# Feasibility Analysis for **Biofuel Production** and Investment Recommendation

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# Technical Details

### Project
Feasibility Analysis for Biofuel Production and Investment Recommendation

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# Contents

# Background

In March 2007 the **US** and **Brazilian** governments signed a memorandum of understanding for biofuel cooperation (MOU), acknowledging the mutual interest in developing sustainable energies. This memorandum consists of the following actions:

- **Bilateral Development**, in which the two countries intend to advance in research and development of new biofuel technologies;
- **Agreements with Third Countries,** in order to encourage local production and consumption of biofuels elsewhere in the planet, beginning with Central America and the Caribbean and continuing to other regions in the world; and,
- **General Developments**, in which the two countries intend to expand the biofuel markets by cooperation and establishing standards.

To implement them the USA appointed the **US Department of State**, as its representative and the Brazilian Government appointed the **Ministry of Foreign Affairs**. Concerning the aspects involving third countries, the American and Brazilian Governments, in conjunction with the **Inter-American Development Bank** (IDB), **Organization of American States (OAS), UN Foundation** and **APEX – Brazil** began feasibility studies for the following countries in Central America and Caribbean: **Haiti**, **Dominican Republic**, **El Salvador** and **St. Kitts & Nevis**. The document herein drafted by **Fundação Getulio Vargas (FGV)** is included in this context.

# Executive Summary

Considering the rise in petroleum prices, various nations are in economic difficulties by importing this input, or face supply problems. In this context, the demand for alternative energy sources has attracted worldwide attention to the production of agricultural raw materials, namely those with feasibility for manufacturing ethanol and biodiesel. This scenario is especially important for the Central American and Caribbean countries, considering the external dependence on non-renewable fossil fuels.

In addition to the economic, energy and social reasons, the new sources of energy are also considered as possible solutions for a long-term problem: the need to combat global warming. This phenomenon, caused and aggravated by the emission of harmful gases into the air (notoriously $CO_2$) is the result of the intensive use of fossil fuels. Therefore, substituting these fossil fuels for renewable fuels creates opportunities for economic and social development, reduces the environmental impacts, and increases the energy security of the countries. However, this substitution is also accompanied by a series of logistics and technological challenges that are discussed herein.

Despite the different positive impacts, the success of introducing biofuels depends on overcoming a series of logistics and technological challenges. The logistics challenges are especially important in a sector whose key input is agricultural, which must be harvested and processed rapidly before it deteriorates. The farming areas must be planned and systematized in order to permit extensive neighboring areas, reducing freight costs and permitting saving from the best use of inputs and machinery. Therefore, the techno-

logical challenges are the essence of competitiveness in this sector, requiring the procurement suitable farm implements, building highly efficient industrial plants and the on-going improvement of the cultivated plant species and their management techniques.

In this context, and within the scope of the Memorandum of Understanding of Biofuels between the USA and Brazil, Fundação **Getulio Vargas** developed, at the request of **APEX-Brazil**, technical and economic feasibility studies for biofuel production in **El Salvador** and the **Dominican Republic**, and prepared the Agricultural Suitability Charts for **Saint Kitts & Nevis**, at the request of **OAS** and, at the request of **IDB**, is developing the feasibility analysis for **Haiti**.

This document summarizes the work done and in progress, and is based on the feasibility analysis for biofuel production in **El Salvador** and the **Dominican Republic**.

# Feasibility Analysis for Biofuel Production

The feasibility analysis for biofuel production developed by **FGV** are divided in three Phases:

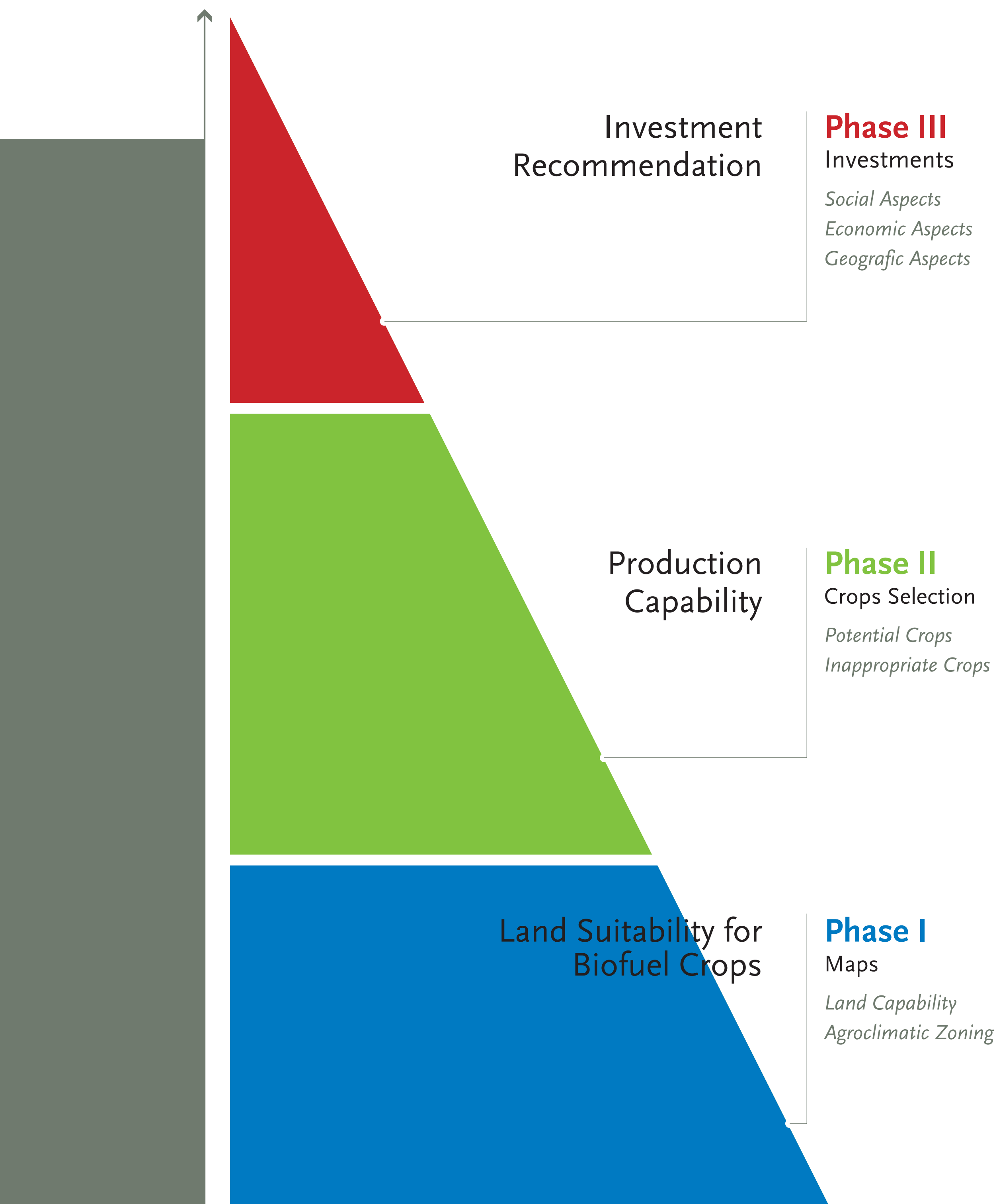
- **Pre-analysis of Feasibility**, determined by a discerning combination of different variables conditioning the agricultural suitability for biofuel production and analyses on the existing regional infrastructure;
- **Production Capability Analysis**, involving the entire production chain for different regions in the same country, from planting to production, passing through the different players involved in each process; and
- **Investment Recommendation,** defining the best places – considering agricultural and infrastructure aspects and other factors.

Figure 1 shows a diagram of the general lines for these studies.

In these feasibility analysis, all the production stages are examined, such as the analysis of conditioning factors of agricultural suitability, the technologies required for adapting these lands to biofuel crops, the logistics and infrastructure aspects, the existing mills and their need for upgrade. The economic and social impacts are also assessed quantitatively and qualitatively based on socioeconomic and demographic data of these countries. Lastly, they assess how the introduction of biofuels could, when substituting petroleum byproducts, cut costs and energy risks of the countries. After analyzing these factors, investments are recommended with focus on the best potential of each reality.

• **FIGURE 1**

Method for Feasibility Analysis



# Phase I

## Defining Land Suitability

This section addresses a concept that guides the feasibility of each agricultural project with regard to **land suitability**. Since the success of an agricultural project's production depends largely on its potential relating to climate, relief and soil, identifying possible investments must begin by conceptualizing this suitability. The variables considered to define the land suitability are as follows:

**Land capability**:

- Soil types;
- Slopes;
- Areas of environmental protection;
- Areas with risk of flooding or flooded areas;

**Agroclimatic zoning:**

- Average annual air temperature;
- Temperature in coldest month;
- Annual potential evapotranspiration;
- Current evapotranspiration;
- Annual rainfall;
- Annual water deficiency and surplus.

To obtain these maps, preliminary visits are made to collect primary data and pre-existing studies with the competent authorities.

This volume of data is required because the soil, relief and agroclimate characteristics directly influence the agricultural potential. Some regions have very suitable natural attributes, requiring few human interventions to be productive. Other not so favorable regions can still be economically feasible, but requiring human interventions and corrections. Lastly, some areas can be unsuitable due to natural particular features or because they are urban or environmental protection areas.

Land suitability for the countries under consideration is then defined for the following plant species, allocated to biofuel manufacture:

- **Sugarcane;**
- **Soybean;**
- **Sunflower;**
- **Eucalyptus;**
- ***Jatropha curcas*; and**
- ***Elaeais guineensis* (dende oil palm).**

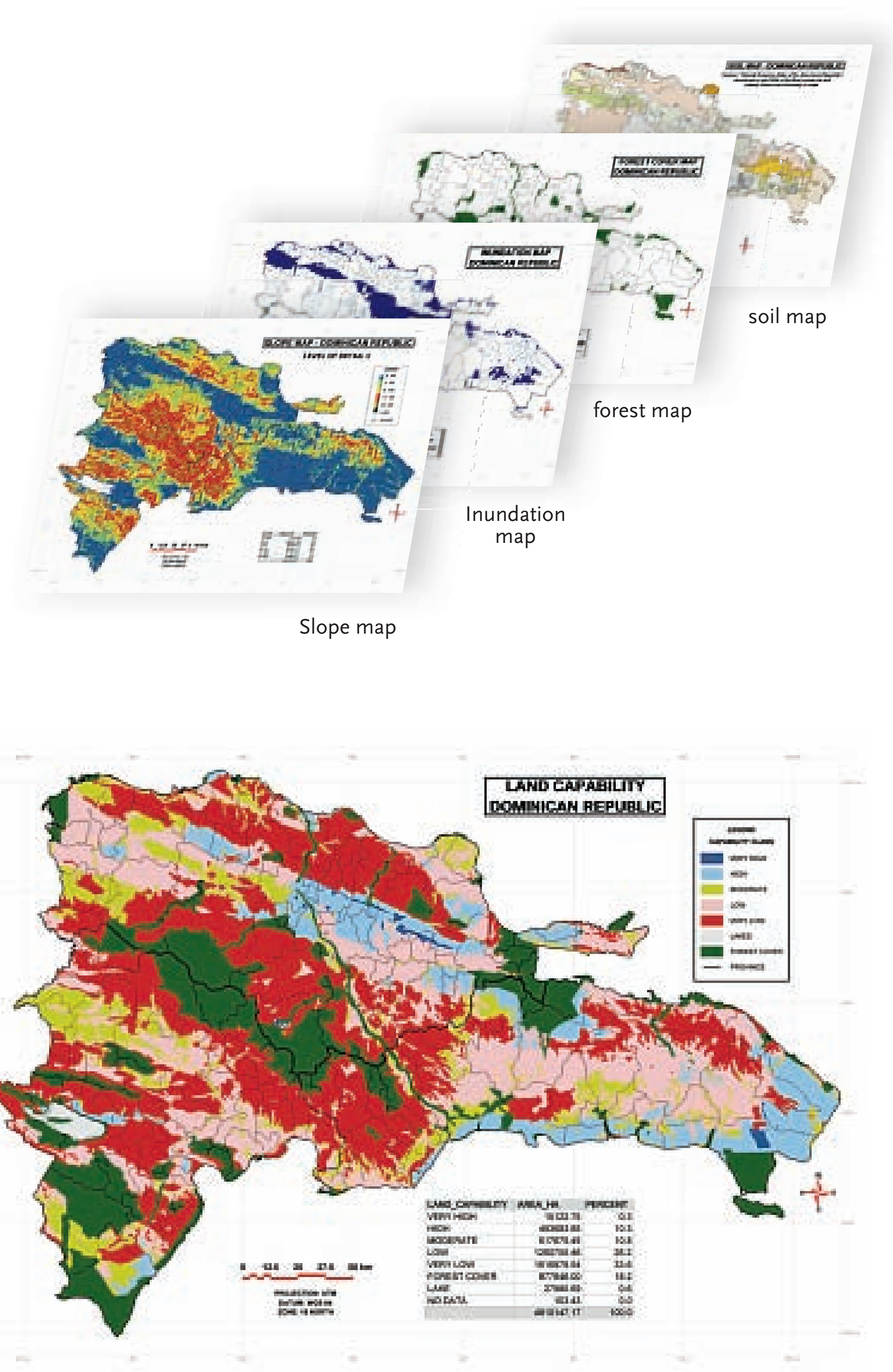
With regard to sugarcane, the production system is subdivided into manual and mechanized harvesting to help in future decision making about the type of harvesting system adopted. It is then necessary to consider the adoption of an intensive labor system with environmental restraints (manual harvesting), or an environmentally friendly hi-tech system with a low demand for labor (mechanized harvesting).

The land capability categories for soybean, sunflower and sugarcane crops under a mechanized harvesting system are examined together, considering the similarities in the requirements of soil type for these crops, with regard to their planting and harvesting systems (as showed in Figure 2). The other crops however have tables that established their capacities.

In general, the result is a measure in percentages of the country's areas where a certain crop is suitable, which are areas of environmental protection or which have lakes and also which areas can be improved by adopting management techniques. Agriculture is very sensitive to climate and weather conditions, which determine the suitable plant species or variants, the farming systems to be adopted and the practices required to produce a high-performance crop.

• **FIGURE 2**

Process for creating the land capability map for the Dominican Republic



The agro-meteorological information, therefore, principally climatological data, is essential for agricultural planning, which will, together with soil information, define the potential of an area for a specific farming activity.

Based on the survey of suitable agroclimates in each region it is possible to pre-analyze the operational capacity in the countries under consideration. It was important, therefore, to adapt the lands to producing feasible raw materials for biofuel production and permitting more secure estimates or agricultural productivities, production costs, required investments and expected financial results (as showed in Figure 3).

The combination of these levels of information summarizes in a classification system the most important soil and climate variants affecting the soil use in different places. It is important to simplify the information in clearly defined categories so that agricultural specialists can assess their suitability for different types of use. The land suitability with regard to its capacity for use is assessed on a qualitative basis. Specialist know-how is the basis for defining the suitability categories in accordance with the combination of the land capability and agroclimate categories.

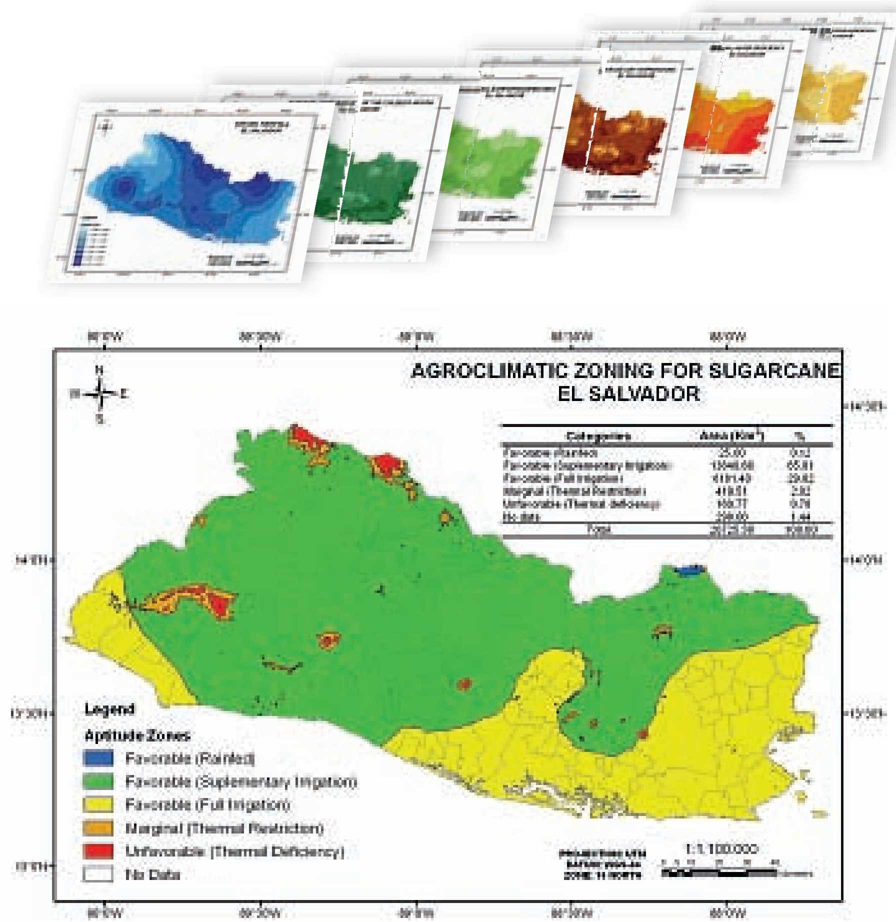
Information on land capability and agroclimate zoning was matched using decision trees, in which the combined data was classified in six suitability categories. These categories are as follows:

- high suitability (HS) for excellent climate conditions and land capability;
- suitability (S) for good climate conditions and land capability;
- moderate suitability (MS) for average climate conditions and land capability;
- low suitability (LS) for low climate conditions and land capability;
- unsuitability for totally inappropriate climate conditions and land capability.

When classifying these categories, the qualification between land capability and agroclimate zoning does not always coincide. For example, in some cases where the land capability is found to be extremely limiting, even when the agroclimate zoning is excellent or good, the suitability category may still be considered low or unsuitable.

• **FIGURE 3**

Process for creating the agroclimatic zoning for sugarcane map for El Salvador

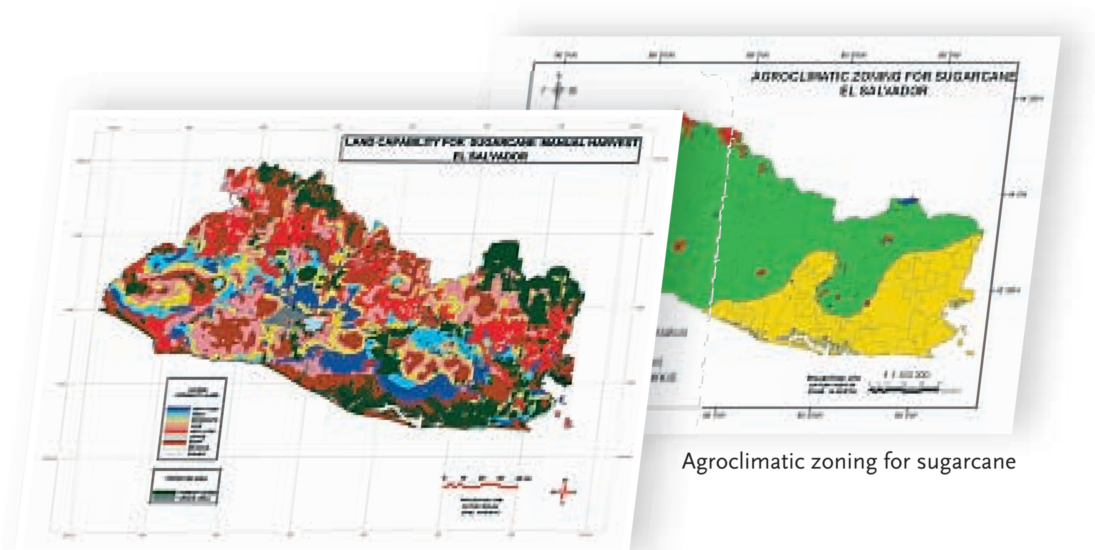



Alongside the agricultural analyses, information is collected on the infrastructure and socioeconomic data of each country; the main logistics modes, the port positions and existing mills, for biofuel production and distribution are charted; various sectors are analyzed, such as import logistics, production and blending capacity (ethanol in gasoline and biodiesel in diesel), storage, existing ports, as well as production plants and sugar mills that could receive investments for ethanol production.

After consolidating the aforementioned contents, namely, land suitability, infrastructure and logistics, Phase II begins, defining the best regions for installing projects, and after this Phase investments are recommended based on economic-financial analyses for each country or region.

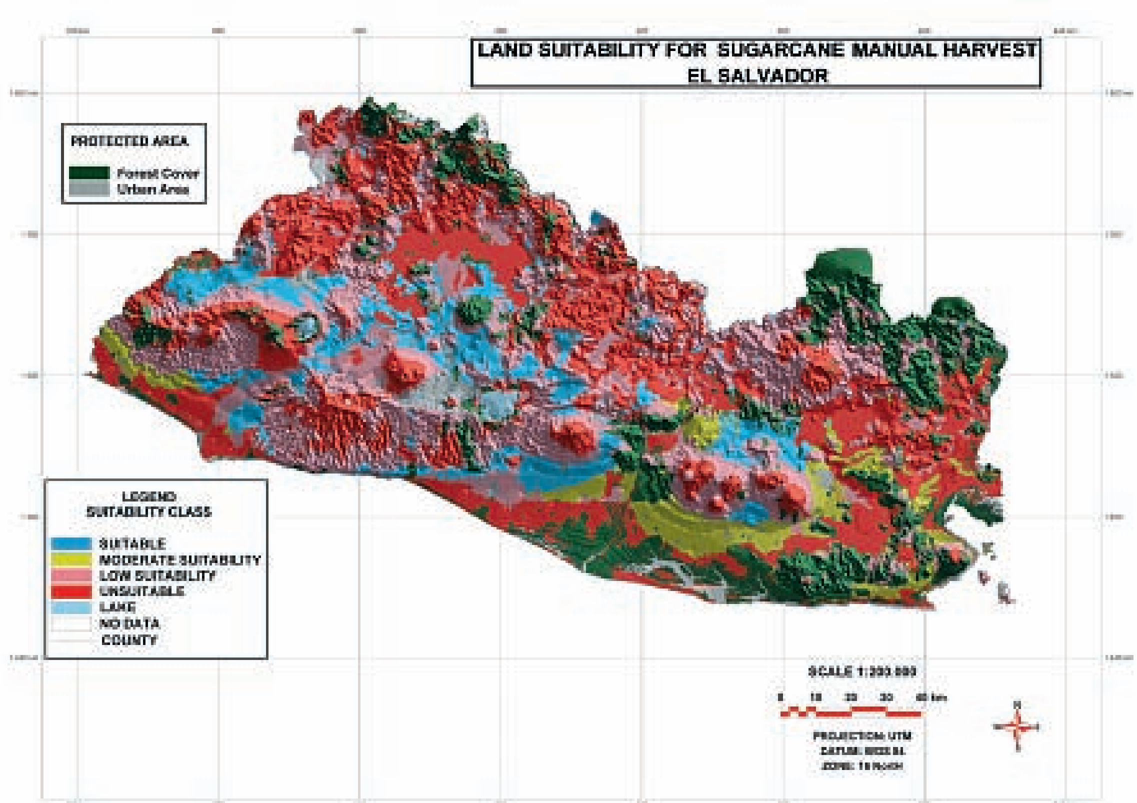
## • FIGURE 4

Process for creating the land suitability map for El Salvador




Agroclimatic zoning for sugarcane

Land capability for sugarcane manual harvest



# Phase II

## Biofuel Production Capacity

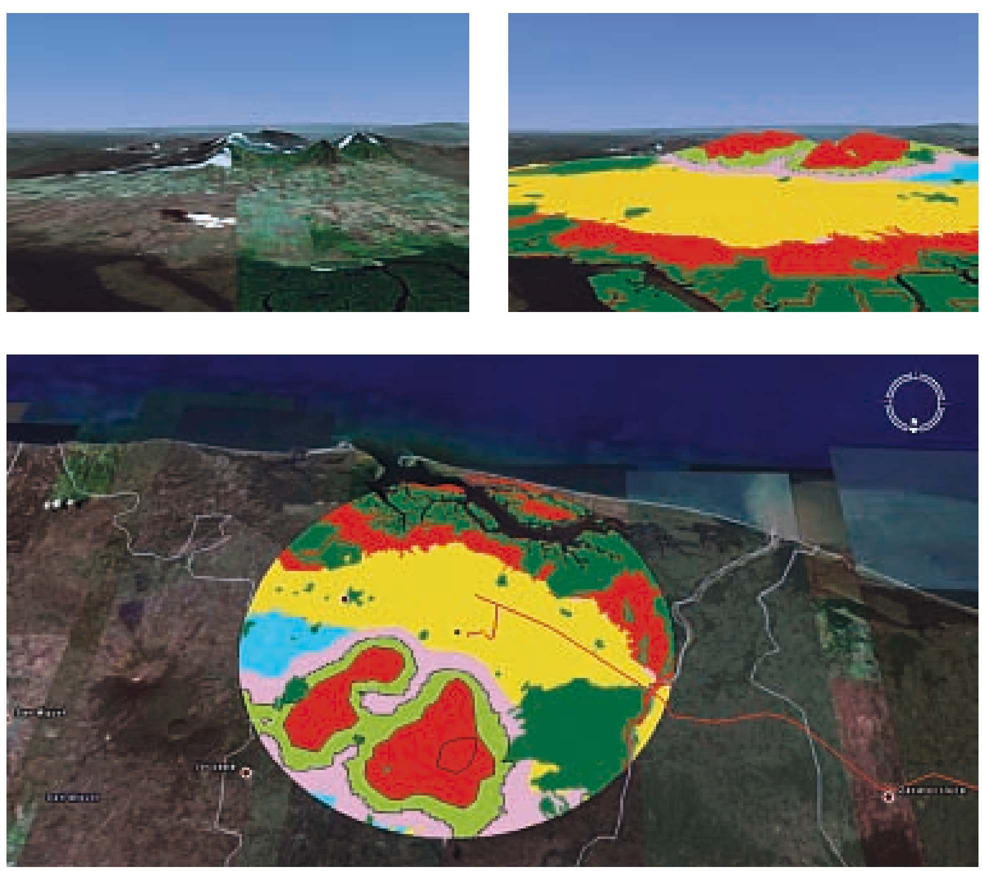
An analysis of which crops are most suitable is made using the results from the **Land Suitability Phase** as a basis. In the case of El Salvador and Dominican Republic, the possibility of cultivating *Elaeais guineensis* (dende oil palm) and soybean was discarded as unsuitable crops. In those countries, the potential crops are:

- Sugarcane;
- Sunflower;
- Eucalyptus;
- *Jatropha curcas*;

An analysis was made, based on these results, of the economic impacts for starting biofuel production, based on the assessment of their socioeconomic performance and energy profile. This information is georeferenced by **FGV**, enabling its processing using software of Geographic Information Systems (GIS).

• **FIGURE 5**

Geographic Information Systems (GIS)



The agricultural suitability of a region varies with the crop considered. Plant species in general show different requirements to be able to express their maximum production potential. Accordingly, each region of a certain location offers different potentials for agricultural exploration, defined by the variability inherent to the production environments. The benefit of considering different crops in the same study is to permit an effective comparison of the arable and financial sustainability of each crop in different places.

**The analysis of the sugarcane crop focuses on ethanol production, that of sunflowers and *Jatropha curcas* as a feedstock for biodiesel, and eucalyptus as an alternative for pellet manufacture, which is a biomass for power cogeneration.**

With the possible establishing of the biofuel production industry in these countries, many different business opportunities arise ranging from the sale of industrial equipment (production plants, components for extending existing mills), farm machinery and implements, technical assistance in consulting projects, technologies relating to new precision agricultural techniques, to advisory services in developing new variants adaptable to local conditions.

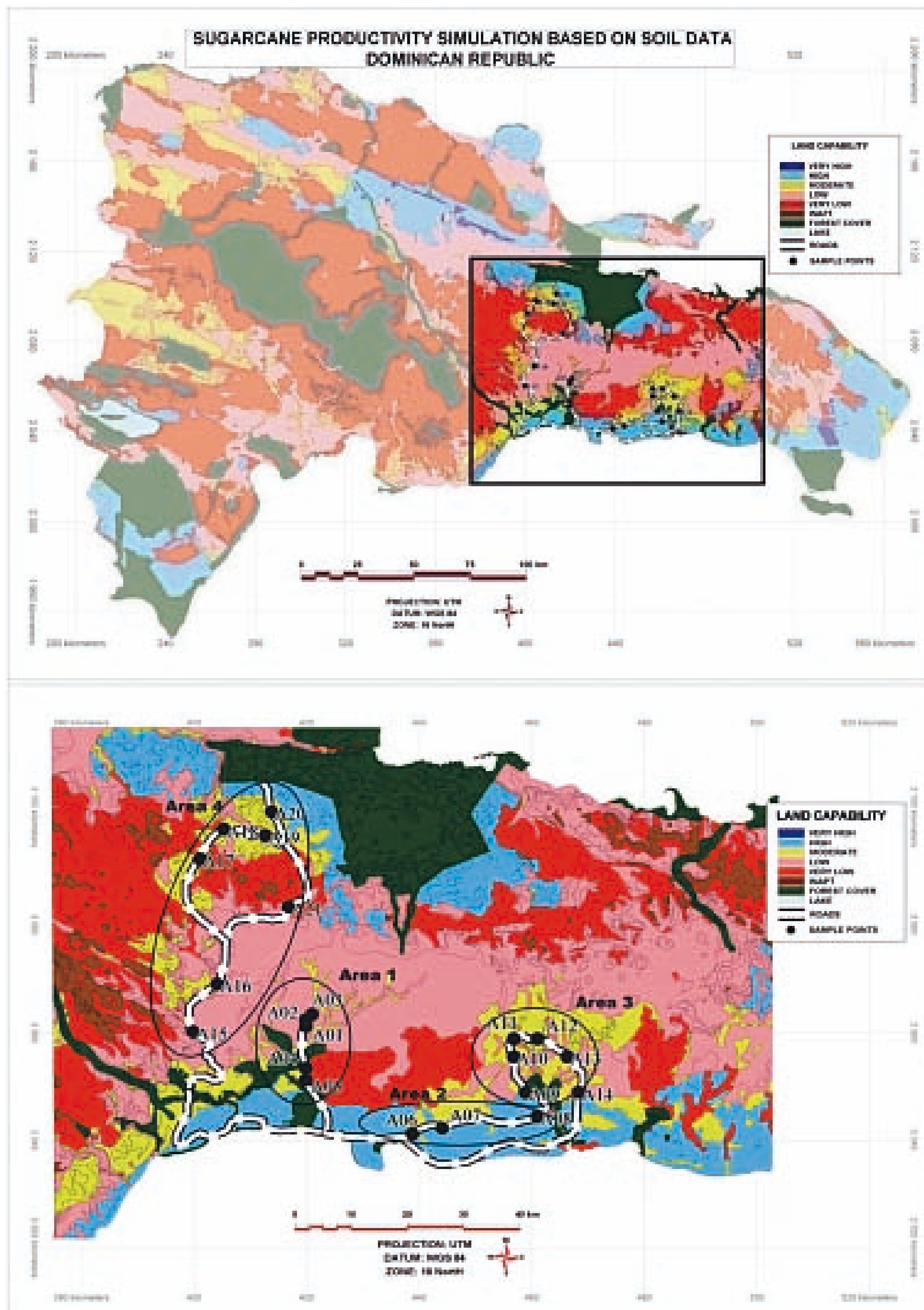
It should be pointed out that investments in the biofuel production chain result in a series of positive effects, such as, for example, income generation in the field and substituting petroleum byproducts in power generation and transportation.  Biofuel production can also increase export opportunities. These impacts are very relevant for developing and oil-importing countries, such as those in Central America and the Caribbean.

Based on results obtained from the land suitability study, productivity was estimated based on the soil characteristics to calculate the values of the productivity potential using calculation models for the different crops. It can therefore be defined in which areas it is possible to install or increase certain projects.

The model used is based on the calculation of the potential productivity using the main soil and land characteristics affecting the productivity of a crop. These soil characteristics were obtained by analyzing the soil samples collected onsite during a visit to the countries. The following is a summary of the methodology adopted for this calculation based on the example of sugarcane, an essential input for ethanol production. This methodology is therefore used for the other crops considered suitable.

## • FIGURE 6

Location of sampling points on the land capability map, potential areas and data on sugarcane potential productivity in the Dominican Republic



## • FIGURE 7

Photographs with examples of some land and soil uses in areas selected in the preceding figure


**1)** Typical landscape (Area 1), **2)** Soil with drainage deficiency (Area 1), **3)** Pastureland (Area 2), **4)** Region sugarcane cultivation potential (Area 2), **5)** Area of pasture and abandoned fruit cultivation (Area 3), **6)** Pastureland with cattle (Area 3)

## Sugarcane

To obtain the best result for production financing and location, a specific assessment is necessary for each crop, both in aspects of soil and climate. The following is an example of this assessment for sugarcane in one of the countries considered for this project based on the use of a model to predict productivity

## Sugarcane Production Considering the Soil

Using the example of sugarcane, the following soil and land characteristics influencing its productivity are used in the model: phosphorus (P), potassium (K), cation exchange capacity (CEC), base saturation (V%), clay content, drainage and slope. These characteristics are chosen because there is a great deal of scientific data relating productivity to soil fertility and land characteristics.

Each of the soil fertility characteristics is divided into three composition categories, which are the intervals used in classifying their soil compositions. Each category is given a rating with regard to its soil composition. The higher the rating the greater the productivity, since all other crop requirements are satisfactory. Lastly, since the rating is in function of the characteristic of the soil composition, equations are given for each category interval

Figure 5, on the next page, shows the location of sampling points and the potential productivity calculated for each of these points based on the soil data obtained from laboratory analysis. The analysis of distribution of the sugarcane potential productivity estimated for the overall data permits us to group the productivities in four areas with different yield potentialities.

The relationship between the estimated potential productivity of sugarcane and the land capacity categories showed a high result in the sampling areas of this example. This illustrates the validity of the criterion used in this first Phase of the project with regard to defining these areas.

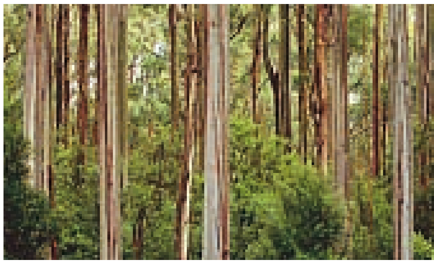
## Sugarcane Production Considering the Climate

Sugarcane production considering climate is the stage in the study that determines the climate risks for its cultivation. Accordingly, a crop simulation model is used to assess the actual and potential production in relation to the climate parameters: air temperature, solar radiation, photoperiod and water deficiency. Thus, long-term information (30 years of historic data series) is considered.

The adopted model consists of two stages: the first considers a physiology model called *Agro-Ecological Zone*, to estimate the potential sugarcane yield in a certain environment, as a result of the interaction between the genotype (crop/variant) and climate parameters. This is basically a model that simulates the photosynthesis process. The second stage considers the impact of the lack of water on the biomass production by genotype. If water is available during the crop cycle, the effective productivity will be the potential production yield. On the other hand, if there is a lack of water, the actual productivity will be less than the potential production yield.

This type of study permits us to identify the effectiveness of the productive system. If the observed productivities are close to the estimated productivities, it is considered to be highly effective; if, however, the observed productivity is less than the estimated productivity, the general effectiveness is low and shows failure in agricultural management.

The climate variation in each region in this study is illustrated by the climatologic water balances in which the inter-annual and inter-seasonal variation of the lack of water and surplus water in each region over a 30-year period is determined.



By using this method it is possible to find differences in terms of standard and climatic variation for regions in the same country. It checks, for example, the intensity of water scarcity and surplus, and defines the wet and dry seasons.

The importance of this study lies in its demonstrating the differences in analyzing the normal conditions (normal water balance) and the average conditions resulting from the sequential water balance.

In traditional crop zoning, the normal water balance is a valuable tool. However, better planning of the crop in a certain region and the sequential water balance offer many more details regarding water availability for planting and the need for irrigation.

As we can see in the places under study, lack of water is significant and this is why it will always be necessary to have some kind of irrigation at a certain time in the crop cycle.

# Phase III

Investment Recommendation

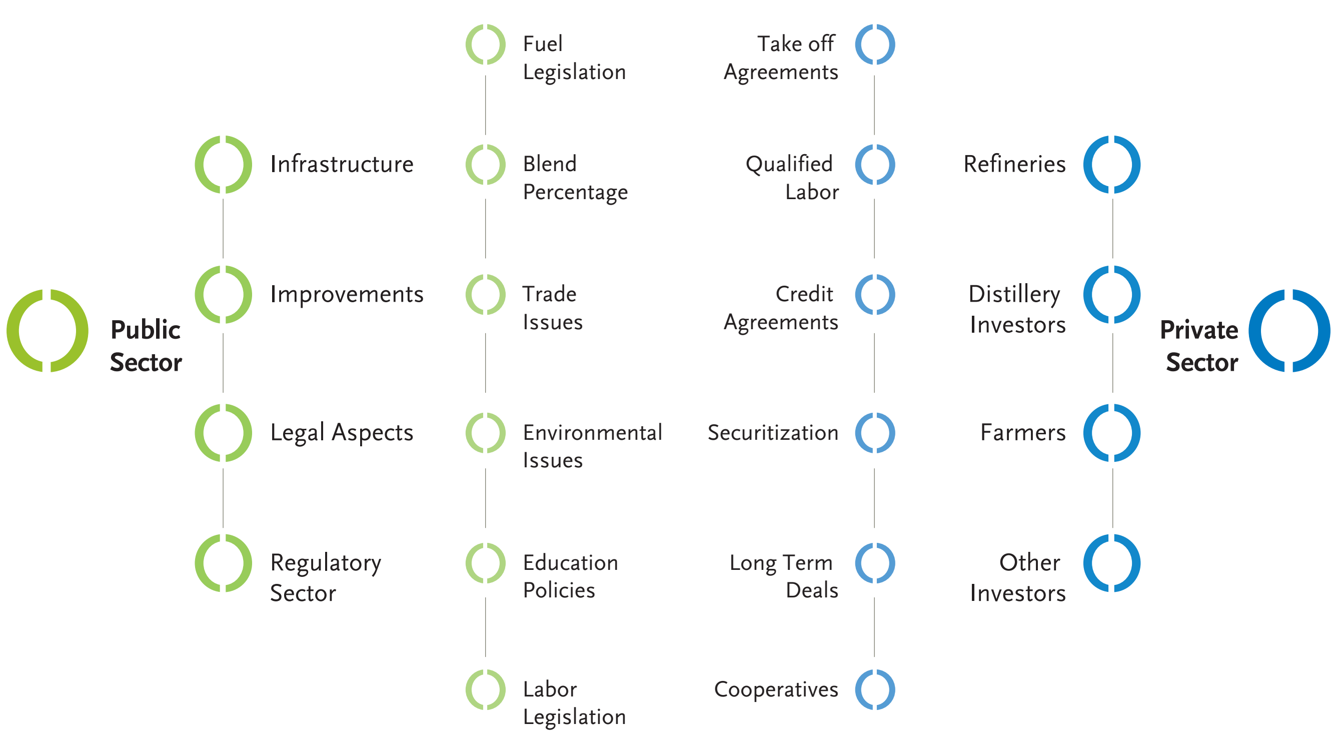
The methodology applied in the countries discussed herein results in the following investment recommendations:

- **Ethanol Plant**;
- **Biodiesel Plant**;
- **Research & Development Center**

In other words, after analyzing **Land Suitability** and the study of **Production Capacity** for each specific crop, specific suggestions may be made for large-scale investments involving the public and private sectors, including the combination of public policies, business actions and cooperatives.

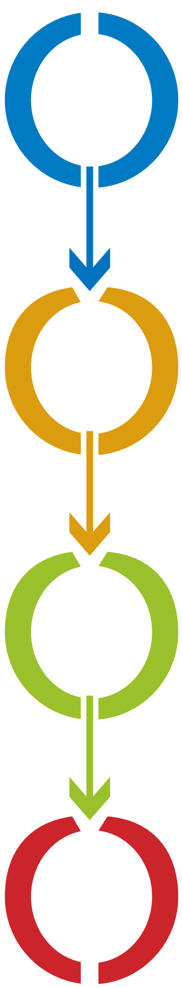
Accordingly, Figure 5 below shows other relevant aspects, highlighting the role of the public and private stakeholders. It should be understood that both sectors are of the utmost importance for development the recommended investments, based on the **farmer**, with **private enterprise** involvement and under the guarantee of the **regulatory agency**, in its different operating jurisdictions.

Stakeholders and Aspects Involved in the Biofuel Investment Process



It should be stressed that biofuel projects in these countries will only develop on a sustainable and economically feasible basis if all sectors involved in the process act together in harmony, as illustrated by Figure 6.

## Sectors involved in biofuel production



**Government**
Legislation for Gasoline/Biodisel mixture

**Refinery**
Take off Agreement for 20 years

**Distillery**
Contract Securitization
70% Finance / 30% Equity

**Farmers**
Long term deal with distillery
Cooperatives

The **public authorities** are therefore responsible for regulating the bioenergy sectors, setting standards and the mandatory nature of the blend. The **agricultural sector** has the task of providing raw materials in quantity and quality stipulated in contracts, permitting income distribution together with social development. The **private sector** is expected to provide investments through the financial sector and private organizations.

## Ethanol Plant

The current trends of global ethanol market point to an increasingly heavy pressure of demand, accompanied by rising prices. There is increasing consensus that alternative fuels should play a leading role in the long term energy supply. Accordingly, local ethanol production from sugarcane proves to be a strategic option, both in meeting the domestic demand and introducing a high added-value product in its list of exports.

Because of its increasing market value, ethanol will be a significant source of job and income generation, adding substantial value to its main inputs (labor and sugarcane). The ethanol industry has potential to substantially reduce the energy dependence of the countries, providing not only fuel to the transportation sector but also electricity, which may cushion the susceptibility of the supply to petroleum prices. Since it represents a source of domestic demand for agricultural production, it will also mitigate the sensitivity toward exchange and international commodities market. These two factors may be a valuable contribution to stabilizing the economy, which, in turn, could contribute to reducing structural unemployment. This economic stabilization may also help intensify long term investments in the country.

In compliance with agronomic restraints and the farming and industrial trade-offs in land use, there are major economic benefits that can be expected from setting up an ethanol production program.

In order to analyze the microeconomic characteristics of sugarcane-based ethanol production, it is necessary to seek subsidy in the only large-scale experience of this kind, namely, that of Brazil. According to the IBGE Table of Resources and Uses (TRU) (for 2005), sugarcane is responsible for 10.2% of the value of agricultural production in Brazil (including forestry and forest exploration). The Brazilian ethanol industry has been responsible for the consumption of 35.3% (in value) of the sugarcane produced (the rest allocated to the food and beverage industry). It is found that ethanol production is one use for cultivating sugarcane, which adds significant value to farm production. This industry has generated gross added value of R$ 5.4 billion in 2005, corresponding to an added value margin of the ethanol production of 78.8%, compared to 24.8% for the average food and beverage production.

Accordingly, the activity creates technical, industrial and administrative jobs that can be considered highly paid. In 2005 it corresponded to 72,762 jobs, and the average remuneration in such jobs (including wages and social charges) was R$ 16.890,68. This value is 47.7% higher than for the average food and beverage production, and 78.4% higher than

the national average remuneration that same year. Moreover, the specific gross added value for the sugarcane crop for ethanol can be estimated at R$ 2.5 billion, associated with 472,114 jobs. These jobs are less skilled with lower pay, but there are many more of them.

Considering the Brazilian example, some microeconomic impacts may be inferred qualitatively that would derive from introducing sugarcane-based ethanol production in these countries. First, it would represent an industrial activity with high added value margin, especially compared to other segments, which could have favorable impacts on the industrial GDP. This characteristic would reflect on the generation of highly paid jobs. Moreover, sugarcane cultivation for industrial use would itself be a source of generating unskilled jobs, which could, in fact, have a substantial redistributive effect on income concentration.

The introduction of biofuels is a strategic measure in which representative benefits can be obtained to reduce the impact of the international conjunctural crises. This measure has two relevant effects. The first is to reduce energy dependence. Consequently, the actual economy is less sensitive to the foreign exchange conjuncture, and the trade balance may be stabilized (which in itself has consequences on the foreign exchange conjuncture).

In addition to the contribution from introducing ethanol manufacture to reduce outside dependence on fuels, it would now act as a local source of industrial demand for farm produce, with which the economy can gain in strength with regard to the fluctuating international economy. Generally, the export agenda of the Central American and Caribbean countries consists primarily of light manufactured goods and farm produce (and sugarcane is now also a significant part of this list). Ethanol production may not only reduce dependence on the farm production value compared to foreign exchange (reflected in greater stability and predictability of supply), but may also generate a high added value manufactured product , whose demand is strong and increasing on the foreign market.

The analysis of the economic feasibility of the project shows that the assessment of critical variables, such as the ethanol selling value, sugarcane procurement prices and discount rates are of the utmost importance for implementing the projects. There are values intervals of these critical variables that keep the project feasible, which attenuates the risks involved in ethanol production.

For the feasibility of this project, and considering such aspects as employability and income distribution, it is understood that a satisfactory alternative for ethanol production as well as for other biofuels is based on the formation of cooperatives.

A cooperative is different from other kinds of associations because of its essentially economic nature. Its purpose is to place the goods and/or services of its members in the market with more beneficial conditions than they would do on their own, and also supply them with raw material for production at lower prices. In this way, the cooperative can be understood as a business that provides services to its members.

Basically, when organizing a cooperative the aim is to improve the economic status of a certain group of people, solving problems or meeting common requirements that are beyond the capacity of each to meet individually.

## Biodiesel Plant

Biodiesel production projects were prepared considering oilseed procurement to be produced by a cooperative of agricultural producers. For El Salvador and the Dominican Republic, two plant species were recommended as suitable for vegetable oil production: *Jatropha curcas* and sunflower (*Helianthus annus L.*). In the scenario under consideration, the cooperative must have the crushing unit, which negotiates the sale of vegetable oil to the biodiesel plant.

In chemical terms, biodiesel is defined as an alternative fuel, consisting of alkyl esters of long-chain carboxylic acids from renewable sources such as vegetable oils or animal fats.

Substituting diesel fuel for biofuels or blends of the latter with diesel is an issue currently in focus, since it was developed to supply the scarcity of petroleum-based fuels.

When analyzing the environmental aspects, biodiesel is a non-toxic biodegradable fuel practically free of sulfur and aromatics.

At the current stage of technological development, the production process with the best cost-benefit ratio is to use the alkaline alcoholisis route. The choice of the alkaline catalyst is due to the fact that it is less corrosive and requires less molar ratios between alcohol and vegetable oil.

Alcoholisis of vegetable oils or animal fats may be conducted by a variety of technological routes in which different types of catalysts may be used, such as inorganic bases, NAOH and KOH (sodium and potassium hydroxides), alkoxides, organic bases, mineral acids (sulfuric acid), ionic exchange resins (strong acid cation resins), activated clayminerals, lamellar double hydroxides and lipolytic enzymes (lipases).

Only simple alcohols, such as methanol, ethanol, propanol, butanol and amyl-alcohol, can be used in the transesterification process. The choice of ethanol as a transesterification agent (thereby obtaining the ethyl esters) instead of methanol (used in Europe and the USA) makes biodiesel a totally renewable product, but the interest in this idea is restricted to the regions where its commercial value is compatible with the market value of methanol of petrochemical origin.

The experience of using biodiesel in the fuel market occurs at four levels of concentration:

- Pure (B100);
- Blends (B20 – B30) – blend between 20% and 30% biodiesel;
- Additive (B5) – blend with 5% biodiesel;
- Lubricative additive (B2) – blend with 2% biodiesel.

Biodiesel can be perfectly mixed and chemically physical, that is, similar to mineral diesel fuel, and may be used in diesel engines without requiring major and costly adaptations.

Thus, it may be used pure or mixed in any proportion with diesel fuel. It also has a unique application when blended with diesel fuel, since it gives it better lubrication conditions. An excellent alternative would be to use esters in addition of 5-8% for reconstituting this lubricity.

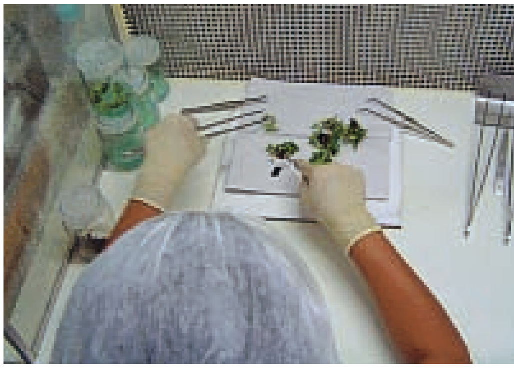
The leading sub-product in biodiesel production is glycerine. Glycerol is produced chemically or through fermentation. The production processes are not very complex and it is currently used in the branches of synthesis of resins, esters; pharmaceutical applications; in cosmetics; food and so on.

Financial and technical feasibility analysis of the biodiesel production based on oilseeds such as sunflower and *Jatropha curcas*, are particularly interesting, considering the possibility of starting in short term oil production from the sunflower crop (annual), moving toward developing the production of *Jatropha* (perennial crop) with more productivity per hectare.

Planning this type of project can be based on defining fundamental strategies including the oil procurement from local rural producers organized by cooperatives and supported by the biodiesel plant, by encouraging phytotechnical information on the sunflower crop in rotation with sugarcane and *Jatropha curcas*. The strategy results in improving the income distribution through added value obtained from crushing the seeds.

The agricultural cooperative plays a leading role in this model, since it is responsible for grain crushing to obtain the vegetable oil and supply the biodiesel plant.

Potential and actual sugarcane productivity is calculated by type of the crop maturity cycle using the FAO model. The FAO model was also used to estimate the impact of irrigation on improving sugarcane productivity, considering all maturation cycles.



## Sugarcane Considerations

The variants and planting times are chosen considering the production environments where the crop will be planted. The study of the productive area and its classification regarding the production systems permit the choice of suitable variants for each case, planting and harvest times, prediction of productivities for each cut and suitable dimensioning of the production systems.

The harvest duration is also in function of the production environments that, in turn, define the planting times. Good knowledge of these environments permits optimizing the production potential of the adopted variants, scale-up of the agricultural cutting, loading and transporting operations; and prevents the concentration of the crushing period to increase the harvest period.

## Research & Development Center

Investments in research and development are also recommended to make the biofuel projects under consideration competitive. Generally, these investments can help develop new sugarcane variants, higher agricultural and industrial income, specific management techniques to meet the needs of the places considered in the projects.

The creation of research and development centers is extremely important for establishing biodiesel projects that use *Jatropha curcas* as a principal raw material. Although it is native to Central America and the Caribbean, the species has not yet been completely domesticated, and there is no commercial variant. This fact is a risk to the commercial exploration of the *Jatropha curcas,* due to the lack of know-how of ideal crop handling and a source of certified genetic material.

# Conclusion

This paper discusses the projects run by **Fundação Getulio Vargas** as an extension of the Memorandum of Understanding (MOU) between the US and Brazil in the biofuel sector. The partnership between a number of institutions renowned worldwide results in feasibility analysis for biofuel production.

In order to comply with this bilateral agreement, the various stakeholders developed and validated their own methodology. Therefore, crops are assessed suitable for biofuel production in each country involved in these studies. The different working stages identify the best regions for installing industrial plants, considering the agronomic and economic aspects, logistics and competitiveness per raw material with other mills.

After completing the studies, investment projects were recommended. In the cases of the Dominican Republic and El Salvador, as mentioned herein, ethanol and biodiesel production is recommended, as well as the creation of research and development (R&D) centers to enhance biofuel production.

Ethanol and biodiesel production has proven to be feasible in these countries so that these products can diversify their energy matrix. This fact is consolidated with the ethanol-gasoline blend and use of biodiesel to substitute diesel fuel. Adopting such measures could diminish the consumption of fossil energies and reduce international petroleum dependence. Moreover, among the possibilities and for other countries, it is also possible to use sugarcane bagasse for power cogeneration.

Specific mention below of the main impacts of this kind of investment is:

**Macroeconomic Stabilization:**

- Reduces dependence on imported energy sources;
- Real economy less sensitive to exchange rate fluctuations;
- Counteracts trade deficit, which also helps stabilize exchange rate;
- Reduces dependence of the value of agricultural production on exchange rate;
- Improves robustness with respect to variations in international demand.

**Energy Optimization:**

- Reduction of energetic dependency through the mixture of gasoline-ethanol and diesel-biodiesel;
- Plus of electricity generation using co-generation system with bagasse from sugarcane;
- Increasing production capacity: possibility to adopt flex vehicles in the future.

**Market Opportunities:**

- Ethanol production is a particularly high value-added industry;
- Strong growing demand in the global market;
- It would represent an important internal source of demand for the agricultural sector.

**Employment Improve:**

- Increase at agricultural and industrial sectors;
- Significant number of high-wage jobs, as well as many more unqualified positions;
- Positive effects on the country's income distribution.

Lastly, in a scenario tending to sharp rises in the international value of petroleum and its byproducts, biofuels can provide producer countries with strategic conditions on the international trade scene, considering that, as oil prices rise, a growing number of countries tend to diversify their energy matrix. The growing concern with the environmental issue is another booster of the demand for this kind of energy, which also valorizes the strategic role of biofuels. It should be stressed that agro-energy projects in Central American and Caribbean countries and other countries involved in this kind of project will only be sustainable if all sectors involved in the process (farmer-government-industry) work together in harmony.

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## Graphic Design

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## List of Illustrations



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