THE CONTRIBUTION OF BIOFUELS TO THE SUSTAINABILITY OF DEVELOPMENT IN LATIN AMERICA AND THE CARIBBEAN

ELEMENTS FOR FORMULATING POLICY

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Project documents

The contribution of biofuels to the sustainability of development in Latin America and the Caribbean: elements for formulating public policy

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Economic commission for Latin America and the Caribbean (ECLAC)

This document was prepared by ECLAC consultants Héctor Pistonesi, Gustavo Nadal, Víctor Bravo and Daniel Bouille, who were assisted in reviewing, coordinating and in preparing portions of the document by Fernando Sánchez Albavera, Director of the Natural Resources and Infrastructure Division of the Economic Commission for Latin America and the Caribbean (ECLAC) and Hugo Altomonte, Head of the Natural Resources and Energy Unit within that Division.

The undertaking also benefited from contributions and commentary by Fernando Cuevas, Head of the Energy Unit at the ECLAC Subregional Headquarters in Mexico, and by Manlio Coviello and Jean Acquatella, Economic Affairs Officers in ECLAC's Natural Resources and Infrastructure Division. The present document was prepared in the framework of the project, "*Towards sustainable and equitable globalisation. Component 2: Sustainable development, integrated management of natural resources and climate change*" GER/06/002, being carried out with financial support from the Government of Germany.

Publication of the United Nations.

LC/W.219

Printed int the United Nations, Santiago, Chile.

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Executive Summary

Given the increasing difficulty of ensuring the supply of crude oil and oil products, and the sharp increase in their prices, biofuels programmes in the developed countries—particularly the United States and the European Union—represent a series of opportunities, challenges and risks for the countries of Latin America and the Caribbean. Thus, if biofuels production is to create economic growth without jeopardising our natural capital and social equity, it must be developed in the framework of well thought-out national policy.

Biofuels public policy cannot ignore national objectives, which involve not only agro productive specialization, but also expanding the availability of energy to the population and protecting the natural patrimony. Accordingly, it is incumbent on each country to define its own agenda, taking advantage of the demand from the developed countries as a means of solving their own problems and creating new opportunities for sustainable rural development.

Given the complex, multi-dimensional nature of biofuels policymaking—as will be outlined in this paper—it is only under certain conditions that biofuels production programmes can contribute to sustainable development.

A significant number of the region's countries have set goals for the local market, and have passed legislation to develop biofuels, without a thorough examination of the impacts that such development may entail in terms of agriculture and natural resource use, as well as in the social sphere—particularly as regards poverty reduction and food prices.

Thus, it remains to define a policy agenda which can assure a real contribution to sustainable development. In other words, though biofuels production clearly has microeconomic benefits, especially in terms of agribusiness, a number of questions must be examined carefully before policy is put in place:

- **The net balance of biofuels programmes**, in terms of fossil fuel energy, must be studied, examining the effect of replacing oil products for domestic consumption (especially in the transportation sector) in relation to the consumption of fossil fuel energy throughout all links of the biofuels production chain. If this balance is not significantly positive, biofuels programmes will risk creating other negative impacts for import-dependent countries, without any compensation whatsoever in terms of fossil energy savings or foreign reserve levels.

- If the above-mentioned balance is not significantly positive, it must be determined whether the introduction of biofuels will actually have a positive effect on greenhouse gas emissions and contribute permanently to achieving the ultimate objective of the Framework Convention on Climate Change.
- In the case of biofuels production based primarily on monocultures, an assessment must be made regarding the impact on the social conditions affecting the labour market, concentration of property, and social distribution of the gains. If monocultures predominate strongly, biofuels programmes could ultimately have a negative impact on employment, on reducing distributive asymmetries, and on rural development.

There are marked differences between the region's countries in regard to production and use of biofuels, natural resources, previous experience and technological development, availability of alternative energy sources for transportation, degree to which the basic energy needs of populations are being met, and poverty and under-nutrition. Thus, no single, across-the-board criteria on the appropriateness of biofuels programmes can be considered valid.

Countries with long experience producing and using bioethanol, with advanced technological development in all links of the productive chain, a mature automobile industry and a very large domestic market could become large exporters of that fuel. In the case of major vegetable oil exporters that also have abundant natural resources, there are actors willing to become involved in the export of biodiesel. However, in terms of natural resources, biodiversity and exacerbating social asymmetries, serious risks could accrue.

As a general matter, it is quite possible that the impact on agricultural activity could be minimal provided that biofuels production does not bring with it greater technology to increase the productivity of existing types of crops, or provides a means of extending the agricultural frontier in a sustainable fashion. At the same time, however, better management of soil and water resources will be needed, and existing varieties must be improved, along with the use of any new varieties that can be appropriately adapted to the ecological conditions.

In those of the region's countries that are poor in natural resources, and in some that suffer from marked poverty, under-nutrition and/or inadequate coverage of basic energy needs, exporting is not a sustainable option, since it would have negative effects on various aspects of sustainable development.

ECLAC has been emphasising that, in addition to expanding supply—which may have unpredictable impacts on a planetary scale, given sharply rising energy consumption—greater priority should be given to moderating consumption, especially in the developed countries. Thus, energy saving appears much more compatible with sustainable development than do biofuels, which are at best a marginal, short-term solution to central problems of energy and the environment.

Since there has been little actual regional or national public policy experience with biofuels in Latin America and the Caribbean, this monograph defines certain types of different scenarios, as a means of dealing with the complexity of the analytical challenge. From the point of view of sustainable development, perhaps the proper approach would be to meet the population's basic energy needs through rural development policies. This approach would place priority on the problems of poverty, indigence and under-nutrition, while guarding against the distributive asymmetries and displacement of small producers that biofuels production could cause.

Such problems, of course, go far beyond the scope of this document. Here, we limit ourselves to looking, by way of example, at policymaking issues in countries that fall under four different categories:

- countries that are dependent on crude oil and/or oil products, that have balance of payments problems due to their high energy bill, and whose coverage of their population's basic energy needs is low;
- countries that are dependent on petroleum, and whose coverage of their populations' basic energy needs is moderate;
- countries that have a variety of energy resources and could diversify their energy matrix further by producing bioethanol and/or biodiesel, but that are nonetheless importers of oil products; and
- countries whose comparative advantages and place in the technological learning curve provide them entry to the world market.

Finally, the perspective adopted here is that the overall public policy approach to biofuels production and use should be multi-dimensional and must be managed in a centralised fashion. Thus, participation must not be limited to energy authorities, but must also draw on input from relevant government entities concerned with agriculture, industry and transportation, finance, natural resources and environment, social areas such as health, and regional entities. A coherent biofuels policy can only be built on the basis of common agreement and adequate information. Once such governmental consensus is achieved, reactions and contributions from civil society can be incorporated in formulating policy. In short, the rules governing investment in biofuels must flow from a comprehensive approach, rather than merely from individual points of view.

Introduction

The present study adopts an integral, intersectoral approach to the problem of biofuels policy and to the issue of the sustainability of development in the region's countries.

It is divided into four chapters. The first deals with the international context, and explains the motivations behind biofuels policy on the world agenda, as well as the challenges and questions arising from market penetration goals in both developed and developing countries.

Since biofuels policy must be part of energy policy more broadly, the second chapter analyses salient aspects of the region's energy situation, as well as the elements of energy policy as they relate to the dimensions of sustainable development.

The third chapter presents "stylised" situations for the development of biofuels, analysing different categories of countries as regards bioethanol and biodiesel.

Chapter four outlines possible paths to an appropriate biofuels agenda, indicating policy elements needed to ensure the sustainability of development, factors that may work against the agenda, and the way in which biofuels policies need to be assessed.

Since biofuels can be obtained from a variety of different agricultural products, ranging from herbaceous and woody plants to different types of agricultural and livestock waste, it was necessary to specify what types of biofuels we would be dealing with here.

Etymologically, the term "biofuels" signifies fuels obtained from biological sources. However, both crude oil and natural gas (at least under the prevailing theories on its organic origin) are of biological origin (since these hydrocarbons come from phytoplankton and zooplankton that have decomposed at great depths). At the same time, coal comes from the decomposition of accumulations of woody material covered by water and mineral sediments. In other words, these fossil fuels are ultimately the products of photosynthesis. The difference between petroleum, natural gas and coal, on the one hand, and the so-called "biofuels" on the other, is that the former are not renewable whereas the latter are.

This document focuses exclusively on the problem of bioethanol and biodiesel, whose production is based on agriculture and forestry.

The term "biofuels" is used to refer to fuels obtained from biomass including, for example, crops, wood, charcoal and biogas. First-generation biofuels are based essentially on agricultural crops, while second-generation biofuels are derived from raw materials obtained through forestry (either in natural forests or through tree plantations created for energy purposes) or from either agricultural or forestry waste.

"Biofuels", then, include "renewable fuels of biological origin, including wood, dung, biogas, biohydrogen, bioalcohol, microbial biomass, agricultural waste, fuel crops, etc [1]", while "agrofuels" include "biofuels obtained from monocultures such as soy, sugar cane, corn, etc"[2].

Thus, bioethanol and biodiesel, which are dealt with in this document, are, strictly speaking, a particular type of agrofuel. Here, however, we shall simply refer to them as "biofuels".

Bioethanol is a renewable fuel that is a complement to, or substitute for, naphthas or gasolines produced from the sugars, starches or cellulose contained in various plants in one of the following ways:

- by a process of fermentation and distillation from the sugars (commonly sucrose) contained in crops such as sugarcane or sugar beets.
- obtained from the starch in the seeds of cereals such as corn, wheat and sorghum, or in tubers such as yucca or cassava, through a process of hydrolysis, scarification, fermentation and distillation.
- obtained from the cellulose in lignocellulosic raw materials such as trees, brush, crop residues and cellulosic wastes, through advanced hydrolysis, fermentation and distillation.

Biodiesel is a renewable fuel that is a complement to, or substitute for, diesel. It is produced from lipids (fatty acids) such as the vegetable oils obtained from palm oil, soy, sunflower seed, the castor-oil plant or cotton, rapeseed, jatropha, animal fats and algae. The key process is esterification, which consists of combining the oil or fatty material with a light alcohol (such as methanol or bioethanol) in the presence of a catalyst such as sodium hydroxide.

We speak of "first-generation" bioethanol and biodiesel, then, when they are obtained from the raw materials provided by the above-mentioned crops and industrial processes, and of "second-generation" bioethanol when it is obtained from lignocellulosic raw material.

The development of first-generation bioethanol production is limited by the availability of land to obtain sugar- and starch-rich raw materials.

This suggests the desirability of "second-generation" bioethanol, since sources of cellulose are more abundant, and since competition with agricultural crops traditionally grown for food is thus avoided.

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1 Hazell, P. and R.K. Pachauri, "Bioenergy and agriculture: promises and challenges. Overview." IFPRI Focus 14, No. 1, Washington. 2006.

2 Another important reference source is FAO's UWET (Unified Wood Energy Terminology), published at the end of the last decade, which considers agrofuels to be a type of biofuels.

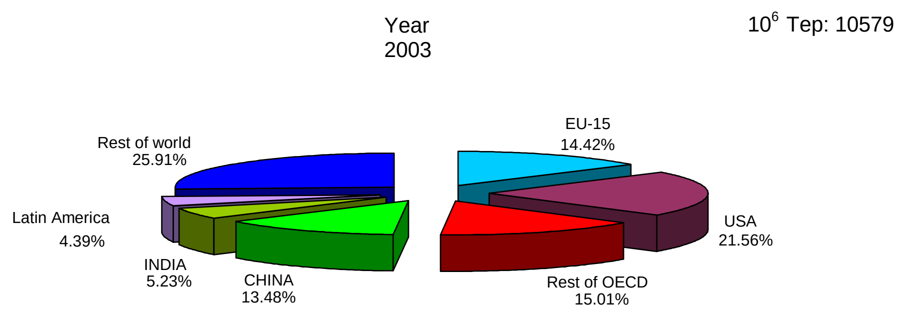
Chapter I

The role of biofuels at the global level

The main structural aspects of the world energy context include:

- *Differences in levels of development, creating unequal distribution of energy consumption.* The developed countries grouped in the OECD are the main consumers of the world's energy, due to intensive growth in their consumption patterns, with the United States and EU-15[3] playing the most important role. (Figure 1).

FIGURE 1
WORLD APPARENT ENERGY CONSUMPTION[4]
(Percentages)



Source: Energy Balances of OECD Countries 2005.

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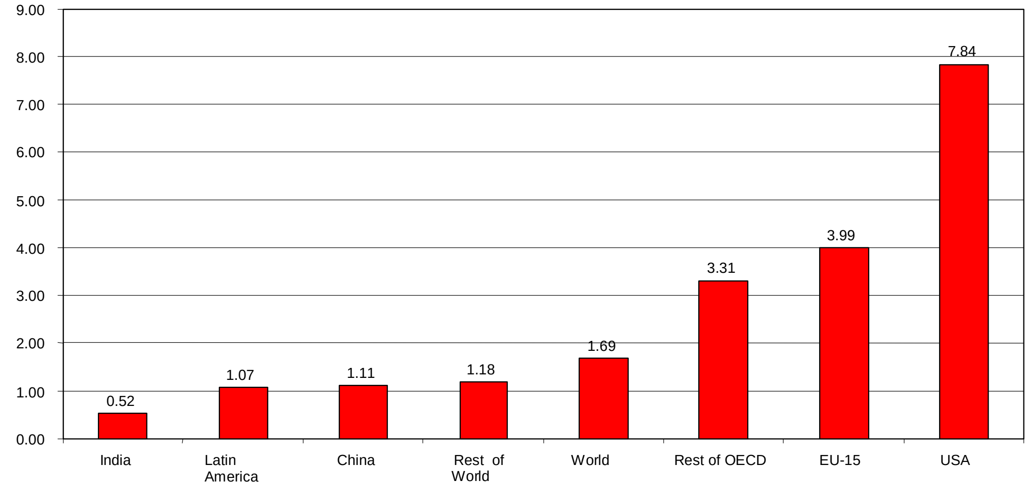
3 Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxemburg, Netherlands, Portugal, Spain, Sweden and the United Kingdom.

4 The rest of the OECD (Australia, Canada, Czech Republic, Hungary, Iceland, Japan, Korea, New Zealand, Norway, Poland, Slovak Republic, Switzerland and Turkey).

Thus, 2003 per capita apparent energy consumption (AEC) in the United States was over 7 times the average for Latin America and the Caribbean (LAC), and 15 times the figure for India (Figure 2.2), although India's share of AEC increased by a factor of 1.6 from 1973 to 2003 (while China's increased by a factor of 1.9).

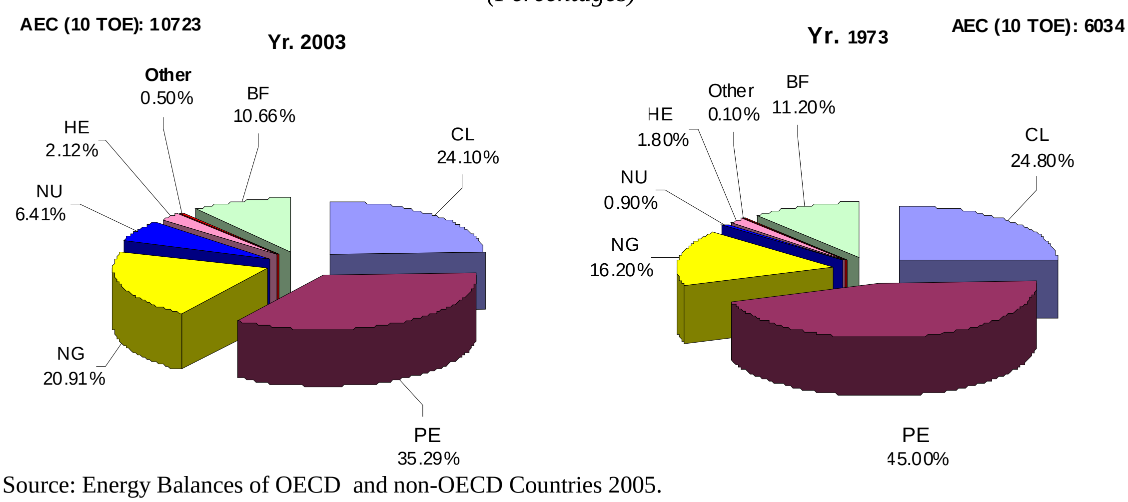
FIGURE 2
PER CAPITA APPARENT ENERGY CONSUMPTION (2003)
(TOE/person)



Source: Energy Balances of OECD Countries 2005. Energy Balances of Non-OECD Countries 2005. Key World Energy Statistics 2005.

- *Marked predominance of crude oil in the energy supply*, despite gradual replacement of oil between 1973 and 2003 as natural gas and nuclear fuels (NU)[5] make strong advances, with oil continuing to be the predominant energy fuel. Its use is concentrated most significantly in the transportation sector (Figure 3).

FIGURE 3
GLOBAL APPARENT ENERGY CONSUMPTION, BY SOURCE
(Percentages)



Source: Energy Balances of OECD and non-OECD Countries 2005.

[5] Petroleum (PE), natural gas (NG), nuclear fuels (NU); hydroelectric (HE); solar, wind and geothermal (Other); biofuels (BF); coal (CL).

1.1 Main drivers of biofuels policy in the global agenda

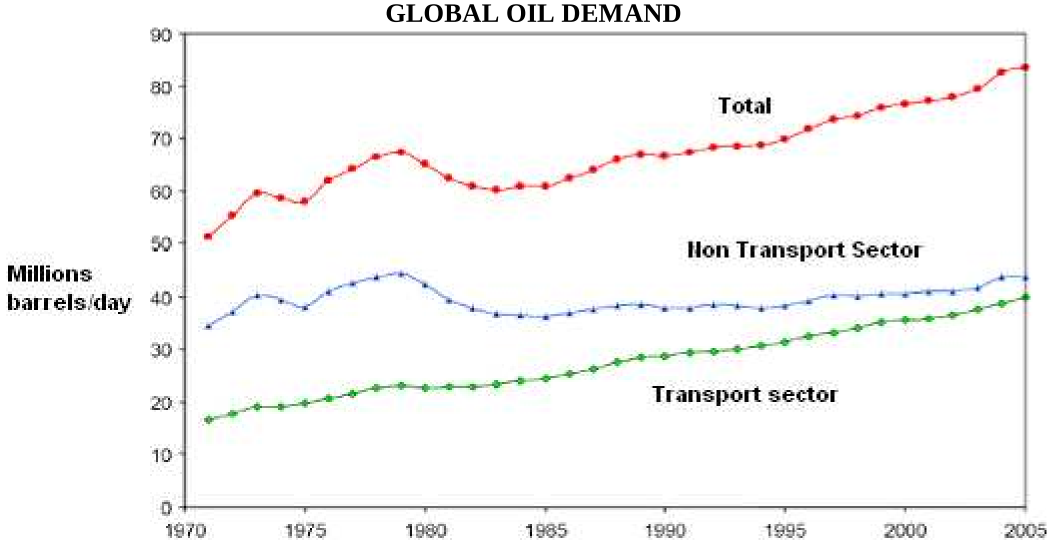
To provide a summary of the major features of the international energy environment, the principal motives behind the promotion of biofuels.

(a) Energy drivers

The dynamics of global oil demand are driven by the transportation sector (Figure 4). There are uncertainties and conflicting opinions regarding the projected duration of proven world reserves, particularly in terms of the maximum annual output that these reserves are capable of producing[6].

This implies an increasing dependency on imported oil for the "developed" countries and regions (United States, Europe, Japan), emerging economies (China, India) and developing countries that are not oil producers. Surpluses to meet shortfalls are located principally in Latin America (specifically, Venezuela and Mexico), in Russia and in the OPEC countries.

FIGURE 4
GLOBAL OIL DEMAND



Source: International Energy Agency

Today's oil price volatility dates to the mid-1980s, when the oil futures market began to operate and created a dynamic, independent of fundamentals—such as changes in reserves, production, rates of consumption and stockpiles—in which oil prices underwent short-term ups and downs similar to those of securities traded on commodities exchanges. Other oil industry realities, such as lack of investment, consumption-driven demand in emerging countries and lack

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[6] According to information on proven petroleum reserves published every June in the "BP Statistical Review of World Energy", estimates of how long the supply will last have grown from 29 years in 1980 to 40.5 years in 2006. The values given by the Oil and Gas Journal, World Oil, the USGS and the International Energy Agency are very similar. According to the noted geologist, Colin Campbell, and scientists at the Oil Depletion Analysis Centre, however, these figures are in reality a reflection of political calculations by governments and companies, not the result of rigorous scientific study. As to the peak of oil production, the Oil Depletion Analysis Centre places it 5 years out, while Cambridge (Massachusetts) Energy Research Associates puts it in 2015, with 110 million barrels per day, as compared with today's 87-million barrel capacity.

of light crude, have contributed to this volatility, which has grown in recent years, producing enormous speculative profits[7].

In the context of this scenario, biofuels programmes essentially aim to ensure supply, reduce dependence on oil imports from areas of conflict or potential conflict, and attenuate the impact of highly volatile international prices that are also highly unpredictable over the long term.

(b) Environmental drivers

Environmental arguments centre on the need to reduce greenhouse gas (GHG) emissions for the sake of both the global and local environments, particularly in large cities. In this respect, the replacement of fossil fuels by biofuels in the transportation sector is in line with commitments assumed under the Kyoto Protocol, insofar as these contribute to reduction of GHG.

Environmental standards in the European Union and the United States provide additional arguments for biofuels. The approach in the United States is to replace MTBE[8], a water-polluting additive for the oxygenation of gasoline, with ETBE[9], a technique that involves mixing gasoline with bioethanol. Similarly, in the European Union, limits on the sulphur content of diesel promote the use of biodiesel, which has very low sulphur content.

The volume of fossil fuels consumed by the “developed” countries, along with the problem of limited land for competing crops (United States, Japan), creates the possibility of an international biofuels market of significant magnitude.

Despite these factors, however, there remains much debate regarding the net effects of biofuels on the environment, given the possible impact of the chain of activities involved in producing them, including pollution (soil and water), deforestation and diminished biodiversity.

(c) Drivers associated with agricultural development

Biofuels open up new opportunities for agricultural development. Producers and exporters in developing countries, located in warm regions with potential to produce biofuels from crops at prices competitive with petroleum, have an opportunity to take advantage of improving raw materials prices, promote biofuels, and thus reduce imports or increase exports.

Nevertheless, there are dangers in terms of land deterioration, water use, changes in land use that could affect the food supply, concentration of land ownership, the exclusion of small and medium-sized producers, and threats to biodiversity.

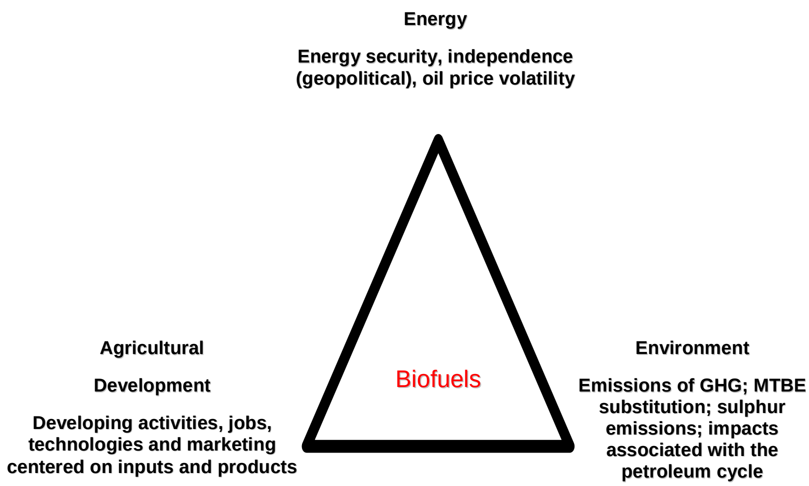
In the context of this paper, it is particularly important to be clear about motivations and objections, if only to make clear the multi-dimensional nature of the issues and to determine what areas must be studied in order to responsibly design and evaluate national biofuels policies.

[7] Between 2002 and 2007, the annual average price of WTI crude rose from US$ 27.73 to around US$ 80 per barrel (in 2006 dollars).

[8] Methyl tertiary-butyl ether.

[9] Ethyl ter-butyl ether.

FIGURE 5
MATOR DRIVERS FOR THE INTRODUCTION OF BIOFUELS



Source: Authors.

1.2 The world agenda from the perspective of different countries and regions

Though the most important factors are common to the great majority of industrialised countries, it is helpful to consider the arguments and positions of different regions and countries, such as the European Union, the United States and Brazil.

(a) European Union (EU)

The European Union (EU) is one of the principal promoters of biofuels. *"In 2030, biofuels will represent 25% of the fuel used for road transport. Successful implementation will help ensure that a substantial part of the biofuels market is provided by a competitive European industry based on sustainable and innovative technologies, creating opportunities for biomass providers, biofuels producers and the automotive industry*[10]*".*

The EU approach is not limited to its own borders. Agreements with developing countries are an important element in its strategy. The EU is interested in developing and strengthening cooperation by identifying and establishing appropriate links that take into account the differing realities of developing countries[11], while moving toward a fuller understanding of local determining factors such as (i) potential scale of production; (ii) size of national and regional markets; (iii) necessary infrastructure investment; (iv) support and promotion through public policy; (v) export options (EU, United States, Japan, China); and (vi) market prices of the raw materials needed to produce biofuels.

[10] European Commission, Biofuels in the European Union: A vision for 2030 and beyond, 2006; An EU Strategy for Biofuels, 2006; An Energy Policy for Europe, 2007.

[11] As noted earlier, the role that biomass sources can play depends heavily on specific factors in each country.

The purpose of the EU's €220-million contribution to the Johannesburg Renewable Energy Coalition (JREC) is to help developing countries develop renewable fuel sources and alleviate poverty, which, in turn, is *connected with the EU's strategy to promote biofuels in the developing countries (EU Strategy, 2006)*. According to the EU, it intends to respect the conditions for sustainable biofuels development. Other actions in the same direction are planned in connection with the Intelligent Energy-Europe programmes, with special focus on promoting market soundness, developing capacity, strengthening cooperation, providing technology transfer, and taking advantage of shared benefits.

The European agenda can be described as[12]:

- a broad agenda, not restricted to energy or climate change, though these are the main driving forces;
- strongly driven by transportation energy demand and the need to reduce GHG emissions to meet commitments under the Kyoto Protocol;
- oriented to increasing the security of supply, reducing dependence on imported crude and attenuating the impact of volatile prices;
- based on comprehensive analysis, and taking into consideration the development of technological niches important for the EU in processing first- and second-generation biofuels;
- based on the belief that self-sufficiency for the entire production chain is feasible or close at hand, and that this will guarantee raw materials for the bioenergy industry; however, this does not exclude linkages between Europe and the developing countries in the form of production of raw materials for biofuels;
- based on the belief that this is a sustainable option for Europe's agricultural sectors, reducing the need for producer subsidies;
- a transitional solution pending development of alternative options and vectors such as hydrogen, which are expected to be sufficiently mature in the long term (2030) to replace oil derivatives in transportation.

(b) United States

Unlike the European Union, the United States has no public documents explicitly setting forth its strategy, which must therefore be inferred from the government's actions. In late March of 2007, support for ethanol production as a means of alleviating energy consumption in the transportation sector was announced, along with a hemisphere-wide ethanol programme. Brazil is seen as a potential supplier for the increasing ethanol demand in the United States, in view of the fact that the short-term demand for traditional ethanol has, for a number of reasons, grown significantly: its use as a substitute for MTBE[13], major tax incentives, the mandate contained in the 2005 Energy Policy Act on the use of renewable fuels and the use of ethanol in gasoline, and the rising price of oil.

[12] "The EU is supporting biofuels with the objectives of reducing greenhouse gas emissions, boosting the decarbonisation of transport fuels, diversifying fuel supply sources and developing long-term replacements for fossil oil. The development of biofuels production is expected to offer new opportunities to diversify income and employment in rural areas." CEC—EU Strategy for Biofuels, Brussels, 2006.

[13] The main advocates of oxygenation with ETBE are the oil companies, which aim to thereby maintain control of gasoline additives and find a market for the butane that constitutes approximately half the volume of ETBE. Per unit of oxygen contained, ETBE holds no advantage, and the supposed potential benefits in terms of steam pressure are unrealistic, since proper formulation of light fractions of gasoline can achieve the same effect. For more details, see the "Estudio de Factibilidad para los biocombustibles en México" (SENER/IDB, 2007), which is available online.

The United States biofuels agenda will promote agricultural business by increasing incentives with "green payments" for farmers who grow energy crops, encourage practices that minimise impact on climate change, increase funds for promoting the use of renewable energy sources, and encourage the creation of cooperatives to build new biorefineries. These incentives clearly reflect the objective of generating more and better income sources for farmers.

The other explicit elements of United States policy are designed to make the energy supply more secure through diversification, so as to reduce the need for importing energy from regions of conflict, and to reduce GHG emissions. A greater United States presence in LAC, in the form of specific agreements with countries in the region, must also be taken into consideration as a possible element of the United States agenda.

In conclusion, the following appear to be important motivations for the United States:

- maintaining adequate levels of profitability and soundness in agricultural sectors;
- overcoming international disagreements about agricultural subsidies (Doha Round) by promoting biofuels facilities in the agricultural sectors;
- diversifying the fuel supply matrix, especially for the transportation sector;
- reducing GHG emissions;
- increasing the security of supply by reducing dependence on oil from areas of conflict; and
- strengthening cooperation with countries in Latin America and the Caribbean, with a programme of regional scope.

(c) Brazil

Brazil is an emblematic case, in that its experience with ethanol is indicative of opportunities that the world market offers developing countries. Brazil's leadership in bioethanol and liquid fuel technologies is undisputed. Thirty years of a programme with a strong State role, technological developments and a growing role for biofuels in Brazil's transportation system make it unique among developing countries.

Brazil's agenda is driven by objectives such as:

- promoting rural development and reducing poverty and inequalities;
- strengthening its leadership in the transitional stage that involves introducing liquid biofuels to the international market;
- furthering its technological development in first- and second-generation biofuels; and
- demonstrating that the development of biofuels is compatible with the objectives of sustainability and environmental conservation.

The countries of South America have approved standards regarding the quantitative role to be played by both bioethanol and biodiesel, while the Central American countries, though their parliaments have not passed biofuels legislation[14], have undertaken a series of projects to strengthen agribusiness and reduce fuel imports, while supporting export—in particular, ethanol exports to the United States in the framework of the US-RD-CAFTA treaty.

[14] At least until June 2007.

1.3 Principal goals of policy designed to replace fossil fuels with biofuels

Motivated by the factors described above, numerous countries have set goals for the replacement of gasoline by bioethanol, and diesel by biodiesel. Table 1 summarises the goals of some countries from the Latin American and Caribbean perspective.

It should be borne in mind that the dynamic nature of the sector could lead to changes in some of these goals in the relatively short term.

The United States goal for 2017 (the Alternative Fuels Standard, or AFS) was approved by Congress in November 2007. This represents an extension of existing legislation (the Renewable Fuels Standard, or RFS), which sets a goal only for 2012. The difference between the two standards is notable, for it implies increasing the volume of alternative fuels by nearly a factor of five in a period of five years. One of the reasons for the new goals is the belief that the incentives of the 2005 Energy Policy Act will lead to considerably more local production capacity for renewable fuels by 2012 than anticipated in the RFS. The AFS is part of the “Twenty in Ten” plan, which seeks to reduce gasoline consumption by 20% in the next 10 years[15].

The European Union’s goals, especially for 2020, set a minimum to be achieved by all of the member countries in replacing gasoline and diesel in the transportation sector. The goals are subject to certain conditions, and it is not yet clear whether these conditions will be met. Specifically, the goals must be achieved in a cost-effective manner, biofuels production must be sustainable, second-generation biofuels must be commercially available, and the Fuel Quality Directive must be modified so as to permit mixture[16]. It should be noted that the European Union was unable to meet its goal of bringing biofuels to constitute 2% of the supply by 2005. The level reached was only 1.2%.

TABLE 1
POLICY GOALS FOR BIOFUELS

Country/Reg.	Bioethanol	Biodiesel
North America		
USA	Renewable Fuels Standard and Alternative Fuels Standard: 28 billion liters of renewable fuels in 2012; 132 billion liters of renewable fuels and alternatives in 2017 (15% of projected use of gasoline by 2017)	
Canada	5% in 2010	2% of renewable content in diesel oil in 2012
Europe		
EU	5.75% by 2010, 8% by 2015 and 10% by 2020 for biofuels replacing diesel oil and gasoline for transportation (energy-based calculation)	

[15] G. Honty and E. Gudynas, “Agrocombustibles y desarrollo sostenible en América Latina y el Caribe”, *Observatorio del desarrollo series*, 2007; “Twenty in Ten: Strengthening America’s Energy Security”, White House Office of Communications, March 2007.

[16] Biomass Action Plan—Communication from the Commission, COM2005 628 final. Presidency Conclusions, 7224/1/07. An EU Strategy for Biofuels—Communication from the Commission, COM2006 34 final.

TABLE 1 (CONCLUSION)

Country/Reg.	Bioethanol	Biodiesel
Asia		
Japan	Replacing 500,000m3 of gasoline for transportation per year by 2010 (1.8 million liters/yr of etanol in the short term, 6 million m3 of etanol produced locally by 2030, representig 10% of current demand for gasolina)	
China	15% of consumption for transp. by 2020	
India	5%by 2012, 10% by 2017	
Oceania		
Australia	350 million liters of biodiesel+bioethanol by 2010	
LAC		
Argentina	5%of final product by 2010	5% of final product by 2010
Bolivia		2.5% as of 2007, until reaching 20% in 2015
Brazil	22% as of 2001	2% by 2008, 5% as of 2013 and 20%by2020
Colombia	10%as of 2006, by region	5% as of 2008
Paraguay	18% minim.	1% in 2007, 3% in 2008, 5% in 2009
Peru	7.8% as of 2006 and gradually, by region	5% as of 2008 and gradually, by region

Source: ECLAC, based on official sources.

(a) Projected biofuels needs

Based on estimated changes in gasoline and diesel consumption, and mixture goals, the demand for bioethanol/ETBE and biodiesel can be estimated (see Tables 1, 2, 3).

(b) Land requirements for achieving the goals

The land requirements for meeting the estimated biofuels demands shown above may place constraints on the feasibility of supplying the needs with local production, and require imports from other regions.

Table 4 shows an estimate of the land areas needed in EU-25, the United States and LAC for local production of the indicated volumes of biofuels, showing their magnitude in relation to total arable land and the amount of land dedicated to major crops in each region.

TABLE 2
TRANSPORTATION DEMAND
(MTOE)

Region / Country	Fuel	2005	2010	2020
USA	Gasoline	363	379	367
	Bioethanol/ETBE	8	11	65
	Diesel Oil	130	138	143
	Bodiesel	0	4	25
EU-25	Gasoline	136	123	109
	Bioethanol/ETBE	0.6	8	12
	Diesel Oil	164	179	230
	Bodiesel	3	11	26

TABLE 2 (CONCLUSION)

Region / Country	Fuel	2005	2010	2020
LAC	Gasoline	69	78	99
	Bioethanol/ETBE	6.9	13	25
	Diesel Oil	64	74	100
	Bodiesel	0	4	11
China	Gasoline	40	47	66
	Bioethanol/ETBE	0.6	2.6	12
	Diesel Oil	37	49	86
	Bodiesel	0	2	15
India	Gasoline	8.5	10.5	15
	Bioethanol/ETBE	0.2	0.3	1.7
	Diesel Oil	22.4	24.9	30
	Bodiesel	0.0	1.0	5.2
Japan	Gasoline	45.5	50.2	58
	Bioethanol/ETBE	0.2	0.3	3.1
	Diesel Oil	27.9	29.3	32
	Bodiesel	0.0	0.0	0.3
World	Gasoline	862.1	918.1	1002
	Bioethanol/ETBE	16.7	34.7	118.0
	Diesel Oil	625.7	703.4	882
	Bodiesel	3.2	21.9	82.5

Source: ECLAC, based on IEA.

TABLE 3
TRANSPORTATION
(% of biofuels as a share of the total)

Region / Country	Fuel	2005	2010	2020
USA	Bioethanol/ETBE	2.2	2.9	15.0
	Biodiesel	0.0	2.9	15.0
EU-25	Bioethanol/ETBE	0.4	5.8	10.0
	Biodiesel	1.8	5.8	1.0
LAC	Bioethanol/ETBE	9.2	14.2	20.0
	Biodiesel	0.0	5.0	10.0
China	Bioethanol/ETBE	1.4	5.1	15.0
	Biodiesel	0.4	3.8	15.0
India	Bioethanol/ETBE	2.3	2.5	10.1
	Biodiesel	0.0	3.7	15.0
Japan	Bioethanol/ETBE	0.4	0.5	5.0
	Biodiesel	0.0	0.0	1.0
World	Bioethanol/ETBE	1.9	3.6	10.5
	Biodiesel	0.5	3.0	8.6

Source: ECLAC, based on IEA.

TABLE 4
LAND REQUIREMENTS FOR BIOFUELS PRODUCTION

a)

Land requirements (EU-25)	2005		2010		2020	
	Etanol	Biodiesel	Etanol	Biodiesel	Etanol	Biodiesel
Average biofuels yield* (L/ha)	4 000	1 300	4 800	1 400	5 900	1 600
Total arable land (millions of hectares	49					
Major-crop land (millions of hectares)	25	4	30	5	29	6
Biofuels land* (millions of hectares)	0,2	2,4	3,1	9,2	4,0	18,7
% biofuels area/total arable area	0,4%	4,9%	6%	19%	8%	38%
% biofuels area/mayor-crop area	1%	60%	10%	183%	14%	312%

Fuente: elaboración propia en base a "Biofuels for transport - an International perspectiva", EA, 2004.

b)

Land requirements (USA)	2005		2010		2020	
	Etanol	Biodiesel	Etanol	Biodiesel	Etanol	Biodiesel
Average biofuels yield* (L/ha)	3 500	600	3 800	600	4 700	700
Total arable land (millions of hectares	133					
Major-crop land (millions of hectares)	30	29	32	31	32	31
Biofuels land* (millions of hectares)	4,6	0	5,9	8,0	27,1	42,1
% biofuels area/total arable area	3%	-	4%	6%	20%	32%
% biofuels area/mayor-crop area	15%	-	18%	26%	-	136%

Fuente: elaboración propia en base a "Biofuels for transport - an International perspectiva", EA, 2004.

c)

Land requirements (LAC)	2005		2010		2020	
	Etanol	Biodiesel	Etanol	Biodiesel	Etanol	Biodiesel
Average biofuels yield* (L/ha)	5 100	600	5 950	700	6 800	2 200
Total arable land (millions of hectares	150					
Major-crop land (millions of hectares)	8,8	41	10,5	49	14,7	69
Biofuels land* (millions of hectares)	2,7	0	4,2	6,5	7,2	5,9
% biofuels area/total arable area	2%	-	3%	4%	5%	4%
% biofuels area/mayor-crop area	30%	-	41%	13%	49%	9%

Source: ECLAC, based on official sources.

These estimates refer to first-generation biofuels with improved per-hectare yields. In all cases, demand is satisfied by local production, and the energy crops are currently appropriate for each region. Excluded are second-generation biofuels (produced, for example, from agricultural residues), since it is still uncertain when they will become commercially available. Thus, it is important to realise that new technologies may substantially change the picture.

The tables present two indicators (biofuels crops as a percentage of total arable land, and biofuels crops as a percentage of land dedicated to major crops) that may portend potential problems in terms of land available for biofuels crops, and competition with other uses such as food growing.

The only one of the three regions capable of supplying its own first-generation biofuels needs is LAC. Both the EU-25 and the United States have significant short-term (2010) and medium-term (2020) problems in these respects (the EU-25 in terms of biodiesel, the United States with regard to both biodiesel and bioethanol).

In 2005, the EU was already using 60% of the land dedicated to major crops for biodiesel production; it would have to triple the amount of land it is using to meet 2020 demand. The United States would encounter problems around 2010 in the context of its new regulations (see

Table 1). It would have to dedicate more than 100% of the current area being used for major crops to biodiesel crops, and close to 85% to ethanol crops.

For LAC, the situation is not quite so severe, partly because of the increase in land under cultivation. Nevertheless, on the order of 9% of arable land will have to be devoted to biofuels crops to satisfy the region's needs, and perhaps as much as 15% if the area devoted to African palm is not significantly increased, making soy the principal biodiesel crop.

By 2010, the portion of EU biodiesel demand that cannot be covered by local production will be equivalent to the entire LAC demand (5 MTOE), and by 2020 the combined United States and EU figure for uncovered demand for biodiesel will be double the entire LAC demand (24 MTOE). Thus, in the absence of major technological developments, both the EU and the United States will probably be importing biofuels from regions such as LAC, significantly increasing demand in the region and affecting the region's rural environment.

(c) Comparative advantages and impact on land use

The comparative advantages of first-generation biofuels in terms of net energy yield ("net" in the sense that it takes account of the entire life cycle of the product) are related primarily to natural resources (temperatures and availability of suitable land and water). Some of these factors could be counterbalanced in one way or another, but the price would be greater energy consumption in the life cycle of the biofuel. This is why two of the highest-yield crops (sugarcane and African palm) are grown in moist tropical climates.

African palm yields 12,030 litres of biodiesel per hectare, as opposed to soy's 426.8, while sugarcane yields 6,800 litres/hectare versus sugar beets' 3,920 and corn's 1,425.6.

In general, energy crops appropriate for the temperate areas in which the industrialised countries are located have lower net energy yields than do those suitable for cultivation in developing countries with tropical and subtropical climates. Two notable exceptions are rapeseed and sugar beets, which can be grown in temperate zones and have good per-hectare yields. For example, the EU obtains a significant portion of its biofuels raw material from these two crops.

Given the amount of land that is occupied in the EU and the United States, the advance of first-generation biofuels will take place at the expense of agriculture, livestock land or idle land.

The EU's potential area includes 8.2 million hectares of idle land and 8.2 million hectares dedicated to non-food crops[17]. This will be insufficient to meet local demand for first-generation biofuels by 2020, which will require production on approximately 23 million hectares.

The United States Department of Agriculture projects a significant increase in the amount of land dedicated to corn (40 million hectares by 2017), largely at the expense of soy, much of which is exported[18]. The increase in corn will be sufficient to meet the domestic ethanol demand in 2020.

In terms of land availability in developing countries, there is debate about which land is actually available for first-generation biofuels crops, and what land should be considered appropriate for the purpose. Ultimately, the debate reflects major differences in views of what impacts are acceptable in association with, for example, the expansion of the agricultural frontier into natural areas, and the displacement of agricultural activity and livestock grazing.

The projected biodiesel deficit circa 2020 in the EU and United States will be equivalent to the output from 31 million hectares in LAC, or double what the region will need to cover its own

[17] Biofuels in Europe, A. Prieur-Vernat, Panorama 2007, IFP, 2007.
[18] Ethanol expansion in the Unites States, USDA, 2007.

demand. In all, this would represent 20% of the region's arable land. These figures could drop to 13 million hectares and 9% of arable land if African palm cultivation becomes widespread. Though estimates of the region's abandoned farmland are not available, it is unlikely that the amount would be sufficient to meet demand. Thus, areas dedicated to other crops and livestock, as well as natural areas, would have to be used, as has already occurred in some of the region's countries.

(d) The outlook from the perspective of international trade

Demand from developed and emerging countries will generate a number of trade opportunities for developing countries. The potential markets for ethanol and biodiesel in 2020 will be in amounts functionally equivalent to 48 million tons of oil, and 35 million tons of oil, respectively.

According to the European Union's Biomass Action Plan, there are three possible import scenarios for the EU: minimum, maximum and balanced[19]. This is because the long-term potential for local production of biofuels in the EU is quite substantial in relation to its needs, if one takes into account new technologies, biomass utilisation and energy crops.

The EU favours the second scenario, in which there is an attempt to balance the impact of fuel prices against the importance of maintaining domestic land-use paradigms. Under this scenario, the EU-25 might import half of its biofuels in 2030, i.e., 12.5% of the amount it consumes for land transportation (45 MTOE)[20].

The imported half of the supply would come primarily from LAC and Southeast Asia. Imports of palm oil from Malaysia and Indonesia in 2005 represented roughly 5% of local biodiesel production. According to some estimates, these countries will supply up to 20% of the EU's needs. However, these imports are being questioned because of the associated deforestation. As regards ethanol, the EU imported 0.25 million cubic meters from Brazil, Pakistan, Guatemala, Ukraine and Peru in 2005.

It should be noted that the EU places technical constraints on the import of soy biodiesel, based, for example, on the amount of iodine, which is a measure of the fuel's stability (resistance to oxidation) and its production of solid deposits. Soy methyl esther (ME) has an iodine index of 133, which falls outside the EU cut-off point of 120.

Due to such issues, the EU's imports of soy biodiesel from countries such as Argentina have, to date, been minimal. This situation gives oil an advantage over biodiesel as an import, which implies a loss of value-added profit for countries producing the raw material. Current exports to the EU are principally in the form of soy oil. The EU's quality standards permit an admixture of up to 10% of soy or palm oil in its own rapeseed oil.

The United States could produce enough ethanol to satisfy its own demand, though this would mean displacing other crops and reducing exports and livestock production. Economic motives could lead the United States to import ethanol from the Caribbean Basin Initiative (CBI) countries, which have tariff advantages over Brazil. Indeed, Costa Rica, El Salvador and Jamaica have already exported ethanol to the United States. For biodiesel production, the United States has imported palm oil from Ecuador.

Brazil's ethanol exports in 2005 totalled 2.6 million cubic meters to India, Japan, the United States, Korea, Jamaica, Costa Rica, Netherlands, Sweden, and other countries. Jamaica and Costa Rica triangulate trade in ethanol to the United States, taking advantage of tariff advantages. Japan is expected to import Brazilian bioethanol to meet its growing demand.

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19 Biofuels in the European Union—A vision for 2030 and beyond, EUR22066 EC.
20 Ibid.

A number of Central American countries (El Salvador, Guatemala, Honduras, Nicaragua, Costa Rica) have plans to export 0.4 million cubic meters of bioethanol by 2010.

Unless there is a technological shift toward second-generation biofuels, China is expected to import half of its ethanol to meet a projected 12 MTOE demand by 2020[21].

Global trade in biofuels will depend on the availability of new technologies, the implementation of standards for the sustainable production of biofuels, and discussions regarding protectionist measures such as tariff barriers. In the medium term, the volume of ethanol imported by the United States, EU-25, Japan and China could nearly double.

TABLE 5
ESTIMATES OF BIOFUELS IMPORTS BY 2020

Reg./Country	Estimated imports for 2020 (MTOE)		Hypothesis
		Biodiesel	
USA	33	13	50% imported[a]
	6	13	50% imported[b]
China	6	8	50% imported[a]
India	0.5	1.6	30% imported
Japan	2.8	0.3	90% imported
Total	47.8	35.3	

Source: ECLAC, based on official sources.
References: [a] Market Evaluation: Fuel Ethanol, Unicamp, 2007.
[b] Biofuels in the European Union—A vision for 2030 and beyond, EUR22066 EC.

1.4 Sustainability of biofuels development targets

The introduction of biofuels requires answering questions such as the following:

- What effect will alternative use of soils for biofuels purposes have on land prices and availability for food production?
- Will it create significant environmental impacts, in particular as regards deforestation and consequent desertification and loss of biodiversity?
- What links are needed in order for rural development to gain from the changes?
- What amount of the value added generated can be appropriated by producers and/or retained by producing countries?
- On balance, does the replacement of fossil fuels represent a net gain in terms of energy and environmental impact[22]?
- Are there options and strategies that are more favourable to sustainability, especially in the poorer countries? To what extent is the biofuels option in competition with natural resources?

These questions and risks have raised numerous concerns about biofuels' contribution to sustainability, especially in less developed countries.

[21] Market Evaluation: Fuel Ethanol, Unicamp, 2007.
[22] "Life cycle" analyses are not conclusive in these contexts (and depend, for example, on the raw materials and processing involved). Runge, F. and Senauer B. "How Biofuels could starve the Poor", Foreign Affairs, June 2007.

(a) Effects on soil use and food security

The opportunities for international trade associated with biofuels will depend on greater availability of land for energy crops, and this will mean making land unavailable for its present uses for food, feed, woods, grazing and conservation[23].

Impact on food security in the short and medium term is essentially related to today's production of liquid biofuels for transportation, which depend almost entirely on raw material from cereals.

Given current technology, the principal types of biomass that can be converted to biofuels in the short and medium term are such "primary" biomass sources as biodiesel crops (sunflower, rapeseed, etc.) and starch and sugar crops for ethanol (corn and sugarcane)[24].

Impact on food security has four dimensions: *availability, access, stability and use*[25]. **Availability** could be threatened as soil, water and other productive sources are removed from food production. Moreover, if fuel production raises the prices of raw materials, as occurred with corn in 2006 and 2007[26], **access** to food could be compromised for lower-income sectors. **Stability** over time could be jeopardised, inasmuch as biofuels prices could be affected by the volatility of oil prices, and such volatility would be transferred directly to agricultural sectors. In other words, stable supply not subject to severe fluctuations cannot be guaranteed. In addition, increases in raw materials prices affects the competitiveness of biofuels. Finally, if biofuels impact the availability of water, this could affect the alternative use of water resources for food crops[27].

Food security is related to under-nutrition and famine, which in turn are related to poverty. FAO estimates that over 850 million people are under-nourished worldwide, and that over 96% of these are in developing countries with annual growth rates of 1.1%, while two thirds of these are children[28]. A further aggravating factor is that the absolute number of hungry individuals has not fallen in the last 15 years. Obviously, famine is concentrated in low-income, grain-importing countries (LIFDCs)[29].

FAO and other institutions[30] also point to the issue of *changes in diet*. "Approximately 30% of the world's grain production is used as livestock feed… One third of projected growth in food demand in the next three decades is expected to be the result of changing diets, with more people consuming more calories from meat and dairy. Shifts to these food sources require more

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23 "The Emerging Biofuels Markets: Regulatory, Trade and Development Implications, UN, 2006.

24 European Environment Agency, EEA/EAS/03/004, 2007.

25 United Nations. Department of Economic and Social Affairs. Commission on Sustainable Development. Fifteenth session, 30 April–11 May 2007; Shell, "The Shell Sustainability Report", 2006.

26 "The flow of immigrants north from Mexico since NAFTA is inextricably linked to the flow of American corn in the opposite direction, a flood of subsidised grain that the Mexican government estimates has thrown two million Mexican farmers and other agricultural workers off the land since the mid-90s." Pollan, M. New York Times Magazine, April 22, 2007.

27 In any case, these phenomena could have positive aspects: increased income for farmers, depending on how the production chain is articulated; expansion of energy services in rural areas, facilitating food availability and access; and freeing of other fuels for other uses and energy services as they are replaced by biofuels.

28 It is estimated that in 2025 there will be 1.2 billion poor people in the world (United Nations. Department of Economic and Social Affairs. Commission on Sustainable Development. Fifteenth session, 30 April–11 May 2007).

29 In many cases, exporters of tropical goods. LIFDCs: "low income food-importing developing countries".

30 FAO, COMMITTEE ON AGRICULTURE Nineteenth Session: BIOENERGY. Item 7 of the Provisional Agenda, Rome, 13-16 April 2005, http://www.fao.org/docrep/meeting/009/j4313e.htm#P31_813; United Nation Convention to Combat Desertification—ICTSD International Centre for Trade and Sustainable Development, "Promoting Sustainable Land Management through Trade: Examining the Linkages between Trade, Livelihoods and Sustainable Land Management in Degraded Areas. A Background Paper", March 2007; UN, op. cit. 2007.

inputs and soil and water resources to feed livestock, thus reducing the availability of such resources for other purposes, or creating greater competition for the resources involved[31].

Encroachment on native forest, tropical forests and fragile ecosystems[32] is one of the major issues. This problem arises with the displacement of livestock operations from soils appropriated for biofuels production, with the consequent shift of livestock operations to more fragile areas and virgin lands, and with resulting damage to habitats, biodiversity, water, air and soil quality.

Also to be avoided are inappropriate agricultural practices involving[33]: impact on soil nutrients, loss of organic matter, the effects of agricultural chemicals and fertilisers, eutrophication[34] of bodies of water, acidification of soil and bodies of water, loss of grass-growing areas, and loss of food for herbivorous animals. Though no global water crises are expected, local crises are occurring in various parts of the planet. Agriculture today uses 70% of the world's available freshwater, primarily to produce food and other products. Much of this is natural rainwater, but three quarters of the crops at risk are in developing countries, which represent approximately 20% of agricultural land and provide 40% of the world's grain production[35]. In terms of water, in addition to the problem of availability, there are issues of access and the institutions that oversee water resources.

(b) Impact on biodiversity

Little is known today about the biodiversity impact of shifting cultivated (or other) land to use for biofuels crops. A number of studies have been conducted regarding small farming areas, but there is little information on the biodiversity impact of such changes in large areas[36]. Thus, only tentative estimates of effects can be hazarded. This, however, is no excuse for uninformed or precipitous action—or inaction.

The development of the biofuels market should provide new stimulus to the growing openness of global agricultural markets.

The potential effects of an increase in international trade in soil-based products may be summarised as:

a) Positive effects in countries that reduce their level of agricultural activity through the implementation of highly technical and specialised systems. The effects of abandoning incentives that have a perverse effect on biodiversity (agricultural subsidies) should, however, be monitored, or their possible implications should be incorporated in comprehensive planning, to prevent changes in soil use that could create problems even greater than those one is attempting to avoid.

b) Negative effects, if producers who "leave the market" move to extensive traditional practices on marginal land that is needed to preserve natural areas with high levels of biodiversity. Keeping protective measures in place for traditional farmers could be a benefit in terms of biodiversity.

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31 UN, op. cit. 2007, p. 33.

32 If the EU's objective of supplying 5.75% of transportation needs through biofuels by 2010 depended on ethanol from corn that would otherwise be used to feed animals, 1.6 million additional hectares of arable land would be needed to replace this corn. Meeting the EU objective would require using between 10% and 30% of Europe's land area for grain production. ("The Shell Sustainability Report", Shell, 2006).

33 United Nations. Department of Economic and Social Affairs. Commission on Sustainable Development. Fifteenth session, 30 April–11 May 2007.

34 In strict ecological discourse, the term eutrophication refers to nutrient enrichment in an ecosystem. More commonly, the term is used to refer specifically to a more or less massive influx of inorganic nutrients into an aquatic system.

35 FAO, Crops and drops: making the best use of water for agriculture, Rome, 2002.

36 Defra Project NF0440, 2007; EEA/EAS, 2005.

c) Expanding agricultural activities in other countries would largely generate effects of the opposite sign. The net effect would depend on (i) changes in, and intensity of, soil use; (ii) the effect and magnitude of income changes and other socioeconomic factors; (iii) the design and implementation of policies in other areas, especially anti-poverty programmes; and (iv) the role and magnitude of technological developments.

d) In agriculture, as in other sectors, regulatory mechanisms become necessary if the environmental and biodiversity impacts of specific inputs, and production technologies are not internalised in the costs of production technologies, specific inputs and other elements that fall under the purview of production decision-makers.

In the cases of sugarcane for bioethanol and soy or palm for biodiesel, the agricultural links of the chain may take the predominant form of monocultures. There are already signs in the region of loss of natural areas, soil and water contamination, and land use imbalances, indicating that these monocultures are moving in a direction opposed to sustainable development[37].

Since clear evidence is not always available before the damage has been done, the "precautionary principle[38]", which has been widely incorporated in international environmental agreements, and subsequently developed in national bodies of legislation, is the appropriate response to such uncertainty.

One of the most notable international actions has been Resolution SCBD/STTM/JM/lj/59120, of the Commission on Biodiversity (July 2007), in response to the XII/7 recommendation by the SBSTTA, requesting the parties to "provide relevant information regarding the impacts that the entire production cycle of biofuels has on biodiversity, and to take these into account". ("Compilation of information on the impacts on biodiversity of the production and use of biofuel[39]").

The words of Achim Steiner, UNEP Executive Director, are appropriate in this context: "Bioenergy offers us an excellent opportunity to address many challenges: climate change, energy security and the development of rural areas. The investments, however, must be carefully planned and managed to avoid new environmental and social problems, some of which could have irreversible consequences. Measures to ensure the sustainability of bioenergy include crops appropriate to the conditions of local ecosystems, good agricultural management practices and development of local markets to provide the dispossessed with modern energy services[40]".

In terms of the rural/agricultural dimension, the role of food-crops farming in GDP, employment and exports (30% of the region's GDP and 40% of exports[41]) continues to be significant. The last few decades have seen a major increase in non-traditional activities (labour-

[37] "Fuel crops in Brazil are generating a great deal of pressure on remaining natural areas in the Cerrado ecoregion, in some parts of the northeast, on the Atlantic coast, and in the Amazon… This is seen with a number of crops that are reducing natural areas and generating a process of ecosystem fragmentation, with negative effects on biodiversity… The expansion of soy is having a major impact in the Cerrado region, where at least 40% of the land is dedicated to agriculture and only 5% has preservation potential. In the state of Mato Grosso alone, which is the centre of Brazil's soy growing, 12,500 square kilometres of forest were lost between 2003 and 2004… The advance of agriculture in Brazil's Cerrado region has largely encroached on land used to graze cattle, pushing cattle raisers to new areas in the tropical Amazon forest… In Paraguay and Bolivia, soy growing has resulted in losses of natural areas and deforestation… Finally, in Argentina there are reports of the advance of soy and other crops into wooded lands in the north and northeast… The pressure on tropical environments is seen in other countries as well. Peru is attempting to promote sugarcane growing in the Amazon region, and Colombia is using Andean valleys and hillsides, as well as land in the Caribbean region." G. Honty, E. Gudynas, "Agrocombustibles y desarrollo sostenible en América Latina y el Caribe", OD, 2007, pp. 14 and 15.

[38] "Guidelines for applying the precautionary principle to Biodiversity conservation and natural resource management", 2006.

[39] This resolution converges with the concern expressed by representatives of various countries at the thirty-ninth meeting of the United Nations Scientific Advisory Body on Biodiversity, where a number of officials demanded that the precautionary principle be applied in the case of biofuels.

[40] United Nations. Department of Economic and Social Affairs. Commission on Sustainable Development. Fifteenth session, 30 April–11 May 2007.

[41] IDB, "Biocombustibles ¿La fórmula mágica para las economías rurales de ALC?, Peter Pfaumann (SDS/RUR), November 2006.

intensive activities, high value-added activities and activities with carry-over effects). However, none of this seems to have been sufficient to reduce rural poverty in most of the countries. Meanwhile, rural homelessness appears to be three times as great as urban homelessness[42].

Biofuels could provide benefits for the population in rural areas if labour-intensive technologies are chosen. In many countries the concentration of land ownership would decline. However, greater demand and higher prices do not necessarily mean better conditions for the members of rural communities. Greater concentration of soils, mechanisation and the accompanying drop in demand for labour, and mere maintenance or even worsening of labour conditions are risks to be taken into account in approaching the development of biofuels[43].

It should be noted, however, that other empirical measurements taken by the Rural Sociology Department of the University of São Paulo, based on census data from the Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatística, or IBGE), have shown positive effects in the agribusiness sector, as compared with other agricultural sectors in Brazil. For example, the level of formal employment in the sugarcane industry rose from 32% in 1985 to 73% in 2005 (Dias de Moraes, 2007), and indicators of stability, wages and education also indicate improvements, with values typically above other agribusiness crops in Brazil[44].

Moreover, the impact of bioethanol and biodiesel may be quite different, since biodiesel can (depending on the raw material used) be produced on smaller scales and employ significant numbers of people.

(c) Effect on national value added

Increased national value added depends on which biofuels development model is used[45]. Job creation, income growth and protection, as well as improved general well-being, will depend on how activities are articulated within the region. A production chain integrated with the region's needs, based on development clusters that maximise impact on regional economies, and designed to meet the region's own biofuels needs, will help increase and retain value added. It will be important to avoid an export-oriented model that requires large areas and functions as an "enclave".

(d) Additional pressure on developing countries with tropical climates

Fuels made from tropically grown crops (sugarcane, palm) are generally more efficient, not only because they are more efficient converters of sunlight into biomass, but also because they are more labour-intensive, less fossil-fuel intensive, and less fertiliser- and pesticide-intensive[46].

The global biofuels industry will naturally increase the demand for raw materials in tropical areas, where yields are higher, production costs are lower, and where there is often less regulatory pressure, and less environmental limitations on crop expansion. This combination of factors could contribute to increasing rates of deforestation and changes in soil use in the ever diminishing tropical forest and jungle areas.

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42 Ibid.

43 The example of improving sugarcane prices without significant effect on rural workers' wages is telling. IDB, 2006, op. cit.; Runge, F. and Senauer B., "How Biofuels could starve the Poor", Foreign Affairs, June 2007.

44 Sugarcane price formation is unusual. The raw material represents approximately 60% of the price of the sugar/alcohol produced. Approximately 60% of the price of sugarcane is due to wages, a markedly different percentage from other energy sectors. Thus, roughly 36% of the value added of the energy production goes to the workers involved in the raw-materials phase of the process.

45 Forum Umwelt & Entwicklung, Global Market for Bioenergy Between Climate Protection and Development Policy, Bonn, 2005.

46 Greenpeace. Bioenergy: opportunities and risks, May 2007.

(e) Energy and environmental balance

Biofuels must demonstrate that their project cycle has a net positive effect in terms of energy, since a significant amount of energy is required in growing, harvesting and processing the crops involved. The amount of GHG produced in the growing[47] and production phases, to say nothing of transportation and the associated fuel use, are also relevant factors. If increased production is achieved through deforestation, the net impact, in terms of emissions, will be even more dramatic[48].

(f) Institutional factors

Recent advances in developing indicators of sustainability attribute special importance to the so-called institutional dimension[49]. An adequate institutional framework is a necessary condition for developing and maintaining a biofuels system that is economically efficient, socially equitable and environment friendly. It is institutions, including legal/political and regulatory frameworks, that produce policy, strategy and action, and thus have an impact on all three planes—economic, social and environmental.

The effectiveness of public policy will require a proper information system, technical capacity, research and development, and reliable monitoring of progress toward meeting objectives.

Institutional structures, legal and regulatory frameworks, and monitoring and control of the distribution of the value added throughout the biofuels production chain, as well as rural producers' location and their share of the ownership of local processing plants, are prerequisites to improving the mix and distribution of benefits.

As we have mentioned, biofuels may have great potential to produce new opportunities for rural areas and reduce rural poverty; however, this depends on how programmes are implemented, since there is a risk that programmes could "lead to land concentration and loss of jobs, if mechanisation increases and input and food prices rise. Thus, the positive effects are neither automatic nor inherent, but depend on how the programmes are designed[50]".

(g) Uncertainties connected with alternative technologies: second-generation biofuels

As will be seen, a number of first-generation technologies have been disseminated and tested —even at the industrial level— and bioethanol and biodiesel have been commercially marketed. There are other alternatives for producing biofuels, especially bioethanol, based on the cellulose from trees, bushes and agricultural residues. For biodiesel, second-generation technology based on the oils from certain types of algae can also be used.

We speak of "second-generation" technologies when the end products are the so-called advanced biofuels, such as those produced by the Fischer-Tropsch reaction, biomethanol, biohydrogen, singas, bioethanol from cellulose, and biodiesel from algae.

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47 This is particularly important for soy, for example, since it emits a great deal of nitrous oxide in the course of its growth. In Argentina, it has become the third largest source of such emissions, with energy and livestock being first and second, respectively.

48 Each hectare destroyed in Brazil represents 500 tons of CO2 emissions. It could take decades, or even centuries, for the lower emissions associated with biofuels to compensate for the destruction of woodland. Greenpeace. Bioenergy: opportunities and risks, May 2007.

49 Indicators for sustainable energy development: An initiative by the International Atomic Energy Agency. I.A. Vera, L.M. Langlois, H.H. Rogner, A.I. Jalal and F L. Toth, 2005.

50 IDB, 2006, op. cit.

These biofuels are not yet being produced commercially on a large scale, but offer an alternative or complementary technological route. Here, we deal only with bioethanol from cellulose, and biodiesel from algae.

(a) Bioethanol from cellulose

Available information indicates that, on balance, the energy impact of producing bioethanol from cellulose is positive. A ratio of 1.98 units of energy produced per unit of energy employed in the process is cited. It is said that to produce 50 million gallons of biomass bioethanol from cellulose on an annual basis in the United States, residues would be sufficient to provide only 40% to 50% of the raw material, while the rest would need to come from energy crops, the plantations of which would have a major impact on the country's agricultural system. Higher levels would seriously affect the cost of agricultural land and generate major competition for land between biofuels and food farming.

A report by the National Resources Defence Council entitled "Growing Energy[51]" provides information on the amount of bioethanol produced per ton of dry biomass and per hectare. Producing 165 billion gallons of bioethanol in the United States would require 116 million hectares of energy plantations (switch grass), and this would surely impact food and feed production and prices, since it would involve 27% of the country's agricultural land. The bioethanol obtained from cellulose would cost almost double that obtained from sugarcane.

Switch grass is the most researched and accepted energy crop. It is a perennial grass native to the United States that is easily cultivated, requiring little nitrogen fertiliser. It takes several years to ripen, and harvests can be as large as 20 tons per hectare. If rainfall is unfavourable, however, there could be no harvest at all.

The Logen Corporation, based in Ottawa, Canada, pioneered the process for obtaining bioethanol from cellulose (April 2004), and has built the first demonstration plant, which produces 40 tons of wheat chaff per day.

In summary, this second-generation technology is still in the development stage, particularly with regard to the microbiological processes involved, and cannot be expected to be commercially available for another 10 years.

(b) Biodiesel from algae[52]

This technology has been demonstrated in the laboratory and in small open-air pools (up to 1,000 square meters). It still remains to implement prototypes of larger areas, as a step toward studying commercial feasibility.

The process takes advantage of two notable aspects of certain varieties of microalgae: their high photosynthetic efficiency in comparison with land plants, which allows them to store a greater amount of solar energy as chemical energy, and a high percentage of lipids usable for the production of biodiesel.

The approaches that have been tested for mass production of this oil involve growing the algae in large, shallow pools with constantly circulating water driven by paddles or other mechanisms. CO2 is put into the water as food, and is transformed into biomass with the use of solar energy.

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[51] See NRDC, "Growing Energy. How biofuels can help end America's oil dependence." December 2004.

[52] Biodiesel from Algae, NREL, 1997. Benemann, J.R., Van Olst, J.C., Massingill, M.J., Weissman, J. C., Brune, D. E., "The Controlled Eutrophication Process: Using Microalgae for CO2 Utilisation and Agricultural Recycling." http/www.unh.edu/p2/biodiesel.

Of the resources needed to make the process work, the most intensive consumption is of brackish, fresh or waste water, large flat areas, low-cost CO2 (e.g., from a nearby thermoelectric plant), solar energy, nitrogen and potassium. The crop tends to use less water than conventional crops with irrigation.

There seem to be no major technical barriers to production, but there is uncertainty as to the economic feasibility of large-scale production, which depends greatly on elements such as productivity in large open-air environments, engineering design and implementation factors, the value of the product and by-products, and credits for mitigation of GHG emissions. Though microalgae's high yield has been demonstrated in laboratory conditions, a number of factors remain to be explored: the technology's competitiveness when used on a large scale; resistance to predators and competition with wild algae in less controlled settings; the effectiveness of systems to mix the CO2 in the water and the effectiveness of the hydraulic design; the impact of fluctuations in wind, light and temperature; and the feasibility of the harvesting process.

Productivity for different types of algae and growing conditions ranges from volumes of 15g/m2/day to 40g/m2/day. The lipid content can vary between 16% and 50% of the dry weight of the algae. Thus, productivity, in terms of lipids obtained in open-air pools, is between 5g/m2/day and 9g/m2/day during the growing season. Assuming an average annual lipid production of 5g/m2/day, some 20m3/hectare/year of oil could be obtained. United States estimates indicate a theoretical maximum yield of 140m3/hectare/year, and an average feasible yield of 47m3/hectare/year. Low temperatures reduce the productivity of the algae (with minimum yields at around 3g/m2/day of algae recorded in the middle of winter in regions with frost), but the lipid content could be greater. Efficiencies in the utilisation of CO2 of close to 90% have been achieved.

In terms of cost, estimates indicate that biodiesel from algae would cost between US$ 60/bbl and US$ 150/bbl (in 2006 dollars), with productivity figures ranging from 20m3/hectare/year to 47m3/hectares/year (with investment costs of US$ 45,000/hectare and operation and maintenance costs of US$ 13,000/hectare/year at 7% over 15 years). The infrastructure for supplying water and CO2 could have a major impact on total investment costs. Thus, the productivity obtained in large-scale open-air prototypes will determine the ultimate commercial viability of growing algae for biodiesel production.

Finally, it should be borne in mind that systems have been developed to obtain high value added products and by-products in closed photobioreactors under much more controlled conditions. However, this line of development still faces the challenge of reducing the high investment cost and of achieving high productivity.

1.5 Second-generation biofuels in Latin America and the Caribbean

Up-to-date information on the potential production of biomass from agricultural, forestry and agribusiness residues is not available. Massive use of such material from agricultural and forestry activity would have an impact on the availability of natural fertilisers and micronutrients, which would have to be replaced by chemical products in agriculture, and there could be problems for biodiversity in the undergrowth of wooded ecosystems.

The spatial dispersion of this biomass would generate additional collection costs, especially if factories were built on a scale designed for the bioethanol markets of the developed countries.

In the case of agribusiness waste, there would be competition with energy supplies for the industrial establishments themselves, and with other industrial processes such as paper production. For these reasons, it has been assumed that cellulose will be taken from switch grass plantations.

Projections for the year 2020 regarding the market for gasoline to be mixed with bioethanol are based on high amounts of bioethanol in the mix (e.g., 23%[53]). Under these assumptions, the impact of switch grass cultivation on arable land would be very low in all of the countries.

The advantages of this means of obtaining bioethanol, however, must be weighed against the technological dependence involved in obtaining the enzymes and other microorganisms that are essential for the conversion process to work, to say nothing of process controls and equipment for the factories.

1.6 Principal conclusions and questions regarding the global biofuels outlook

This chapter has described the many opportunities that the global biofuels market represents: new markets and increasing international trade for countries that can produce significant export volumes; opportunities for countries with negative energy trade balances, especially in terms of fossil fuels, to reduce their energy dependency and increase the security of their energy supply; new and greater opportunities for rural development, and for the creation of a production chain downstream of primary activity that increases value added, creates jobs and opens up new technological niches; reduction and mitigation of environmental impacts; and even reduced vulnerability to, and improved adaptability to, climate change.

We have emphasised, however, that achieving actual benefits from these opportunities depends on policy decisions, as well as on the presence of institutional, regulatory, economic, financial, social and environmental strategies that make it possible to manage the risks and uncertainties associated with the development of liquid biofuels.

Finally, how should Latin America's strategies and plans prepare for second-generation biofuels?

Exploring these questions is essential if biofuels policy is to be built upon a solid, informed foundation.

53 The amount of switch grass-growing land needed to produce the cellulose biomass, as well as the figures on bioethanol yield from that biomass, are taken from Nathanael Greene, "How Biofuels Can Help End America's Oil Dependence", Natural Resources Defence Council, Growing Energy, July 2005. This study cites figures of 11.17 tons of dry biomass per hectare, and 208.9 litres of bioethanol per ton of dry biomass.

Chapter II

Biofuels as part of energy policy

It is clear that OECD goals for biofuels—in terms of the proportion of fuel used in the transportation sector—cannot be reached through local production, and while many programmes are justified based on their ability to improve or maintain rural conditions or as a response to pressures on such sectors, the proposals have been driven principally by energy and environmental concerns. As one of the main players in the provision of raw materials (oils and more highly processed products such as ethanol and biodiesel), the Latin American and Caribbean region can be expected to experience strong positive impacts in terms of international trade.

Major actors believe that the region's role offers opportunities to strengthen South-South cooperation, through approaches such as tripartite activities encompassing Africa, Central America and the Caribbean, in which the technology provided by South America can be combined with the favourable climatic conditions and soils of other regions. Such opportunities depend on greater openness in OECD markets, with the elimination of agricultural subsidies and of barriers to the importation of biofuels.

In terms of global biofuels geopolitics, the OECD and China constitute the greatest sources of demand, while Africa, India, and Latin America and the Caribbean (LAC) are potential suppliers. With regard to biodiesel, oil-rich plants will continue to play an important role in the medium and long term, with Latin America enjoying a clear advantage in this field.

The countries' strategic alternatives call for an assessment of three options: establishing links with the international market, through exports; producing oil products substitutes for the domestic market; and a combination of these two approaches.

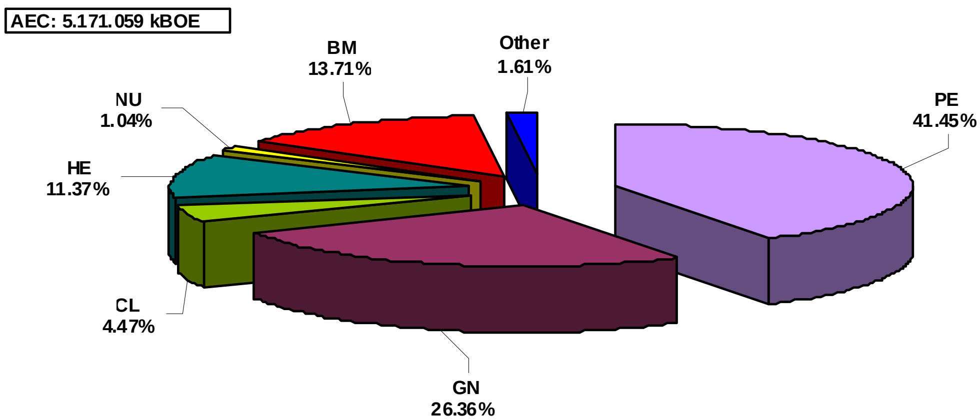
There are opportunities for increased international trade, with the region holding great natural potential. In order to determine which countries can best establish links with the international market, which are best positioned to take advantage of the domestic market, and which might not find it feasible to make use of the local market, a better understanding of the potentials and risks associated with the different alternatives is required. Gaining such an understanding is, therefore, the primary objective of this chapter.

2.1 Brief overview of the region's energy situation

It is beyond the scope of the this paper to provide an exhaustive description of the region's energy situation. Thus, it will touch only on those aspects that are helpful in categorising the region's countries—one step in attempting to place the discussion within the context of biofuels policy.

LAC represents nearly 5% of apparent world energy consumption[54]. Figure 6 shows the make-up of apparent consumption, according to primary energy source, for the region in 2005.

FIGURE 6
LATIN AMERICA AND THE CARIBBEAN: APPARENT ENERGY CONSUMPTION BY SOURCE (%) 2005



Source: Energy Statistics Report: OLADE 2005.

As the figure indicates, the region as a whole is heavily dependent (67.8%) on fossil fuels–more so, indeed, than the world average (65.6%). The same is true of the roles of hydroelectric power and biomass energy in the region. On the other hand, the region is less dependent on nuclear energy and coal than is the world at large (at 6.5% and 24.4%, respectively). Stated simply, the region is dependent on oil.

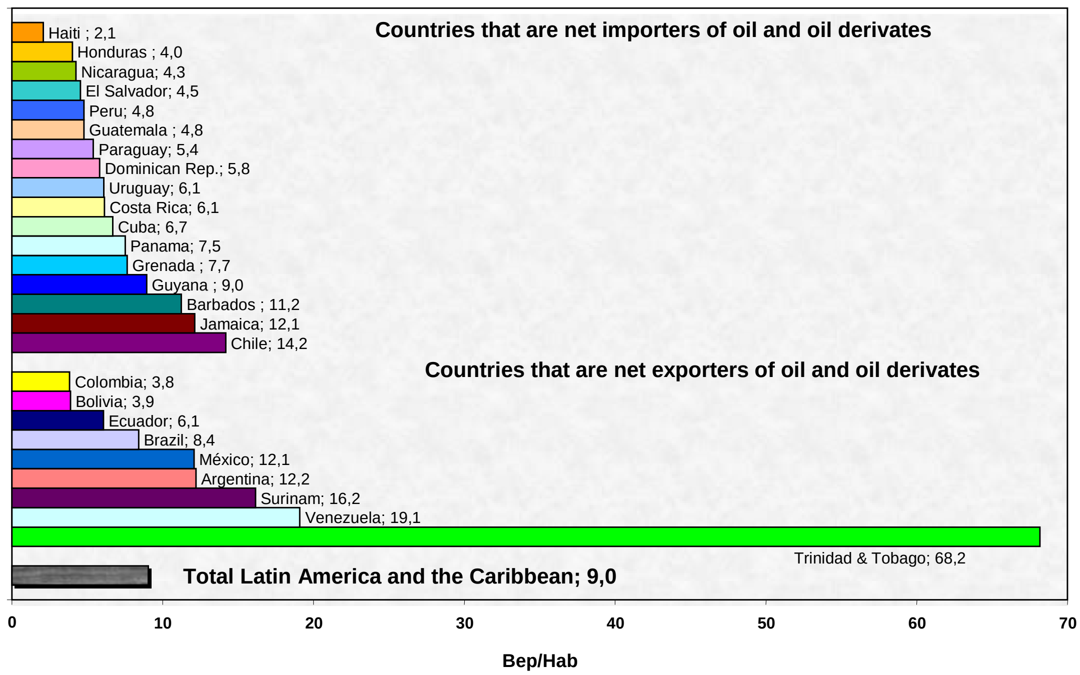
The above suggests an initial energy-based categorisation of the countries: countries that are net importers of oil and oil derivatives (the majority of the countries), and those that are net exporters (the minority).

Examining parameters for each of the countries, Figure 7 reveals a notable inequality in terms of total per capita energy supply. Such inequality would be even more pronounced if this indicator were stratified by income level within each country.

In general, the highest per capita values are for net oil exporters, with half of the countries being above the average for the region. On the other hand, 14 of the 17 net oil importing countries fall below the average, which is 9 BOE/person.

[54] Apparent energy, expressed in terms of primary energies, equals output plus imports, minus exports, plus or minus changes in stocks.

FIGURE 7
LATIN AMERICA AND THE CARIBBEAN: TOTAL PER CAPITA ENERGY SUPPLY - 2005
(Boe/person)



Source: Energy Statistics Report: OLADE 2005.
Population: ECLAC Statistical Yearbook for Latin America and the Caribbean 2005.

Table 6 includes selected energy indicators, on the basis of which the following may be noted:

- Seven countries, all net oil importers—generally the region's poorest countries, in which wood plays a role in final energy consumption55—are situated above the 30% mark.
- The net oil importing countries are totally dependent on imported oil, except for four countries which, in addition to importing it, produce it.
- Of the net exporters, two countries are net exporters by only a small margin. One is Brazil, which is on the verge of reaching total self-sufficiency; the other is Bolivia, which imports significant volumes of oil products, especially diesel fuel.
- From the biofuels perspective, consumption in the transportation sector is of particular interest, and within this sector, as might be expected, almost all energy is drawn from oil derivatives.
- Gasoline consumption represents the major portion of the potential ethanol market.
- Note that in considering gasoline to be 100% replaceable by substitutes, one assumes the use of hydrated alcohol, which requires vehicles with specially designed motors. If one considers only anhydrous alcohol, which can be mixed with gasoline and used

[55] Final energy consumption is consumption by the socioeconomic sectors, and is regarded as energy consumption plus non-energy consumption.

in normal gasoline-powered engines, the potential market declines in proportion to the percentage of bioethanol in the mix.

- The total consumption of diesel fuel in transportation is increasing in almost all of the countries, and must be imported in many. A certain portion of this amount could be replaced by biodiesel.

2.2 The contribution of biofuels to sustainable energy policies

This section offers a conceptual framework for examining and evaluating biofuels policy in the region's countries. The first step is to describe the production chains that will most commonly be needed to produce biofuels.

Second, it is important to examine the nature of sustainable development as a concept, and to describe the factors relevant to making it a reality. Thus, the present paper draws on ideas set forth in the ECLAC/OLADE/GTZ publication, "Energy and Sustainable Development in Latin America and the Caribbean. Guide for Energy Policymaking[56]."

Third, this section proposes constructing a scheme that brings together a set of relevant "elements" to analyse the impact of biofuels policy on the sustainability of development. It is therefore essential to identify such elements, since the multiple issues involved in biofuels and the relationship between biofuels and sustainability parameters must be explored.

Fourth, it is important to examine the criteria to be used in identifying stylised situations representative of the most important biofuels policy issues—i.e., a series of stylised situations for bioethanol and biodiesel.

(a) Biofuels production chains

A production chain constitutes a subsystem of the productive apparatus comprised of processes connected by input-product relationships, which are affected by the characteristics of relevant markets and by the factors influencing the provision of inputs and capital assets and/or technology.

Consequently, describing biofuels production chains requires an examination of primary production processes in the agriculture/forestry sector, processing of primary products in the agribusiness sector, and the mix and distribution involved in industrial and service activities. All of the relevant buying/selling markets for the products and inputs involved in each of these processes, as well as in the provision of technology and capital goods, must also be examined.

The description must also separate bioethanol and biodiesel, since the two are different—principally in terms of the primary link of the chain—due to the crops and industrial processes involved in each.

By way of example, Figures 1, 2 and 3 show the production chains for bioethanol (beginning with sugarcane and corn as raw materials) and biodiesel (with soy as the raw material).

The sugarcane-based bioethanol production chain offers an alternative option to sugar[57] or alcohol production (with the relative role of the latter two activities depending on

[56] ECLAC, OLADE, GTZ, Santiago, Chile, 2003.

[57] Besides Brazil's experience and technological development in the sugarcane industry, particularly in agronomy, Colombia, Costa Rica and Guatemala have traditional research institutions with significant and regular output, since improving varieties is a matter of highly local specificity. For the same reason, endogenous development is important in situations where biofuels are being promoted.

circumstantial factors). Brazil, with its automobile industry, also has the flexibility of producing flex-fuel vehicles capable of running on either a mixture of gasoline and anhydrous alcohol or pure hydrated alcohol.

In the case of bioethanol production, the industrial links of the chain are usually close to primary production areas (especially when sugarcane is the raw material), and the technology employed depends on an extremely large scale of operation and control over the primary link of the chain[58]. Thus, it is important to analyse the effects that concentration and control over the primary links may have on the value chain.

In general—at least, where first-generation fuels are concerned—the technologies used in the industrial phases of the process are known. However, in terms of the provision of equipment, given the scales of production involved, there may be a difference (especially for bioethanol production) between the larger countries that can produce domestically, and smaller countries that must rely on importation.

In this respect, the situation is different for biodiesel, since the vegetable oil industry can operate with plants of any size, thus making medium-sized cooperative organisation viable.

[58] In Brazil, 70% of the area cultivated is controlled by 340 mills, while the other 30% is in the hands of some 60,000 small and medium-sized producers (Rothkopf, G. "A blueprint for green energy in the Americas." (Inter-American Development Bank, Washington, D.C. 2007)

TABLE 6
LATIN AMERICA AND THE CARIBBEAN: ENERGY INDICATORS 2005

Net oil and oil-derivatives importing countries	Final energy consump-tion	Wood as a share of final energy consumption	Oil as a share of final energy consumption	Imported oil as a share of total oil supply	Net oil imports	Consumption by the transportation sector	Oil as a share of consumption by the transportation sector	Gasoline consumption for transporta-tion	CNG or VNG consump-tion for transporta-tion	LPG consumption for transportation	Ethanol consumption for transportation	Potential bioethanol market(*)	Diesel oil consumption for transporta-tion	Total electricity coverage
	kBOE	kBOE	(%)	(%)	kBOE	kBOE	(%)	kBOE	kBOE	kBOE	kBOE	kBOE	kBOE	(%)
Barbados (2)	2 026.0	0.0	54.3	100.0	1 999.0	940.0	100.0	724.0				724.0	216.0	95.0
Chile	155 639.0	18.6	46.1	88.0	89 121.0	57 098.0	98.9	17 036.0	255.0	5.0		17 296.0	25 602.0	96.8
Costa Rica	22 204.0	9.5	55.9	100.0	13 793.0	10 572.0	95.9	4 173.0		19.0	401.0	4 593.0	5 757.0	98.1
Cuba	60 813.0	2.3	35.1	62.9	35 938.0	12 227.0	97.5	3 818.0		3.0	242.0	4 063.0	5 757.0	95.5
El Salvador	24 152.0	35.1	35.5	100.0	13 378.0	7 487.0	100.0	3 321.0				3 321.0	3 597.0	84.0
Grenada (1)	490.0	7.1	71.8	100.0	563.0	259.0	98.5	199.0				199.0	19.0	82.0
Guatemala (2)	52 680.0	45.5	33.1	71.1	16 454.0	12 653.0	100.0	6 093.0		132.0		6 225.0	6 151.0	84.0
Guyana (1)	5 484.0	31.8	39.8	100.0	3 660.0	1 109.0	100.0	596.0				596.0	322.0	82.0
Haiti(1)	16 818.0	62.6	26.2	100.0	4 910.0	2 961.0	100.0	1 647.0				1 647.0	1 134.0	34.0
Honduras (1)	24 278.0	41.0	39.2	100.0	14 041.0	5 009.0	100.0	2 035.0				2 035.0	2 961.0	67.0
Jamaica	29 091.0	0.5	46.3	100.0	30 105.0	8 612.0	99.5	4 093.0				4 093.0	2 604.0	93.0
Nicaragua	18 156.0	58.6	26.1	100.0	8 890.0	3 424.0	100.0	1 297.0				1 297.0	1 996.0	55.2
Panama	21 570.0	17.8	45.9	100.0	11 708.0	7 818.0	100.0	3 049.0				3 049.0	2 521.0	83.0
Paraguay	26 119.0	37.5	27.9	100.0	7 144.0	7 117.0	96.0	1 023.0		120.0	165.0	1 308.0	5 685.0	93.2
Peru	98 351.0	12.5	57.6	47.7	24 787.0	33 874.0	99.4	9 799.0		199.0		9 998.0	22 287.0	78.1
Dominican Republic	38 837.0	12.6	45.8	100.0	35 470.0	13 834.0	86.0	7 093.0		1 930.0		9 023.0	3 812.0	92.3
Uruguay	16 846.0	17.1	47.3	100.0	11 056.0	5 340.0	100.0	1 540.0				1 540.0	3 790.0	98.0

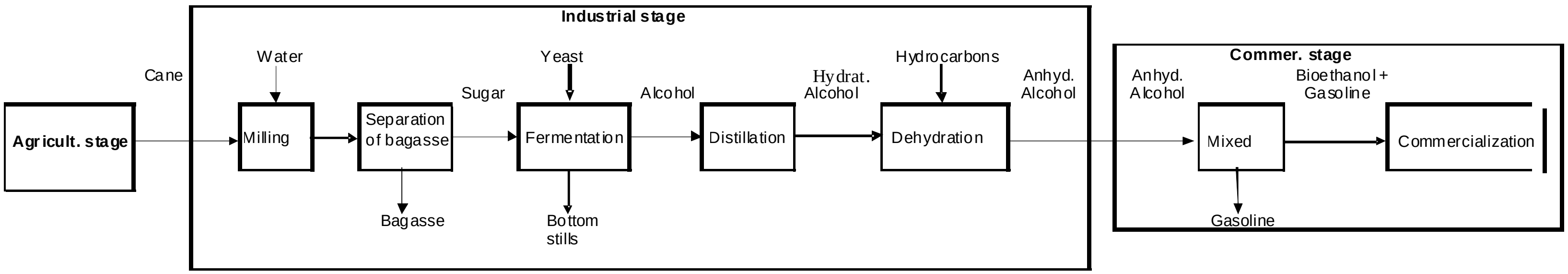
Net oil and oil-derivatives exporting countries	Final energy consumption	Wood as a share of final energy consumption	Oil as a share of final energy consumption	Exported oil as a share of oil production	Net oil imports	Consumption by the transportation sector	Oil as a share of consumption by the transportation sector	Gasoline consumption for transportation	CNG or VNG consump-tion for transporta-tion	LPG consumption for transportation	Ethanol consumption for transportation	Potential bioethanol market	Diesel oil consumption for transportation	Total electrical coverage
	kBOE	kBOE	(%)	(%)	kBOE	kBOE	(%)	kBOE	kBOE	kBOE	kBOE	kBOE	kBOE	(%)
Argentina	334 284.0	0.4	34.0	36.0	88 119.0	94 429.0	79.5	23 070.0	18 946.0			42 016.0	49 003.0	95.0
Bolivia	24 580.0	9.1	33.2	7.3	1 121.0	8 561.0	95.1	3 035.0	800.0			3 835.0	3 784.0	67.1
Brazil	1 283 384.0	9.0	34.5	1.7	10 650.0	376 420.0	83.7	75 324.0	12 329.0		73 000.0	160 653.0	190 801.0	97.0
Colombia	166 148.0	7.2	39.2	72.9	139 149.0	56 709.0	94.3	24 602.0	1 907.0		2 190.0	28 699.0	22 106.0	90.9
Ecuador	58 986.0	2.7	69.2	67.0	133 949.0	30 782.0	100.0	11 475.0				11 475.0	17 009.0	89.7
Mexico	1 230 035.0	3.5	32.5	54.0	623 796.0	320 809.0	96.7	205 804.0	128.0	10 022.0		215 954.0	84 452.0	96.0
Surinam	4 586.0	7.4	36.7	22.4	2 163.0	1 019.0	100.0	554.0				554.0	287.0	97.0
Trinidad and Tobago(3)	71 672.0	0.0	7.0	70.5	33 018.0	4 533.0	100.0	2 832.0				2 832.0	1 627.0	92.0
Venezuela	297 000.0	0.0	42.3	88.5	1 075 876.0	107 154.0	106 318.0	83 652.0	838.0			84 490.0	17 779.0	97.0

	Final Energy Consumption	Wood as a share of final energy consumption	Oil as a share of final energy consumption	Exported oil as a share of oil production	Net oil imports	Consumption by the transportation sector	Oil as a share of consumption by the transportation sector	Gasoline consumption for transportation	CNG or VNG consumption for transportation	LPG consumption for transportation	Ethanol consumption for transportation	Potential bioethanol market	Diesel oil consumption for transportation	Total electrical coverage
	kBOE	kBOE	(%)	(%)	kBOE	kBOE	(%)	kBOE	kBOE	kBOE	kBOE	kBOE	kBOE	(%)
Total Latin America and the Caribbean	4 082 663.0	7.5	37.5	48.0	1 794 845.0	1 189 530.0	95.7	497 298.0	35 203.0	12 429.0	75 998.0	620 928.0	479 063.0	91.9

Source: Energy Statistics Report:: OLADE 2005.

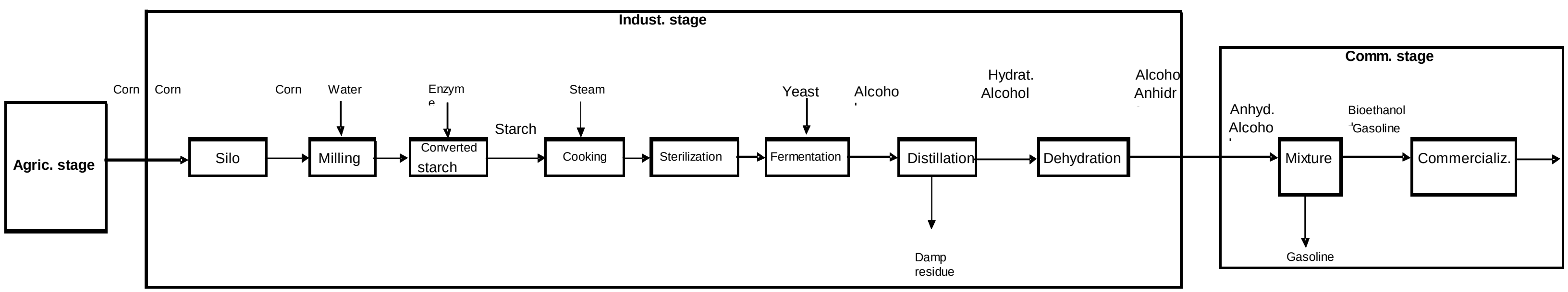
(*) Potential market is considered to be the sum of consumption indicated in the four previous columns; it should be noted that bioethanol could account for 100% only in the case of hydrated alcohol, whose use requires vehicle engines specially designed for this fuel. In the case of anhydrous alcohol, the mix with oil products would have upper limits.

DIAGRAM 1
SUGARCANE-BASED BIOETHANOL PRODUCTION CHAIN



Source: Author.

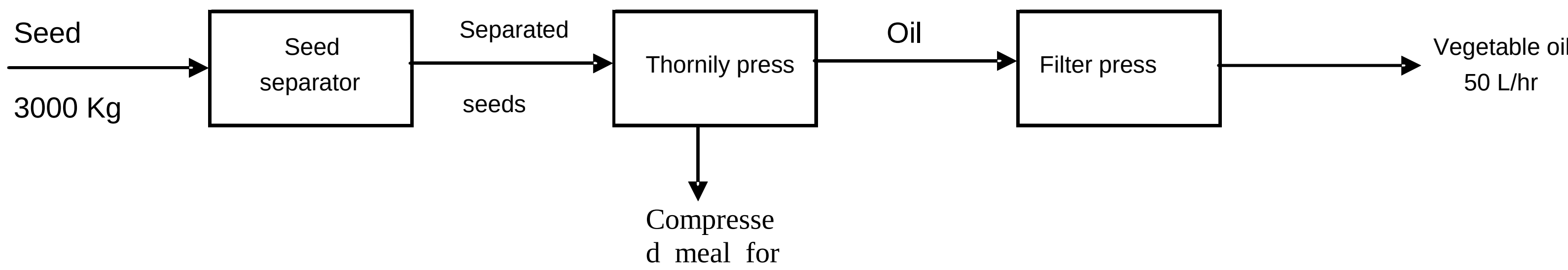
DIAGRAM 2
SIMPLIFIED CORN-BASED BIOETHANOL PRODUCTION CHAIN



Source: Author.

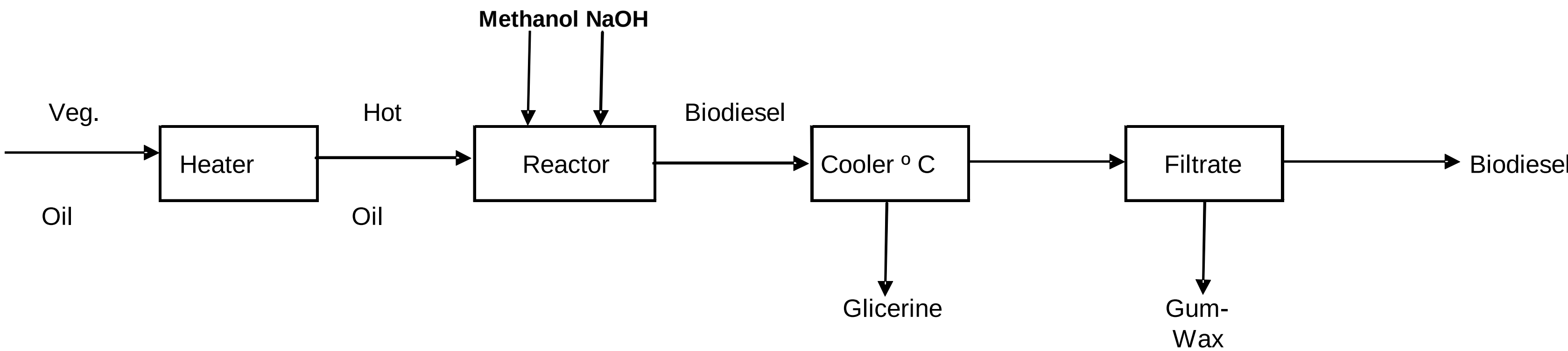
DIAGRAM 3
SOY-BASED BIODIESEL PRODUCTION CHAIN

A – Industrial oil production stage



Source: Author.

B. Biodiesel production stage



Source: Author.

(b) The dimensions of sustainable development

The term "sustainable development" refers to the dynamic of a complex system with multiple facets, one that can be difficult to grasp in its totality. Thus, any attempt to apply the term "sustainable" to a particular approach to socioeconomic/environmental development is somewhat arbitrary and generally reflects value judgments[59].

The Latin American and Caribbean Commission on Development and Environment[60] found it important to emphasise distributive factors in characterising sustainable development processes as those "which distribute the benefits of economic growth in a more equitable manner, which avoid a high level of environmental deterioration and which truly improve the quality of life—not only the per capita income level—of present and future generations[61]."

The OLADE/ECLAC/GTZ perspective, as reflected in the "Energy and Sustainable Development in LAC" project[62], is that human beings should be the active subjects and ultimate targets of development, and that human development is therefore central to sustainability—a notion that leads to the concept of human development set forth in the annual reports of the United Nations Development Programme (UNDP)[63] as an approximation to the idea of sustainable development.

Based on this definition, there has been an attempt to deduce what dimensions support sustainable development[64]:

The dimensions in question (economic, social, environmental and political) are closely related, and interact dynamically in the overall reality of a particular socioeconomic system. Thus, for example, the skills of a labour force have a decisive influence on the production process. However, these skills depend, in a vital way, on the population's extent of formal schooling, which is a social factor. Similarly, improving a population's quality of life depends on a country's rate of economic growth and the distribution of the fruits of that growth. It is also clear that equitable distribution of the social product reduces conflict, improving the conditions for governance.

On the economic dimension, sustainability is related to the possibility of sustaining growth in the future. Naturally, every economic system changes its form of accumulation over time. (In particular, there are changes in which certain sectors take the lead in growth, in the technological configuration that characterises the productive system, and in the ways in which a system is linked with the world economy.) However, every type of accumulation has a set of basic features, thus permitting a glimpse of its future viability, given reigning contextual conditions and their expected evolution. It is also clear that the availability of resources (natural

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59 In 1987, the World Commission on the Environment and Development (WCED) defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, "Our Common Future", Oxford University Press, Oxford, 1987). This very general definition, however, does not specify under what equity criterion the needs of the present are to be met, nor how resources should be managed to achieve the objective of not compromising the ability of future generations to satisfy their needs.

60 Jointly sponsored by the Inter-American Development Bank (IDB) and the United Nations Development Program (UNDP), with support from ECLAC and the United Nations Environment Programme (UNEP).

61 "Our Own Agenda", Washington D.C., 1990.

62 OLADE/ECLAC/GTZ, "Energy and Sustainable Development in Latin America and the Caribbean. Approaches to Energy Policy", Quito, May 1997.

63 According to UNDP, human development is conceived as "the process of enlarging people's choices, providing them greater opportunities for education, medical care, income and employment, and addressing the full spectrum of human options, from a good physical environment to economic and political freedoms" (UNDP, Human Development Report 1992, published for UNDP, Bogota, 1992, p. 18.

64 ECLAC, OLADE, GTZ, "Energy and Sustainable Development in Latin America and the Caribbean. Guide for Energy Policymaking", Santiago, Chile, 2003, pp. 29-33.

resources, human resources—including the skills of the labour force—and productive equipment and facilities) is a determining factor in the potential for growth.

On the social dimension, attention must be focused on factors associated with the quality of life. In general terms, however, in a given social/cultural context, it is clear that family income levels are the principal determinant of a population's quality of life, though a country's social policy is, of course, also an important factor.

The environmental dimension includes the wide range of elements making up the natural surroundings. Certain features of these elements are important to highlight. One is the fact that the non-reproducibility of these elements, as original resources, implies the irreversibility of changes produced in them as a result of society's production and consumption. In addition, the natural system's response to such changes in many cases creates a high level of uncertainty (unexpected consequences), creating, in turn, major difficulties in assessing the effects of human activity on the environment. A significant number of the elements making up the biosphere are "common", global or social property. This suggests the need to consider the presence of externalities[65], whose social and private costs and environmental impacts may lead to inefficient allocation of resources, and to difficulty in implementing proposals (taxes and subsidies, or the creation of markets that do not yet exist). Thus, the presence of externalities can lead to inequitable distributive effects.

On the political dimension, sustainable development is linked to governance and to conditions that ensure respect for human rights. In principle, the existence of democratic systems of government based on effective participation and representation for a society's various groups would appear to be one of the best means of achieving sustainability on the political plane. Important in this respect is the development of strong governmental institutions.

Thus, using a set of indicators that relate to the dimensions cited above, it is possible to evaluate progress (or lack thereof) on each individual dimension. In the case of public policy, in particular, it is important to examine the potential impact of specific policies (objectives, goals, strategies, instruments and actions or programmes) by establishing indicators that make it possible to identify the contribution that given policies are making to sustainability in development.

2.3 Analysis of biofuels policy through the various dimensions of sustainable development

For this task, one must examine the issue from multiple perspectives—ones that do not always translate easily into indicators capable of providing an overall view of the different situations. This dilemma gives rise to the concept of "elements" of analysis linked with the various areas of sustainable development. Figure 8 shows in schematic form the elements considered most relevant to the assessment of biofuels policy.

Within the *Economic Dimension,* the following elements or axes of analysis are crucial:

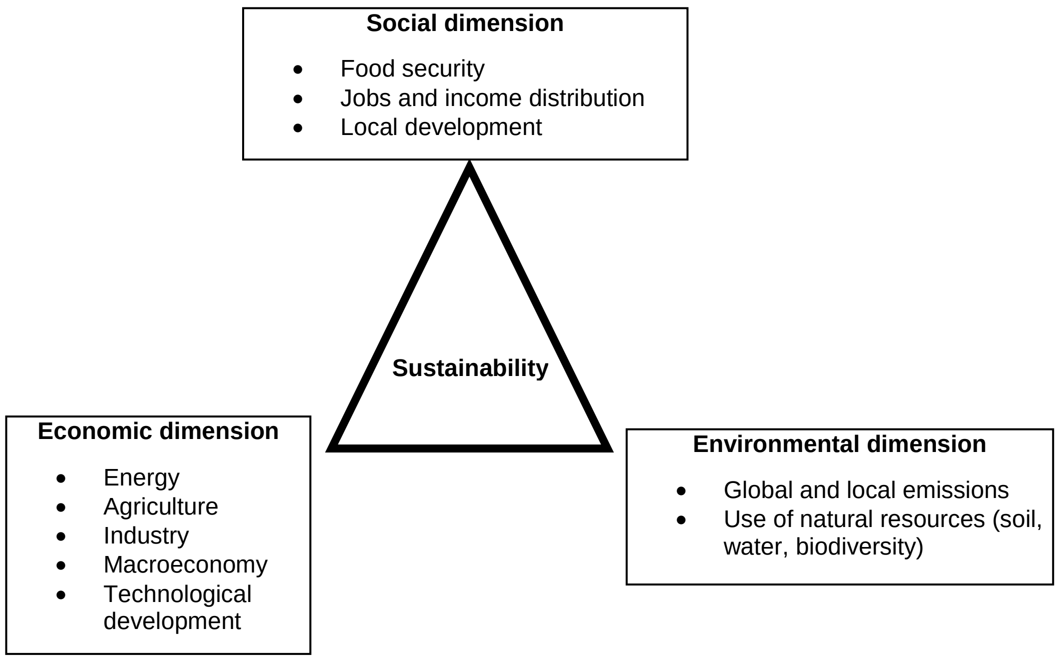
- Energy

Biofuels' contribution to the sustainability of national energy systems must be analysed. Thus, we examine the contribution that biofuels make to self rule, secure supply, diversification of the energy matrix and energy conservation. The latter, however, will only occur to the extent to which the energy used in production processes, including the production of inputs, is less than the energy contained in the biofuels obtained. The results will, of course, vary according to the agricultural raw materials used, the organisation of production, and the by-products (and their

65 And of "public goods".

use) produced by the industrial processes involved. There is ongoing debate regarding the ultimate balance, in energy terms, resulting from biofuels, and highly divergent positions on this issue exist. However, what remains clear is that this is one of the most important aspects of energy sustainability, and that specific policies on this merit close attention[66].

FIGURE 8
DIMENSIONS IN THE ASSESSMENT OF BIOFUELS PROGRAMS: ELEMENTS FOR ANALYSIS



Source: Authors.

- Agriculture

The contribution of biofuels will depend on the type of crop used as raw material; the availability of land and water; the ways in which production is organised and the manner in which land-holding is patterned; the incorporation of technology; links with the agribusiness processes that form part of the production chain; and access to financing. All of these factors will influence the ability of agricultural players to appropriate a portion of the value created by the production chain as a whole[67].

In this element, one must also examine land-use issues involving the allocation of land to different agricultural and livestock activities (including dairy production) and to forestry. In particular, one must examine competition for use of the soil that can lead to certain activities

[66] Lobato, V., "Metodologías para optimizar el análisis de materias primas para biocombustibles en los países del MERCOSUR", PROCISUR, IICA. Montevideo, 2007.

[67] "They also point to the possibility that still-larger companies may enter in the rural economy, putting the squeeze on farmers by controlling the price paid to feedstock producers in given area and by owning the rest of the value chain. If so, the real profits are likely to go not to those who can produce large quantities of feedstock, but to those with the proprietary technology to play this biomass into fuel and products. Thus, the entire bioenergy chain needs to be analysed in order to identify and overcome actual and/or potential barriers and inefficiencies." UN-Energy, "Sustainable Bioenergy: A Framework for Decision Makers", United Nations, 2007, pp. 24-25.

displacing others[68]. Thus, biofuels policy must be coordinated with the governmental agency responsible for a country's agricultural and forestry policy, in order to prevent certain perverse effects that might otherwise occur.

Biofuels should be viewed as providing an opportunity to diversify agriculture. It therefore becomes important to analyse the meaning of the value added of activities connected with the primary sector, and their influence on agricultural GDP.

- Industry

The features of the industrial processes that comprise biofuels production chains, as well as their geographic location, may vary according to whether bioethanol or biodiesel is involved, and according to what raw agricultural material is used. In the case of bioethanol production (especially sugarcane-based), vertical integration tends to occur between the agricultural link of the chain and the industrial production plants involved. Given relatively large plant size and capital intensiveness, this may lead to a high degree of agribusiness concentration and relatively little contribution to job creation.

In the case of biodiesel, the situation may be different. Small plants producing for internal consumption, or for domestic markets through small and medium-sized firms, are a viable possibility. Nevertheless, it is quite possible for production to be dominated by large export-oriented firms. From the point of view of local development, significantly different repercussions may ensue from the two types of scenarios.

In short, the agribusiness activities connected with biofuels can represent more or less significant impact on a country's industrial activity, especially when provision of equipment and facilities and cross-industry effects are considered.

- Macroeconomy

Macroeconomic elements include fiscal factors (tax exemptions, subsidies), as well as trade balance and balance of payments issues (exports, reduction in imports, importation of equipment) and related matters.

- Technology

In this regard, it is important to have a store of accumulated knowledge in the development of raw materials and in the incorporation of technology for biofuels development. Given that launching investments in research and development in this area can increase the possibilities for gaining access to second-generation biofuels, the issue assumes special importance, particularly for countries that do not enjoy comparative advantages for developing first-generation biofuels.

Within the *environmental dimension*, the following elements or axes of analysis are important:

- Emissions of greenhouse gases and other pollutants

One of the principal benefits cited for biofuels is that they may help to reduce greenhouse gas emissions, since the gases produced in burning them are absorbed during the growth of the crops. However, the crucial question is the balance of energy consumed in the entire production chain. To the extent that the energy used comes from fossil fuels, the emissions balance may be negative. This issue cannot be resolved a priori, and specific assessment is required in each case.

[68] "…[B]iofuel programmes can result in concentration of ownership that could drive the world's poorest farmers off their land and into deeper poverty…. one thing is clear: the more involved farmers are in the production, processing, and use of biofuels, the more likely they are to share in the benefits." Ibid. p. 24.

In addition, changes in land use (e.g., planting energy crops in areas that were previously forest or woods) can cause emissions and loss of carbon dioxide sinks, reducing yet further the advantages of biofuels from the greenhouse gas perspective[69].

Also to be considered is the problem of local air pollution, especially in the large cities of the region: biofuels appear to have advantages in terms of certain pollutants and disadvantages in terms of others[70] [71].

- Use of natural resources

Land and water use and biodiversity impacts take on special significance, both in terms of the sustainability of development and in terms of the sustainability of biofuels themselves.

We have already noted certain negative environmental effects from cultivation of the monocultures on which biofuels production is based[72]. These include exhaustion of soils in the absence of sufficient crop rotation, water pollution due to use of pesticides, herbicides and fertilizers, and pressure on natural areas and native forests to the detriment of biological diversity[73].

On the social dimension, the most important analytical axes are:

- Food security

Discussion of biofuels vs. food is generally cast in terms of land availability and competition for land use.

The introduction of biofuels on the agenda of the "developed" countries, given the magnitude of the needs, is already creating upward pressure not only on food prices, but also on the cost of animal feed. These price increases undoubtedly make food much less accessible to the poorest populations[74]. In some of the region's countries, rising prices may be due to shrinking supply as a result of crop substitution. Thus, study is needed to determine whether price increases are due to internal decisions, or reflect increased food importation.

69 "Carbon mitigation by biofuels or by saving and restoring forests?", R. Righelato and D. Spracklen, Science, vol. 317, p. 902, August 2007.

70 Impact of biodiesel fuels on air quality and human health, R.E. Morris et al., National Renewable Energy Laboratory, NREL/SR-540-33793, May 2003.

71 Effects of Ethanol (E85) versus Gasoline Vehicles on Cancer and Mortality in the United States, M. Jacobson, Environmental Science & Technology, 41 (11), 4150-4157, 2007.

72 See footnote 57.

73 "Effects such as loss of natural areas, contamination of soils and water, and imbalances in land use indicate that these monocultures are advancing in a direction opposed to sustainable development." G. Honty, E. Gudynas, "Agrocombustibles y desarrollo sostenible en América Latina y el Caribe", OD, 2007, p. 11.

74 "But rapid growth in first-generation liquid biofuels production will raise agricultural commodity prices and could have negative economic and social effects, particularly on the poor who spend a large share of their income on food. In many countries, the current structure of agricultural markets means that the bulk of the profits go to a small portion of the population. Unless ownership is shared more equitably, this divide could become as true for energy commodities as it is for food commodities today. For instance, two companies, Cargill and Archer Daniels Midland, control more than half of the world's grain trade." UN-Energy, op cit., p. 4.

TABLE 7[75]
UNDER-NOURISHED POPULATIONS AND FOOD EXPORTS

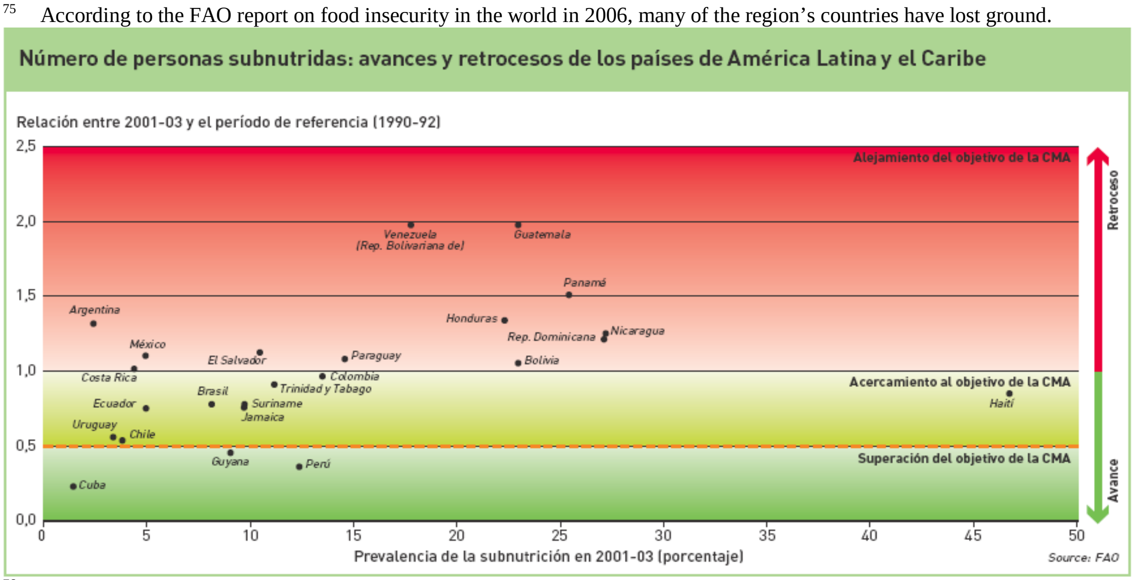
		Food exports in 2004 (% of total exports)		
		0-20%	20-40%	>40%
% of population under-nourished in 2004	>20		Bolivia	Guatemala, Honduras, Nicaragua, Panama
	10-20	Colombia, Trinidad & Tobago, Venezuela	El Salvador, Peru	Paraguay
	5-10	LAC, Mexico	Brazil, Costa Rica, Ecuador, Jamaica	Guyana
	<5		Barbados, Chile	Argentina, Uruguay

Source: ECLAC, based on WDI data, World Bank.

- Jobs and income distribution

One of the arguments adduced in favour of biofuels is job creation. While the growth of given economic activities or the appearance of new ones theoretically implies increased employment in the agricultural sphere, as well as activity in agribusiness and services, there remains the possibility that these processes could displace existing activities. This is particularly true in agriculture (with crop substitution), with changes in production technology leading to fewer workers per unit of output. Thus, the impact on employment must be calculated in net terms[76].

75 According to the FAO report on food insecurity in the world in 2006, many of the region's countries have lost ground.



76 For example, net employment in Brazil's sugarcane production fell 33.5% between 1992 and 2003 (permanent workers: 37.6%; temporary workers: 28.4%), due principally to the introduction of mechanical harvesting. (Smeets, E. et al., "Sustainability of Brazilian bioethanol", UNICAMP, August 2006. In Argentina, "…rural unemployment, particularly in the small cities in the country's interior, increased as a result of the disappearance of regional crops and due to the labour saving involved in soy production." (Domínguez, D., Sabatino, P., "Con la soja al cuello: crónica de un país hambriento productor de divisas", CLACSO, March 2006).

In regard to income distribution, it is important to compare wages paid in activities relating to biofuels production with other similar activities[77], and to examine the effect that the growth of such activities would have on the value and concentration of land, and on the distribution of value among the participants in the chain.

In terms of land values, there must be studies to determine whether there is upward pressure on, and pressure to displace, small and medium-sized producers in favour of operations with large land holdings—a circumstance that could lead to greater social asymmetries[78].

- Local development

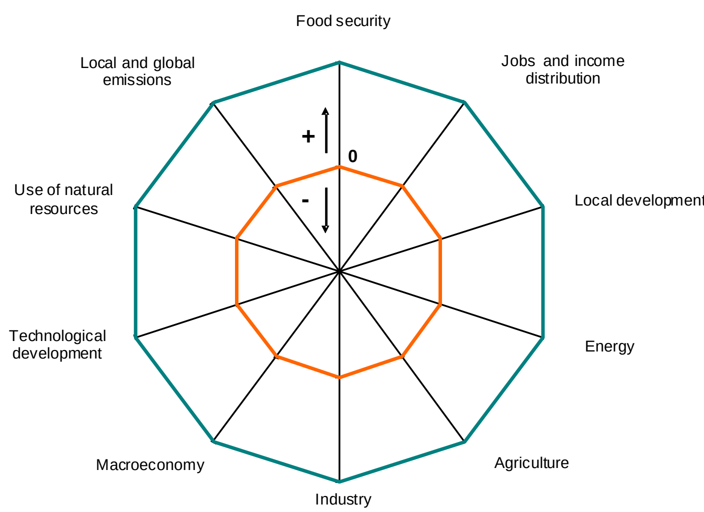
In this element, attention must be given to the impact of biofuels development on local growth and on the availability of goods and services.

Considering the issues set forth in the preceding paragraphs, an initial approximation to the value of the contribution of biofuels policies may be provided by a graphic in the form of a ten-sided "spider web" (see Figure 9).

In this connection, it would be helpful to link public policy in each element with its potential for promoting positive convergence in biofuels development. A set of indicators, associated with each of these elements, for use in monitoring biofuels programmes and policies should also be constructed. Ultimately, assessment through the scheme represented in Figure 8 should be based on an analysis of such indicators.

This will make it possible to determine whether, for certain elements, given policies will produce negative impacts on sustainability. This would be represented by axes that move toward the "negative" area in Figure 9.

FIGURE 9
SCHEMATIC REPRESENTATION OF THE IMPACT OF EACH "ELEMENTS OR AXES" ON OVERALL SUSTAINABILITY



Source: ECLAC, based on official sources.

[77] Smeets et al., op cit., discuss the influence of the bioethanol production chain, comparing the resulting Gini indices in the links of that chain with the corresponding links of other chains, and conclude that this chain has a positive effect on income distribution, since the Gini indices associated with it are lower than the Brazilian average. Nevertheless, comparing the average wages in the ethanol chain with prevalent wages in other industries suggests that the opposite is true: R$ 552.2 versus R$ 575 in food and beverages, R$ 1281.1 in the fuel industry and R$ 1074.6 in chemicals. In addition, if only the primary link of the chain is considered (sugarcane crop), the average wage is R$ 446.6.

[78] "In Argentina, the overwhelming advance of soy and other monocultures for agribusiness use led to a decline in the number of rural producers—with family producers, in particular, declining—and produced conflicts with other productive uses, which were reduced or displaced (e.g., dairy, cotton, grains, etc.), land concentration, proliferation of contracts in which land owners turned over management of their land to firms or investors, and technological packages that implemented transgenics" (Ibid. p. 21.).

Box 1 shows a possible set of indicators whose informational content would provide for a preliminary assessment of the impact of public policy on biofuels in the different proposed elements, as a means of analysing the support such programmes could offer in terms of the various dimensions of sustainable development.

BOX 1
SUGGESTED FOR INDICATORS FOR EACH "ELEMENTS OR AXES" OF SUSTAINABLE BIOFUEL POLICY

1. Energy:
1.1. Impact on the structure of total final consumption
1.2. Gasoline and diesel imports as a percentage of all imports of goods
1.3. Extent to which basic needs are met: consumption of useful energy per person
2. Agriculture:
2.1. Net contribution of biofuels production to the sector's value added
2.2. Land area allocated to biofuels production, as a percentage of total agricultural area
2.3. Yields by type of crop grown for biofuels production
3. Industry:
3.1. Net contribution of biofuels production to industrial value added
3.2. Amount of concentration of industrial biofuels production
3.3. Magnitude of investment required to reach goals regarding biofuels, as a percentage of total foreign direct investment
4. Macroeconomy:
4.1. Net effect on trade balance as a result of import substitution in fuels (not counting imports of agricultural chemicals and fertilizers)
4.2. Net fiscal effect (increase or decrease in tax revenue)
4.3. Percentage of technological development research funded by the State
5. Technological development:
5.1. Existence or absence of international cooperation for technological development relating to biofuels
5.2. Existence or absence of importation of species for the production of agricultural raw materials
5.3. Level of spending on technological development for the adaptation of species
6. Use of natural resources:
6.1. Rate of deforestation or displacement of pasture caused by expansion of crops associated with biofuels
6.2. Water required per unit of land area planted with biofuels crops
6.3. Exhaustion of soil caused by growing raw materials for biofuels
7. Local and global emissions:
7.1. Local production of biofuels as a percentage of local consumption of such fuels
7.2. Emissions prevented by use of biofuels
8. Food security:
8.1. Index of under-nourished population
8.2. Importation of food as a percentage of local supply
8.3. Increase in prices of basic foods in the last year
9. Employment and income distribution:
9.1. Employment conditions in the agricultural link of the biofuels production chain (length of work day, child labour)
9.2. Average wage in the agricultural production of raw materials for biofuels, as a percentage of average wage in the rural sector
9.3 Percentage of the sales price that remains in the hands of the producer
9.4. Displacement of population whose land holdings are precarious in nature
10. Local development
10.1. Predominant type of producer (small, medium-sized, large)
10.2. Origin of those involved in local production (local, national, multinational)
10.3. Type of organisation (community organisation / individual producers)

Source: Authors.

Chapter III

Biofuel development in different country situations

This chapter describes the current and potential situation facing the region's countries in regard to biofuels, examining policy goals, future fuel needs for transportation (including questions concerning the origin of future supplies) and the potential for bioenergy crops.

It also looks at a number of criteria designed to stylise those representative situations that appear most important in terms of biofuels policy. A number of indicators are used to place each country in relation to these stylised situations relating to bioethanol and biodiesel—situations which, it should be noted, need not be identical.

After describing the stylised situations for bioethanol and biodiesel, an initial assessment is made of their implications for the various dimensions of sustainability, providing schematic representations of the potential impact of biofuels in the form of qualitative "spider webs".

Based on projections for the 2020 bioethanol and biodiesel contestable market in various countries of the region, and hypothesising a 10% penetration for bioethanol (except in Brazil, where the figure of 40% is used) and 10% (of total energy) for biodiesel, the land area required to obtain the raw material needed for different countries can be estimated (Table 8). These estimates presuppose improvements in agricultural productivity and bioethanol yields over time.

To analyse the availability of land needed in each country to produce the volumes specified in Table 8, distinctions must be made between wooded areas, agricultural areas, grazing lands and areas with restrictions on agricultural activity. However, basing the analysis on soil use statistics may have drawbacks, since these statistics normally refer to countries' existing agricultural land, including grazing land, which in many cases represents a significant percentage of total area (e.g., Argentina 46%, Brazil 31%, Colombia 44%, Mexico 56%).

TABLE 8
PROSPECTIVE DEMAND FOR BIOFUELS VS. AVAILABILITY OF LAND[79]

Country	Demand by 2020		Area required			Area required as % of arable land
	Bioethanol	Biodiesel	Bioethanol	Biodiesel	Total	
	(ktoe)		(thous. of hectares)			
Argentina	713	1 506	238	1 962	2 200	8%
Bolivia	76	87	22	41	63	2%
Brazil	12 673	5 711	3 667	2 678	6 345	11%
Chile	360	788	142	616	757	38%
Colombia	532	560	154	164	318	14%
Costa Rica	137	114	40	34	73	32%
Ecuador	263	320	76	94	170	10%
El Salvador	101	104	29	30	60	9%
Guatemala	189	271	55	79	134	9%
Honduras	76	83	22	24	46	4%
México	4 760	2 045	1 377	599	1 977	8%
Nicaragua	35	48	10	14	24	1%
Panamá	104	108	30	32	62	11%
Paraguay	24	164	7	77	84	3%
Perú	135	300	39	88	127	3%
Trinidad & Tobago	84	58	24	17	41	55%
Uruguay	36	120	12	156	168	12%
Venezuela	1 739	370	503	109	612	24%
Total	22 035	12 756	6 447	6 814	13 261	9%

Source: ECLAC, based on official sources.

Grazing land generally constitutes a significant portion of agricultural land, but there is no clear delineation. It may include areas of trees or bushes, savannah and other types of natural areas that are, in themselves, of interest[80]. Therefore, it is useful to more precisely determine the characteristics of each country's agricultural land, and what constraints there may be on using it for the production of biofuels.

- Other major constraints on the use of land (agricultural or other) relate to:
- protected forests or ecosystems, or areas that are of interest for conservation purposes;
- land required to meet domestic and international food needs;
- areas with soil constraints;
- deserts, and arid or semi-arid areas;
- steep terrain; and
- degraded land.

Table 9 summarises some of these factors as they relate to the countries of the region.

The area needed to feed the entire population is calculated on the basis of a balanced food basket, representing 2,414 kcal/person/day. The comparison is based on arable land, since this is a more precise category than agricultural land. Indicators close to or above 100% represent potential[81] shortages in terms of land required to feed the population while simultaneously producing biofuels. The extent to which this is a limitation on biofuels production depends on

[79] The potential demand from the faro sector is included. We presuppose crops appropriate for each country, and average yields associated with them. For biodiesel, the land required could rise substantially if palm cultivation does not expand significantly.
[80] FAOSTAT glossary, http://faostat.fao.org/site/375/default.aspx.
[81] "Potential" because different countries' food baskets, though containing the same number of calories, may require a different amount of land to produce.

how much non-arable grazing land can be used for agricultural purposes. In some cases, such limitations can be overcome; in others it cannot.

TABLE 9
CONSTRAINTS ON AGRICULTURAL LAND USE

Country	% of agricult. land (2003)	% of arable area (2003)	% of permanents crops (2003)	% of permanents grassland & pasture (2003)	% wooded área (2005)	% of desert area and semi-arid areas	% of degraded land (moderate to severe)	% land with soil constraints	Area required to feed the entire population (% of arable lands)
Antigua & Barbuda	32,0	18	4,5	9,1	20	-	-	-	206
Argentina	46,0	10	0,4	35,9	12	71	63	67	28
Barbados	44,0	37	2,3	4,7	5	-	-	100	340
Belice	7,0	3	1,4	2,2	72	0	29	79	79
Bolivia	34,0	3	0,2	31,2	54	30	37	73	64
Brasil	31,0	7	0,9	23,3	56	3	52	91	65
Chile	20,0	3	0,4	17,3	22	72	48	82	167
Colombia	44,0	2	1,5	40,5	55	1	37	73	410
Costa Rica	56,0	4	5,9	45,8	47	0	100	62	393
Cuba	61,0	28	6,6	26,1	25	0	61	61	75
República Dominicana	76,0	23	10,3	43,4	28	0	100	51	170
Ecuador	29,0	6	4,9	18,4	39	11	29	63	167
El Salvador	82,0	32	12,1	38,3	14	0	94	52	213
Guatemala	43,0	13	5,6	24,0	36	0	72	65	182
Guyana	9,0	2	0,2	6,2	77	0	14	83	32
Haití	58,0	28	11,6	17,8	4	0	100	51	240
Honduras	26,0	10	3,2	13,5	42	0	87	64	142
Jamaica	47,0	16	10,2	21,1	31	0	100	45	308
México	56,0	13	1,3	41,9	34	87	54	72	87
Nicaragua	57,0	16	1,9	39,7	43	0	82	68	58
Panamá	30,0	7	2,0	20,6	58	0	88	66	121
Paraguay	63,0	8	0,2	54,6	47	0	30	72	42
Perú	17,0	3	0,5	13,2	54	0	54	85	154
Puerto Rico	25,0	9	4,7	11,6	46	39	100	65	1 019
Suriname	0,6	0,4	0,1	0,1	95	0	18	80	149
Trinidad & Tobago	26,0	15	9,2	2,1	44	0	100	-	352
Uruguay	85,0	8	0,2	77,4	9	0	13	61	51
Venezuela	25,0	3	0,9	20,7	54	3	29	79	209
Latin America & the Caribbean	36,0	7	1,0	27,9	45	26	50	81	80

Source: Author, based on Statistical Yearbook for Latin America and the Caribbean 2004, ECLAC; World Bank online WDI; TERRASTAT online; "FAO methodology for the measurement of food deprivation", FAO Statistics Division, Rome, October 2003.

3.1 Criteria for identifying stylised country situations

Though the multiple dimensions of biofuels development make stylising representative situations a highly complex matter, given that the issues and the debate are very much a function of local circumstances (climatic, agronomic, economic and social), it is important to describe situations that have significant relevance to public policy.

The most important criteria in describing these situations include:

- each country's energy structure, particularly its dependence on imported fossil fuels, or its status as a natural gas, oil or oil-derivatives exporter. This criterion is chosen in order to identify the impact of fuel substitution in a transportation scenario involving biofuels;
- the prospective size of the contestable domestic market[82] for biofuels;

[82] The basic idea of contestability is that a market can be vulnerable to competitive forces even if it is monopolistic or oligopolistic. In other words, if the firms in the market are inefficient, set excessive prices, or exploit consumers in other ways, the successful entry of competitors is possible. Consequently, contestable markets should be characterised by free and easy entry and exit, so that potential competition is sufficient to discipline the behaviour of the oligopolistic or monopolistic firms in the market. In the case of oil derivatives, however, the existence of significant sunk costs in the distribution and marketing area (port and warehousing infrastructure, established distribution channels, service stations that operate with exclusive contracts with a given oil company) strongly limit the possibility of introducing contestability. Even in the largest markets for these products in the region, the oil derivatives production structure is oligopolistic, due to intense economies of scale in refining. In countries with smaller markets, it may be deceptive to think that the marketable nature of oil derivates will necessarily introduce contestability into the market through importation. In such circumstances, under a strict application of the theory of contestable markets, price regulation is required. See Héctor Pistonesi, "Elementos de la Teoría Económica de la Regulación", IDEE/FB, Bariloche, 1998;

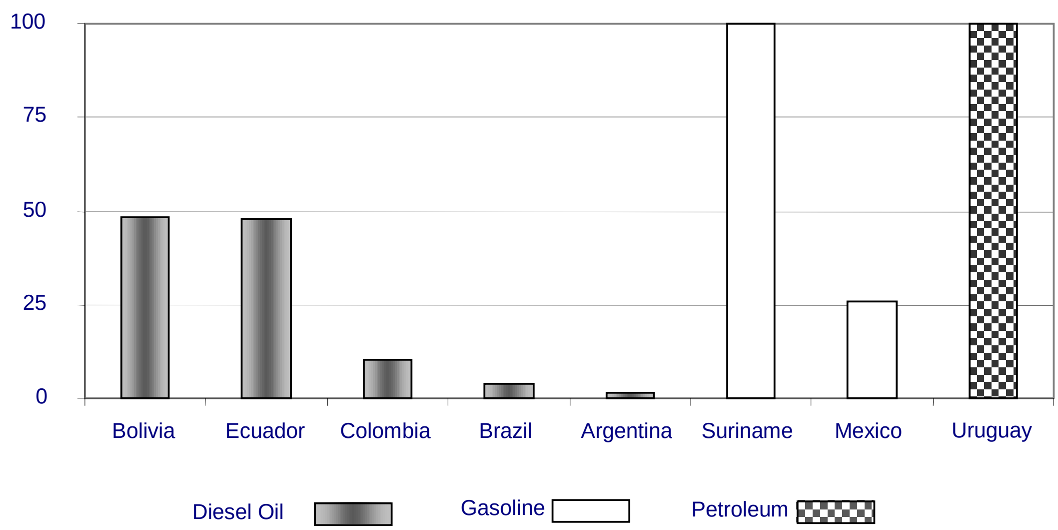
- the climatic conditions suitable for the production of appropriate crops as raw material for biofuels;
- the natural resources (land, water) needed to produce the agricultural raw material used in producing biofuels, either for the domestic market or for export, in prospective terms;
- the presence of under-nutrition and poverty, making food production a higher priority than biofuels for the use of agricultural land. Also relevant here is whether the country is a net importer or exporter of food.

Using these criteria, a set of stylised situations has been identified, distinguishing those that are most relevant to bioethanol, and those most relevant to biodiesel. The distinction takes account of the relative size of the contestable prospective domestic market for both types of biofuels, as well as climatic conditions and the presence of natural resources for the production of the agricultural raw materials involved.

The region's countries are then placed in relation to the different stylised situations, assigning them to the situations that best describe them. Countries for which the biofuels option seems unreasonable because of their hydrocarbon resources—such as Venezuela and Trinidad and Tobago—have been excluded. In certain other cases, available information is insufficient for an adequate characterisation.

The figures below present data on various parameters—the criteria used to define our stylised situations—presented in the succeeding section.

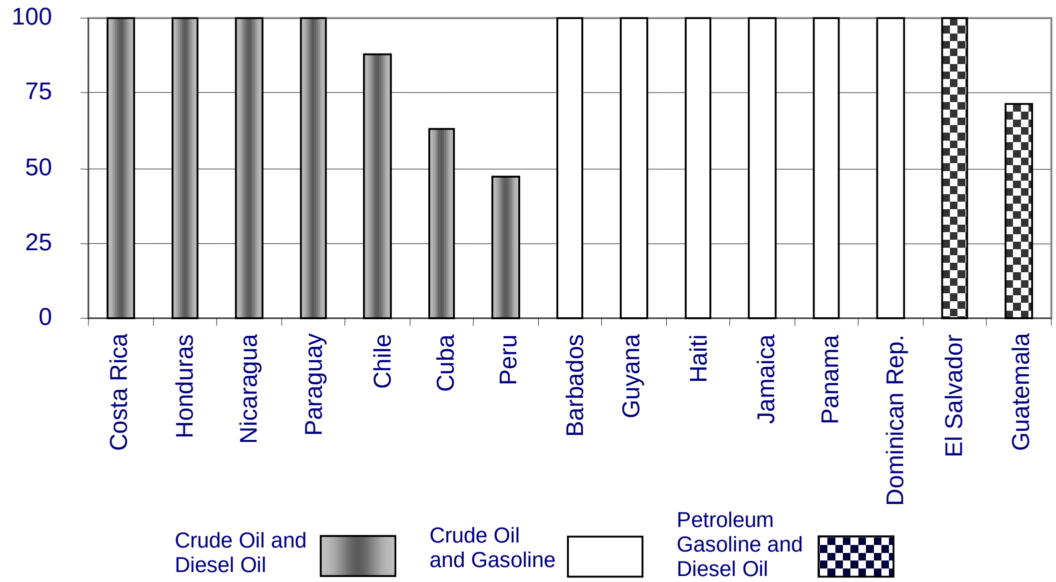
FIGURE 10
OIL AND DERIVATIVES IMPORTS
(Gasoline and/or diesel as percentage of consumption in transportation)



Source: ECLAC, based on OLADE , Energy Statistics Report 2005.

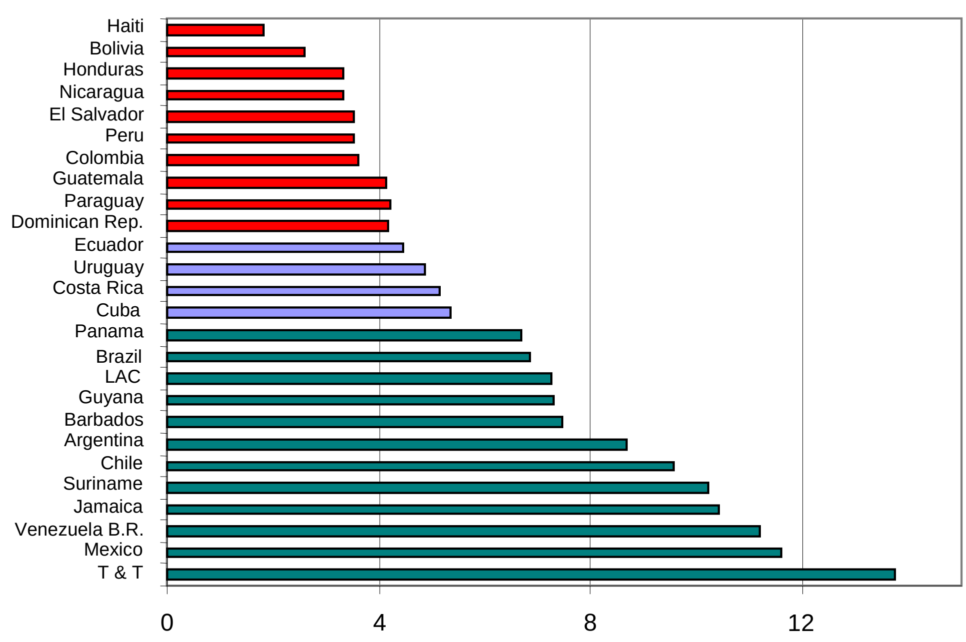
and OLADE/ECLAC/GTZ Energy and Sustainable Development in Latin America and the Caribbean. Guide for Energy Policymaking. Second edition, Santiago 2005.

FIGURE 10 (CONTINUED)
IMPORTATION OF OIL AND OIL DERIVATIVES
(Gasoline and/or diesel imports as percentage of consumption in transportation)



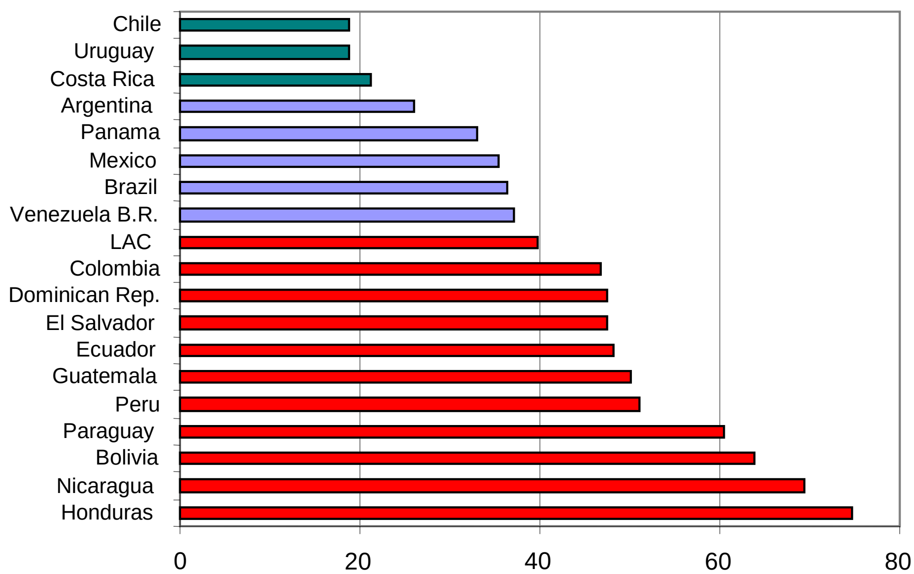
Source: ECLAC, based on OLADE, Energy Statistics Report 2005.

FIGURE 11
PER CAPITA ENERGY CONSUMPTION
(BOE/per)



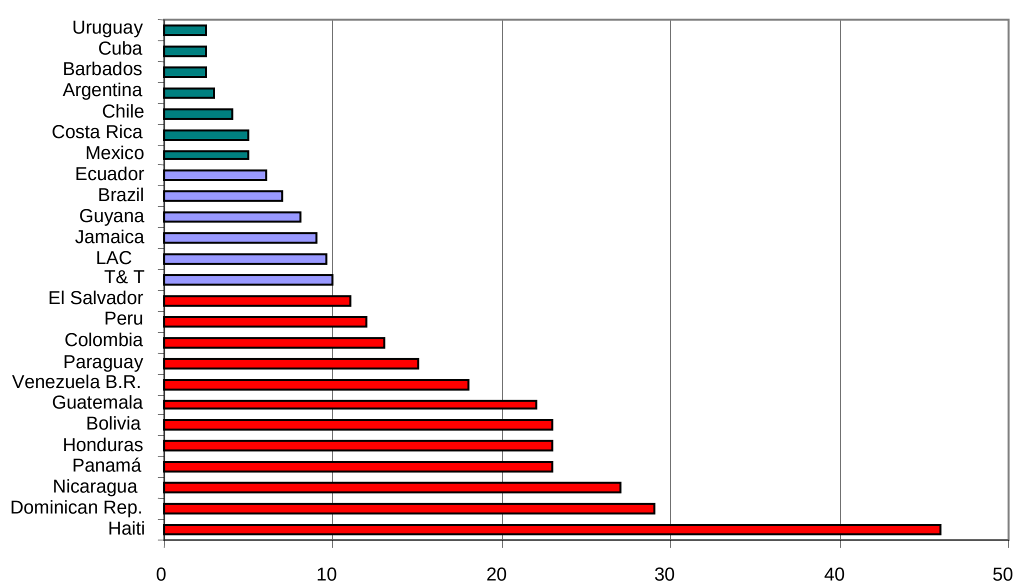
Source: ECLAC, based on OLADE, Energy Statistics Report 2005.

FIGURE 12
POVERTY
(Percentage of poor and indigent)



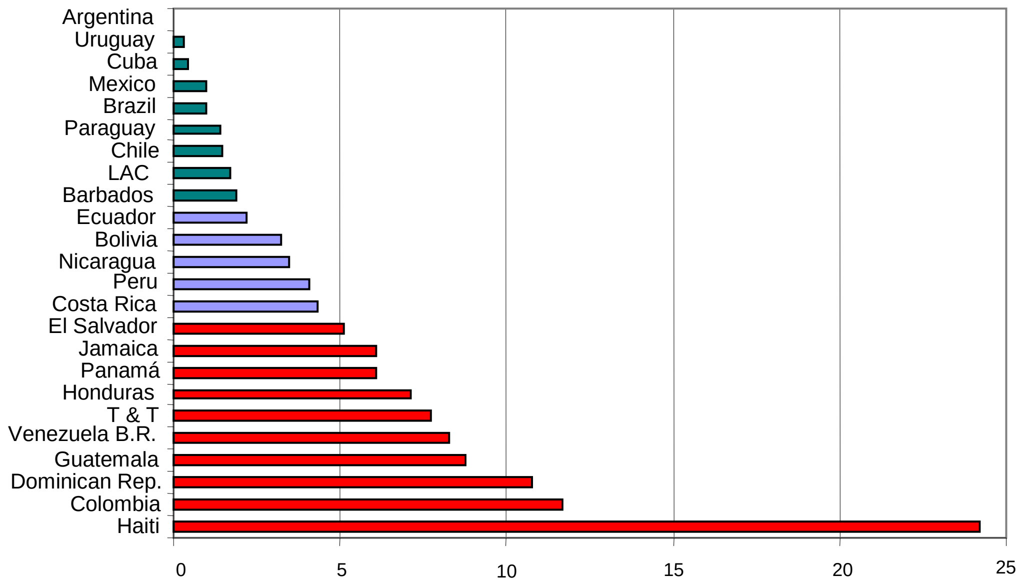
Source: Based on ECLAC, Statistical Yearbook for LAC 2006.

FIGURE 13
UNDERNUTRITION
(Percentage of population under-nourished 2004)



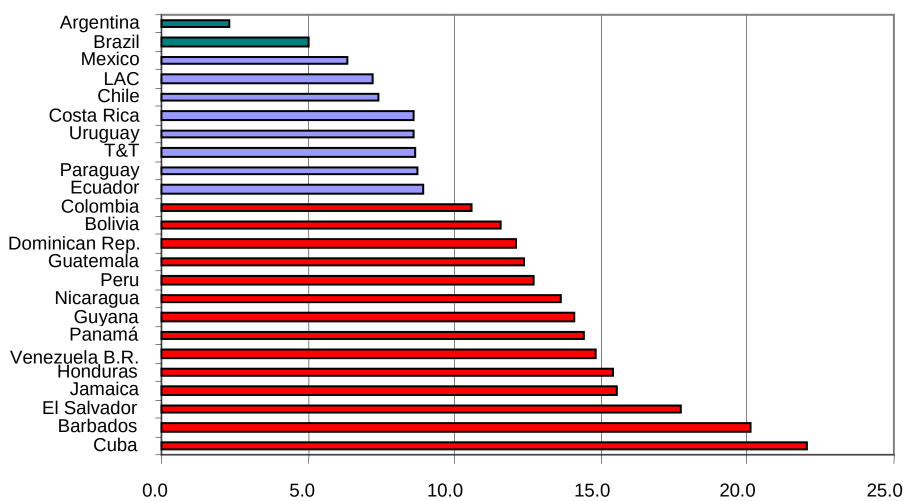
Source: Based on ECLAC, Statistical Yearbook for LAC 2006.

FIGURE 14
LAND REQUIREMENTS FOR ADDRESSING UNDER-NUTRITION
(Percentage of arable land)



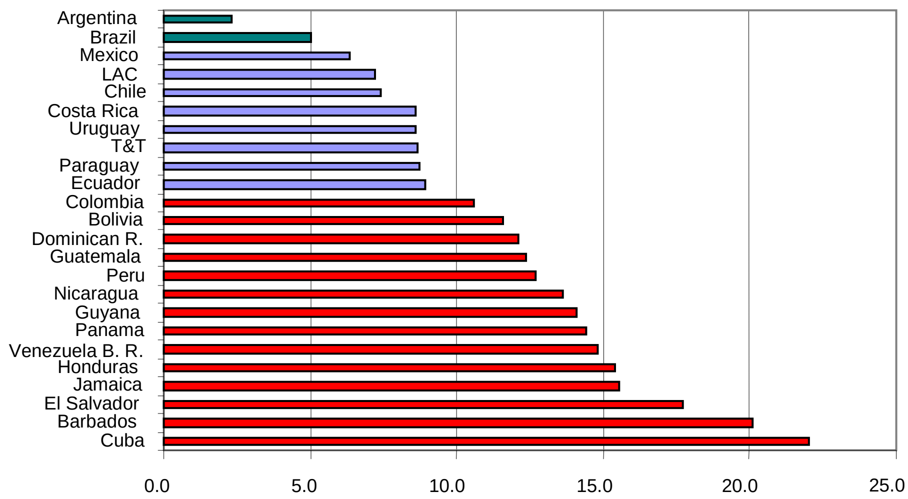
Source: Based on ECLAC, Statistical Yearbook for LAC 2006.

FIGURE 15
LAND REQUIRED TO FEED THE ENTIRE POPULATION
(Percentage of arable land)



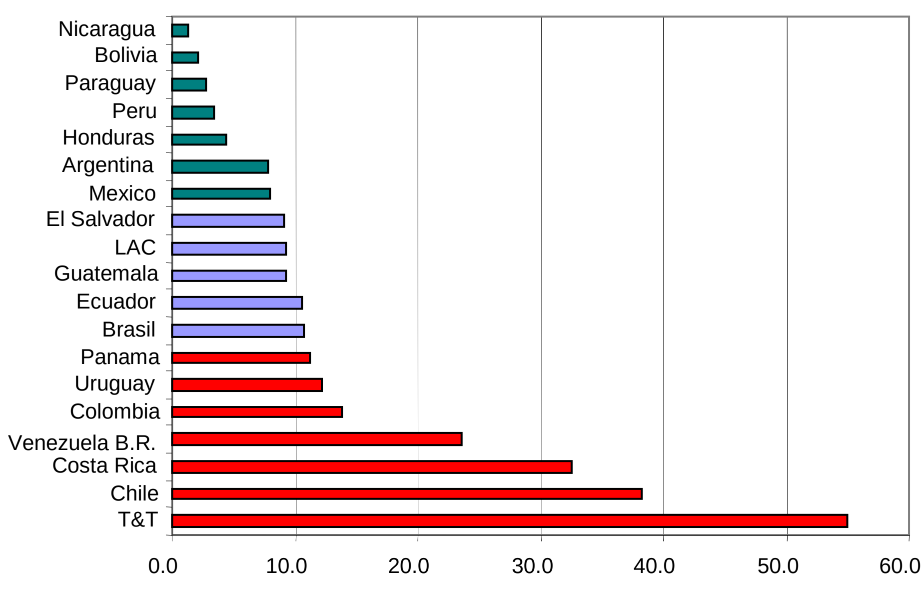
Source: based on "FAO methodology for the measurement of food deprivation", and ECLAC, Statistical Yearbook for LAC 2006.

FIGURE 16
FOOD IMPORTS
(Percentage of total imports of goods)



Source: Based on information from the WDI database (http://publications.worldbank.org/WFI).

FIGURE 17
REQUIREMENT FOR SUPPLYING THE NATIONAL BIOFUELS MARKET
(Percentage of arable land)



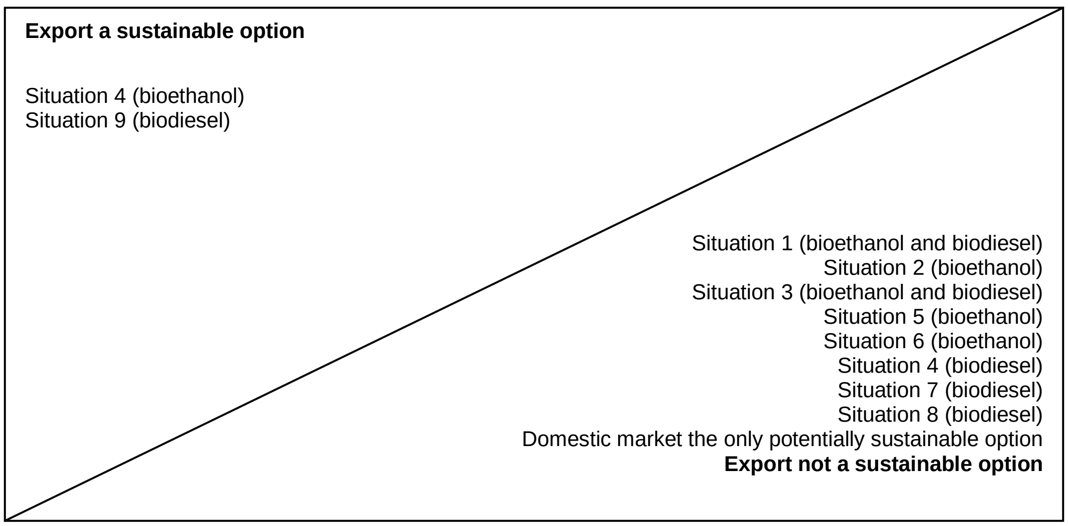
Source: ECLAC, based on OLADE, Energy Statistics Report 2005.

3.2 Stylised country situations and sustainable development of biofuels

In formulating biofuels policy, it may be helpful to begin with some hypotheses regarding possible national strategies. The hypotheses are embodied in the different situations presented below, and take account of the end use of the biofuels involved, i.e., whether they are designed for the domestic market to replace fossil fuels (gasoline/diesel), for export, or for both purposes.

It is clear that, given the availability of natural resources (land, water) and technology, in both the agricultural and the industrial phases of the process, and the need for land to address situations in which there is under-nutrition, exporting will be a sustainable option for only a small number of countries with an abundance of available land (Figure 18).

FIGURE 18
HYPOTHESES REGARDING SUSTAINABILITY OF VARIOUS TARGETS FOR BIOFUELS



Source: Authors.

Based on these hypotheses regarding the import substitution option versus exportation, and options concerning the different links of the production chains involved, we proceed to examine a series of elements that should be considered in evaluating biofuels programmes.

3.3 Bioethanol production: categories of countries

The stylised situations most relevant to bioethanol are the following:

Situation 1

Situation 1 includes countries that:

- have tropical climates;
- are highly dependent on imported oil and/or oil derivatives;
- have low or very low per capita energy consumption;
- have high poverty rates;
- have moderate or high rates of under-nutrition;

- have moderate or elevated needs for land to remedy under-nutrition;
- are food importers; and
- have moderate or elevated needs for land to supply the domestic biofuels market.

If a country's main objective, in this situation, is to close the domestic food gap, then the export option is not sustainable. Even programmes aimed at replacing imported oil derivatives would necessarily be of limited scope, given the limited natural resources and the need to use existing resources to address the food gap.

Moreover, since energy coverage is low among the poorest segment of the population, especially in rural areas, it would be helpful if biofuels production initiatives gave priority to rectifying that situation. In such a context, it is clear that biofuels programmes could complement other, priority initiatives, but could not realistically be the central or sole focus in efforts to combat poverty.

In regard to the conditions or characteristics of the production chains involved, the best competitive options would appear to be sugarcane for bioethanol, and palm for biodiesel[83]. However, expansion of these crops could take over current grazing land and/or natural areas. Attention must also be given to increased agricultural productivity as a function of the above-cited indicators of competitiveness.

In this context, the dominant actors in the agricultural link of the chain would be the traditional growers, who may eventually adopt imported varieties and agricultural chemicals and move toward mechanising sugarcane harvesting. In production, a high degree of concentration will take place. In such a scenario, working conditions and wages would require special attention, though these could be expected to see a gradual improvement. It would also be important to assess the effects of displacing small producers, and to monitor rising land values and land concentration, as well as rises in food prices.

The agribusiness phase of the process, in this situation, would be vertically integrated, and controlled by those involved in agricultural production. The mix and distribution of fuel would be under the control of oil companies that are active in the country. Given the costs involved in the production chain, such a situation calls for a system of tax incentives to encourage biofuels development.

Presumably, bioethanol in this type of situation, would be sold on the contestable domestic market; otherwise, monopsony would occur, and biofuels prices would probably decline over time, with agricultural wages following in their wake.

Thus, if 10% of the gasoline market were supplied by biofuels, biofuels programmes would show some strength, though making only a moderate contribution to energy diversification, secure supply and agricultural and agribusiness development, and very little contribution to technological development, since the technologies used would be imported. The macroeconomic impact would also be only minor. The positive impact on the balance of trade resulting from fuel import substitution could be neutralised by increasing imports of agrochemicals. The fiscal cost of promotion could also be an important factor if there is a subsidy within the production chain.

Increased prices for imported foods could also occur as a result of changes in international prices, or as a result of competition between biofuels and food for the use of land.

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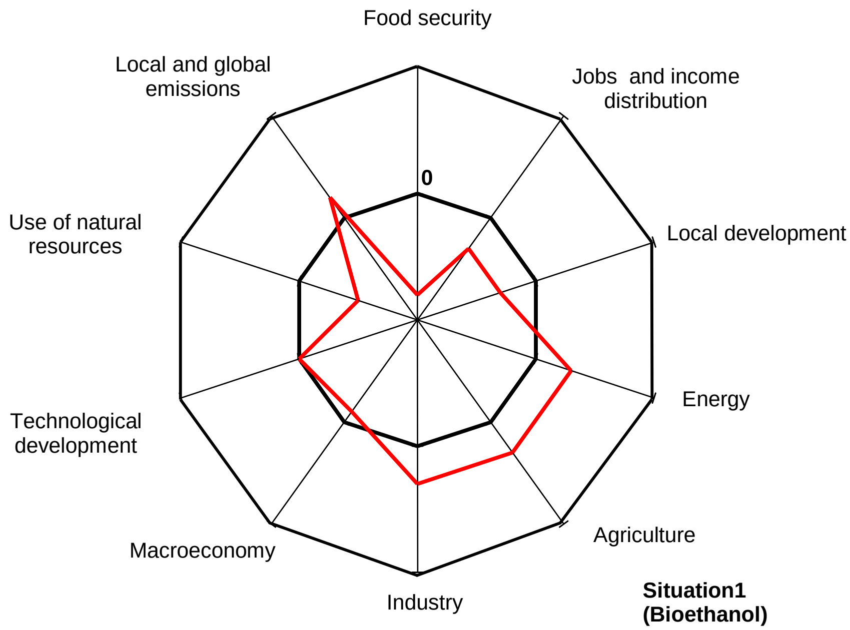
[83] These hypotheses are formulated based on historical trends and general conditions in the socioeconomic system. Chapter IV sets forth policy lines more conducive to sustainable development.

The qualitative impacts on the sustainability of national development would be as shown in Figure 19. Thus, countries that could fall in this category (e.g., El Salvador, Haiti, Honduras, Nicaragua, Panama, Dominican Republic, Guatemala) would be wise to construct their own schematics—using the information and variables shown below, through the various axes—to assist in decision-making to support sustainability.

FIGURE 19
SITUATION 1 (BIOETHANOL)



Source: Authors.

Situation 2

Situation 2 includes countries that:

- have tropical climates;
- are highly dependent on imported oil and/or oil derivatives;
- have high per capita energy consumption;
- have low rates of poverty and under-nutrition;
- have little pressure for land to address under-nutrition;
- are food importers;
- have moderate or elevated needs for land to supply the domestic biofuels market;

As in situation 1, there is limited availability of natural resources. Here, however, under-nutrition is not a major issue, energy of reasonable quality is largely available to the population, and poverty is not a significant issue. Consequently, though there are other interesting bioenergy options, biofuels production for a minor percentage of the contestable domestic market may be a sustainable strategy, provided that the situation meets certain conditions with regard to the development of the production chains involved.

In such situations, the bioethanol crop would be sugarcane, while varieties of palm or jatropha could be used for biodiesel. In order to prevent these crops from encroaching on grazing land and/or natural areas, agricultural activity would need to increase under this scenario. Agribusiness production should be managed to include organisations of small producers, with agrochemicals and technologies continuing to be supplied from abroad. Given the market shares of firms in the domestic market, control over mix and marketing would be in the hands of oil companies, in some cases publicly owned enterprises.

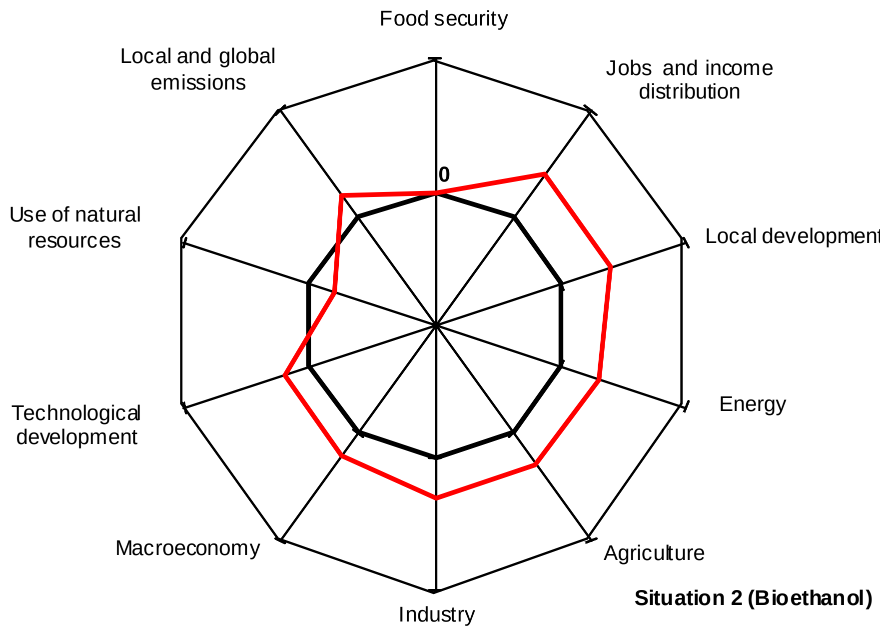
In this situation, the replacement of 10% of gasoline imports by biofuels would have certain positive impacts in terms of jobs and income distribution, as well as local development, due to the presence of cooperative forms of organisation in the agribusiness link of the chain and the presence of publicly owned oil companies in the final links (mix and distribution).

To a lesser extent, there would be positive effects due to the moderate contribution to energy diversification, to agriculture and to industrial activity, while the impact on local emissions would be neutral or slightly positive.

There would be little macroeconomic benefit or benefit to technological development, for reasons similar to those present in situation 1. It would be important to evaluate the possible impact of bioethanol production on natural resources for each country.

Countries that could fall in this category, such as Barbados, Jamaica, Grenada, Guyana, Suriname, Cuba and Costa Rica, would do well to examine the data and study the conditions under which the domestic supply would be provided, assessing the strengths and risks of biofuels activity, and its contribution to sustainable national development. Thus, impact can be estimated, and a schematic such as that shown in Figure 20 can be constructed.

FIGURE 20
SITUATION 2 (BIOETHANOL)



Source: Authors.

Situation 3

Situation 3 involves countries that:

- have subtropical/tropical climates;
- are oil and/or natural gas exporters;
- import oil derivatives;
- have low per capita energy consumption;
- have high poverty rates and moderate rates of under-nutrition;
- have undemanding needs for land to remedy under-nourishment;
- are importers/exporters of food; and
- have undemanding needs for land to supply the domestic biofuels market.

Though significantly more land is available here than in the preceding cases, alternatives are also created by the more efficient use of available fossil fuels that is possible (natural gas and/or oil derivatives) and by the fact that there are high-priority uses for bioenergy that could supersede a focus on biofuels—namely, remedying the unmet basic needs of the poorest population, especially in rural areas, within an overall poverty-reduction strategy. In some countries, it would be necessary to complement the introduction of biofuels with transportation policies that encourage saving and rational use of energy, both because of how this would impact dependence on imported fuels, and for its effect on local environmental quality. The priority in using agricultural capacity should be to meet food needs.

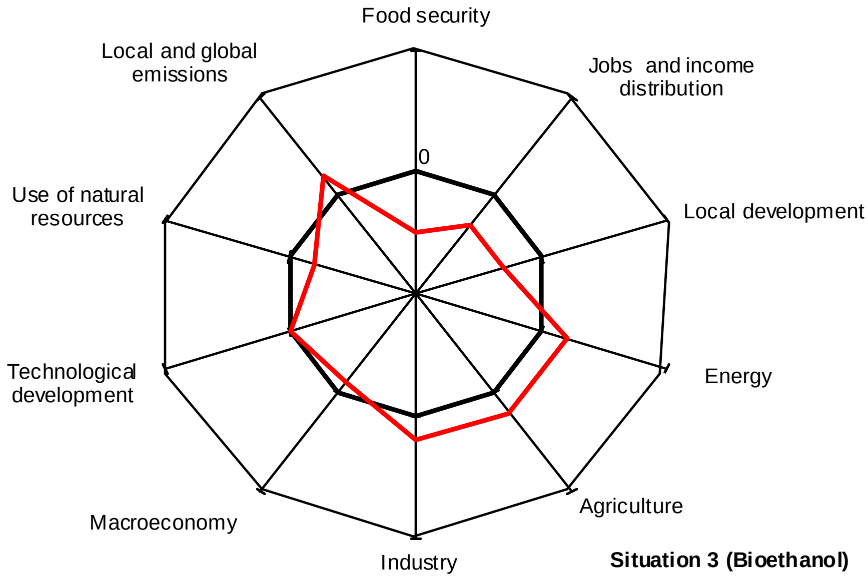
If one of these countries decides to produce biofuels, based on the productivity of the raw materials involved, the bioethanol crop would be sugar cane, and the biodiesel crop, palm. However, the expansion of these crops could encroach on grazing land and/or natural areas and require moderate increases in agricultural productivity. The predominant actors in the agricultural link of the chain would be vertically integrated with agribusiness, and would potentially adopt imported varieties and agrochemicals, while increasingly mechanising the sugarcane harvest. Heavy concentration of production would occur.

Given the environmental and hydrological factors, as well as the type of technology and raw materials used, some countries in this situation could experience water shortages (hydrological stress). Mix and distribution would be controlled by transnational oil companies in some cases, and by publicly owned companies in others. Given the prospective costs of the production chain, tax incentives would be required in order to implement the biofuels programme.

Under these conditions, the adoption of such programmes, with goals on the order of 10% for bioethanol, would translate into positive impact on the security of the energy supply, and to a lesser extent on agricultural and industrial development. Macroeconomically, the potential exports would balance the need for imported agrochemicals, and the net effect would depend on the final balance of the two trade flows.

Given these conditions, the qualitative pattern of positive, neutral and negative impacts is that shown in Figure 21. Thus, countries potentially in this situation, such as Peru, Bolivia and Ecuador**,** should analyse the contribution of biofuels to their sustainable development.

FIGURE 21
SITUATION 3 (BIOETHANOL)



Source: Authors.

Situation 4

Included here would be countries that:

- have subtropical/tropical climates;
- are self-sufficient in terms of oil and oil derivatives;
- have moderate per capita energy consumption;
- have moderate poverty rates;
- have low rates of under-nutrition;
- have undemanding needs for land to address under-nutrition;
- are food exporters;
- have undemanding needs for land to supply the domestic biofuels market;
- have extensive experience in ethanol production, as well as in technological development in the agricultural and industrial spheres;
- have a mature automobile industry and home-grown technology for the use of bioethanol; and
- have a State-owned oil company with links to the other energy-producing chains.

(a) Bioethanol

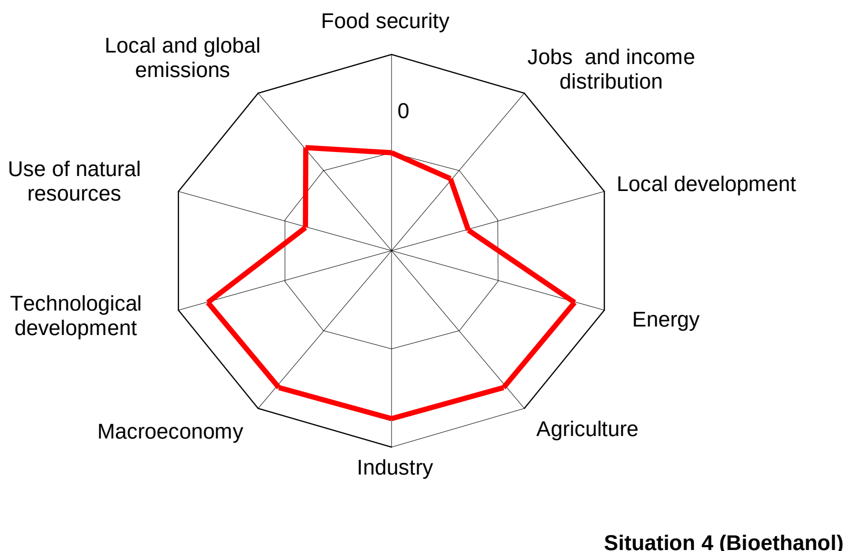
This situation is relevant to countries with long experience in bioethanol production, such as Brazil, with notable increases in productivity due to development of new sugarcane varieties, ample land for expansion, and development of automobiles, within their own auto industries, capable of running on a range or mix of fuels. These characteristics would make the bioethanol producing option feasible, not only for the domestic market but as an agribusiness activity. The low level of under-nutrition in comparison with other countries, along with the moderate per capita energy consumption, means that neither food security nor basic energy needs would be in jeopardy. The threats would appear to be in the social and environmental dimensions.

In this situation, the most competitive bioethanol crop is sugarcane. The expansion of the crop would take place through large, vertically integrated producers using mechanised harvesting methods. In this case, small food and livestock producers might be displaced. Fertilisers, herbicides and pesticides would be partially supplied domestically. Exports would be produced principally by the large producers, and mix and distribution would be handled primarily by the oil company in which the State held the largest share.

Figure 22 diagrams the impact with domestic market penetration of around 40%, flexible automobile technology with a variety of bioethanol/gasoline mixtures, and the option of exporting bioethanol. In this case, there would be significant impact in almost all dimensions, due to the size of the domestic market, including positive impact on security of supply and agribusiness activity, and direct and indirect effects on industry. The macroeconomic effects could also be considerable, due principally to the positive impact on trade balances. There would also be significant impact on technological development.

On the other hand, the effect on natural resources and local and global emissions remains a question mark. The effect on natural resources could be negative because of displacement of livestock to protected areas. Social impacts would be neutral (food security), while working conditions and income levels would require attention.

FIGURE 22
SITUATION 4 (BIOETHANOL)



Source: Authors.

(b) Biodiesel

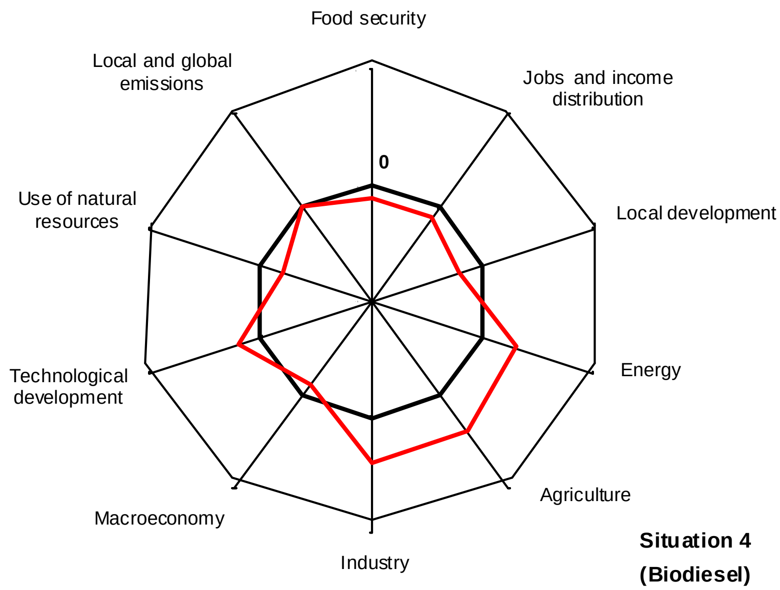
In this case, unlike bioethanol as a substitute for gasoline in transportation (where there is long and extensive experience), there is no tradition or significant technological development in producing and using biodiesel. Moreover, though production and export of oil-bearing plants and oils is important (especially soy and its derivatives), the country has other plant species that could be used to produce biodiesel (African palm, castor-oil plant and rapeseed), though these would appear to be uncompetitive at small scales. However, given the environmental implications (natural resources, biodiversity) and social impact (jobs, local development, social asymmetries), these alternatives might be better options than expanding soy monocultures.

The relevant characteristics of the biodiesel production chains suggest that the predominant crop for this purpose would be soy, though African palm and castor oil would also be used and, to a much lesser extent, jatropha and canola. The main actors in the case of soy are large producers vertically integrated in the agribusiness link, using mostly domestic inputs. The expansion of these crops could displace small producers and/or encroach on natural areas.

On the other hand, under this scenario, actors growing other crops would primarily be small and medium-sized producers whose subsistence relies on State support designed to promote rural development and local production. Undertakings in alternative agricultural raw materials would also require assistance from the State. Finally, mix and distribution for the domestic market would be controlled by the oil company in which the State held the largest share.

Figure 23 shows the principal qualitative impacts on the various dimensions of sustainable development. In comparison with bioethanol, positive impacts would be less pronounced, while negatives would remain at the same level, due principally to the use of soy as the base crop. The macroeconomic impact would be negative in this case, due to fiscal costs that would not be present in the case of bioethanol.

FIGURE 23
SITUATION 4 (BIODIESEL)



Source: Authors.

Situation 5

This situation includes countries that:

- have tropical climates;
- are crude oil exporters and, marginally, diesel importers;
- have low per capita energy consumption;
- have high poverty rates;
- have moderate rates of under-nutrition;
- have elevated needs for land to address under-nutrition;
- are moderate food importers; and
- have moderate needs for land to supply the domestic biofuels market.

In general terms, the availability of natural resources in such countries is acceptable, poverty and under-nutrition moderate, and energy needs not completely satisfied, especially in the rural population. This situation contrasts with the diverse energy resources of these countries, allowing them to export oil, coal and natural gas, though the magnitude of the proven hydrocarbon reserves would be very limited.

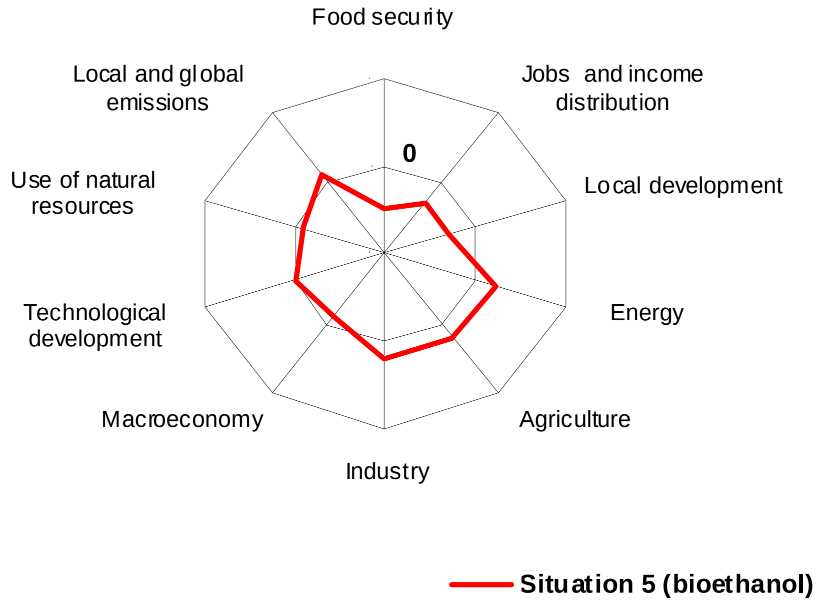
If the decision is made to produce biofuels in this scenario, given the productivity of the different raw materials, the bioethanol crop would be sugarcane, and the biodiesel crop, palm. As in situation 3, there would be limited possibilities for diversification and for the entry of new actors in the agricultural link of the chain, where most of the players would be vertically integrated with agribusiness, and imported varieties and agrochemicals might be used, with increasing mechanisation of the harvest, and with the production structure exhibiting heavy concentration.

Even if the mix and distribution phase were controlled by the State oil enterprise, tax incentives could be needed to close the gap between bioethanol and biodiesel production costs and market prices.

The potential qualitative impacts of adopting these programmes, with goals of around 10% for the bioethanol mix and 5% for biodiesel, are unclear in terms of their effects on sustainability. Besides a very slight effect on the energy supply and agricultural and industrial activity, impact would be neutral in the macroeconomic sphere (as a result of the need for fertilisers and imported agrochemicals), as would be the case in regard to technological development and the environment.

Figure 24 presents a qualitative representation of the neutral and negative impacts implied by these conditions and the characteristics of the production chains involved. The countries that might be included here, such as Colombia, would do well to estimate the values of the different variables in analysing biofuels' contribution to overall sustainable development.

FIGURE 24
SITUATION 5 (BIOETHANOL)



Source: Authors.

Situation 6

Situation 6 includes countries that:

- have subtropical/tropical climates;
- are oil exporters and marginal importers of gasoline;
- have high per capita energy consumption;
- have moderate poverty rates and low under-nutrition rates;
- have undemanding needs for land to address under-nutrition;
- are marginal food importers; and
- have moderate needs for land to supply the domestic biofuels market.

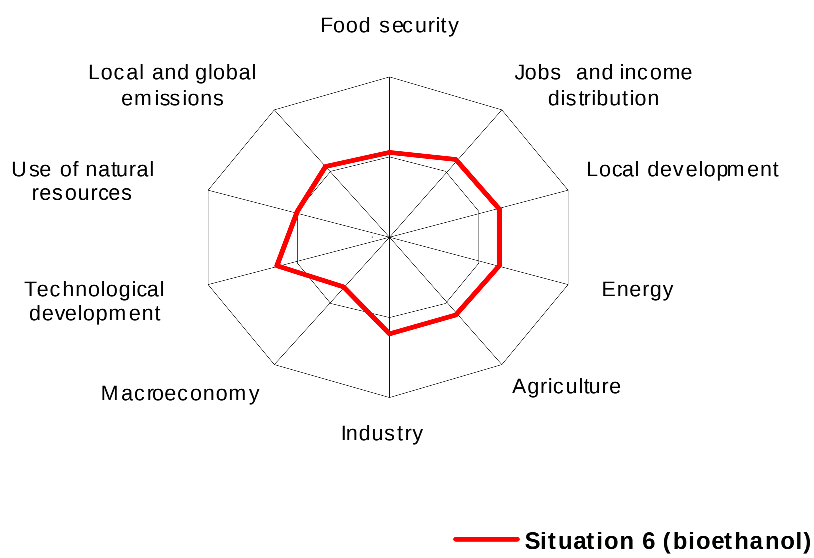
Even if poverty and under-nutrition are moderate or low, and basic energy needs well covered, the introduction of biofuels programmes would involve a series of challenges and threats relating to institutional arrangements and promotional measures that could have a fiscal cost and a negative effect on the poor population's access to food, as well as certain effects on the other social dimensions.

Based on the characteristics and productivity of the raw materials involved in the production chains, sugarcane and corn would be grown for the production of bioethanol, with palm and castor oil for biodiesel. Large producers would be needed to reach competitive scales. Intervention by the State oil company in regulating purchase prices, mix and distribution is not likely to obviate the need for fiscal incentives.

Given a biofuels programme with goals of approximately 10% of the contestable bioethanol market and 5% of the biodiesel market, the qualitative impacts would be as shown in Figure 25. A positive contribution to sustainability is evident: modest contributions to energy security and to agricultural and industrial activity, and a slightly positive effect in terms of local air emissions. There would be a slightly negative macroeconomic impact from tax incentives and agrochemicals imports, no significant effect on technological development, and a slightly negative impact on natural resources.

The threats here are in the area of social impact. The countries with these characteristics, such as Mexico, would be wise to assess the parameters reflected in Figure 25, to decide whether biofuels substantially contribute to overall sustainable development.

FIGURE 25
SITUATION 6 (BIOETHANOL)



Source: Authors.

3.4 Categories of countries for biodiesel products

In relation to biodiesel, three situations are examined, analysing each in terms of edafo-climatic conditions and the production chains described below.

Situation 7

This situation includes countries that:

- have subtropical climates;
- are highly dependent on imports of oil and/or oil derivatives;
- have low per capita energy consumption;
- have a high poverty rate and moderate rates of under-nutrition;
- have undemanding needs for land to address under-nutrition;
- are food exporters; and
- have undemanding needs for land to supply the domestic biofuels market.

Though available land makes it potentially possible to produce an appreciable quantity of biodiesel in this situation, this scenario is characterised by moderate rates of poverty and under-nutrition, and deficiencies in the amount and quality of energy for basic energy needs, especially in rural areas. Public transportation would have options based on abundant hydropower potential.

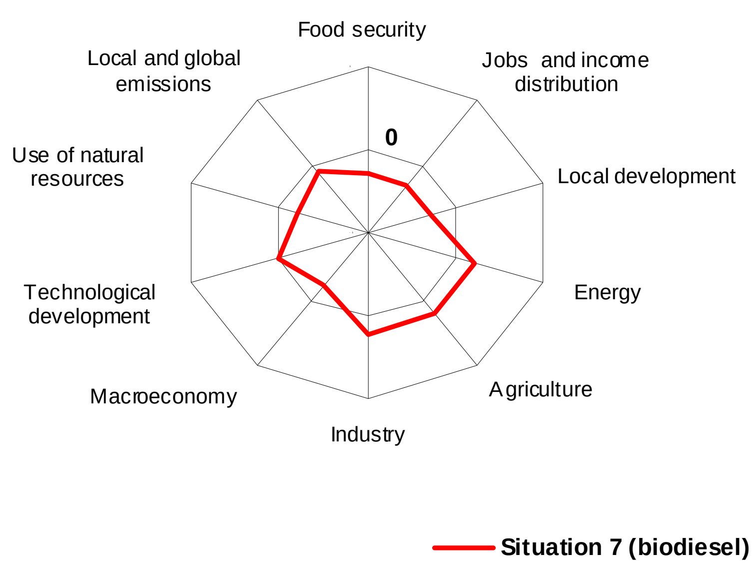
Given the edafo-climatic conditions of these countries, soy and, to a lesser extent, palm would be the logical biodiesel crop. The production chain would be dominated by large producers, not necessarily local, using imported transgenic varieties and agrochemicals.

If the current situation continues, the expansion of these crops would displace small producers and/or encroach on some natural areas, while the agribusiness link of the chain would be subject to heavy concentration, and would exert strong control over the rest of the chain. Mix and distribution of biodiesel would essentially be controlled by private oil companies.

If 10% of the domestic diesel supply were to be replaced by biodiesel, there would be advantages and strengths in certain dimensions of sustainability: a slight contribution to energy diversification and security, slightly positive impact on agriculture and agribusiness (based on the nature of the actors involved), some positive impact on technological development, and a neutral effect on net emissions.

In this situation, the impact on natural resources and biodiversity as a result of monoculture practices, deserve attention. Particular focus should be directed at the social realm, given the characteristics of the crop involved and the characteristics of the agribusiness link of the chain. If the conditions described in the preceding paragraphs occurred, the qualitative impacts would resemble the configuration presented in Figure 26. Thus, countries like Paraguay should make a quantitative assessment of all of the parameters in determining the contribution of biodiesel to overall sustainable development.

FIGURE 26
SITUATION 7 (BIODIESEL)



Source: Authors.

Situation 8

This includes countries that:

- have temperate climates;
- are highly dependent on oil imports;
- have moderate per capita energy consumption;
- have low rates of poverty and under-nutrition;
- have undemanding or minimal needs for land to address under-nutrition;
- have moderate or high food export/import ratios; and
- have moderate or high needs for land to supply the domestic biofuels market.

Unlike the preceding situation, this case involves countries with temperate climates and more limited natural resources, rates of poverty and under-nutrition that are not highly significant and relatively robust coverage of basic energy needs. However, such countries do not have ambitious biofuels goals, at least in terms of first-generation fuels, because of their climatic conditions and lack of available natural resources.

Where second-generation technologies are concerned, the potential availability of lignocellulosic residues opens up more possibilities. An initial step for these countries would be replacement of oil derivatives on a very limited scale, though they cannot expect to escape their pronounced dependence on such imports.

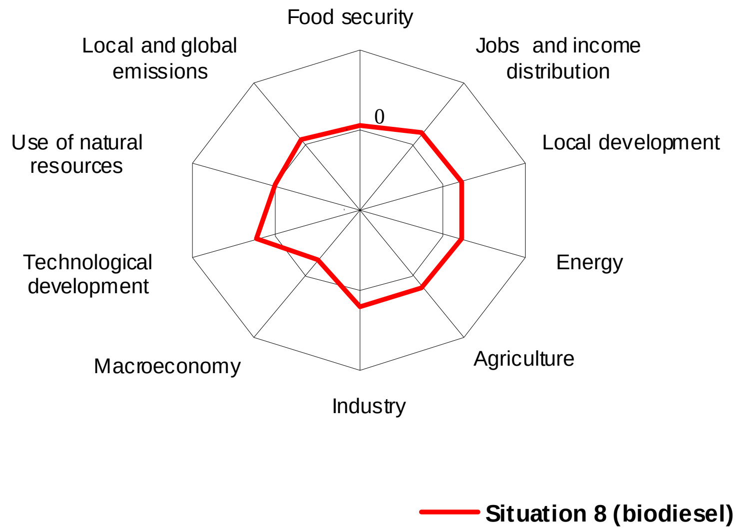
Though the most important links in the biodiesel production chains would involve soy, rapeseed or jatropha as the basis for first-generation biofuels, the use of imported raw material would not be out of the question. Small-scale production would be encouraged in depressed areas to promote local development. Although mix and distribution would be overseen by State-owned oil companies, tax incentives would probably be required for the development of biodiesel.

If these conditions occurred, and there were an attempt to supply 10% of the domestic biodiesel market, there could be significant positive impact on social dimensions, provided that proposed agricultural and anti-poverty policies were implemented in rural areas involved in biodiesel production. The impact on technological development could also be positive, since the experiment would pave the way for second-generation biofuels, where the natural resources available provide for a more promising match. Finally, there would be minor positive effects on the energy dimension, agricultural activity and industrial development.

Environmental impact would not be highly significant, but special attention should be given to macroeconomic issues, both because of fiscal costs (tax exemptions or subsidies) and trade balances.

The expected qualitative effects on sustainable development would be along the lines shown in Figure 27. Countries in this situation, such as Chile and Uruguay, would be wise to perform the quantitative exercise of constructing schematics for their countries, as a means of supporting their biodiesel development programmes.

FIGURE 27
SITUATION 8 (BIODIESEL)



Source: Authors.

Situation 9

This situation includes countries that:

- have temperate climates;
- are self-sufficient in oil and natural gas;
- are marginal importers of diesel;
- have low poverty rates and moderate rates of under-nutrition;
- have undemanding needs for land to address under-nutrition;
- are strong food exporters;
- are strong producers of vegetable oils; and
- have undemanding needs for land to supply the domestic biofuels market.

Countries with these characteristics, in comparison with other countries in the region, have abundant natural resources, low poverty and under-nutrition levels, are major food producers and exporters (particularly of vegetable oils) and have good coverage and quality in regard to basic energy needs. These conditions make it possible, in addition to supplying the domestic market, to export biodiesel. However, the agricultural crop on which production would be based is a monoculture that, in recent history, has been shown to affect natural resources and biodiversity, occupying land previously used for grazing, and featuring large producers in whose hands a large portion of the production is concentrated.

Thus, the basic characteristics of the production chains suggest soy as the base crop. The dominant actors in the primary link of the chain, in this scenario, are large producers, who displace small and medium-size producers (principally livestock producers). To maintain high productivity levels and achieve increasing volumes, the expansion of the crop would occupy natural wooded areas, use hybrid seeds, and employ a high degree of technification.

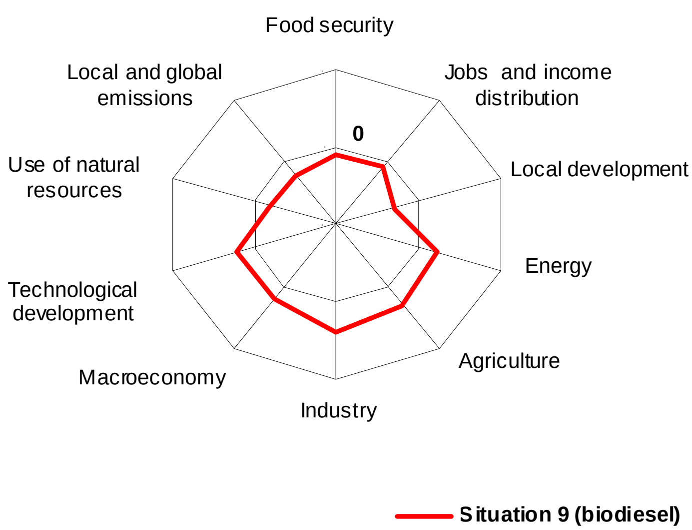
In the agribusiness link, medium-sized and large producers dominate under this scenario, while export opportunities could bring in large transnational grain marketers, as well as medium-sized or large domestic actors. In general, mix and distribution for the domestic market would be controlled by private oil companies.

If biodiesel production along these lines occurred, assuming that 10% of the domestic diesel market was replaced, and that some of the output was exported, there would be significant positive impact on technological development, and some less significant positive effects on energy diversification and security. Given competition with vegetable oil production and exportation, there would not be much effect on agriculture and agribusiness activity, and therefore little contribution on the macroeconomic level, especially if export supports were eliminated.

At the same time, however, special attention should be given to possible negative impact on natural resources (particularly in terms of biodiversity). Also worthy of note are the social dimension, since there would be slight effects on food access due to higher prices, as well as on employment and income distribution because of the displacement of small producers and rising land values. Local development would also suffer somewhat.

If biodiesel production occurred under these conditions, the qualitative impacts would resemble the scheme represented in Figure 28. Countries that might be part of this scenario, such as Argentina, should evaluate biodiesel's contribution to overall sustainable development by analysing data relating to all dimensions of the figure.

FIGURE 28
SITUATION 9 (BIODIESEL)



Source: Authors.

Chapter IV

Towards a regional biofuels policy agenda

This chapter sets forth guidelines for active public policy that involves a positive contribution to the sustainability of development in the region's countries, aiming to build a suitable biofuels agenda.

We take four of the stylised situations described in the foregoing chapter, moving from an *approach* to the principal problems (where we start) to the formulation of *objectives* (where we intend to arrive), and then identifying *strategies* (how to get there) and the *instruments* (the tools for getting there) to put the strategies into practice. Section IV.3 analyses the matrix of impacts, and then examines the dichotomy or controversy of individual versus comprehensive approaches.

Given the scarcity of national and regional experience in this type of exercise, we limit ourselves to examples, analysing some of the types of situations described above, to demonstrate the complexity of the analysis needed. The formulation of actual policy will remain for a subsequent stage of this work, with a publication that examines the empirical results of national workshops applying this methodology.

4.1 Guidelines for development of public policy according to sustainability criteria

It is important to point out that from the perspective of the sustainability of development, the starting point should perhaps be an **approach** that emphasises overcoming the **problems** of poverty, indigence and under-nutrition, as well as those of distributive asymmetry and potential problems arising from the displacement of small producers as a result of biofuels production. These problems, however, go far beyond the scope of this document. Hence, we will focus on the problems that need to be addressed from the point of view of the energy sector, though we shall also attempt to assess impact on the dimensions of sustainable development analysed above.

In general terms, "once the concrete results that are the object of each specific objective are established, we examine what must be done to achieve them. This is a matter of discerning the directions and magnitudes of the efforts needed, and the manoeuvring room available in each case. This means analysing the strategic forces favouring and impeding the desired result. Here, the fact of having identified strategic guidelines becomes highly useful. This matrix consists of rows showing both the threats and opportunities due to external factors (facing those responsible for formulating policy—in this case, the energy sector) and the weaknesses and strengths associated with internal factors. Comparing threats with weaknesses helps to define **survival** strategies; contrasting threats with strengths leads to **defensive** strategies; comparing opportunities with weaknesses and strengths leads to defining **adaptive** and **offensive** strategies, respectively. Some strategies are very versatile, and serve both to defend and consolidate what has been achieved, as well as to advance toward higher levels of sustainability. The strategies, or "lines of action", will depend on each country's specific situation[84].

In order to illustrate different alternatives, we shall attempt to describe four situations: (a) the case of countries that are dependent on oil and/or oil derivatives and that have balance of payments problems due to their high energy bill, while providing a low level of coverage of the poor population's basic energy needs; (b) oil-dependent countries that have a moderate level of coverage of basic energy requirements; (c) countries that have a varied basket of energy resources and can diversify their energy matrix further by producing bioethanol and/or biodiesel, but that are importers of oil derivatives; and (d) countries whose comparative advantages and technological learning curve make it possible for them to become part of the world market.

Situation (a) Bioethanol and biodiesel production in oil-dependent countries that have balance of payments problems and suffer from low coverage of basic energy needs.

Here, we shall analyse countries with tropical climates[85] that, in addition to oil-dependence and coverage of basic energy needs, have high levels of poverty and under-nutrition, and hence have a great need for land to address these problems, and that at the same time are food importers and have a high need for land to supply the domestic biofuels market.

The **approach** with which we start must answer the question, "To what extent can biofuels production contribute to overcoming the **problems** of basic energy deficits and balance of payments?" Since the countries in this category are dependent on crude oil and/or derivatives imports, if policy is to contribute to sustainability, it must place priority on the use of its own natural resources, directing them to the **objective** of providing greater and higher-quality coverage of basic energy needs to the rural and marginal urban populations. In accordance with those objectives, the emphasis on using bioenergy for electrical generation on a small scale in isolated systems, and the small-scale local use of biodiesel and/or self-consumption of biodiesel in productive activities, attention must be given to mitigating dependency on imported fuels by replacing them in the transportation sector. However, it would seem to be more difficult to use bioenergy to generate electricity on a small scale in isolated systems, and in local small-scale use of biodiesel and/or self-consumption of biodiesel in productive activities. This is because the available technologies (gasification and alternative motors, small steam groups, etc.) are not very functional, are costly and, except for certain exceptions that prove the rule (use of residues from sawmills or agribusiness), there have been no lasting and successful experiences with the use of bioenergy for small-scale electrical generation. This is a field of great interest for studies and experiments, with vast potential for Latin America, but it remains very much in the development stage.

The **strategy** to achieve these objectives requires coordination among governmental agencies in the areas of energy, the social sphere, environment, agriculture, and planning with the participation of local authorities and non-governmental organisations.

This strategy would address the *weakness* of lacking adequate articulation with the institutions that must be involved in biofuels policy. The principal *strength* would be the

[84] OLADE/ECLAC/GTZ, "Energy and Sustainable Development in Latin America and the Caribbean. Guide for Energy Policymaking", pp. 179-188.

[85] In principle, countries such as the Dominican Republic, El Salvador, Guatemala, Haiti, Honduras, Nicaragua and Panama could be included.

awareness of the need to use autochthonous renewable resources to deal with the problem of dependency on imports, and to mitigate the low coverage of basic requirements. The principal *threat* is connected with the problems of efficiency in existing institutions and the low purchasing power of the relevant social sectors. The most outstanding *opportunity* is help from international cooperation agencies, which is beneficial to renewable energy programmes. In other words, it would be necessary to foster programmes for the massive introduction of renewable sources, principally biomass sources.

As regards the **instruments** to put these strategies into practice, there needs to be: (a) greater priority on allocating budgetary resources and training human resources; (b) land use regulation, establishing environmental protection standards (requirements for management plans to control erosion and soil and aquifer degradation, etc.); (c) coordinated inter-institutional commissions to unify public policy; (d) support for local actors with informational and promotional means at their disposal; (e) channelling of competitive efforts so as to direct international cooperation towards projects that promote the priority objectives; and (f) social programmes (subsidies) to meet populations' energy needs and to combat poverty.

In summary, then, we have:

PROBLEMS	OBJECTIVES	STRATEGIES	INSTRUMENTS
Deficit in coverage of basic energy needs, along with oil dependence.	Increasing energy coverage through productive and end use of biofuels, and reduction of energy imports.	Strengthening the articulation of public institutions at the national and local levels, and specifying their areas of authority as regards oversight of land use; promoting international cooperation, and designing social programmes.	Greater allocation of budgetary resources; regulation of land use; more information available to, and greater promotion of, local actors; creation of commissions for coordinating national and international cooperation.

Situation (b) Oil-dependent countries with moderate coverage of basic energy needs.

This group includes countries with tropical climates[86], that are highly dependent on oil imports, that have low levels of poverty and under-nutrition, that are food importers, and that have a low level of need for land to address under-nutrition and to supply the domestic market with biofuels.

The dominant approach for these countries should recognise dependence on imported fuels as a priority problem, without excluding social programmes designed to better cover basic energy needs, especially for the poorest. From this flows the objective of replacing some gasoline imports in the domestic market under conditions that favour sustainability. This objective must be complemented by action to replace imported fuels for other uses (electrical generation, local needs in regard to productive activity, etc.).

The principal strategy should be directed at establishing incentives for the domestic use of biofuels, promoting producer organisations working to achieve an equitable distribution of benefits, and improving the quality of local life; preventing deforestation and destruction of natural habitats; promoting the recovery of degraded land and abandoned arable land; establishing mechanisms to facilitate cooperation for access to modern technologies for the conversion and use of biofuels, and setting relevant minimum quality standards.

86 Barbados, Jamaica, Grenada, Guyana, Suriname, Cuba and Costa Rica could be mentioned as examples of this situation.

The principal threat involved in this strategy lies in failing to place priority on social impacts, and in favouring agribusiness interests and private profitability to the exclusion of others.

Instruments appropriate to this strategy could include: (a) differential taxation for the domestic use of biofuels and of their raw material; (b) tax and financial benefits for the production of biofuels with the participation of local producers; (c) a land management plan; (d) dissemination of available technologies, and international cooperation agreements; (e) programmes and goals for the incorporation of biofuels; (f) specification and adoption of standards for fuel mixtures and for their marketing.

In summary, then, we have:

PROBLEMS	OBJECTIVES	STRATEGIES	INSTRUMENTS
Dependence on imported fuels.	Reducing imports in accordance with a biofuels penetration goal for the domestic market.	Promoting the organisation of producers to achieve land planning based on sustainable management goals; obtaining greater international cooperation for the incorporation of new technologies and quality standards; defining a sustainable management plan.	Sustainable management plan; tax benefits for production and consumption; land planning and legislation to protect land and environment; adoption of marketing standards; creation of programmes and goals for insertion in international cooperation and market regimes.

Situation (c) Countries with a broad basket of energy resources that can diversify their energy matrix further by producing bioethanol and/or biodiesel, but that import oil derivatives while exporting hydrocarbons.

These countries[87] have subtropical/tropical climates, low per capita energy consumption, high levels of poverty, and moderate levels of under-nutrition and of land needs to address it, while they are food importers/exporters and have relatively little need for land to supply the domestic market with biofuels.

This situation also calls for an approach that emphasises reducing imports and providing greater coverage for the basic energy needs of the poorest, especially in rural areas. Recognising these problems as priorities for advancing toward more sustainable development, the following objectives are obvious options: reducing importation of oil derivatives, diversifying the matrix by using internal sources to cover energy needs, and maximising the impact of biofuels production on local development.

Strategies to achieve these objectives include: (a) promoting the use of compressed natural gas in automobiles; (b) massifying rural and urban LPG distribution networks; (c) developing projects to use bioenergy for electrical generation in isolated systems; (d) promoting the production of biofuels for self-consumption and local productive use; (e) authorising biofuels exports once the domestic market has been supplied.

The most important weaknesses here relate to the lack of articulation among the entities that must be involved in policy making, and a lack of institutional development among those entities responsible for public policy in the bioenergy area.

The principal strength relates to the availability of natural energy resources. The principal threat for this strategy lies in failing to devote priority attention to social impacts, favouring agribusiness interests and private profitability to the exclusion of others.

[87] Bolivia, Ecuador and Peru could be part of this group.

Notably, one of the opportunities here relates to the interest of international cooperation agencies in preserving biodiversity and in developing small-scale bioenergy projects for local development.

Instruments needed to put these strategies into practice include: (a) expansion of local fuel supply, refining and distribution centres; (b) distribution of LPG containers for rural households; (c) setting of reference prices for the sale of compressed natural gas for residential use in each region; (d) promotion and incentives for community initiatives, and assistance to local communities for bioenergy projects; (e) technical assistance to small producers capable of using biofuels for their own needs; (f) setting of a goal for biofuels mixtures; (g) exportation of biofuels once the domestic market is supplied; (h) standards for the production of biofuels and their inputs; (i) cost-benefit analysis of the use of land and water resources for the development of the biofuels market, versus other rural development options.

Situation (c), then, can be summarised as follows:

PROBLEMS	OBJECTIVES	STRATEGIES	INSTRUMENTS
Deficit in coverage of basic (especially rural) energy needs, and the replacement of oil derivatives for transportation needs.	Increasing basic coverage; reducing dependence on imports of oil derivatives; maximising the social impact of biofuels production.	Introducing compressed natural gas in the transportation fleet; organising LPG distribution networks; identifying hydroelectric potential; promoting biomass for electrical generation; promoting biofuels for local self-consumption.	Setting reference prices for the sale of LPG; promoting community initiatives relating to bioenergy projects; establishing sustainability criteria for biofuels production; preparing a water resources management plan; regulating exports and defining goals for domestic biofuels consumption; assessment of land use for biofuels production; social programmes (subsidies) to diversify the matrix based on local sources.

Situation (d) Countries whose comparative advantages and technological learning curve make it possible for them to become part of the world market.

These countries[88] have subtropical/tropical climates, are self-sufficient in oil and oil derivatives, have moderate per capita energy consumption and moderate poverty indices, and low levels of under-nutrition. Given these conditions their needs for land to address under-nutrition and to supply the domestic biofuels market are low. They are also food exporters, and have strong experience in ethanol production and technological development, in both the agricultural and industrial phases of the process. They have mature automobile industries and their own technological development in connection with bioethanol use. Finally, they have state oil enterprises with a presence in other energy production chains.

The approach for this situation could involve a leadership role in technological development related to liquid biofuels, and an eventual position as an important producer and exporter to the international market. From the point of view of sustainable development, however, it will be important to avoid the social and environmental problems associated with the monocultures involved in the first link of the biofuels chain. Thus, the objectives compatible with this approach are: (a) to establish limits on the territorial expansion of monocultures into natural reserves or food-producing areas; (b) to support various forms of business organisation among local producers in the raw materials production and processing links of the productive chain; (c)

[88] Brazil could be part of this group.

to promote the participation of small producers and prevent their being displaced; and (d) to establish conditions for the social protection of the work force in the primary link of the chain.

Strategies that should be considered in order to gradually achieve these objectives include: (a) sustainability criteria for the production of biofuels and their inputs; (b) management criteria to control erosion and degradation of soil and aquifers; (c) restrictions relating to land use regulation; (d) support for the production and certification of biofuels; (e) assistance to producers to prevent their being displaced by the advance of monocultures associated with biofuels; (f) government intervention in the labour market associated with the bioethanol production chain, especially where primary production is concerned; (g) greater local and national retention of the value added produced in the productive chains.

The principal instruments capable of making these strategies workable include: (a) perfecting methods regarding information on, and regulation of, soil use, and addressing land use provisions in general; (b) monitoring working conditions and preventing precarious work conditions; (c) adopting measures that promote tax and financial incentives and biofuels certification mechanisms; (d) providing financial support and other assistance to small producers (agricultural management and marketing assistance) to increase their profitability; (e) continuing to strengthen mechanisms designed to obtain budgetary resources for governmental and private initiatives in the area of biofuels research and development; and (f) adopting tax and regulatory measures that promote the retention of the surplus by producers, and sanctioning oligopolistic practices that lead to control of the production chains.

In summary:

PROBLEMS	OBJECTIVES	STRATEGIES	INSTRUMENTS
Productive specialisation in ethanol, with attendant social and environmental problems associated with traditional biofuels monocultures.	Limiting the expansion of monocultures; organising the links of the production chain to obtain greater profitability for producers and to improve working conditions.	Establishing sustainability criteria in biofuels production, and optimising land management; generating synergies with local producers, and achieving better working conditions.	Strengthening institutions involved in land use regulation; adopting tax incentive measures; providing financial support to small producers; promulgating legislation to regulate working conditions; providing financial support for research and development.

4.2 Principal factors that could work against the possibility of creating an appropriate biofuels agenda

The adoption of biofuels programmes by the developed countries, particularly the United States and the European Union, creates a series of opportunities for the region’s countries. However, national biofuels policies must be put in place so that the development of biofuels production is accompanied by economic growth, protection of the natural patrimony and social equity.

In taking advantage of the trade opportunities, attention must be paid to national objectives beyond those involved in productive specialisation—e.g., greater coverage of the population’s energy needs and protection of the natural patrimony. Thus, each country must define its own agenda if it is to extract advantage from the demand in the developed countries, moving towards resolution of its own problems and opening up new opportunities for rural development.

The analysis presented in the foregoing chapters of this document shows the complexity and multi-dimensional nature of the issues, and it can be seen, if only qualitatively and preliminarily, that certain conditions must be met if biofuels' contribution to the sustainability of development in the region's countries is to be maximised.

A good number of the region's national governments have set goals for the local market and have passed legislation to develop biofuels, without thoroughly examining the impacts that such development could have on agriculture, natural resource use, and the social sphere, especially in regard to combating poverty and the effect on food prices. Hence, developing an appropriate biofuels policy agenda that truly contributes to the countries' sustainable development is a task yet to be fully realised.

4.3 Evaluation of biofuels policy

Chapter III presented some guidelines or policy proposals for certain stylised situations considered to be of special importance, taking account of developmental sustainability issues. Now, we shall relate those predictable qualitative images to the actual possibilities of creating policies that take all of the dimensions of sustainable development into account.

(a) Matrix of biofuels policy impacts

Below is a matrix of impacts on the axes of sustainability set forth above, underlining the magnitude of the effects, the degree to which the effects will depend on the way public policy is implemented, and critical aspects of the approaches adopted (See Table 10)

As the table shows, impacts on the energy factor are largely uncertain, since only empirical verification of the quantity of fossil energy used in producing biofuels will determine the ultimate verdict. Though the energy balance across the production chain may be difficult to evaluate, a simple indicator is whether or not it lowers fuel imports in those countries that are net importers, using local production to replace imports.

Global effects on agricultural activity are, as a general matter, highly significant, and their very existence is in doubt, unless biofuels production permits greater incorporation of technical progress to obtain more productivity from existing crops, and unless the agricultural frontier can be expanded in a sustainable manner. Only in situation (d) for bioethanol would these impacts be of significant magnitude in terms of exportation.

However, even in this case problems can already be detected for a country with long experience in producing and exporting bioethanol. Hence concern should centre on the possible negative impact of monocultures on the social conditions that affect the labour market, on the concentration of land ownership, and on the social distribution of the gains.

In regard to the global effects of biofuels programmes and policy, the magnitude of the impact will be related to the size and evolution of domestic markets, and to the type and magnitude of the export markets, which are viable only for situations of the (d) type involving bioethanol.

TABLE 10
MATRIX OF THE IMPACT OF BIOFUELS POLICIES

"*Ambito" Situation	Energy	Agriculture	Industry	Macro-Economy	Technolog. Develop.	Use of natural resources	Local & global emissions	Food security	Jobs and income distribution	Local development
Situation 1	c	xd	x	d	-	*	-	**	c	c
Situation 2	c	x	x	cd	-	*	-	-	c	c
Situation 3	c	xd	x	cd	-	*	-	*	c	c
Situation 4 (bioethanol)	c	xx	xx	xxc	xx	c	c	c	**	**
Situation 4 (biodiesel)	c	x	x	d	x	c	-	c	c	c
Situation 5	c	xd	x	d	-	*	-	*	c	c
Situation 6	c	xd	x	d	c	*	c	*	c	c
Situation 7	c	c	x	d	c	c	-	c	c	c
Situation 8	cd	xd	x	d	xd	d	-	c	c	c
Situation 9	c	x	xx	xc	x	c	c	-	**	**

Source: Author.
Notes:
c: conditional on the form of implementation
d: doubtful effect on sustainability
x: insignificant effect
xx: significant effect
-: neutral or no effect
*: predominantly negative effect
**: significantly negative effect (critical aspect)

The negative macroeconomic effects will depend on the net effect of gains achieved by replacing hydrocarbons imports, and could have widely differing results. For the most part, the gains seem doubtful (indicated in the table by "d" or "cd"), due to the fiscal costs of the potential need for promotional measures (tax exemptions or subsidies) and/or the importation of inputs, especially for the primary link of the chain (agrochemicals). In this case, too, the impact in situation (d) for bioethanol is of note, given its magnitude in terms of export markets. However, the results in this case should show an increasing positive balance in the energy sector. Something similar, though of different magnitude, could occur in countries that are exporters of raw materials for biodiesel (primarily soy). Meanwhile, the attraction for importing countries is the possibility of reducing imports, with the concomitant effect on the national oil bill.

The impact on technological innovation will depend on the conditions and size of the market, and the availability of sufficient financial resources to maintain and further these innovative activities throughout the links of the productive chains (especially in the bioethanol chain), including automobile production activity.

In terms of effects on natural resources and biodiversity, there are a number of situations with critical aspects (indicated in the table by an asterisk), whether due to the more limited availability of natural resources and biodiversity and/or because the production of agricultural raw materials is likely to advance into forest zones or natural reserves. In other cases, there is a conditional effect (indicated with a "c" in the table), due to greater availability of these resources, although biodiversity and soil quality may be affected.

On the food security element or axis, an additional emphasis is given to particularly critical factors (denoted in the table by ** or *), or factors that could become critical (c). These are situations with widespread under-nutrition or poverty, or where the production of raw materials for biofuels production could displace food production.

The jobs and income distribution axis and the local development axis have a similar structure in terms of their effects. The situations in which export markets could become important present a particularly critical (**) issue, because of the highly mechanised nature of monoculture and the prevalence of large producers. In the remaining situations, the consequences would be conditional on the effective incorporation of small local producers in primary production.

(b) Divergence between individual versus integrated policy approaches

To the extent that the activities involved in the biofuels production chains prove profitable, there will be private-sector agents interested in them. Since the production of agricultural raw materials represents the most important portion of the production cost of biofuels, the factors that determine that cost will be decisive in determining competitiveness. Thus, labour costs become an adjustable variable, while the incorporation of technical progress will be a crucial factor in increasing productivity—in which case some of the efficiency gains should translate into wages.

With international oil prices above US$80/barrel, there is a large margin for private profitability in first-generation biofuels production. Thus, there are numerous initiatives in the region to invest in the agribusiness activities involved.

In this situation, it is especially important to analyse the possible discrepancy between individual approaches (essentially based on financial profitability) and the comprehensive approach that should orient active sustainable development policy.

Naturally, the above-mentioned comprehensive approach is difficult to describe, since it reflects the preferences of authorities in applying policy, and these authorities are, in practice, multiple actors within government (and may have differing visions of problems, objectives, strategies and instruments).

Based on the totality of issues dealt with in this study, it can be stated that the above-mentioned comprehensive approach is multi-dimensional and thus must be managed in a centralised fashion. Thus, participation must not be limited to energy authorities, but must also draw on input from relevant government entities concerned with agriculture, industry and transportation, finance, natural resources and environment, social areas such as health, and regional entities. A coherent biofuels policy can only be built on the basis of common agreement and adequate information[89]. Once such governmental consensus is achieved, reactions and contributions from civil society can be incorporated in formulating policy. Thus, the rules of the game for investment must be governed by a comprehensive, rather than an individual, approach.

[89] Also see ECLAC, OLADE, GTZ, "Energy and Sustainable Development in Latin America and the Caribbean. Guide for Energy Policymaking", Santiago, Chile, 2003.

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