Figure 2.12).

Table 2.18 provides the data for the palm sector for 2008 (SAG), while Table 2.19 shows the high number of small and medium-size producers, proving that palm-growing in Honduras is not strictly limited to large-scale agribusiness enterprises. Through the National Agriculture Development Bank (Banco Nacional de Desarrollo Agrícola - Banadesa), the government encourages small-scale producers to complement the cultivation of staple food crops with African Palm in order to diversify and compensate possible harvesting losses during the rainy season. Considering the crop's profitability, financing for the cultivation of African palm has been made accessible to small and independent producers who are affiliated with the National Rural Workers Association of Honduras (Asociación Nacional de Campesinos de Honduras - ANACH).

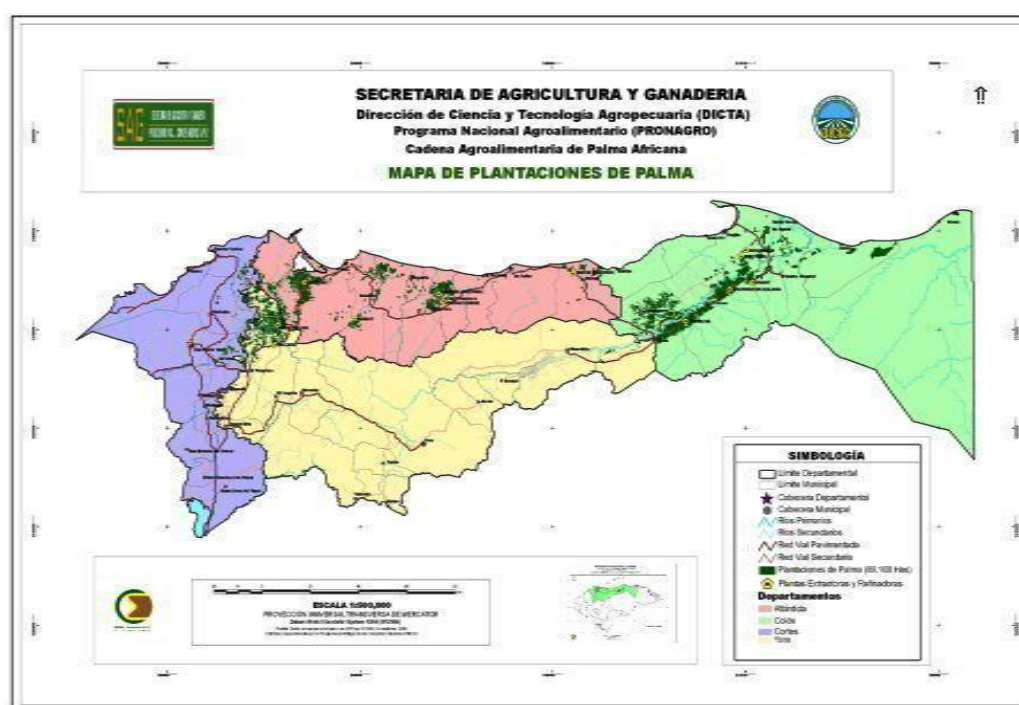
With the main objective of the National Plan for the Production of African Palm being to increase the area of cultivation, training and technical assistance is offered to farmers so that they can improve overall farm management capabilities and increase productivity. Special assistance is given to new producers, while the approximately 6,000 current producers receive technical assistance and training in specific areas of production such as palm seed propagation and production, and genetic

²⁶ Desarrollo de una Cadena de Valor de Biocombustibles en una Plantación de Palma Africana - El caso de Hondupalma. SNV, Tegucigalpa, 2009.

²⁷ Honduran Government, Secretaría de Agricultura y ganadería - SAG
http://www.sag.gob.hn/index.php?option=com_content&task=view&id=1628&Itemid=892

improvement and control of plagues and diseases²⁸. In addition, producers are included in a geo-referenced register currently being developed by the Ministry of Agriculture (Secretaría de Agricultura y ganadería – SAG).²⁹ Principal players participating in the African Palm value chain include small, medium or industrial-scale producers of raw material and their investors, refineries, local distributors and service providers and exporters.

Figure 2.11: African Palm plantations in Honduras (SAG 2008)



Source: Ministry of Agriculture (Secretaría de Agricultura y Ganadería SAG), available at http://www.sag.gob.hn/ca/agroindustria/palma/Plantaciones_palma.pdf

Table 2.18: Current data on the African Palm in Honduras (SAG 2008)

Cultivated Area	109,000 hectares
Production Area	86,000 hectares
Average age of plant	14 years
Fresh fruit yield	17.54 TM/hectare
Oil yield	21,00 %
Extractor plants	11
Industrial plants	4
Extraction capacity	497 TM/Hr. FF
Beneficiary	120,000 individuals, aprox.100,000 men, and 20,000 women

Source: Ministry of Agriculture (Secretaría de Agricultura y ganadería - SAG), available at http://www.sag.gob.hn/index.php?option=com_content&task=view&id=1628&Itemid=892

²⁸ Implemented through governmental agencies such as Dirección de Ciencia y Tecnología Agropecuaria (DICTA), Servicio Nacional de Sanidad Agropecuaria (SENASA) or Programa Nacional Agroalimentario (PRONAGRO)

²⁹ http://www.sag.gob.hn/index.php?Itemid=116&id=301&option=com_content&task=view

Table 2.19: Distribution of African Palm producers in Honduras by size of enterprise

Description	Area (hectares)	Producers	Area (1,000 hectares)
Small	less than 10	1,485	6.80
Average	10 – 100	773	31.39
Large	100 – 1,000	106	34.82
Extra large	More than 1,000	7	36.09
TOTAL		2,371	109.10

Source: Ministry of Agriculture (Secretaría de Agricultura y ganadería - SAG), available at http://www.sag.gob.hn/index.php?option=com_content&task=view&id=1628&Itemid=892

Hondupalma, a company that belongs to the social sector of the organized economy, consists of 30 cooperatives and public interest companies, with over 600 associate members and 125 independent producers. The company has an extractor plant for African Palm oil, which is supplied by approximately 6,000 hectares of planted palm crops, producing 89,282 tons of fresh fruit per year, with a processed yield of 15,200 tons of palm oil. The cooperative has a participative business model and is a leading agro-industrial entrepreneur in the region. Its most important products include vegetable oil, different types of unsaturated fats and biodiesel derived from low quality palm oil.³⁰

Since 2007, Hondupalma, the Netherlands Development Organization (SNV) and the World Wide Fund for Nature (WWF) have been implementing a project to develop a sustainable biofuels value chain based on Hondupalma's African Palm plantations. The principal objective is to create more jobs and income-generating opportunities for 30 cooperatives and companies that include 600 small-scale African Palm oil producers so that they may participate in the emerging Honduran biofuel sector through the sustainable management of natural resources and the mitigation of climate change. The project design includes three principal areas of work: Experimentation, Adaptation and Implementation of Improved Agricultural Practices (Mejores Prácticas Agrícolas - MPA), Cleaner Production and the Clean Development Mechanism (CDM). The results of the project are reflected in improvements in production processes and technical design, administrative, technical and management capabilities, enhanced environmental sustainability, an overall increase of industrial competitiveness and the identification and exploration of new economic and environmental opportunities³¹. The project demonstrates the economic viability of biofuel production with small-scale farmers in an environmentally sustainable way without compromising food production.

Regarding the economical, ecological and social viability of producing biodiesel in Honduras, the Honduran Council of Private Enterprise (Consejo Hondureño de la Empresa Privada - COHEP³²) concluded that:

Biodiesel production should be economically feasible and competitive, without depending excessively on incentives and subsidies. Raw material production should be local, with low production costs. The production chain must be efficient and sustainable, from both the energy and the environmental point of view.

³⁰ Desarrollo de una Cadena de Valor de Biocombustibles en una Plantación de Palma Africana - El caso de Hondupalma. SNV, Tegucigalpa, 2009

³¹ Producción Más Limpia y el Mecanismo de Desarrollo Limpio en HONDUPALMA - Estudios de caso. SNV, Tegucigalpa, 2009

³² Biocombustibles, Ambiente y la Gestión Empresarial en Honduras. Nota Técnica. Centro de Investigaciones Económicas y sociales - CIES del Consejo Hondureño de la Empresa COHEP, Tegucigalpa, Abril 2008

Honduras has identified and selected the areas most suitable for growing energy crops.

The production of biofuels must essentially rely on raw material obtained from the environmentally friendly cultivation of semi-perennial crops, such as African Palm, Jatropha/ Physic Nut (*Jatropha curcas* L.) or Castor (*Ricinus communis* L.)

In the case of the African Palm, the opportunity costs for the possible export of both raw and refined palm oil could reduce the feasibility of biodiesel production for national consumption in Honduras. However, the introduction of biodiesel in the country's energy matrix might offer important social advantages, such as the creation of jobs and income, establishing the rural population firmly on the land as a result of the economic opportunities offered by the production of raw material and the possible use of idle, degraded and formerly unproductive land, the application of proper land-use planning, the organization of the agro-industrial territory and possibly avoided deforestation.

3. The conflict between food production and biofuels

3.1. Food security

The conditions that ensure food security are:³³

- a) *Physical availability of quality food* in sufficient amounts either produced domestically or imported.
- b) *Universal access to food* by means of available economic or other resources to purchase appropriate quantities of nutritional food.
- c) *Achievement of nutritional well-being* in such a way so as to satisfy every physiological need, through adequate diet, availability of and access to drinking water, health care and medical assistance (importance of inputs in the diet).
- d) *Stability in terms of access to adequate food at all times*, without risk of food scarcity as a consequence of a sudden political, economic or climate-related crisis or cyclical events (seasonal lack of food security).

These conditions cover the aspects of food availability and accessibility. Any possible conflict whose origin lies in the production of biofuels would be reflected in some of these conditions.

Aspects that could impact food availability and access are a function of the raw materials and the generation of technology used to produce biofuels, as described below:³⁴

First generation biofuels are obtained from food crops (corn, sugarcane, beetroot, soy, palm, etc.) and through simple technologies used for fermentation (bioethanol) and transesterification (biodiesel).

1.5 generation biofuels include those produced using conventional technologies and alternative raw materials relative to those that are more readily available. They are less sensitive than the crops used for food. Among them are castor bean, jatropha, sweet sorghum or bicolor sorghum.

Second generation biofuel represents a change in conversion technology that allows for the replacement of sugar, starch and oil in the raw materials used by generation one biofuels with different forms of lignocellulosic biomass (agricultural and primary and secondary forestry residues, perennial grass, fast-growing trees, etc).

The FAO recognizes that the current debate on biofuels and food is mainly restricted to first generation liquid biofuels that are made of grains – mostly corn – which are in direct competition with the production of food for human consumption and will be used mostly for the transportation sector.^{35, 36}

At the High Level Expert Forum on How to Feed the World in 2050 held in Rome in October 2009, one of the many challenges presented for discussion was that bioenergy has created the largest new demand for agricultural products over the past few years. This is a

³³ Brathwaite, Chelston W. D. 2009. La seguridad alimentaria en las Américas: la exigencia de un nuevo modelo de desarrollo para el siglo XXI. Posición Institucional. In: COMUNIICA. Year 5 January - April 2009. P.10

³⁴ Ganduglia, F y Equipo de Proyectos de Biocombustibles (EPB) – ARPEL. Inédito. Guía ARPEL – IICA sobre Biocombustibles. Guía ARPEL REF N° 01-2009 – IICA REF N° 01-2009

³⁵ FAO. 2008. Panorama del hambre en América Latina y el Caribe. Available at: <http://www.rlc.fao.org/es/politicas/pdf/panorama.pdf>

³⁶ Liquid biofuels: bioethanol, biodiesel, vegetable oils and methyl esters from vegetable oils.

unique opportunity to incorporate measures aimed at mitigating climate change and adjustments into agricultural practices.^{37, 38}

To achieve this, bioenergy production must be promoted without endangering the food supply by including biofuels, specifically ethanol and biodiesel, in the energy mix of LAC countries. This would make it possible to evolve from oil-dependent agriculture to a more sustainable one.³⁹

3.2. Indicators for change in land use

Direct and indirect land-use changes have become critical factors for the greenhouse gas balance and have brought about some major environmental implications. Policies that limit land conversion, promote good agricultural practices, integrate food and energy production systems and focus on the landscape can help mitigate environmental risks.⁴⁰

The next step towards obtaining preliminary indicators related to changes in land-use and biofuel management practices in LAC countries will be to assess the use of natural resources and their effect on the agricultural structure from a broader standpoint.

There are some larger categories for the primary biomass used to produce biofuels, with a vast spectrum of natural resource requirements (soil, water, climate and nutrients), which include energy crops and residues.

Energy crops can be classified, depending upon their category, as:⁴¹

- a. Sugar crops (sugarcane, beetroot, etc.)
- b. Starch crops (cassava, potatoes, grains, etc.)
- c. Oilseed crops (rapeseed, soy, sunflower, etc.)
- d. Short-cycle forestry crops (willow, poplar and eucalyptus)
- e. Grasses (switchgrass, miscanthus, etc.)

Residues can be classified as:

- a. Forestry, agricultural, animal feces (manure)
- b. Residues generated by cities – solid (organic waste, animal fat) and liquid (used oil).

³⁷ FAO, 2009. Office of the Secretary of the High-Level Expert Forum on How to Feed the World in 2050. Challenges related to food and agriculture posed by climate changes and bioenergy (Desafíos en relación con la alimentación y la agricultura planteados por el cambio climático y la bioenergía). Rome, October 12 – 13, 2009. Available at: http://www.fao.org/fileadmin/templates/wsfs/docs/Issues_papers/Issues_papers_SP/cambio_clim%C3%A1tico_y_la_bioenerg%C3%ADa.pdf

³⁸ Number 30 of the DECLARATION OF THE WORLD SUMMIT ON FOOD SECURITY. World Summit on Food Security. Rome, November 16–18, 2009. FAO WSFS 2009/2. Available at: http://www.fao.org/fileadmin/templates/wsfs/Summit/Docs/Final_Declaration/K6050S_WSFS_OEWG_06.pdf

³⁹ IICA, 2009. Agricultura de América Latina y el Caribe: bastión ante la crisis mundial y motor para el desarrollo futuro / IICA – San José, C.R.: IICA, 2009. 28 p.; 15 cm. Available at: <http://www.iica.int/Esp/conocimiento/actualidad/Documentos%20Seguridad%20Alimentaria/Agricultura%20en%20ALC.%20Basti%C3%B3n%20ante%20la%20crisis%20y%20motor%20del%20desarrollo%20futuro.%20Espa%C3%B1ol.pdf>

⁴⁰ FAO – CEPAL. Opportunities and risks arising from the use of bioenergy for food security in Latin America. Available at: <http://www.rlc.fao.org/es/prioridades/bioenergia/pdf/bioenergiaen.pdf>

⁴¹ Hoogwijk et al. (2005). "Potential of biomass energy out to 2100, for four IPCC SRES land-use scenarios". Biomass and Bioenergy 29, p. 225-257. Available at: http://igitur-archive.library.uu.nl/chem/2007-0320-200454/Vries_05_%20Potential-of-biomass-energy-out-to-2100,-for-four-IPCC-SRES-land-use-scenarios.pdf

Given the scope of this study, we have provided below details of a preliminary assessment of natural resource requirements for sugar, starch, and oilseed crops, without expanding on other sources of raw material necessary to produce biofuels. The use of each of these natural resources is also explained.

Table 3.1: Preliminary assessment of soil, water, nutrient and climate requirements for some crops that are considered agro-energy in Latin America and the Caribbean

Crops used to produce ethanol				
Crop	Soil	Water	Nutrients	Climate
Corn	The soil must be well aired and drained.	Uses water efficiently.	Requires a great deal of fertility and nutrients should be provided continuously.	Temperate to tropical conditions.
Sugarcane	Does not require a special type of soil, but it should be preferably aired with at least 15% water content.	High and well distributed throughout the growth season.	Great need for nitrogen and potassium, but during maturity the soil nitrogen content should be as low as possible to allow for a good recovery of the sugar.	Tropical and subtropical climate.
Cassava	Can adapt to infertile soils. Can be grown in sandy Oxisols, Ultisols, Inceptisol and Entisols.	Ideal precipitation between 1000 and 1800 mm/year.	A very high increase in accumulation of nutrients during the growth cycle takes place between 2 and 4 months after the seeds have been planted, especially N, K and Ca.	Humid tropical, even though it is highly resistant to draught conditions, originating from prolonged summers/dry seasons.
Sorghum	Light to moderate soils, well aired and drained and with relative tolerance to short periods of flooding.	Shows great flexibility regarding the depth and frequency of the water supply because of its resistance to draught.	Grass-like crop that requires very high supplies of nitrogen.	Ideal temperatures for high-yield plant varieties of more than 25° C.
Crops used to produce biodiesel				
Soy	Humid alluvial soils with a good organic content, presence of water, good structure, loose soil.	High	Ideal soil pH - 6.0 to 6.5	Tropical, subtropical and temperate climates.
Oil palm	Good drainage, pH between 4.0 and 7.0; flat terrain, rich and deep.	Uniform rain distribution between 1800 and 5000 mm a year.	Low	Tropical and subtropical climate with temperatures ranging from 25 to 32° C.
Rapeseed	Mild, deep loamy soil, medium texture, good drainage.	600 mm of rain a years	High	Sensitive to high temperatures, grows better between 15° to 20° C.
Sunflower	Can be grown under dry conditions in many types of soil.	Ranges from 600 to 1000 mm, depending on the climate and growth period.	Moderate	Climate ranging from arid, dry, to temperate, under dry conditions.
Jatropha	Not very demanding, does not require tillage.	Can be grown under irrigated or dry conditions.	Adapted to low fertility land and alkaline soils, but the use of fertilizers can improve production	Different environmental conditions, preferably mild climates.

Source: 1/ Bioenergía sostenible: Un marco para la toma de decisiones, 2007. Traducción informal por la Oficina de la FAO en América Latina y el Caribe.: Available at <http://www.oei.es/decada/biocombustible.pdf>
 2/ Cadavid, L. 2008. Fertilización del cultivo de la yuca (Manihot esculente Crantz). CLAYUCA – CIAT. Cali, Colombia. P.4
 3/ CEPAL. 2007. Producción de biomasa para biocombustibles líquidos: el potencial de América Latina. Serie desarrollo productivo No 181. Unidad de Desarrollo Agrícola. División de Desarrollo Productivo y Empresarial. Santiago de Chile, November, 2007.

3.2.1. Resource: “land”

The general view is that arable land is already completely occupied, or that there is very little space for expansion with new crops. Figures for Latin America and the Caribbean show that the exact opposite is true and that there is still great potential for expansion. Part of the available arable land could be used for energy crops if they come with a well-designed package of policies and programs. They could benefit millions of small-scale producers, who currently live below the poverty line, without compromising forested areas or the food security of the region.

According to the following table, there are different scenarios possible for Latin America regarding the land needed to produce biofuels to meet the needs of 2030, which would be added to planting sections that would not surpass 3.4% of the total planted area.

Table 3.2: Land needed to produce biofuels, by region

Region	2004 ^{a/}		2030 reference estimate ^{b/}		2030 alternative policy estimate ^{c/}		2030 Second generation biofuels ^{d/}	
	Million ha	% agriculture	Million ha	% agriculture	Million ha	% agriculture	Million ha	% agriculture
USA and Canada	8.4	1.9	12.0	5.4	20.4	9.2	22.6	10.2
European Union	2.6	1.2	12.6	11.6	15.7	14.5	17.1	15.7
Pacific OECD	Ins	ins	0.3	0.7	1.0	2.1	1.0	2.0
Transition economies	Ins	ins	0.1	0.1	0.2	0.1	0.2	0.1
Developing countries in Asia	Ins	ins	5.0	1.2	10.2	2.5	11.5	2.8
Latin America	2.7	0.9	3.5	2.4	4.3	2.9	5.0	3.4
Africa and the Middle East	Ins	ins	0.8	0.3	0.9	0.3	1.1	0.4
World	13.8	1.0	34.5	2.5	52.8	3.8	58.5	4.2

Notes:

- Land used to produce biofuels in 2004 and as a percentage of the total planted area.
 - Situation in 2030 if current trends persist.
 - Situation of countries that will adopt all the policies they are currently studying, regarding energy security and carbon emissions.
 - Situation where part of the biomass for biofuels is obtained from land not suited for agriculture and residues, which decreases the need for using planted land.
- Ins = insignificant; ha = hectares.

Source: FAO. El cambio climático, los biocombustibles y la tierra. Available at: <ftp://ftp.fao.org/docrep/fao/010/i0142s/i0142s05.pdf>

However, if we separate the data for the Latin America region, each country's unique position can be divided up into the three large groups listed below, according to the availability of the potential area accessible for planting (see table in Annex 1):⁴²

- Low availability: Chile, Dominican Republic, El Salvador, Haiti, Jamaica, Honduras, Trinidad and Tobago, Costa Rica, Belize, Guatemala and Panama. This group of countries has less than 1 million hectares of highly adequate soil.

⁴² Gazzoni, Decio Luiz. Biocombustibles y alimentos en América Latina y el Caribe. San José, C.R.: IICA, 2009.

- II. Medium availability: Cuba, Nicaragua and French Guiana, with availability of up to 5 million hectares, which represents a comfortable situation for the domestic supply of biofuels, food and other agricultural products, and a small margin for agricultural exports.
- III. High availability: Ecuador, Surinam, Guyana, Paraguay, Uruguay, Mexico, Peru, Venezuela, Colombia, Bolivia, Argentina and Brazil. These countries have between 6 and 343 million hectares available, making it feasible to expand the area for any type of crop, and to possibly provide other countries with food and biofuels.

According to the FAO, with regard to highly adequate soils, the total potential for agricultural expansion in Latin America and the Caribbean is 599.9 million hectares.

When compared to the prospective demand for annual crops (116.0 million ha), perennial crops (9.9 million ha), planted forests (7.7 million ha) and biofuels (9.5 million ha) for the 2010 – 2030 period, this availability establishes a positive demand for only 143.1 million hectares, according to estimates found in the Gazzoni-study(2009) and illustrated below. The area under pasture is expected to decrease by some 65.0 million ha.

Table 3.3: Latin America and the Caribbean. Prospective demand for area used for agriculture - 2010 – 2030 (in million ha)

Year	Biofuels	Annual crops	Perennia l crops	Pasture land	Woods	Total	Expansion area still available
2005	3.0	144.0	19.8	550.0	12.0	728.8	599.9
2010	5.0	175.0	20.0	557.0	13.3	770.3	558.4
2015	7.0	197.0	22.0	553.0	14.7	793.7	535.0
2020	11.8	215.0	24.4	539.0	16.2	806.4	522.3
2025	12.0	234.0	26.9	516.0	17.9	806.8	521.9
2030	12.5	260.0	29.7	485.0	19.7	806.9	521.8
Increase 2005 to 2030	9.5	116.0	9.9	-65.0	7.7	78.1	

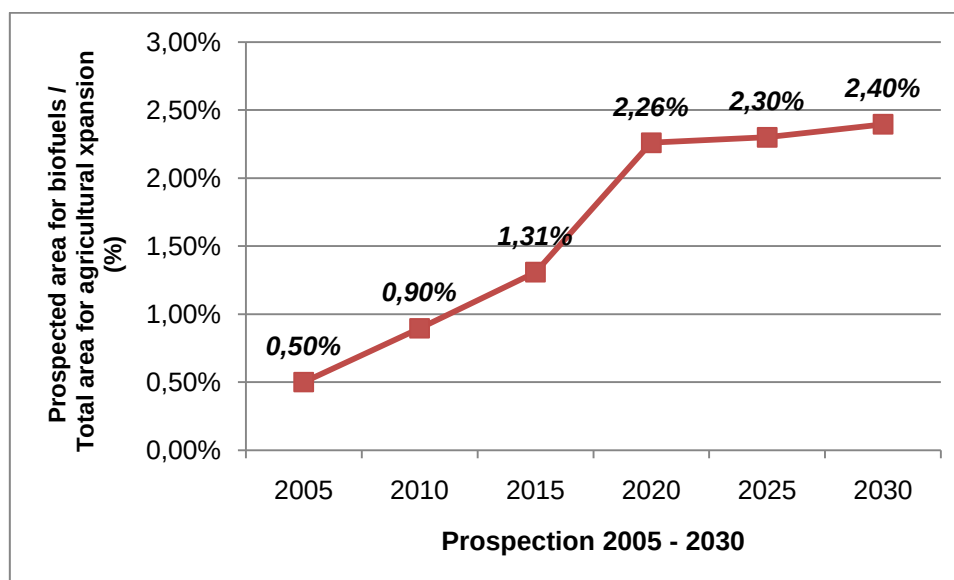
Source: Gazzoni, Decio Luiz. Biocombustibles y alimentos en América Latina y el Caribe. San José, C.R.: IICA, 2009.

Considering the data presented in table 3.3 and calculating the ratio between cultivable area demanded for the expansion of biofuels and total area still available for agricultural expansion, there are only 2,4 % of total area needed for biofuel expansion (figure 3.1).

With regard to expanding the area planted with energy crops, a CEPAL study showed the magnitude of the expansion in relation to the current cultivated area.⁴³ In a mixed scenario for E5, using sugarcane as a raw material, only Mexico would have to expand the current cultivated area 0.4 times, while Panama, Barbados, Jamaica and the Dominican Republic would require 0.2 times the current cultivated area. Argentina, Bolivia, Colombia, Costa Rica, Haiti and Trinidad and Tobago are in a better situation, since they would only have to increase their current cultivated area 0.1 times. Comparatively smaller expansions, representing only 0.06 and 0.01 times the current cultivated area, are needed for countries like Brazil, El Salvador, Guatemala, Honduras, Nicaragua and Cuba.

⁴³ Each area was calculated as if the crop in question were the sole raw material supplier for a 5% ethanol and/or biodiesel blend, compared to total consumption in each country.

Figure 3.1: Percentage of projected demand of area for biofuels in relation to total area available for agricultural expansion 2000 - 2030



Source: Gazzoni, Decio Luiz. Biocombustibles y alimentos en América Latina y el Caribe. San José, C.R.: IICA, 2009.

On the other hand, in a B5 scenario, the same CEPAL study revealed that by using oil palm as a raw material, countries like Colombia, Ecuador, Costa Rica, Guatemala and Honduras would have to expand their current area planted with this crop 0.1 to 0.3 times. Using soy as the raw material, Argentina, Bolivia and Brazil would require an expansion of 0.1 and 0.24 times the area dedicated to this crop. Paraguay is an exception, since the current cultivated area would have to be expanded 0.07 times.

In countries with severe limitations to expand cultivation area and high energetic vulnerability research and development related to second and third generation biofuels and the needed raw materials becomes even more fundamental for the possible and intended changes in their energetic matrices towards renewable energies. This is the case for Chile, which due to its physical restrictions regarding the growing of first generation energy-plants has adopted an active strategy respectively. (Box 3.1).

Box No. 3.1: Successful experiences of the biofuel production chain as a consequence of government policies in Chile

The government in Chile has several instruments at its disposal to foster the development of the biofuels sector. It provides resources to the relevant agents, who in turn benefit from the participation of the private sector. Resources and support are available for training courses; field trips; technical visits; visits to fairs; technology; the organization of seminars, training sessions and meetings; studies and applied research; technological consortiums, etc.

With the help of such tools, the formulation of a consistent and applicable legislative framework and the creation of the Renewable Energy Centre (Centro de Energías Renovables CER), Chile's biofuel chain is moving ahead. Special emphasis is placed on regional and local solutions and the prevention of competition with food crop production. (See www.cne.cl and <http://www.odepa.gob.cl/servlet/articulos.ServletMostrarDetalle?idcla=2&idcat=16&idn=2106>).

Most liquid biofuel in Chile is currently produced from biodiesel from recycled vegetable oils for human consumption in the metropolitan region and in the south of the country. Research and development is focused on introduced (exotic) species (e.g. *Jatropha curcas* L.) as well as endemic species and their suitability for biofuel production.

Three research consortiums were recently selected, which had submitted their proposals for research and development on biofuels from algae, issued by the program "Innova Chile" of the Production Development Corporation (Corporación de Fomento de la Producción - Corfo) and the National Energy Commission (Comisión Nacional de Energía - CNE). The purpose of the tender was to enhance economic and productive development through the creation of sustainable research consortiums for the production of biofuel from micro- and macroalgae, and had a major impact due to the adoption, transfer and marketing of its results. These consortiums, which are integrated by universities, research centers and associated companies as a result of the application of promotional public policies, will conduct coordinated investigations on biofuel production.

With regard to bioethanol production, a pilot program was jointly developed by the Chilean and Brazilian governments to evaluate the technical and economic feasibility of ethanol distribution in the country. Research and global development programs are being implemented in different parts of the country, focusing on bioethanol production based on turnip (*Brassica* spp.) and on lignocelluloses residues.

In addition, there are two research consortiums that are focusing on the subject of producing ethanol from lignocelluloses, approved by Innova Corfo, and are receiving funds for the research, development and innovation of biofuel produced from lignocellulosic biomass, which facilitates the incorporation of second generation biofuel in the national energy matrix.

3.2.2. Resource: "water"

The potential impact on freshwater resources is at its greatest wherever agricultural production is dependent on irrigation, while it is negligible in cases where rain-fed production is practiced. Wherever irrigation is required for agriculture, the increased production of biofuel could result in the reduced water allocation for other crop commodities.⁴⁴

Some production systems require a considerable amount of water, both for the production of basic materials and for their conversion into biofuel.

The most common crops used to produce ethanol and biodiesel, which are sugarcane (*Saccharum officinarum*) and oil palm (*Elaeis guineensis*), respectively, require a significant amount of water (between 1,500 and 2,500 mm/year), while corn (*Zea mays*), cassava (*Manihot sculenta*), soy (*Glycine max*), castor bean (*Ricinus communis*) and cotton (*Gossypium* sp.) are among the crops that are considered possible sources of biofuel that only require moderate amounts of water (between 500 and 1,000 mm/year).⁴⁵

Around 7,130 km³ of water is evapotranspired by crops annually worldwide, not counting biofuel crops, which account for an additional 100 km³ (or around 1%).⁴⁶

⁴⁴ UN. 2009. The United Nations World Water Development Report 3: Water in a Changing World. World Water Assessment Programme. Paris: UNESCO, and London: Earthscan.

⁴⁵ FAO. 2008.

Thirtieth Regional Conference for Latin America and the Caribbean. Opportunities and challenges of biofuel production for food security and the environment in Latin America and the Caribbean. Brasília, Brazil, April 14 to 18, 2008.

⁴⁶ Charlotte de Fraiture, Mark Giordano and Yongsong Liao. 2007. Biofuels and implications for agricultural water use: blue impacts of green energy. International Water Management Institute. Colombo, Sri Lanka. <http://www.iwmi.cgiar.org/EWMA/files/papers/Biofuels-Charlotte.pdf>

In the U.S., where mainly rain-fed corn is used, only 3% of all irrigation withdrawals are for biofuel crop production, corresponding to 400 liters of irrigation water withdrawals per liter of ethanol. In Brazil, where the main biofuel crop – sugarcane – is mostly grown under rain-fed conditions, very little irrigation water is used for ethanol production. Under current production conditions, such as in Brazil and the U.S., roughly 2,500 liters of water are needed to produce 1 liter of liquid biofuel (see Table 3.4).

Table 3.4: Brazil and U.S.A. Water used to produce biofuels (2005)

	Units	Country	
		Brazil	USA
Feedstock		Sugarcane	Corn
Bioethanol (EtOH)	Million liters	15,098	12,907
Crop water ET	km ³	46.02	22.39
% of total ET used for biofuel	%	10.7	4.0
Irrigation withdrawals for biofuels	km ³	1.31	5.44
% of total irrigation withdrawals for biofuels	%	3.5	2.7
Crop water ET / Bioethanol	liters ET / liter EtOH	3,048.1	1,734.7

Source: UN. 2009. The United Nations World Water Development Report 3: Water in a Changing World. World Water Assessment Programme. Paris: UNESCO, and London: Earthscan.

With regard to other crops that can be used to produce biofuels, cassava is an important source of starch from which ethanol can be produced in LAC countries, requiring 2,250 liters of water from evapotranspiration for each liter of ethanol under rainwater storage systems. Similarly, for canola and oil palm, consumption is reported to be between 2,360 and 3,330 liter of water from evapotranspiration for each liter of biodiesel, respectively, with both crops in a rain-fed regime. Soy is the only crop that surpasses those quantities, needing 10,000 liters for each liter of biodiesel under the same rainfall regime.⁴⁷

3.2.3. Changes in land use

For this subtopic, a hypothesis needs to be formulated that can establish a relationship between biofuel production and the possible intrinsic risks of soil conversion, particularly in forested areas.

If we exclude from the scenario analysis the fact that we can use the wood produced in the existing forested areas, as well as wood residues and the wood recovered from these areas to produce energy, (these scenarios are not included in the scope of this paper), we could consider it a hypothetical scenario, as per the FAO Forestry and Energy Key issues paper:⁴⁸

Possible scenario: Introduction of crops for the production of liquid biofuels in the forested areas of LAC countries.

⁴⁷ UN. 2009. Op. Cit.

⁴⁸ FAO. 2008. Forestry and Energy. Key issues. FAO Forestry Paper: 154. The Food and Agriculture Organization of the United Nations. Rome, 2008. Available at: <ftp://ftp.fao.org/docrep/fao/010/i0139s/i0139s00.pdf>

Hypothesis: This practice would cause deforestation and produce adverse effects on biodiversity and other forest-related goods and services. It would also result in an increase in greenhouse gas emissions.

The hypothesis formulated previously assumes that intensifying the requirements regarding the availability of land to produce first generation liquid biofuels will probably translate into increased pressure on forested and wetland areas throughout the world and in the LAC region unless the large expanses of degraded land found in many developing countries can be used for the possible expansion of energy crops.

For LAC countries, especially those in which the tropical forests are at risk of being converted into land to be used for other purposes, expansion of biofuel production must be accompanied by specific and enforceable land-use legislations.

In view of this scenario, it would be highly unlikely that the goals of climate change-related policies would be achieved, since the amount of carbon released during deforestation surpasses that which could be recaptured by bioenergy crops over many years.

There is very little evidence being generated to date that would help assess the magnitude of the changes that have occurred on lands originally occupied by forests, which have now been planted with bioenergy crops. However, there are estimates as to changes that have occurred when soils previously occupied by forests were used for pasture land and for planting other crops, as illustrated in the table below.

Table 3.5: Expansion of land actually used for pasture and crops in some LAC countries (in 1,000 ha)

Countries	Expansion of pasture land (in 1,000 ha)	% of total forested areas	Crop expansion (in 1,000 ha)	% of total forested areas
Costa Rica	82	82	18	18
Guatemala	321	60	216	40
Honduras	371	63	218	37
Nicaragua	537	77	163	23
Panama	376	73	143	27
Subtotal Central America	1,688	69	757	31
Bolivia	942	47	1,058	53
Brazil	13,974	61	9,119	39
Colombia	2,714	68	1,286	32
Ecuador	872	82	188	18
Guyana	355	89	45	11
Paraguay	778	63	452	37
Peru	1,519	54	1281	46
Venezuela	1,237	88	163	12
Subtotal South America	22,391	62	13,592	38

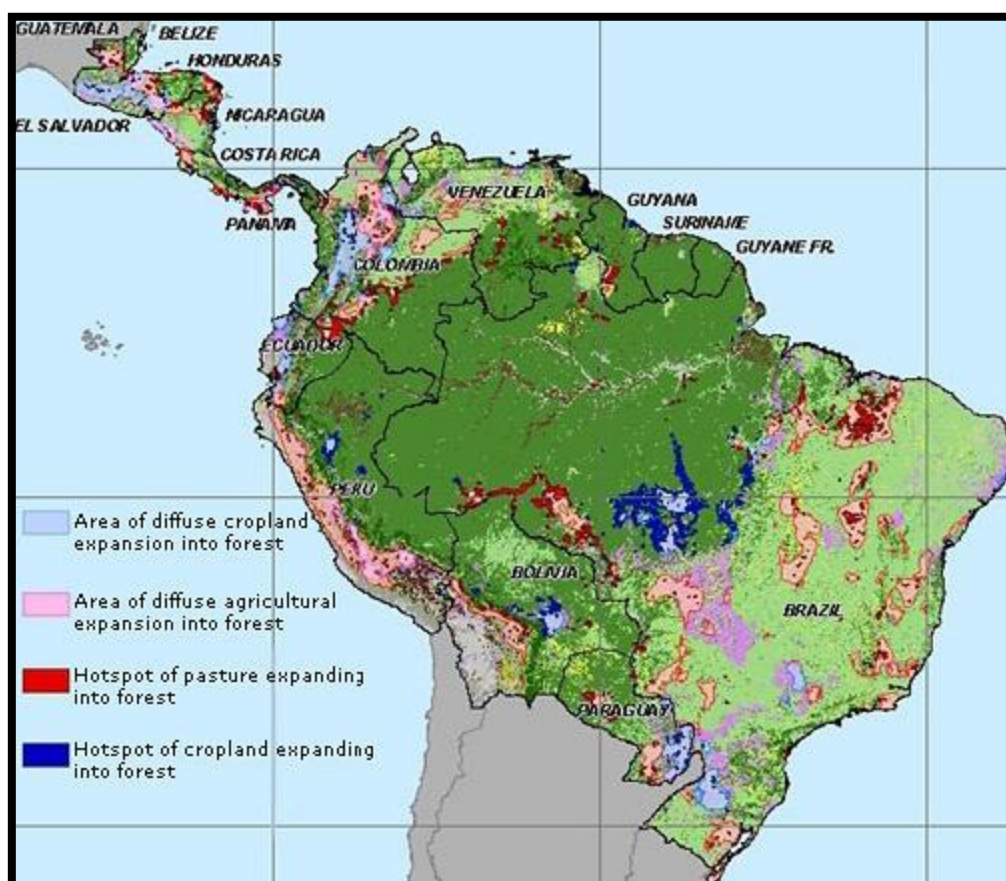
Source: Wassenaar, T., et al. Projecting land use changes in the Neotropics: The geography of pasture expansion into forest. *Global Environmental Change* 17 (2007) 86–104

An analysis of the driving forces that could affect the forestry sector was presented in an FAO paper, The Latin American Forestry Sector Outlook Study. This paper presents the principal changes that could have medium and long-term implications for the forestry sector of the Amazon sub-region, among which the following macroeconomic aspect were highlighted:^{49 and 50}

Replacement of oil-based fuels with alternative fuels, such as bioethanol and biodiesel, will not only affect domestic trade, but also the social and environmental sectors. There will be a trend towards the greater development of ecological monocultures, and we will see adjustments in the area of engineering being made in the auto industry.

In view of this possible macroeconomic scenario, reviewing of estimates made in the previous chapter on the availability of the resource "land" is pertinent: For Latin America, we can envision different scenarios regarding the need for land to produce biofuels by 2030, in no case surpassing 3.4% of the total cultivated area.

Figure 3.2: Central America and the Amazon sub-region - Map of projected land-use changes - 2000-2010



Source: Wassenaar, T., et al. Projecting land use changes in the Neotropics: The geography of pasture expansion into forest. *Global Environmental Change* 17 (2007) 86–104

⁴⁹ FAO (2005). The Latin American Forestry Sector Outlook Study. A paper on the Amazon subregion. Working paper written by Jefferson García for the FORESTRY DEPARTMENT. THE FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS. ESFAL/SR/1. Rome, 2005.

⁵⁰ The paper covers the Amazon sub-region including the following countries: Bolivia, Brazil, Colombia, Ecuador, Peru and Venezuela.

The above map shows the areas at risk of being used for agriculture in different parts of Central and South America for the period between 2000 and 2010. The study used a model that explicitly incorporates aspects such as location, adequacy and other factors that affect land-use-related economic values to identify areas at a higher risk of being transformed into pasture and agriculture land.⁵¹

Dark green represents thickly forested areas, while light green represents open or fragmented forests. Light blue corresponds to cropland expansion into the Amazon forest, while pink corresponds to diffuse agricultural expansion into the Amazon forest. Purple represents critical hotspots of pasture land expanding into the forest, and dark blue represents critical hotspots of cropland expanding into the forest.

3.3. Effects on the agrarian structure at system level

The productive structure is the result of governmental policy decisions regarding investments, and the players involved in the different production systems. These decisions are made based on opportunities that arise within their specific context, just as technological capabilities and the production quality structure are part of the institutional environment.⁵²

It has thus been demonstrated that the adoption of biofuels as the engine behind development shall impact, among other things:⁵³

- a. Land ownership structure.
- b. Production systems and the crops to be promoted.
- c. Economies of scale.
- d. Value chains.
- e. Production and support service mechanisms.

Concurrently, a related ECLAC study reached the following conclusion:⁵⁴

“The increase in energy crops may cause significant changes in the agrarian structure. The most important structural changes expected are greater production and land ownership concentration, and the influx of new types of players and norms. Significant changes may also occur in the economic structure, particularly due to the creation of economies of scale. Pressure on natural resources and ecosystems may also increase. Correspondingly, there would be an impact on agriculture-related jobs although it is hard to evaluate the actual figures involved”.

Given the numerous aspects that relate to the aforementioned agrarian structure, for the purpose of the following analysis, aspects such as the increase in production, the size of the cultivated area of agro-energetic crops, price evolution and aggregate value generation will be considered possible evidence of changes in the agrarian structure.

⁵¹ Wassenaar et. al., 2007. Op Cit.

⁵² CEPAL - IRDC. 2007. Progreso técnico y cambio estructural en América Latina. Documento de proyecto. Comisión Económica para América Latina y el Caribe – International Research Development Centre, Canada. Available at: <http://www.cepal.org/publicaciones/xml/9/32409/LCW136.pdf>

⁵³ Sepúlveda S., Sergio. 2007. Potencial de la agricultura y los territorios rurales para producir bioenergía. Serie Cuaderno Técnico de Desarrollo Rural No. 37. Instituto Interamericano de Cooperación para la Agricultura. San José, Costa Rica. Available at: http://www.iica.int/esp/regiones/sur/argentina/varios/ct_37.pdf

⁵⁴ CEPAL (2007). Biocombustibles y su impacto potencial en la estructura agraria, precios y empleo en América Latina. Carlos Razo, Sofía Astete-Miller, Alberto Saucedo, Carlos Ludeña. (LC/L.2768-P) 2007. Available at: <http://www.iadb.org/intal/intalcdi/PE/2007/00999.pdf>

3.3.1. Increase in production

Assuming that Latin America has both the land availability as well as the climatic conditions necessary for the production of energy crops, the increase in the production of biofuels is a transaction that is dependent on the production potential of the raw material source, the increase in the surface area sowed and the agricultural and industrial production yield.

a. Raw material source

Table 3.6 demonstrates that a total of 13 crops show the greatest potential for liquid biofuel production. Estimates for obtaining ethanol and biodiesel have been made based on these crops as well as on average yields for the different crops of the LAC. In almost every country in Latin America and the Caribbean, the potential main source for the production of bioethanol is sugarcane, since each one has surplus availability. For biodiesel, the most widely used crops in the region, based on planted area and oil yield, are currently palm oil and soy bean. However, countries such as Colombia and Brazil have recently been promoting jatropha as a potential alternative raw material.

Table 3.6: Conversion factor from biomass to biofuel and average crop yields according to crops with bioenergy potential

Crop	Conversion to ethanol (l/ton) ^{1/}	Average Yield LAC (t/ha) ^{2/}
Corn	410	2.5
Sorghum	402	2.2
Yucca	180	9.9
Yam	125	42.2 ^{3/}
Potato	110	16.3 ^{4/}
Beets	103	32.4
Sugarcane	81	59.4
Crop	Conversion to biodiesel (l/ton)	Average Yield LAC (t/ha) ^{2/}
Sunflower Seed	418	1.3
Castor Oil	393	0.8
Colza	392	1.8
Palm Oil	223	15.9
Soy Bean	183	2.1
Cotton	103	0.8

Sources: ^{1/} Matt Johnston et al. 2009. *Resetting global expectations from agricultural biofuels*. Environmental Research Letters. 4 (2009) 014004 (9pp). Available at: http://www.iop.org/EJ/article/1748-9326/4/1/014004/erl9_1_014004.pdf?request-id=f7eaac1d-97fb-4eee-bf7d-5e47648f07ea

^{2/} CEPAL (2007) *Producción de Biomasa para combustibles líquidos: el potencial de América Latina y el Caribe*. C. Razo, et. Al.. Serie desarrollo productivo N° 181 LC/L. 2803-P, 2007. <http://www.cepal.org/ddpe/publicaciones/xml/9/33879/lcl2803e.pdf>

^{3/} Média. Seleção e avaliação de dez cultivares de batata-doce para produção de etanol nas condições do Estado do Tocantins - Universidade Federal do Tocantins - UFT (1997-2007). Brasil.

^{4/} FAO. 2008. Año Internacional de la Papa 2008. FAO. Rome, 2008 Available at: <http://www.fao.org/docrep/011/i0500s/i0500s00.htm>

In light of the ECLAC assessment of the LAC potential for biomass production, the following conclusion was reached:⁵⁵

The selection of an optimal crop combination is specific to each country and is subject, among other things, to the availability of land with the appropriate climate for each species, the availability of technologies, production costs and public policies.

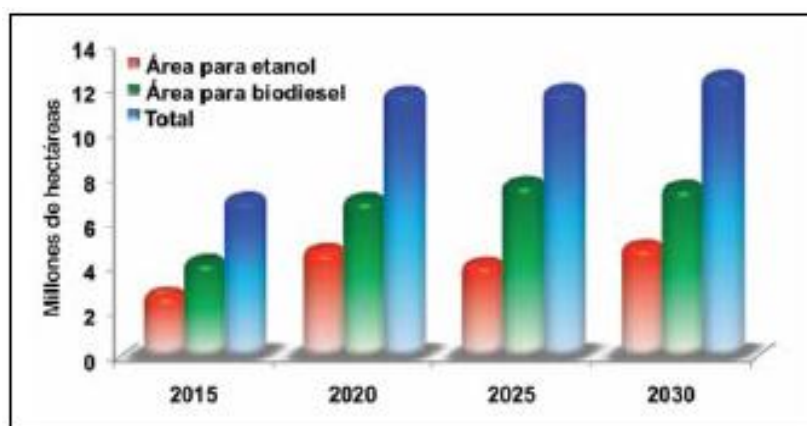
Residue may also be used in the production of biofuel. Nonetheless, new machinery is required to make harvesting easier, and for effecting changes in the post-harvest system and transportation.

Biomass obtained from silviculture may be used to generate energy such as heat, electricity and liquid fuels.

b. Increase of area

Based on the raw material sources for biodiesel production as shown in the previous table, it has been found that a total of 12.5 million hectares would be needed for biofuel production in the LAC for 2030, 9.5 million hectares of which would correspond to the incremental crop surface area aimed at energy production as shown in the following chart (figure 3.3).^{56 and 57}

Figure 3.3: Agricultural area required for energy crops for use in biofuel production, 2015 - 2030



Source: Gazzoni, Decio Luiz. Biocombustibles y alimentos en América Latina y el Caribe. San José, C.R.: IICA, 2009.

⁵⁵ CEPAL (2007) Producción de Biomasa para combustibles líquidos: el potencial de América Latina y el Caribe. Carlos Razo, Carlos Ludeña, Alberto Saucedo, Sofía Astete-Miller, Josefina Hepp y Alejandra Vildósola Serie desarrollo productivo N° 181 LC/L. 2803-P), 2007. Available at: <http://www.cepal.org/ddpe/publicaciones/xml/9/33879/lcl2803e.pdf>

⁵⁶ Gazzoni, D. (2009) óp. cit

⁵⁷ The reference for ethanol production was sugarcane, which can be produced in almost every country in the LAC. For biodiesel, a basket of annual or perennial oleaginous plants was considered.

Box N° 3.2: Agro-ecological Zoning for Sugarcane in Brazil

Faced with the probable expansion of the sugarcane agribusiness, Brazil's government issued a decree in September 2009, the Agro-ecological Zoning for Sugarcane (ZAE Cana). The decree creates zoning for sugarcane crops and is part of a set of initiatives meant to ensure the environmental, economic and social sustainability of Brazilian ethanol production from sugarcane.

The bill establishes rules for sugarcane expansion and criteria for granting loans for the sugar and alcohol production sector and is designed to ensure the sustainability of Brazilian control in the context of the increasing demand for biofuels, and the balanced and sustainable growth of its production. The policies outlined establish the agro-ecological zoning for sugarcane throughout the national territory, and were coordinated by the Ministry of Agriculture, Ministry of Livestock and Supply and the Ministry of the Environment.

The ZAE analyzed climatic and soil conditions, as well as environmental, economic and social aspects in order to guide the sustainable expansion of sugarcane production. The decree prohibits the expansion of sugarcane production in any native vegetation area in the Amazon, Pantanal and the Alto Paraguay River Basin (see Figure 3.3). The new rules also determine that sugarcane plantations can only be established in areas suitable for mechanized harvesting, which is defined as land with a slope of less than 12°. Those areas, plus the conservation units and indigenous reserves, where the legislation has already banned sugarcane plantations, cover 81.5% of the national territory. It is in these areas where sugarcane growing is prohibited by the government. About 7.8 million hectares of Brazilian territory (= 0.9%) are currently used for growing sugarcane (Table 3.7).

Figure 3.4: Amazon, Pantanal and the Alto Paraguay River Basin



Another goal in addition to regulating the future expansion of sugarcane is to end the use of fires for deforestation in existing production areas, according to the transition scheduled to take place by 2017. As a first step, in sugarcane plantation areas where mechanized harvesting is possible, all harvest-related burning activities are banned within five years. That would help reduce costs related to greenhouse gas emissions that are the equivalent of 6 million tons of CO₂ compared to 2008.

Box N° 3.1 (cont.)

With the publication of the ZAE, the Brazilian government is implementing an explicit FAO recommendation⁵⁸:

“(i) Development and land use policies, starting with agro-ecological zoning that indicates the available land for energy crops, a system of incentives and penalties for the use of forests, water, etc.

Biofuel production should be oriented towards sustainable territorial development. Often, areas with potential for biofuel production are made up of communities of low social organization, with absence or shortage of basic infrastructure and social and technological difficulties in entering the global market. Overcoming these problems requires qualification, logistics, technology etc. Territorial development policies must start with a system based on a comprehensive view of the region concerned, with their potential expressed in productive vocations and their varied problems: economic, political, technological, legal, cultural and environmental.

On the other hand, agro-ecological zoning or natural resources inventory should take into account the potential impacts on land being used for the production of feedstock for biofuels, particularly virgin land and land of high conservation value, and its associated effects on habitat, biodiversity and water quality, air and soil”.

Agro-ecological zoning combines information from maps that includes soil, climate, environmental reserve areas, and geomorphological and topographical data. It also identifies the current land use, examines federal and state environmental legislation and analyzes agronomic sugarcane data, as well as ideal temperatures for growth, most suitable soil types, water requirements etc. Areas with the greatest potential for the establishment of sugarcane plantations and those where such crops (see Figures 3.3 and 3.4) are not allowed or recommended are thus defined and classified. The most important factor in the expansion process relates to the selection of areas that do not require full irrigation and thus save energy and water resources, and are also suitable for mechanization, while eliminating the cost of manual harvesting and the practice of setting fires for clearing the forest. According to the ZAE criteria, 92.5% of the national territory is not suitable for sugarcane.

Table 3.7: Agro-ecological Zoning (ZAE) for Sugarcane in Brazil – summary table

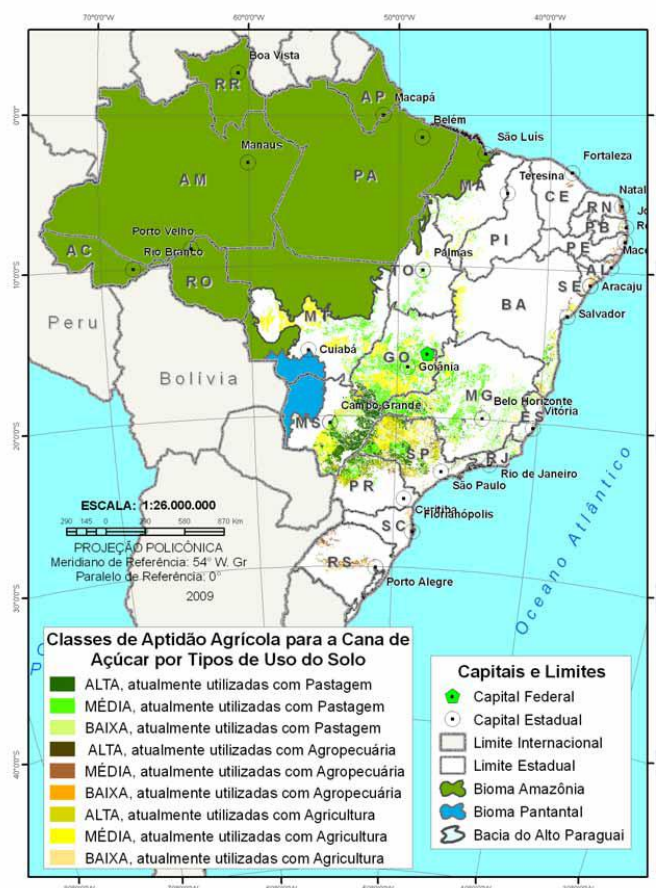
Territory or estimated area	Millions of hectares	Percentage of the national territory
National territory (IBGE)	851.5	100.00%
Land suitable for agriculture	553.5	
Land use in 2002 (estimated by PROBIO)	235.5	27.70%
Areas with environmental restrictions (including biomes in the Amazon, Pantanal and the Paraguayan River Basin)	694.1	81.50%
Areas suitable for cultivation/expansion under various agricultural uses (livestock, farming and agriculture)	64.7	7.50%
Areas suitable for cultivation/expansion used with pasture	34.2	4.02%
Area currently occupied by sugarcane crops (harvest of 2008/09)	7.8	0.90%
Planned expansion by 2017 for the production of sugarcane (EPE)	6.7	0.80%

⁵⁸ FAO: “Opportunities and Challenges of Biofuels production for food security and the Environment in Latin America and the Caribbean” 30th FAO Regional Conference for Latin America and the Caribbean, Brasília, Brazil, 14 to April 18, 2008.

Box Nº 3.1 (cont.)

With the requirement of using degraded or pasture areas for crop expansion, the area available for such development is reduced to 34.2 million hectares, the equivalent of about 4.02% of the national territory. Most of the future demand forecasts estimate that sugarcane production will double over the next 10 years. Assuming an increase in productivity, it may be possible to satisfy such a demand by expanding the current plantation area to 6.7 million hectares, using only one fifth of the area originally intended for expansion.

Figure 3.4: Agro-ecological Zoning for Sugarcane in Brazil



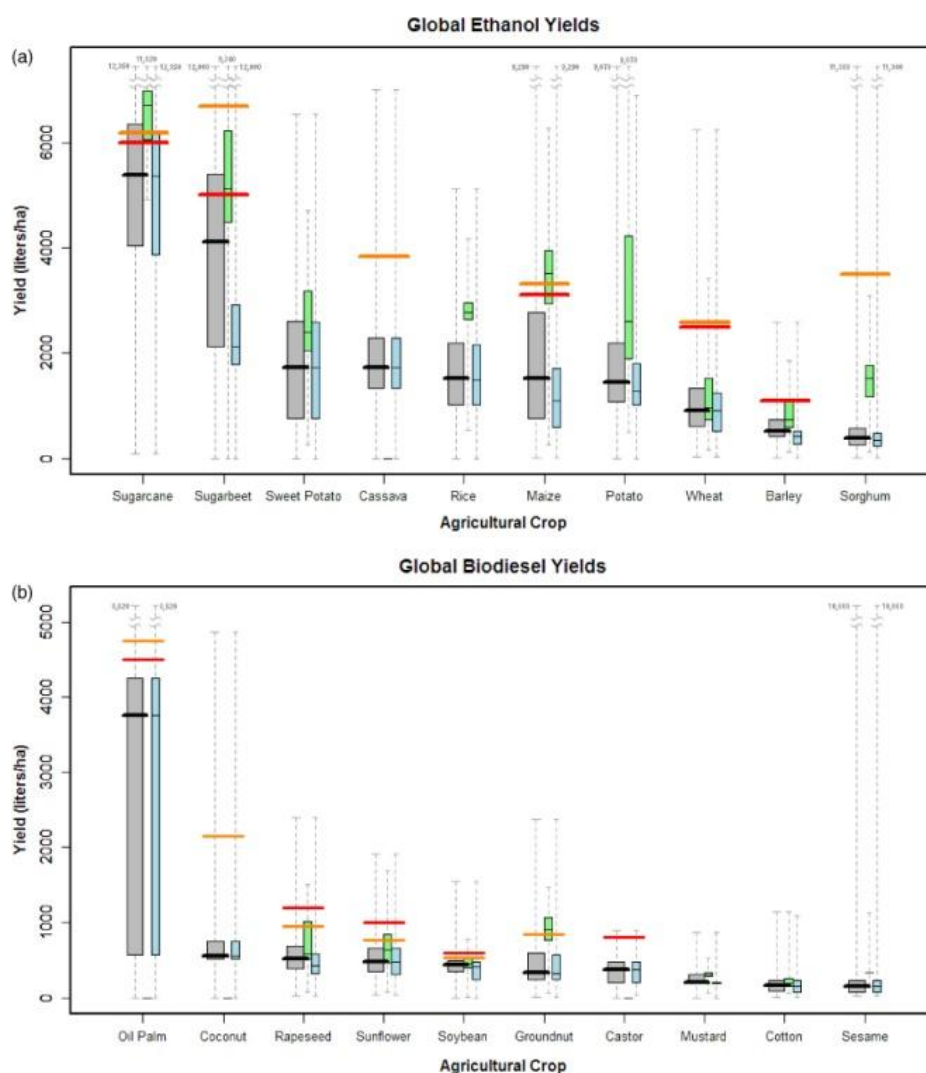
Source: República Federativa do Brasil: “Zoneamento Agroecológico da Cana-de Açúcar: Expandir a produção, preservar a vida, garantir o futuro”, EMBRAPA, Documentos 110, Brasília, Brasil. Available at http://www.cnps.embrapa.br/zoneamento_cana_de_acucar/

c. Crop yields

Crop yields are influenced by several factors, including mean climate and variability, soil conditions, inputs and management. They are also impacted by social, political and economic criteria.⁵⁹

Inputs such as irrigation, fertilizers and pesticides, and management factors such as planting and harvest date, machinery use and efficiency of farming operations also contribute largely to the variability of global yields.

Figure 3.6: Revised estimates of global biofuel crop yields



Notes: (a) Global ethanol yields, (b) global biodiesel yields. (Box plots represent the variation of yields for common biofuel crops. Here we show average results for the entire globe (gray), developed countries (green) and developing countries (blue). The horizontal black bars represent median yields, and the boxes are bound vertically by 25th percentile yields on the bottom and 75th percentile yields on the top. The whiskers (in light gray) represent the absolute minimum and maximum yield values recorded in the M3 cropland datasets. The red and orange bars offer comparisons to two previous examples of biofuel feedstock yield estimates, reported by Worldwatch Institute [18] and Brown [16] respectively. Please note: the M3 results for sorghum are compared to Brown's estimate for sweet sorghum, which is a different variety with higher sugar content than that normally grown and traded commercially.)

⁵⁹ Source: Matt Johnston et al. 2009. Resetting global expectations from agricultural biofuels. Environmental Research Letter 4 (2009) 014004 (9pp). Available at: http://www.iop.org/EJ/article/1748-9326/4/1/014004/erl9_1_014004.pdf?request-id=f7eaac1d-97fb-4eee-bf7d-5e47648f07ea

ECLAC summarized the regional state of crop yields as follows:⁶⁰

"Current average yields for each bioenergy crop for the different countries in Latin America and the Caribbean are quite heterogeneous.

The regional average yield surpasses or is within the scope of worldwide averages for yucca, sorghum, palm oil and soy bean. Conversely, others are below the global average.

In the case of crops used for bioethanol production, the average yield of sugarcane at the global level is between 40 and 80 ton/ha. The average for Latin America and the Caribbean is 59 ton/ha, and for most of the major producer countries in the region it is above this amount. The countries with the highest average yields are Peru (128 ton/ha), Guatemala (92 ton/ha) and Colombia (86 ton/ha), all three of which report higher figures than both global and regional averages."

3.3.2. Size of energy crop plantations

Information regarding the size of energy crop plantations was requested as follows from the same ECLAC source mentioned above:⁶¹

"Current distribution of area used for energy crops, depending upon the plantation size, varies according to land ownership.... In countries with abundant land ownership (over 12 ha per agricultural worker working the land) larger plantations of crops predominate, as is the case of Argentina, Uruguay, Brazil, Chile and Nicaragua, among others. This results in a smaller number of producers (greater concentration), lower transaction costs and fewer logistical problems.

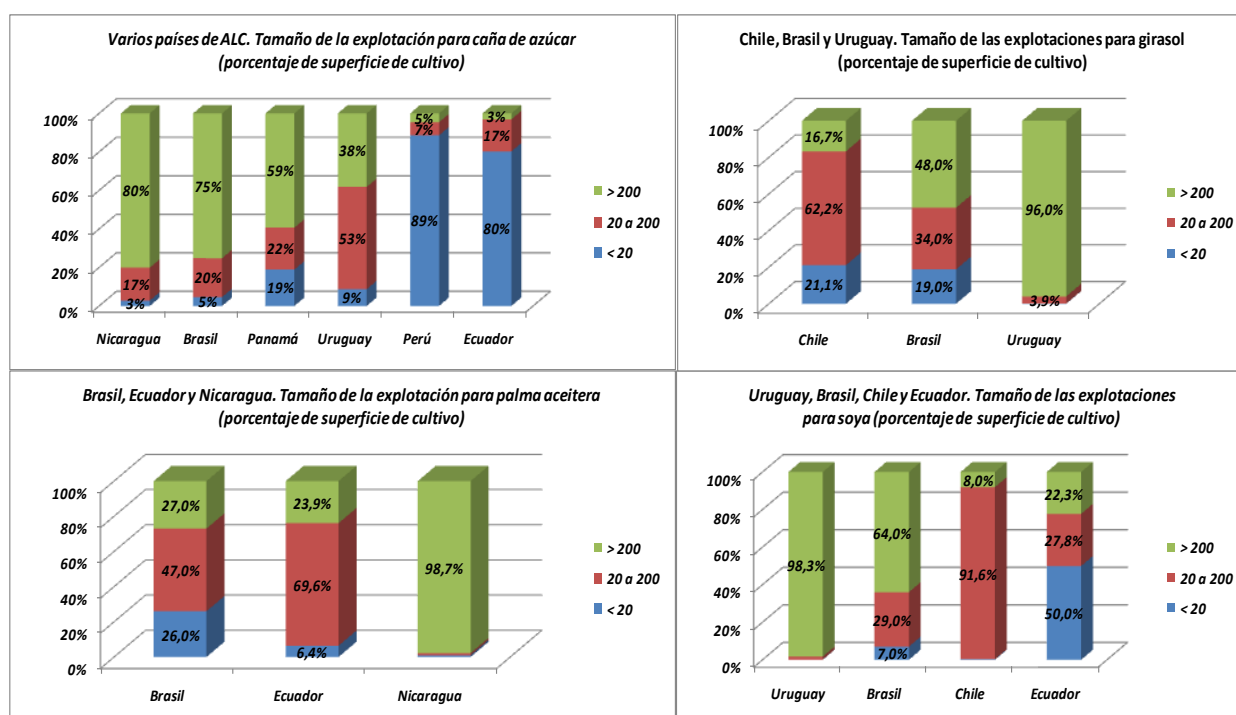
On the other hand, in countries with less land ownership (less than 12 ha of agricultural land per agricultural worker), smaller plantations clearly predominate, such as in Ecuador, Peru and Panama. In those countries, the opportunity for crops geared towards biofuels is dependent on the cooperation of several agents, keeping in mind that there will be a greater number of producers per crop, lower technological levels, less capacity building and higher transaction costs."

The following charts illustrate the magnitude of agro-energy crop plantations, based on information compiled by ECLAC on the national agrarian census for each of the countries examined:

⁶⁰ CEPAL (2007). Biocombustibles y su impacto potencial en la estructura agraria, precios y empleo en América Latina. Carlos Razo, Sofía Astete-Miller, Alberto Saucedo, Carlos Ludeña. (LC/L.2768-P) 2007. Available at: <http://www.iadb.org/intal/italcdi/PE/2007/00999.pdf>

⁶¹ CEPAL (2007). Biocombustibles y su impacto potencial en la estructura agraria, precios y empleo en América Latina. Carlos Razo, Sofía Astete-Miller, Alberto Saucedo, Carlos Ludeña. (LC/L.2768-P) 2007. Available at: <http://www.iadb.org/intal/italcdi/PE/2007/00999.pdf>

Figures 3.7 to 3.10: Size of Energy Crop Plantations in Selected Countries of the LAC region



Source: CEPAL (2007). Biocombustibles y su impacto potencial en la estructura agraria, precios y empleo en América Latina. Carlos Razo, Sofía Astete-Miller, Alberto Saucedo, Carlos Ludeña. 2007. Available at: <http://www.iadb.org/intal/intalcdi/PE/2007/00999.pdf>

3.3.3. Price evolution

a. Recent developments 2005 - 2008

The latest FAO report on food and agriculture corresponding to the year 2008 stated that the prices of agricultural products had drastically increased over the past three years due to a combination of factors that are mutually reinforcing, among which the demand for biofuels could be included. The report also states that the historic links between agriculture and energy are growing stronger and that their characteristics are changing. Several factors contribute to this, although it is difficult to pinpoint exactly what the respective causes were.

An IICA study (2009) listed four factors that have influenced grain price acceleration for 2008:⁶³

- I. The increase in the demand for biofuels.
- II. The increase in demand in developing countries, particularly China and India.

⁶²FAO (2008). EL ESTADO MUNDIAL DE LA AGRICULTURA Y LA ALIMENTACIÓN 2008. BIOCOMBUSTIBLES: perspectivas, riesgos y oportunidades. Organización de las Naciones Unidas para la Agricultura y la Alimentación, Roma, 2008.

⁶³Paz, J. y Benavides, H. (2009). Evolución de los precios de productos agrícolas: Posible impacto en la agricultura de América Latina y el Caribe. En: COMUNICA. Instituto Interamericano de Cooperación para la Agricultura. Año 4 Segunda etapa, Enero - Abril 2008.

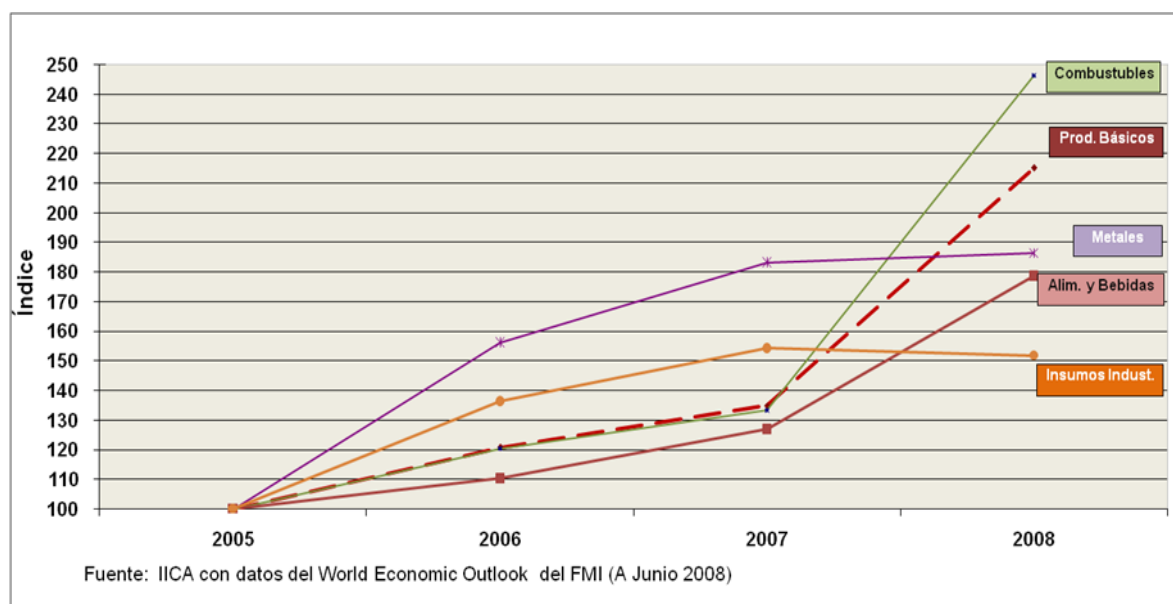
- III. Worldwide low levels of grain stock.
- IV. The decrease in supply due to climatic conditions that have affected harvests in the main supplier countries (Australia, United States, European Union, Canada and Ukraine).

In parallel, Joachim von Braun, General Director for the *International Food Policy Research Institute (IFPRI)*, has listed a set of scenario-driven and structural aspects as causes for the imbalances and the volatility of the worldwide food equation that are as follows (in decreasing order of importance):⁶⁴

- I. The growth of income and demand.
- II. Biofuels.
- III. Low investments in technology and agricultural productivity.
- IV. Trade policies and low inventory.
- V. Production crises due to the emerging climate changes.
- VI. Incidence of high costs on agricultural inputs and transportation.
- VII. Population growth.

With regard to biofuels, IFPRI has indicated that the main change in the establishment of worldwide food prices is the result of energy costs, which impact agricultural prices through inputs (for example, the price of fertilizers, biocides, irrigation, transportation) and strongly affect the prices of agricultural products through opportunity costs. Moreover, a flexible demand for energy creates price trends and levels for agricultural commodities and/or basic products as demonstrated in the following graph.

Figure 3.11: International price index for selected basic products 2005 – 2008



Source: Paz, J. y Benavides, H. (2009). Evolución de los precios de productos agrícolas: Posible impacto en la agricultura de América Latina y el Caribe. En: COMUNIICA. Instituto Interamericano de Cooperación para la Agricultura. Año 4 Segunda etapa, Enero - Abril 2008

⁶⁴ Why Are They Rising, Who Is Affected, How Are They Affected, and What Should Be Done? Presented at a U.S. Agency for International Development (USAID) conference on "Addressing the Challenges of a Changing World Food Situation: Preventing Crisis and Leveraging Opportunity" Washington, D.C. April 11, 2008.

Over the past few years, other relationships between the energy and agricultural markets have evolved. Energy was traditionally thought of as an agricultural input, just like fertilizer and transportation cost entries. Now it is considered agricultural raw material for the production of biofuels.

According to an FAO Report for 2008⁶⁵:

"Recent increases in oil prices have contributed to higher production costs for agricultural products, for example: USD prices for some fertilizers have risen over 160 percent the first few months of 2008 compared to the same period in 2007. In fact, the increase in energy costs has been very fast and perceptible, as indicated by the CRB-Reuters energy price index (Commodity Research Bureau), having grown threefold since 2003. Furthermore, with the rise in freight fees, which have doubled between February 2006 and 2007, the cost of transporting food to importing countries has also been affected.

The influence of energy prices on agricultural products is nothing new, since fertilizers and machinery have been used as inputs in product production processes for a long time."

The document *Perspectivas de la agricultura y el desarrollo rural en las Américas 2009: una mirada hacia América Latina y el Caribe*⁶⁶, has indicated that a new link for the period between 2005 – 2008 was recently created, derived from the increase in the demand for certain agricultural raw materials for producing biofuels. This has strengthened ties between energy and agricultural prices as shown in the following comparative table for price variations for five-year periods for different product groups:

Table 3.8: Global price variations for different products in five-year periods

	Periods		
	1995-2000	2000-2005	2005-08
Commodities (totals)	-1.6%	9.6%	16.2%
Non-fuel commodities	-6.0%	5.3%	13.5%
Fuels	4.9%	13.3%	18.5%
Industrial Inputs	-5.0%	5.5%	13.8%
Metals	-4.9%	10.2%	19.4%
Food and Beverage	-6.9%	5.1%	13.3%

Source: IICA with data from: World Economic Outlook Database (IMF) and International Commodities Prices (FAO)

The increase in the demand for raw materials for biofuels is not the only determining factor that has influenced agricultural prices during the study period. It has been noted that, in addition to other factors, the increase in the demand of emerging countries, speculative

⁶⁵ FAO (2008). El estado mundial de la agricultura y la alimentación 2008. Biocombustibles: perspectivas, riesgos y oportunidades. Organización de las Naciones Unidas para la Agricultura y la Alimentación, Rome, 2008. Available at: <ftp://ftp.fao.org/docrep/fao/011/i0100s/i0100s.pdf>

⁶⁶ *Perspectivas de la agricultura y el desarrollo rural en las Américas: una mirada hacia América Latina y el Caribe*. 2009. This document was a consensus between the Economic Commission for Latin America and the Caribbean (ECLAC), the Food and Agriculture Organization for the United Nations (FAO) and the Inter-American Institute for Cooperation on Agriculture (IICA).

demand for financial tools in the basic product markets, including agricultural products, and the occurrence of extreme climatic events have all had an impact on the food supply.^{67 and 68}

Oil prices will play an essential role in the development of agricultural prices over the next decade. Barrel prices in excess of US\$90-100 would cause agricultural prices to rise significantly, not only due to an increase in costs, but also to an upsurge in the demand for raw materials to produce biofuels at the expense of other food crops.^{69 and 70}

b. Price forecasts

The 2009 U.S. and World Agricultural Outlook published by the Food and Agricultural Policy Research Institute (FAPRI), has projected the prices of biofuels and feedstock:⁷¹

"The world ethanol price increased 13.7% in 2008, to \$0.465 per liter. It is projected to decrease by almost 16%, to \$0.391 per liter in 2009 because of the dramatic drop in crude oil prices coupled with a significant reduction in U.S. ethanol imports. The ethanol price continues its downward trend until 2011, after which it begins to increase because of higher ethanol demand from the U.S. brought about by the Energy Independence and Security Act (EISA) 2007 biofuel mandates.

The world price of biodiesel (Central Europe FOB) decreases to \$0.988 per liter in 2009, driven by a lower crude oil price and large supplies in the world market. The price then recovers as EU countries attempt to achieve their biofuel targets and because of rebounding crude oil prices. Expanded production in Argentina and Brazil also contributes to the temporary price decline and to a sharp increase in exports before the start of the countries' B5 mandates. However, the world price increases to \$1,469 per liter by 2018, driven by higher demand from the EU.

In the outlook for sugar, despite a production shortfall in 2008/09, the world price of sugar declines by 5%, aided by a 10% reduction in stocks. The price increases by 15% over the projection period, as more sugarcane is used for ethanol in Brazil, and sugar imports of the European Union, China, and India remain strong.

World prices of oilseeds and vegetable oil retreat from the historic highs of 2007/08 because of weaker demand. World trade of soy beans, soy meal, and soy oil grows by 33%, 31%, and 37%, respectively, over the next decade. Argentina, Brazil, Paraguay, and the U.S. account for 85% of the 296 mmt of world production in 2018/19. China continues to dominate world soy bean imports and expands its net trade to 56 mmt by 2018/19. Palm oil remains the cheapest and most widely traded edible oil."

⁶⁷ International Sugar Organization. 2009. Sugarcane ethanol and food security. MECAS(09)07 Market Evaluation Statistics Committee. April, 2009. London, U.K.

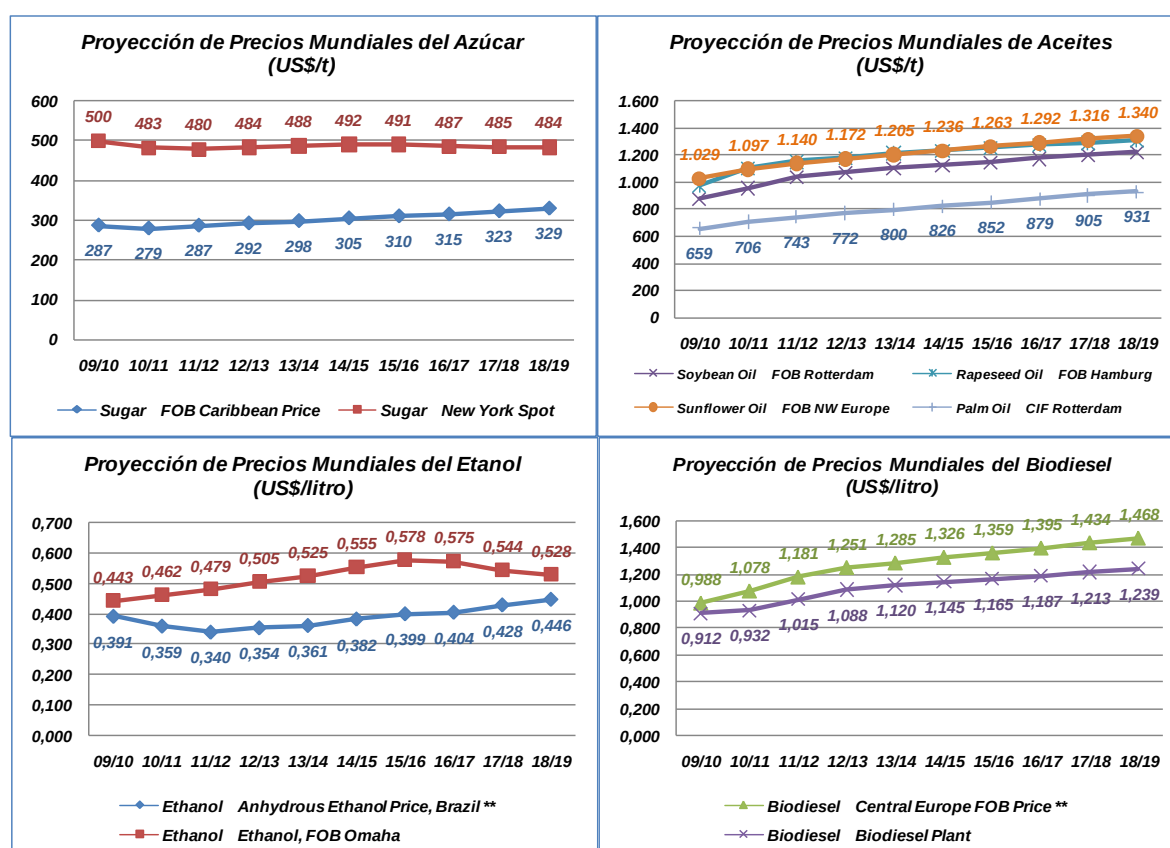
⁶⁸ Mielke, Thomas. *World Supply, Demand and Price Outlook for Oilseeds, Oils / Fats and Oilmeals Opportunities & Challenges for Can. Canola*. Annual Convention of the Canadian Canola Council in Toronto, March 10-12, 2009.

⁶⁹ CEPAL – FAO – IICA. 2009. *Ibíd.*

⁷⁰ von Braun, Joachim. (2008) El aumento en los precios de los alimentos ¿Qué hacer? IFPRI Perspectiva de Políticas Alimentarias. Abril 2008. International Food Policy Research Institute (IFPRI) <http://www.ifpri.org/sites/default/files/publications/bp001sp.pdf>

⁷¹ Food and Agricultural Policy Research Institute. FAPRI 2009 U.S. AND WORLD AGRICULTURAL OUTLOOK. Iowa State University & University of Missouri-Columbia. Ames, Iowa. U.S.A. January 2009 <http://www.fapri.iastate.edu/outlook/2009/text/OutlookPub2009.pdf>.

Figures 3.12 to 3.15: Projections of world market prices for sugar, vegetable oils, bioethanol and biodiesel



Source: Food and Agricultural Policy Research Institute (FAPRI)

3.3.4. Aggregate value

A desirable effect, if possible, would be to set up local industries to process biofuels from their byproducts or other raw materials in order to increase the aggregate value of primary production.

Raw material prices are a high percentage of the total production costs for biofuels and have a considerable effect on economic viability. In early 2005, raw material costs were responsible for 58% to 65% of total production costs for ethanol. In addition to raw material costs, other fully expressed costs include those for equipment required for production, agrochemicals, labor and energy used for production, maintenance and the net amount of the byproducts from the production process.⁷²

Many of the economic aspects of the production and consumption of biodiesel are comparable to those of ethanol. Opportunity costs for the raw materials used in biodiesel production correspond to the higher prices of vegetable oils in the international market.⁷³

⁷² Masami Kojima, Donald Mitchell, and William Ward. 2007. Considering Trade Policies for Liquid Biofuels Renewable. Energy Sector Management Assistance Program (ESMAP). The World Bank. Energy Special Report 004/07. Disponible en: http://siteresources.worldbank.org/INTOGMC/Resources/Considering_trade_policies_for_liquid_biofuels.pdf

⁷³ One liter of vegetable oil produces approximately one liter of biodiesel.

In addition to raw material costs, plant costs need to reflect the return on capital expenditures for building the biodiesel plant, as well as operational costs, including the purchase of methanol. Earnings on sales of byproducts, such as glycerin, are deducted and a regular profit margin is added to reach the plant costs of biodiesel. This biodiesel balance point must be compared to that of diesel and oil, taking into account the economic penalties associated with fossil fuels and the environmental benefits resulting from the reduction of environmental emissions, regardless of whether or not current fuel prices take those aspects into account.

Most production costs thus far are related to the costs of raw materials, and the commercial viability of any biofuel is extremely dependent on raw material prices. Within the context of the market and predominant policies, the price that a farmer receives for a biofuel crop depends mainly on its potential energy, conversion and transportation costs and the value of the byproducts.

There is an estimated aggregate monetary value (profit) per energy unit for the intensive production systems under tropical conditions and in developing countries as shown in the table below. With regard to the first agricultural production system, which is called “farmers”, crop exploitation is carried out as intensive production in marginal soils, while in the intercropping system, biofuel production is derived from wood from intensive intercropping.

Table 3.9: Earnings from selected studies from developing/ tropical countries biofuel production (*thousands of \$ per peta joule*)^{1/}

Bioenergy systems & Related activities	Intensive production farmers Farmers Mix		Intensive intercropping Intercropping Mix	
Establishment	82.3	11.8%	54.9	9.3%
Weeding	205.8	29.6%	126.9	21.5%
Harvesting	257.2	36.9%	257.2	43.6%
Transport	68.6	9.9%	68.6	11.6%
Chipping	13.7	2.0%	13.7	2.3%
Administration	68.6	9.9%	68.6	11.6%
Total	696.2	100.0%	589.8	100.0%

Note:1/ Joule (SI unit) J = kg m² s⁻²; Petajoule (PJ) = 10¹⁵ J; 1 ton of oil equivalent (toe) = 0.00004184×10¹⁵ J

Source: J. Domac et al. Socio-economic drivers in implementing bioenergy projects. Biomass and Bioenergy 28 98 (2005) 97–106

Aggregate amounts per energy unit produced as shown in the foregoing table confirm that the agricultural phase is responsible for about 78.3% and 74.4% of the total aggregate value, including establishment, weeding, and harvesting both for the farmers system and the crop association system, with intercropping, respectively.

Evidence from the table thus implicitly leads us to the conclusion that the agro-energy projects based on energy crops generate a significant aggregate value in the agricultural production systems.

4. Elements for the formulation of public policies

4.1. Opportunities, technological challenges and impacts

In addition to providing the option of a new agricultural activity, the emergence and current configuration of the global agro-energy and biofuel production chain introduces the possibility of being at the center of a new paradigm, with numerous prospects and challenges. For countries in Latin America and the Caribbean, whether they are producers now, or will be in the future, the development of agro-energy and biofuels means economic, environmental, social and strategic opportunities.

Biofuel production systems are extremely complex, especially where there is a number of interrelated factors such as global and domestic markets, the possible impact on climate change, geopolitical issues and decisions pertaining to public policies that regulate this topic.

Moreover, the dynamism and uncertainty that usually accompany the emergence of a new activity also come with latent risks, conflicts and tensions, where a lot of attention is focused on the dilemma of “food vs. energy” as well as the potential negative effects on the environment and biodiversity that might be caused by the sector’s uncoordinated global expansion.

Some of the most relevant results of the implementation of the agro-energy and biofuel production chains are: (a) less dependency on non-renewable energy sources and increased assurance of the continuity of the energy supply; (b) improved environmental conditions due to the reduction of polluting emissions; (c) generating direct and indirect, regional and rural investments and employment, thus creating new possibilities of entry for small and medium-size agricultural enterprises and family-run agricultural activities; (d) product diversification in the agricultural and livestock farming sector; (e) value added to the agro-industrial chain; and (f) an opportunity for the delayed development of regional economies, starting with energy crops in marginal areas (Ganduglia, 2008).⁷⁴

Although biofuel production is relatively low given the overall demand for energy, its potential to cause unexpected adverse effects on land, water and biodiversity is still a major concern. This underscores the importance and necessity of developing and refining instruments such as land-use or economic-ecological zoning, and implementing good agricultural practices (conservation agriculture), all of which are key elements for mitigating the negative externalities of biofuel production.

According to Gazzoni⁷⁵, the key to maintaining the competitiveness of systems for biofuel production will be the introduction of new technologies in three main areas:

- a. Production of raw materials, which should focus on products with high energy density, are easy to produce and transport and don’t conflict with the production of food or other agricultural products. From this perspective, cellulose and hemicellulose are the most suitable organic molecules for the production of affordable energy. Organic waste and algae offer excellent medium-term alternatives, the latter being heavily dependent on the development of mass production technology.

⁷⁴ Ganduglia, F y Equipo de Proyectos de Biocombustibles (EPB) – ARPEL, loc. cit.

⁷⁵ Gazzoni, Decio Luiz. Biocombustibles y alimentos en América Latina y el Caribe. San José, C.R.: IICA, 2009.

- b. Transformation processes that lead to more efficient and affordable biofuels, have less negative impact on the environment and are safer for inventory, transportation and use.
- c. Engines and power converters for the progressive improvement of current diesel engines (otto cycle) until the introduction of fuel cells. The cells can be moved with low cost and high energy density organic molecules (such as alcohols) or molecular hydrogen (H₂), which represents the apex of the energy density of a biofuel substance.

The management capacity for the "business" of biofuels also needs to be strengthened. The introduction of ethanol in Brazil's energy mix has proven to be a success for the production and marketing of biofuels. This could be the basis of a cooperative program to train entrepreneurs and policymakers in other LAC countries.

Other relevant information comes from the IV Latin American and Caribbean Seminar on Biofuels, held in Cali, Colombia in April 2009, an event institutionalized by the Latin American Energy Organization and implemented in coordination with the Food and Agriculture Organization of the United Nations (FAO), the Inter-American Institute for Cooperation on Agriculture (IICA) and the Ministry of Energy and Mines of Colombia, with technical support from the Ministry of Mines and Energy of Brazil⁷⁶.

- a. The U.S. will increase strategic cooperation with other countries in the hemisphere, giving priority to energy security and climate change, expanding cooperation with other countries in clean energy and fossil fuels, and energy efficiency. It will also develop policies to increase investments in clean energy and reduce emissions.
- b. Biofuels in Brazil are considered a component of energy security, since dependence on imported energy makes a country more vulnerable. Ethanol consumption is higher than that of gasoline in Brazil.
- c. In Colombia, the use of ethanol and biodiesel is mandated by government policies in which private sector players play an active part. Ten percent of ethanol is mixed with gasoline and five percent of biodiesel is mixed with diesel fuel.
- d. Using 10% ethanol-gasoline blends worldwide is possible using currently available technologies.
- e. Specific public policies are necessary for the inclusion of biofuels in countries interested in this technology.
- f. Definitions for the following are given: (i) first-generation biofuels: ethanol and biodiesel, currently produced with known and established technologies, processes and trading channels; (ii) second-generation biofuels: medium-term developing processes that use biomass, agricultural waste and microalgae; (iii) third-generation biofuels: long-term processes, including new energy and raw materials with genetic changes.
- g. Commercial applications for the production of biofuels using second-generation technologies are already available.
- h. Significant progress has been reported on the potential use of microalgae, including in commercial aviation.

⁷⁶ OLADE/FAO/IICA/Ministerio de Energía y Minas de Colombia/Ministerio de Minas y Energía de Brasil: IV Seminario Latinoamericano y del Caribe de Biocombustibles: Informe Final. Available at <http://www.olade.org.ec/biocombustibles/informe.html>

- i. The assortment and processes of first-generation technologies need to be optimized: e.g. higher yield sugarcane (existing varieties in Colombia) and reduction of water use.
- j. Emphasis should be placed on the introduction of the life cycle as an evaluation tool for processes and the sustainability of biofuel extraction.
- k. Important experiences in the region have been presented on the use of alternative raw materials for fuel production: pine nut (*Jatropha curcas*), waste from tilapia processing and coffee byproducts, among others.
- l. Progress has also been made in the use of biodiesel in the mass transit system in Bogota, which is beneficial to the environment.

According to ECLAC (2007)⁷⁷, Latin America and the Caribbean have the potential to meet a substantial part of the global demand for ethanol and biodiesel. However, biofuel production could also mean the expansion of the production frontier, which is a serious challenge for the agricultural sector and possibly the environment of the countries in that region.

One of the limitations of biofuels is their high production cost compared to fossil fuels (gasoline and diesel). Factors such as international oil prices, the cost of biofuel processing and the price of alternative uses of crops all play a key role in determining profitability, opportunity costs and consequently the incentives for biofuel production. It is important to consider these aspects when designing public policies used to generate incentives for biofuel production.

Growing energy crops can cause significant changes in the agrarian structure, such as the increased concentration of production and ownership, and in the emergence of new players and standards. Significant changes in the economic structure could be another potential result, mainly due to the creation of economies of scale, with more pressure on natural resources, ecosystems and agriculture-related employment.

An increased demand for biofuels could also lead to higher prices for energy and non-energy crops and the reduction of products obtained from the production of biofuels. Livestock and forestry would also be affected. The impact on the livestock sector may be manifested through changes in the prices of animal feed. Such an effect could hamper the goal of some countries to strengthen the income of rural areas.

It is important that countries design policies that promote and ensure the profitability of biofuels, that the benefits of biofuel production reach rural areas and that the countries promote and safeguard access to food for the most vulnerable sectors.

⁷⁷ CEPAL, Biocombustibles y su impacto potencial en la estructura agraria, precios y empleo en América Latina, 2007

4.2. Public policies

Public policies on biofuels should also take into account national goals related to productive specialization (agribusiness), the energy supply for the population and the protection of their natural heritage. Each country must therefore define its own agenda and leverage the demand of developed countries to open up new opportunities for sustainable rural development.

Many governments of countries in the region have established goals for the local market and promoted legislations designed to develop biofuels without first consistently examining their potential impact, not only on agriculture and the use of natural resources, but also at the social level, especially with regard to their effective contribution to combating poverty and its impact on food prices.

Therefore, according to ECLAC (2008)⁷⁸, a task that lies ahead is the definition of its own public policy agenda that would truly contribute to sustainability, giving careful consideration to a set of topics before formulating these guidelines, such as:

- a. The investigation of the net balance of fossil energy, considering on the one hand the substitution of petroleum products in domestic consumption, particularly in the transport sector, compared to the consumption of fossil energy throughout all stages of the biofuel production chains. In the case that this balance is not significantly positive, there may be other negative impacts without any advantages in terms of fossil energy savings or the use of foreign currency for import-dependent countries.
- b. In case the previous balance is not significantly positive, verify if the introduction of biofuels has a positive effect on greenhouse gas emissions, and if it makes a real and permanent contribution to achieving the goals of the Framework Convention on Climate Change.
- c. When biofuel production is mainly based on monocultures, assess the impacts on social conditions that define the labor market, the concentration of ownership and the social distribution of benefits from exploitation. If only the monocultures prevail, the contribution of biofuel programs to employment, improvement of distributional asymmetries and rural development could be negative.

At any rate, the situations in LAC countries present very marked differences regarding the production and use of biofuels. For some countries that have a long tradition with the production and use of bioethanol, technological developments at the different stages of the production chain, a mature automotive industry and a large domestic market would help them become large-scale exporters of that biofuel. In those countries, biofuel production could have a great impact on agricultural activities if it also leads to better management of land and water resources and improvement of existing varieties, as well as the incorporation of new varieties that are adapted to the ecological conditions.

For countries in the region with limited natural resources, some with marked poverty and/or malnutrition and inadequate fulfillment of basic energy requirements, the export option cannot be considered, as it would have adverse effects on different areas of sustainable development.

⁷⁸ CEPAL, 2008: Aporte de los Biocombustibles a la Sustentabilidad del Desarrollo en America Latina Y el Caribe – Elementos para la Formulacion de Políticas Publicas

ECLAC insists that energy consumption should be moderated, especially in developed countries, so that saving energy becomes an alternative that is more compatible with sustainable development than biofuels. However, this appears to be an inconsequential and short-term solution to the most important energy and environment-related problems.

With regard to the sustainability of development, the most effective measure could be to meet the population's basic energy requirements by fostering policies that promote rural development. This would help surmount problems of poverty and malnutrition, inequalities of distribution and the relocation of small-scale producers that may be caused by biofuel production.

ECLAC believes that public policies should take into consideration four groups of countries:

- a. Those that depend on oil and/or byproducts that have problems with the balance of payments due to the high cost of energy bills, and minimal capacity to meet the basic energy needs of the poor;
- b. Those that depend on oil and have an average capacity to meet basic energy needs;
- c. Those that have a diversified range of energy resources and may further diversify their energy mix with the production of bioethanol and/or biodiesel, but are importing byproducts;
- d. Those whose comparative advantage and technological learning curve enable them to have a presence in the global market.

ECLAC recommends that a multidimensional approach should be used when designing policies for biofuels, i.e. in addition to the political energy authority, the participation of policy-making authorities on agriculture, industry and transport, finance, natural resources and the environment, social and public health and regional entities should also be enlisted. Only with prior and well-founded agreements will it be possible to create a coherent biofuel policy. Once such a consensus is reached within the public authority, the reactions of stakeholders from civil society should be evaluated, and their contributions should be incorporated into the proposed policy. The rules of the game for investment should thus comply with a global rationale, and not an exclusively private one.