Assistance for Biofuels Development and Policy Support in Jamaica

Final Report

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Organization of American States

WINROCK INTERNATIONAL

ACKNOWLEDGMENTS

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Executive Summary

This report covers the initial phase of a project, sponsored by the Organization of American States, to lend technical assistance and policy support for the development of a biofuels industry in Jamaica. The findings presented here, in conjunction with policy analysis conducted separately for the government's Biofuels Task Force, will form the basis of additional activities to be carried out in the future, including public education and awareness, pilot project development, and ultimately implementation in the form of investments in biofuels production capability.

Based on its research, the project team reached several conclusions regarding the prospects for a Jamaican biofuels industry:

- With 47,000 hectares of suitable land available for sugar cane, Jamaica has the capability to produce all the sugar and molasses the nation needs for its domestic consumption and rum production plus enough ethanol for 10 percent blending in gasoline (E10) throughout the island. Increasing yields per hectare could expand production significantly above this level, as well as reducing cost.

- Ethanol production from cane can be cost-effective but will require year-round operation for efficient utilization of the distillery and a market for surplus energy in the form of reliable electric power. All-season operation will require economically increasing available feedstock to the distillery and providing supplemental fuel for the cogeneration power plant.

- Various ways to increase distillery feedstock should be considered, including: extending the cane harvesting season by introducing varieties of sugar cane or perhaps sweet sorghum that are suited to early/late harvesting, using partially processed and stored cassava, and storing concentrated whole sugarcane juice and/or molasses,

- Concerning supplemental fuel, Jamaica has plenty of land to grow biomass crops, including bamboo, for off-season sugar mill operation or other uses. Sorghum and cane varieties selected for energy value are other possibilities. Field trials, such as the Petroleum Corporation of Jamaica's fuelwood demonstration project at Font Hill Farm, are necessary to evaluate energy crop species, perfect cultivation and harvesting techniques, and refine cost estimates. The aim has to be to ensure that the average cost of supplemental fuel remains below the average proceeds from sale of electricity to the grid when supplemental fuel is being used.

- In general terms, the cost of processing vegetable oils into biodiesel are in approximately the same range as refining petroleum (US $ 0.50 per gallon), so the oil feedstock has to cost less than crude oil to be profitable without subsidies in some form.

All countries with commercial biodiesel subsidize it one way or another, e.g., through lower excise taxes or mandatory use. Based on Brazilian experience, the cost of small-scale production of castor beans, for example, containing 48% oil, is US $0.50 per Kilo ($1.00 per Kilo of oil), which amounts to $3.40 per gallon, or roughly twice the cost of crude oil.

- Large-scale mechanized production of castor or jatropha could be less costly, but it might also displace sugarcane. As a large-scale field crop, soy might be a better alternative, since it has food as well as energy value, although it too could compete with cane for land. Another solution would be higher oil-yielding palm trees, which would not compete with cane for land and could possibly provide solid fuel for off-season sugar mill operation.

- Adequacy of land for biodiesel depends on the crops involved. Ongoing field trials will determine the conditions under which castor and jatropha can be cultivated, but other crops should also be considered as well, including oil palm, provided disease resistant cultivars can be identified.

- While B5 blending has been discussed as a biodiesel market outlet, Jamaica's diesel fuel consumption is much greater in stationary engines than in automotive engines, and biodiesel could be introduced with fewer institutional and technical complexities for electric generation than for vehicles. Truck and bus fleets represent another application that would not require an island-wide blending program.

- Although E10 has been established as the national fuel formulation, public communication efforts will still be needed as Jamaica builds production capacity, especially in rural communities likely to be affected by new farming practices, construction activities, and changing labor markets. Education and awareness campaigns can serve both to elicit stakeholder concerns early enough to accommodate them, and to lessen resistance to implementation when it occurs.

- Biofuels production is capital intensive, so the Ministry of Finance has an important role to play in creating a positive financial framework for investments to occur. This framework should reflect the economic merits of supporting domestic production, including job creation, rural development, etc. compared to welfare costs and spending foreign currency to import liquid fuels.

1. Introduction

In early 2010, the Organization of American States contracted Winrock International to conduct a project designed to help the Government of Jamaica in its efforts to take advantage of biofuel technology and the island's agricultural resources to offset the cost of imported petroleum and reduce its impact on the local economy. After extensive fact-finding, including background research, meetings with government agencies, interviews with experts and decision makers, and visits to sugar estates, the Winrock team undertook a broad prefeasibility study, reported in the pages that follow, covering the following topics:

- Biomass Resource Assessment, including a discussion of available land, alternative uses, topographic and rainfall considerations, and suitability for biofuel feedstocks (Section 2.)
- Human and Institutional Resources and Roles, including industrial and research organizations, as well as technically skilled personnel (Section 3.)
- Economic Analysis, including product markets, pricing and financial considerations (Section 4.)
- Processing and Distribution, including ethanol and biodiesel conversion options (Section 5.)
- Technology Assessment, including emerging technologies (Section 6.)
- Risk Assessment, including potential hazards for investors and approaches to mitigating them (Section 7.)

The team also worked closely with the government's Biofuels Task Force and performed research and policy analysis that contributed to the government's draft *National Biofuels Policy 2010-2030* released in October 2010. In addition to formulating a public education and awareness program for advancing biofuels (Annex I), the team presented material on biofuels technology at a summer course at the University of the West Indies and also presented preliminary findings from the prefeasibility analysis to a broad audience at a workshop in Kingston, organized by the Task Force, in November 2010. In addition to obtaining valuable reactions to the analysis from participants, Winrock's team also took advantage of breakout sessions and informal discussions at the workshop to identify pilot projects (Annex II) and formulate an implementation plan (Annex III). The pages that follow contain the results of initial background research, drawing on published sources and extensive meetings and interviews in Jamaica.

2. Biomass Resource Identification

2.1 General Overview

As illustrated in Figure 1 and Table 1, Jamaica appears to have ample land for food crops and biofuel/bioenergy crops.

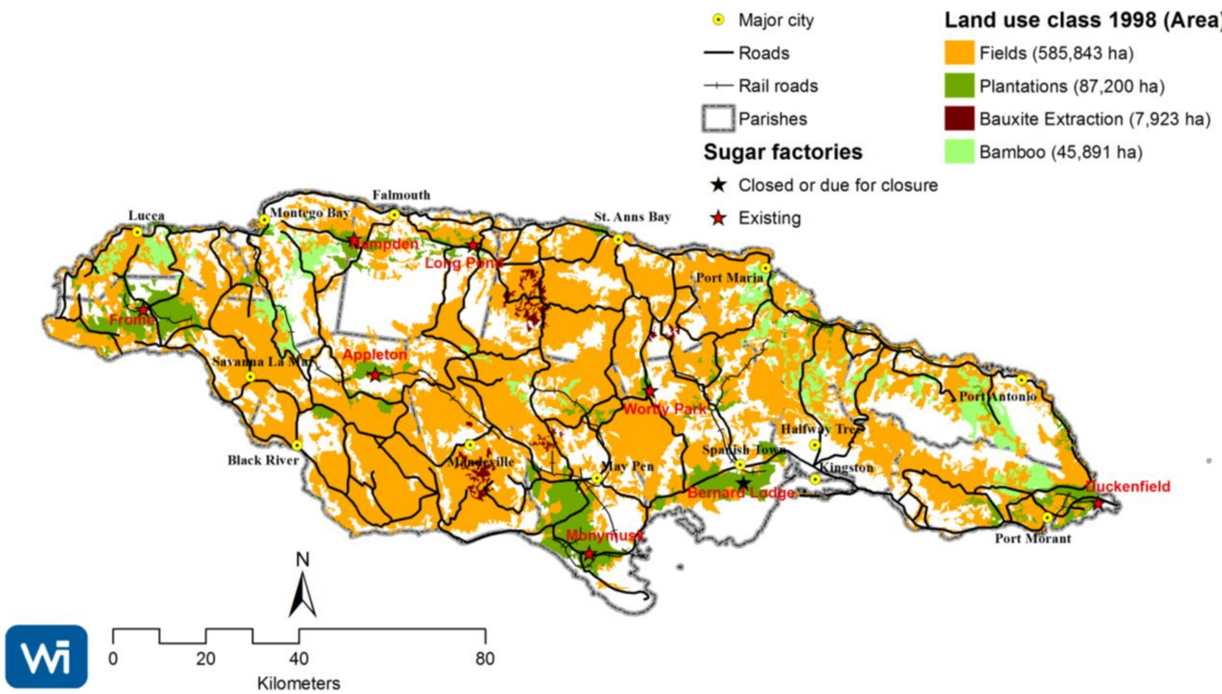

Figure 1: Location of plantations, fields, bamboo and bauxite extraction areas and area (ha) according to the Forestry Department 1998 land use map (Annex IV)

According to the Forestry Department of the Ministry of Agriculture and Fisheries, plantation areas, which will be discussed in the next sub-section, amount to 87,200 ha. The Department classifies an additional 585,800 ha under four other categories that are either wholly of partly fields, so the total area that could be suited to food and bioenergy crops amounts to 673,000 ha. In addition, there are more than 45,000 ha of bamboo, which can be a particularly good source of biomass fuel.

Table 1: Decrease of area classified as "field" categories after applying sustainability and slope criteria

Land use category	Extent in 1998	Extent after exclusion of protected areas	Extent after exclusion of slope >12%	Percent of area remaining to original area
	ha	*ha*	*ha*	*%*
Fields and Secondary forest	120,539	115,690	60,052	50%
Fields: Herbaceous crops, fallow, cultivated vegetables	292,681	282,468	195,259	67%
Fields and Secondary Forest/ Pine Plantations	4,287	1,783	58	1%
Secondary Forest and Fields	168,336	159,654	79,515	47%
Plantations[1]	87,200	85,171	79,610	91%
Bamboo	2,980	2,671	852	29%
Bamboo and Fields	29,430	26,979	8,699	30%
Bamboo and Secondary Forest	13,481	12,783	5,902	44%

Table 1 provides the quantities of various land types derived from the Forestry Department data. Even when protected areas and land with slopes exceeding 12%, above which degree of incline agriculture becomes difficult, are excluded from consideration, the area of land remaining is relatively large. The total area for plantation crops including sugar cane is just less than 80,000 hectares. Areas that are fields with some secondary forest exceed 330,000 hectares, and the area of bamboo exceeds 14,000 hectares. The areas are shown graphically in Figure 2.

In addition to a good supply of land, Jamaica also had a rainfall pattern that while it varies from one part of the island to another offers generally good prospects for crop yields. The patterns shown in terms of the severity of the dry season are indicated in Figure 3.

[1] Area of 9,780 ha from the plantation located southeastern from Monymusk sugar mill is overlapping with Portland Bight Protected Area established by UNESCO in 1999. This area was not excluded from the analysis since currently most of the area is under sugar cane cultivation.

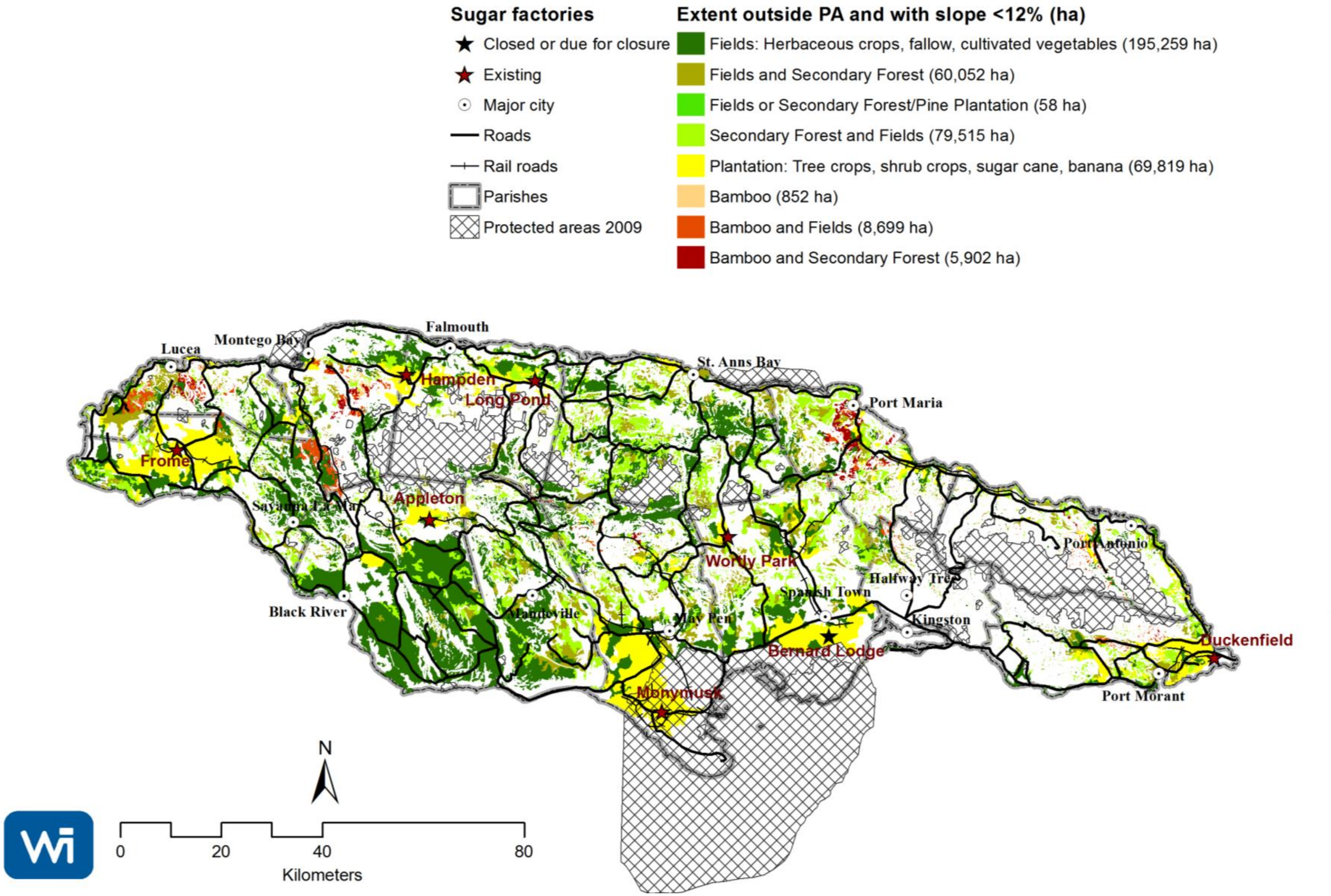

Figure 2: Areas of land in classes classified as 'fields' (some with secondary forests), 'plantation' and 'bamboo' from the Ministry of Forestry data and quantities of each classification after exclusion of areas under protection as of 2009 [2]and areas with slopes greater than 12%

[2] An area of 9,780 ha of "plantation" land covering the Monymusk sugar mill and some of the cane estate areas is within the Portland Bight Protected Area established by UNESCO in 1999. This area was not excluded since most of the area is believed to be under sugar cane cultivation.

Regarding rainfall, areas with a continuously wet season will cause ripening problems for cane and also for bamboo, the latter of which will be with too green to be stored for later burning. Cane ripening can be managed, and other cultivation schemes, like soybean with sorghum in rotation or two annual crops of castor, are promising theoretically and worth testing.

Severe dry seasons are less desirable for biofuel crops, but sorghum is a possibility, as is cane with irrigation perhaps enriched with vinasse. However, since the areas with a severe dry season are located on the north side of the island, are relatively small and largely coincide with tourist developments, this land is of little use for biofuel purposes in the long term.

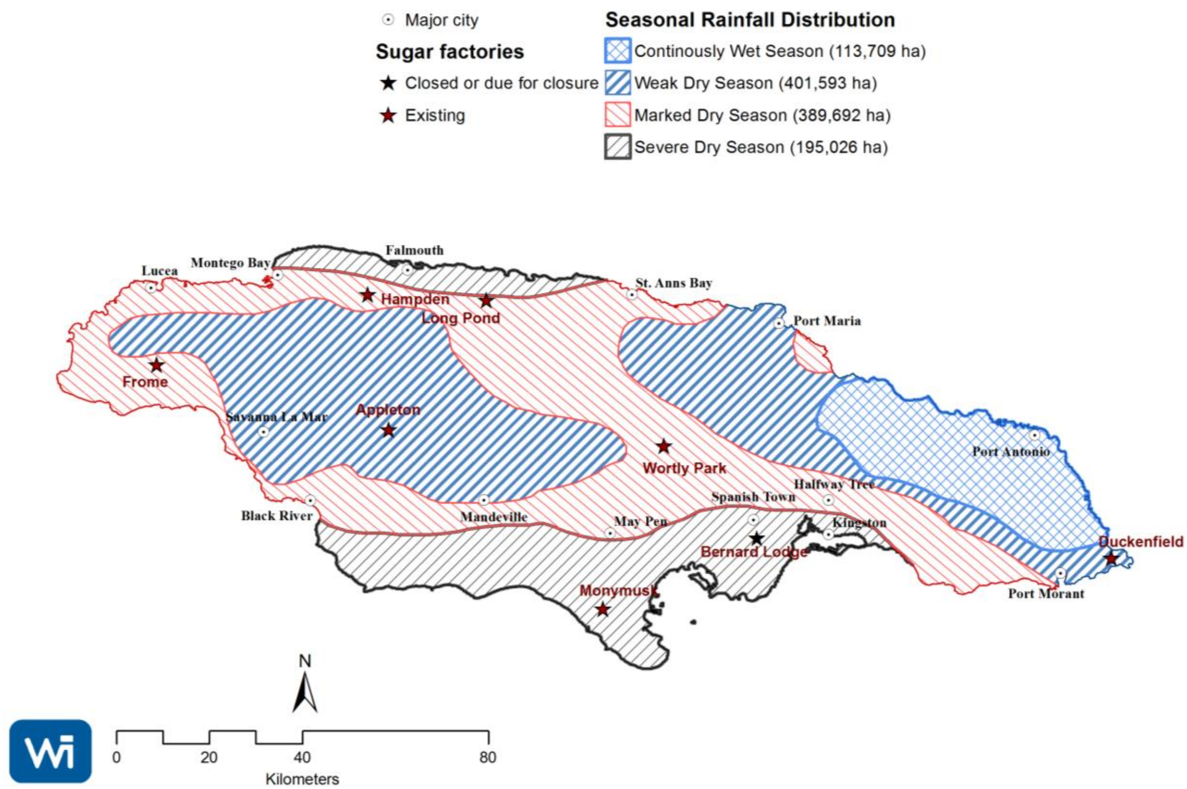

Figure 3: Rainfall Seasonality and locations of sugar mills in Jamaica

Areas with weaker dry seasons are generally best for all crops and should be the preferred, other things being equal.

2.2 Ethanol

<u>Sugar Cane</u>

Sugar cane, a C4 plant, is regarded as the most efficient crop in converting solar energy into chemical energy through photosynthesis, and this is the main reason to use it as a mainstream for any biofuels policy. It is a crop well adapted to tropical weather and under optimal conditions accumulates dry mass under and above the ground, with an exuberant vegetation and vigorous root system. When a stress period occurs, drought and/or cold weather, it accumulates sugar in the stalks.

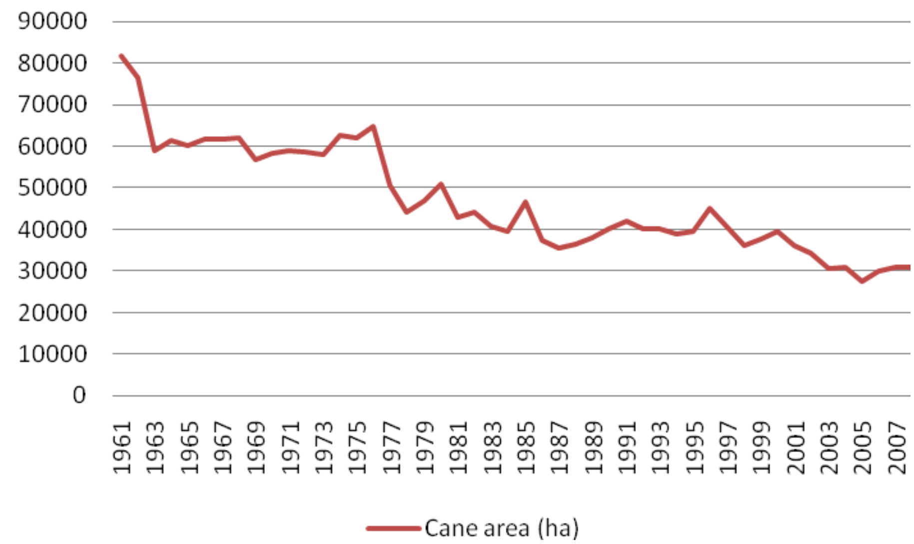

Figure 4: Total sugar cane area from 1961 to 2008 on an annual basis (FAO data)

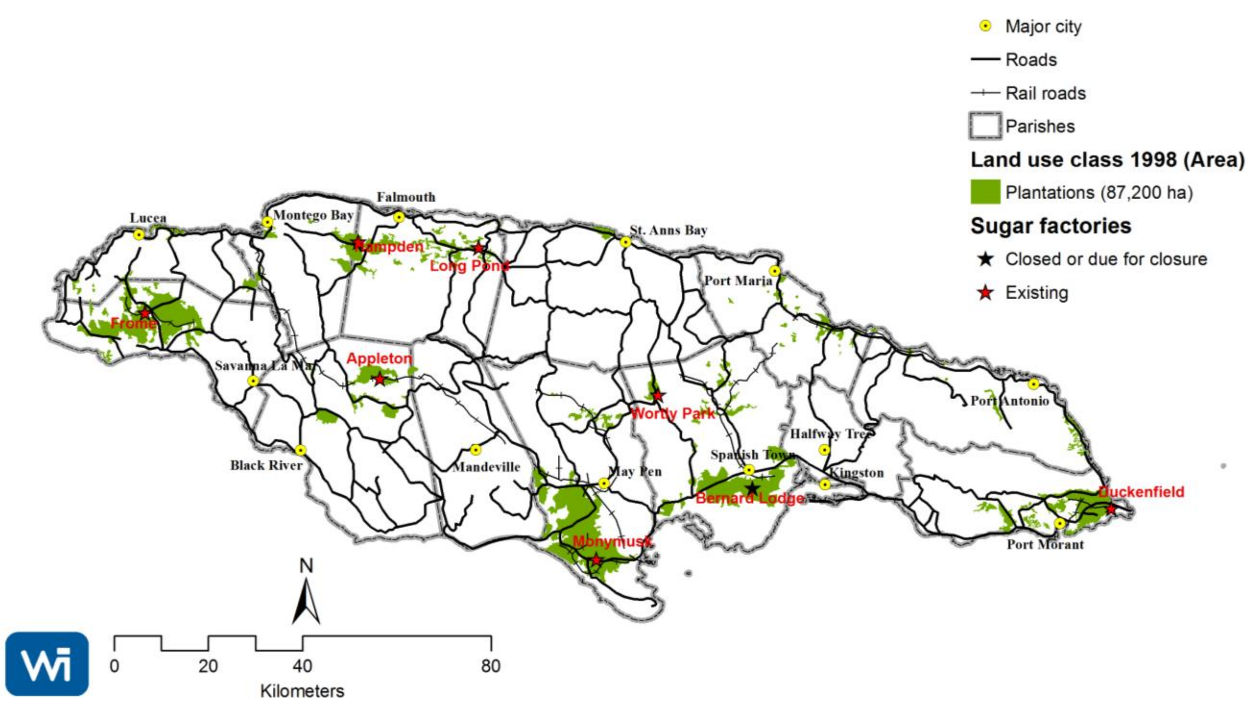

Figure 5: Plantation Area and Mill Locations

Historically, sugar cane has been produced in Jamaica and other countries of Central America for centuries, and is highly suited to these tropical regions. Jamaica's production has in the past been significantly higher than it is currently, as can be seen in Figure 4. The last comprehensive land use data for Jamaica shows that the cumulative area of plantation crops in 1998 was 87,200 hectares[3]. FAO data for 1998 indicates that 36,000 ha of sugarcane were grown and more might have been possible because the amount of idle cane land is unknown. Indeed, only two years previously, in 1996, FAO reported that 45,000 ha of cane were grown. Earlier FAO data indicates a maximum area used to grow cane of 81,800 hectares in 1961. The area remained at about 60,000 hectares through the 1970's before falling to about 40,000 until 2000, after which a downward trend to the current 30,000 hectares occurred. Although some land has been lost to urbanization, a combination of ground observations and satellite imagery indicates that much of the areas used 50 years ago for cane remain available today. Jamaica would require an estimated 47,000 hectares[4] (including 4,000 ha for intervals, irrigation and drainage infrastructure plus plots for trials and breeding) to produce all its current domestic needs for granular sugar, molasses for rum production and ethanol to reach E10, so availability of adequate land does not appear to be an issue.

Sugar cane is grown by relatively larger plantations that are owned or leased long term by individual sugar mills, and by independent growers whose sizes of operation range from a few hectares to several thousand. Due to its long history, local growers are quite familiar with this crop and given appropriate conditions should be able collectively to reach previous production which cannot be said about alternative biofuel crops without trials and further studies.

While a number of factors have lead to the decline of sugar cane, the most important in recent years is the removal of price support for Jamaican sugar by the EU. This means that for the sector to expand, it needs to find a way to achieve economic sustainability by cost saving and revenue enhancing measures. Optimising revenue from sales of granular sugar, molasses for rum, ethanol and sales of surplus electricity will require new approaches by all stakeholders including the cane farmers. An examination of the current Jamaican production system for cane and comparison with Brazilian practices by a cane specialist from that country has revealed that many improvements can be achieved with relatively low investment. The specialist also felt that the production of cane does not receive as much attention as it should and that the fields often appear quite abandoned or lacking application of latest technology applied. To correct this some general policies are proposed to that focus on increasing the probability that future production goals can be achieved. These policies fall into four main categories:

1. Sugar cane varieties and observations
2. Range of yields and ranges of sucrose and total sugars
3. Varieties suited to soils with elevated salinity
4. Work being undertaken by SIRI [based on visit to trial plots May 20]

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[3] Forestry Department, Land Use Data 1998 – includes sugar cane, bananas, coconuts and fruit trees/bushes.
[4] The basis for the 43,000 ha is discussed later in this report

1. Sugar cane varieties and observations

The general conditions of Jamaica suggest that varieties specially adapted to high photosynthesis efficiency are desirable because they convert solar energy to accumulate total carbon as sugars and fiber. More specifically, Jamaica should trial varieties with characteristics of the following types:

a) High total sugar varieties rather than high sucrose, since rum and ethanol do not require sucrose as granular sugar does

b) High fiber varieties where more bagasse is needed to allow a modern cogeneration plant to run year round, including varieties with high sucrose content and salinity tolerance

c) Varieties that mature early or late to allow an ethanol plant to receive feedstock over a longer period annually

d) Varieties of sweet sorghum as a supplement to sugar cane where it can help increase overall profitability or require less water and grow in dryer areas

To develop suitable varieties, the current cane-breeding program should be expanded in order to select those that match the changes to the products and not just to focus on good varieties for granular sugar, as has been the past need.

The ripening period seems to be quite challenging due to the absence of low temperatures or severe drought throughout the year. The yields found in the visited mills show that there is a lot of room to increase cane yield and sucrose content, especially through the introduction of new varieties.

The SIRI plots visited are a testimonial that there is a huge potential to increase production with new varieties, but the numbers are still relatively small for future sector growth plans. The breeding program receives material from the West Indies Central Sugar Cane Breeding Station (WICSBS), Barbados, but this source should not be relied upon solely. Cooperation with other breeding programs must be initiated with priority to programs with similar weather conditions as Jamaica. Many breeding programs around the world are willing to have agreements with other places and countries in order to develop new varieties. We recommend that Jamaica considers contacting the following breeding centers with a view to establishing a working relationship with at least two in addition to the current relationship with WICSBS:

(1) Sugar Breeding Institute (Indian Council of Agricultural Research), Combitore, Tamil Nadu, India [www.sugarcane-breeding.tn.nic.in]

(2) Philippines Sugar Research Institute (PHILSURIN), Victorias City, Negros Occidental, Philippines. [www.philsurin.org.ph]

(3) Indonesian Sugar Research Institute (P3GI), Jalan Pahlawan No 25, Pasuruan 67126, Indonesia [www.sugarresearch.org]

(4) Centro de Technologia Canavieira (CTC), Piracicaba, Sao Paulo, Brazil [www.ctcanavieira.com.br]

(5) Others similar to the above in Australia, Thailand and South Africa.

Nursery practice is already familiar to Jamaican growers, and all new varieties go through this process of multiplication. Before planting, the cane should be heat-treated or propagated by meristem tip culture to prevent diseases. Since the process is applied on a small scale, the material is multiplied under good care. Usually the rate of 1:8 is achieved, so enough cane is treated in the first year to plant one hectare, which will provide seed cane to plant 8 hectares the following year, and so on. Techniques like irrigation, larger row distance, high fertilization, etc. can improve the rate.

While we recommend trials of sweet sorghum as a potential adjunct to sugar cane, we should stress the need to undertake extensive trials covering local conditions for those areas in Jamaica where it may be grown. These trials need to be completed before any significant reliance is placed on sweet sorghum as a biofuel or bioenergy feedstock, since only limited experience exists for such applications even on a worldwide basis.

2. Range of yields and ranges of sucrose and total sugars

The yields currently achieved for sugarcane in Jamaica are low, suggesting that some limiting factors that are not being corrected. The yield of sugar cane achievable under ideal conditions is approximately 200 tonne/ha, and the sucrose content can reach values greater than 15% pol. By comparison, the average yield in Jamaica is currently 63 tonne/ha compared to a peak of 80 tonne/ha in 1966. In addition to the introduction of new varieties, improved agricultural practices and technology are required. These include but are not limited to the following:

- biological control of pests;
- weed control;
- soil preparation with systematization of lands, minimum tillage, deep and combined row furrowing;
- soil correction, fertilization and soil recovering through addiction of organic matter and recycling of nutrients with mill`s residues;
- ripeners in some cases;
- better planning and scheduling of harvest suited to each variety;
- harvest without burning cane in order to increase organic matter content of the soil;
- use of nursery practices to propagate and test new cane varieties prior to field trials
- efficient irrigation;
- increased mechanization; and
- improved management techniques.

3. Varieties suited to soils with elevated salinity

Sugar cane is naturally tolerant to salinity, using sodium in some metabolic functions where other plants use potassium. This does not mean that excess sodium will not cause harm. Where soil sodium is higher than normal, varieties with higher tolerance to these salinity conditions need to be developed through the breeding program. Additionally, soils with high sodium require greater care in the application of vinasse as fertilizer, due to reduced margin for error before the plants are harmed.

4. Work being undertaken by the Sugar Industry Research Institute (based on visit to trial plots May 20, 2010)

The Sugar Industry Research Institute (SIRI) is doing a very good job in selecting new varieties and using good agricultural practices showing, in the field, that it is possible to achieve higher yields than currently being realized. Without resort to revolutionary techniques, SIRI is showing that significantly higher productivity is possible. However, there are limitations due to the limited number of sites where trials are conducted and dependence on the current limitation of breeding stocks from a single source (Barbados). The selection of the breeding program works with about 30 thousand seedlings/year, and considering the great variability of sugar cane breeding, it can be characterized as a relatively small program. However, it is well conducted.

It is strongly recommended that this program be expanded to cover all existing conditions in the island and through the introduction of breeding stock from other sources. The program can be used to adapt and develop other agricultural practices and be a testimonial of how to grow the crop for local farmers. Based on this, SIRI can play an important role in extension services to achieve the improved production goals, because they have knowledge that can be disseminated to the farmers.

Among the different plots visited at the SIRI Experimental Station, two varieties shown great potential: BJ 75-04 and BJ 74-52. The plots were prepared with good soil to a depth of approximately 40 cm to ensure good root system development and vigorous aerial parts. The plots received a fertilization program based on 250 kg/ha of 14-28-14 (N-P_2O_5-K_2O) and 250 kg/ha of 17-00-20 in ratoon crop. Overall the trial shows that these simple practices alone are adequate to increase the productivity of sugar cane in Jamaica, in the short term, by approximately 50% in some areas.

5 Options for Jamaica

Since there is a need for biomass to produce energy as well as granular sugar, molasses and ethanol, the sugar cane crop seems to be the most reliable crop to fulfill these combined goals in Jamaica. Other crops (e.g., sweet sorghum) that could supplement sugar cane for one or more of these products may be possible over time but not in the short term and not without experimentation and slow introduction. Additionally, in Jamaica there is already a strong demand for molasses by the rum industry. So in order to achieve the overall needs, it is necessary to increase production both in area planted and in yields (total recoverable sugars/area). The total tonnage must be increased over a larger area and within current areas.

Besides this, the cane quality also must increase, with higher sucrose content that is dependent on varieties fully adapted to its conditions, good management to harvest each one in its right time and proper practices during its growth and ripening period in order to use the weather conditions in favor of production.

Sucrose content seems to be little bit over 10% in sugar cane grown in Jamaica. This can be improved, but it is a long process that goes through breeding and adoption of good practices. For molasses and ethanol production high total sugars (sucrose plus invert sugars) may be required as opposed to highest possible sucrose. The final product mix (granular sugar, molasses, ethanol, electricity) will influence the aims for variety improvements. Regarding fiber content, while higher fiber content may increase the bagasse available for cogeneration, high bagasse quantity tends to reduce the sugar recovery efficiency of the milling process. The actual industrial equipment of the Jamaican sugar mills are quite old and out dated with low extraction and energy efficiency, so without investment in improving the mill's equipment, probably no profits will come from increasing quality in the fields.

To increase the sucrose content in some cases it may be useful to apply ripeners. This should only be introduced commercially after field trials that will need to take into consideration the range of local conditions across the island. As well as having relevance in terms of increasing sucrose, it is also something that should be considered as a means to increase the length of the harvesting period.

As granular sugar becomes less the primary product and mill owners begin to optimize for the combined revenues from sugar, molasses, ethanol and electricity combinations, the total sugars, as opposed to just sucrose content, and even fiber content will become significant indicators for raw material both in the field by growers and in the factory by processors. A payment method or methods should be quickly introduced in order to incentivize the farmers to produce cane with the characteristics most suited to the changing needs of their buyers. There are many methods around the world that could be utilized quite easily.

For sugar mills where granular sugar is the main objective and no ethanol is being produced at the same plant, the system should incentivize the sucrose content more than any other parameter, and the simplest model is to pay for kg of sucrose in each load based on standardized methods of sampling and analysis. One approach is to sample sugar deliveries and measure the "Pol"[5] of each delivery. Applying the measured Pol to the delivered mass of cane in each load allows the mass of sucrose to be calculated and paid for.

For sugar mills where either ethanol or molasses production is important, an alternative approach, applied in Brazil, involves measuring the total recoverable sugars that are fermentable to ethanol. The measurement is based on a combination of both Pol and "Brix"[6], which latter includes all soluble solids, including salts, sucrose and other sugars. The total

[5] "Pol" is a commonly used term in sugar technology defined as: the apparent sucrose content of any substance (normally sugar cane) expressed as a percentage by mass (of the sugar cane as delivered to a sugar mill) and determined by the single or direct polarization method"

[6] The term used when a refractometer equipped with a scale, based on the relationship between refractive indices at 20°C and the percentage by mass of total soluble solids of a pure aqueous sucrose solution, is used instead of a hydrometer to test the solids concentration of a sucrose containing solution.

fermentable sugars are calculated for each delivered load of cane using the measured Brix and a formula to account for the proportion of reducing sugars (e.g. glucose and fructose), salt content, and other factors. The final Brazilian cane price formula also reflects industrial processing productivity and the mix of final products and their corresponding prices in a given year.

A Brazilian-style formula may be premature in Jamaica, depending as it does on knowledge of the operation of existing mills and ethanol product markets, and developing a scheme for independent producers in Jamaica will require negotiation among the interested parties within the specific context of an emerging industry. That said, the system, when it comes into being, should be designed to reward producers who deliver their cane in short periods and with higher quality, because it will reduce industrial costs. At the same time, it should not unduly penalize harvesting at the beginning and end of the season, when Pol may be lower, but raw material is still needed to keep the mill operating. Remuneration of the fiber for energy processes can be accomplished through a separate system, especially during the off season, when the mill would be able to accept other materials like bamboo, grasses, wood, etc. for cogeneration or distillation

At the Moneymusk Estate, payments are based on Pol and Brix, and the formula has a byproduct component, which is not currently utilized. Moneymusk sells Grade C molasses to the rum factory next door, along with steam. Quality based payment seems to be the best way to go, since sugar is produced in the fields and only recovered in the factory. Under an effective quality-based payment system, some practices like burning will naturally stop, because burning begins the inversion of sucrose, resulting in an inferior material detrimental to both sides of the transaction. Besides that, the fiber content can be increased without harming the extraction efficiency, since the cane cleaning system will have to be dry, and a surplus of fiber with lower water content will be available for the boilers. This component of the raw material can be rewarded for both sides, industrial and agronomical.

Sorghum

Varieties suited for ethanol are available but with far less long term experience than with sugar cane. If sorghum proves to be adapted to Jamaica in the future, it can theoretically be grown in rotation with soybeans. It would be possible to have two harvests of sorghum (plant and ratoon), one for each 3-4 months, and before replanting it, a soybean crop.

To make this possible, as it is already in use in other Caribbean countries, it must begin with field trials to find a suitable variety to present conditions. The use of sorghum may have some advantages like being planted by seeds produced by the own farmers, and the excess production can be sold to cattle growers.

- Method of cultivation – grown from seed, 5-6 months to maturity, two crops per year with second crop from ratoon. Requires less water than sugar cane.

- Sorghum properly conducted may produce two harvests in one year, plant and first ratoon should be economically liable. The crop is more efficient in water use and this can make it to become a good option if a deficit of water in soil is registered. It can be grown even with a deficit over 200 mm

- Peak total sugar lasts for a shorter time than sugar cane so needs to be cut within a tighter window of time
- If this crop is use for ethanol production, it must be very well planned to ensure that the sugar content in the stalks can be recovered. Otherwise, it only will produce seeds and fiber.
- Produces a bagasse which cattle can digest more easily than sugar cane otherwise similar in terms of fuel use. The fiber of sorghum has better qualities for burning in boilers or for cattle feed than sugar cane fiber.
- Some varieties produce seeds that may be of value to smaller farmers as an animal feed.
- Experience in similar conditions to Jamaica cannot be found extensively, but it is being introduced in Dominican Republic after two years of field trials and selection of cultivars. So sorghum, though promising, entails some risk.

Cassava

Cassava is a tropical starch crop that forms rhizomes. It is grown primarily as a source of food in many part of the developing world but has become a feedstock for ethanol mainly in Thailand, Vietnam and China. Although a potentially interesting crop for Jamaica, harvesting costs are relatively high, due to a typical need for manual techniques. Table 2 provides comparative yield and cost information for cassava in relation to sugar cane based on experience from Brazil.

Table 2: Comparison between Cassava and Sugar Cane as Feedstock for Ethanol Production (Cabello, 2005)

PARAMETER	CASSAVA	SUGAR CANE
Annual agronomic yield - t/ha.	30.0	80.0
Total sugars	35.0%	14.5%
Annual yield in sugars - t/ha.	10.5	11.6
Theoretical conversion - m^3/t sugars	0.718	0.681
Annual ethanol yield - m^3/ha.	7.54	7.90
Price of feedstock - US$*/t	$64.70	$22.76
Cost of ethanol - US$*/m3	$257.45	$230.53

*US$ 1.00 = 1.70 Brazilian Real

Note that total sugars in cassava refer to starch, not simple sugars, so processing costs are not strictly comparable, and theoretical conversion rates are not achieved in practice. In addition, the cassava does not provide residual biomass to fuel boilers, so process energy must be purchased in some form from elsewhere. Because of these and other factors, as the table indicates, the cost of ethanol from cassava is generally higher than from sugar cane. However, it does offer a possible way to extend the operational use of a distillery to full year.

Petrobras invested in a cassava mill during the period of 1978 to 1983, but Brazilian experience with ethanol from cassava since then is limited. Although there is room, in all likelihood, for increased productivity, as has occurred with cane in the past, the average yield of cassava in Brazil is only 20 t/ha. Also, according to Felipe and Alves (2007), it is very difficult to average more than 20% starch in cassava over a season. At those rates, about 100 L of ethanol could be produced annually per hectare under pilot and laboratory conditions.

New varieties of cassava are being developed, and while it is worth more as food, some processing residues could be used economically to produce ethanol. Before cassava can be considered for commercial application in Jamaica a number of challenging issues need to be evaluated by local field trials and a number of other factors taken into account:

- Cassava can be produced in a wide range of soil types and conditions, but like any other crop, it responds positively to better practices. Sandy soils are better than loam soils because of the development of the rhizomes with less soil resistance. It is a robust crop capable to produce even in quite low technology conditions.
- Experience growing cassava in similar conditions to Jamaica involves food production on a small scale, so it has to be tested under local conditions.
- Preprocessing requirements, such as enzymatic or acid hydrolysis to break down the starch into fermentable sugars before it can be fermented and fed to a distillery designed primarily for sugar cane, with some process adjustments
- Supplemental fuel requirements for processing. While above ground parts of the plant could theoretically supply some fuel, these are likely to be needed to provide natural humus for the restoration of the soil.
- Storage requirements and seasonal factors for year-round continuous processing. Cassava may have an application in Jamaica as a crop that can be stored in piles or as dried chips to provide feedstock when sugar cane is out of season.

2.3 Biodiesel

<u>Castor</u>

- **Characteristics**

Castor is a perennial plant that grows wild in many locations and is well adapted to poor soils, so it commonly appears as a weed among other crops. As such, the economical growth of this crop often needs more care than most farmers are willing to provide for the attainable return. For success, it needs a suitable fertilization program, proper soil preparation, weed control and other good practices.

If properly cultivated and with adequate rainfall and/or irrigation, it can produce two crops per year, since it takes somewhat less than 6 months to complete its cycle. The germination process is very dependent on water availability. Approximately two to three months after germination, flowering begins, a process that also requires adequate water. Harvesting, either manually or with coffee harvesting machinery, will be completed three to four months after flowering. Provided adequate water is available, under ideal conditions with appropriate equipment and technology, the oil content of the fruits can reach 60% and productivity 2,200 kilograms of oil per hectare. Due to the varying impacts tied to local conditions, field trials in the local area where castor is planned for commercial use are necessary in order to determine the best time for planting and the possibility of having two crops per year. The total required precipitation over the fruiting cycle is approximately 650 mm. Variations will influence the oil content.

- **Experience in similar conditions to Jamaica**

Brazilian experience with castor is under quite different conditions from those found in Jamaica, but some lessons can be learned. In Brazil, castor is grown in areas with very pronounced dry and wet seasons, where it is planted immediately before the rainy season to ensure germination and high oil content of the beans. The actual average yield is about 600 kg/ha of beans with a 45% content of oil, but the potential with existing technologies is over 1.5 t/ha, the yield considered as the "break even point" for economic analysis in Northeast Brazilian conditions. The oil content can also reach 48%. The average castor productivity in Brazil is 600 kg/ha, but it can reach 1.8 t/ha without irrigation using proper fertilization and cultivation practices. The potential yield in the field, projected by EMBRAPA for the next 15 years, reaches 5 tonnes of beans per ha. Productivities above 1.5 t/ha are now achieved in big biodiesel enterprises, but lower values remain typical for smaller scales of production. The costs of production are between US$ 200 and US$ 300 /ha with limestone and fertilizer application and weed control.

- **Use by smallholders**

The small farmers have many incentives to grow castor in Brazil. These include: special loans and "*bolsa familia*," an income support program for families with incomes under $2,000/yr., which make the Brazilian biodiesel costs appear lower than they would under conditions where similar incentives are not available. Hence, Brazilian biodiesel economics are not directly comparable to the Jamaican situation and may be misleading.

As a crop that can be totally cultivated manually, it also can grow in areas with steeper slopes, where higher fertility soils may prevail. As an annual crop, unless irrigated, it will not employ manual labor year round. In Brazil, small farmers apply practically no consumable inputs and essentially leave the crop to grow wild.

- **How it might be used as the basis for gradual development of biodiesel production in Jamaica**

This crop can be used theoretically by small and big farmers, with different production systems, different yields and incomes. Subsidized castor cultivation can be an effective tool for social welfare, but sustainable production will need modern production technology and higher investments.

Coconut Palm

- **Characteristics**

Coconut palm is a perennial plant that produces a fruit with the highest oil content of any terrestrial plant. The oil content in coconuts can easily reach 80%. Generally, the coconut fruit and its oil have too high value to be used as a biofuel, but coconut shells can also be used to produce energy,

- **Experience in similar conditions to Jamaica as a feedstock for biodiesel**

The oil and other products of this crop have high market prices in Brazil for human consumption, so except for residues, which are burned as fuel in boilers, they are never used as a bioenergy source there. On the other hand, coconut palm has been used as the feedstock for biodiesel in the Philippines where it is the basis for that country's mandated B2 blended biodiesel for vehicle use.

- **Use of Coconut as a source of Biofuel in Jamaica**

For Jamaica, the primary use should be for human consumption, and as tourism is a major industry in Jamaica, it would not be recommended that this product be used for fuel, with such a high demand by tourists and locals alike. Besides that, coconut trees in Jamaica have been infected by a disease called "yellowing" that killed coconut plants throughout the island. This disease could be related to poor drainage, as it was diagnosed in Brazil, but there is no confirmation of those conditions causing the problem in Jamaica.

- **Significant of the loss of Jamaican tall varieties by lethal yellowing and other diseases**

It is quite dangerous to include this crop with that infection potential that may harm other options. It will be needed investments in breeding and cultural practices that only will have return in long term.

- **How it compares to castor as an option**

It loses in any comparison if the goal is to produce biodiesel. On the other hand, it probably will be more profitable for the growers because of the high values of its products for human consumption. The costs are higher as the risks compared to castor to produce oil for fuel.

Africa Oil Palm

- **Characteristics**

Oil palm is a crop that can be grown in areas with higher slopes than 12%. It is considered semi-perennial since it produces 3 years after planting and continues to 25 years with the peak of production happening after 7 to 9 years. It has many advantages in tropical areas, because it can grow with other crops (vegetables) in inter-row systems during most of its cycle. It can be manually cultivated and can produce yields from 7 tonne/ha of fruits in the third year, increasing to 14 tonne/ha in the fourth year, and reaching 25 t/ha at maturity with stable production of 22 tonne between 10th and 20th year before declining. These yields are currently achieved in Brazil by specialized farmers who use good cultural practices to produce fruit with a 25% of oil content at an average yearly costs of US$ 150.00/ha.

Oil palm is not tolerant to flooding, and when it happens, the trees show symptoms of yellowing, so good drainage practices are important. Its introduction into Jamaica must be done carefully because of diseases that might be prevalent.

- **Experience in similar conditions to Jamaica as a feedstock for biodiesel**

In the last few years, major palm oil companies from Malaysia have set up large new palm oil plantations, and In Brazil, it is grown in the northeast, close to the rain forest, in conditions quite similar to some Jamaican areas. The average productivity of oil in Brazil is of 5t/ha year. This oil is very much appreciated as spicy oil for some typical foods, and this makes the price in the market more attractive for other purposes than fuel.

- **Potential lethal yellowing and other diseases**

Since African oil palm in Brazil is also susceptible to a disease similar to coconut yellowing, and to ensure that other serious diseases are not prevalent, it is strongly recommended that some trials should be conducted under local conditions before any large scale planting of oil palm is undertaken in Jamaica.

- **How palm compares to castor as an option**

Palm will produce more oil than castor, but disease prevention is a challenge that cannot be ignored, and the risks of total loss of the crop by disease are high. All the knowledge of production systems for oil palm comes from its use for human consumption in very restricted sites.

Jatropha

- **Characteristics**

Some advocates consider Jatropha as the preferred oil plant for biodiesel due to its non-competitiveness as a food crop and its ability to be grown on poor soils, where other oil crops are not economical. On a worldwide basis, while some good results in field trials have been achieved, transferring these to larger scale commercial applications has proven generally elusive. Specific experience in Brazil thus far has not been conclusive.

Jatropha is a perennial crop that will grow in poor soils and withstand dry periods but it responds well to better soil conditions and adequate water. It is suitable for manual labor and can be planted where mechanization is not possible. It grows in shady conditions, which means that it does not need total land clearing to plant it. Due to limited field trials, the tolerance of Jatropha to pests and diseases is largely unknown, but it does seem to be generally resistant. It does leave a residue very rich in organic matter that can be used for energy purposes with the resulting ash recycled for fertilization with high phosphorus and potassium contents. The harvest occurs over about 6 months but can be increased by the use of irrigation when regular rainfall is seasonal, and jatropha is very tolerant to salinity and salted water. It grows fast and helps in controlling erosion and desertification, and it can be used as a live fence (20 cm of spacing) for cattle, pigs and others. It can grow in combination with castor and leucena, and it matches very well with apiculture for pollination. It flowers 3 to 5 times a year. It produces celluloses from its cultivation and is quite tolerant to drought. The produced oil also doesn't contain sulfur and has superior yield in ester, around 90%.

The theoretical production is of 5 tonne of beans/ha, with 38% of oil content or 1,650 liter of oil /ha. The residual cake would be 3,200 kg/ha. The actual average in Brazil is half of this value, and although not all reports are reliable, the cost of production, which depends on hand labor for harvesting, appears to be decreasing with time.

- **Experience in similar conditions to Jamaica as a feedstock for biodiesel**

The field experience in Brazil to date has not demonstrated the many advantages claimed for Jatropha. One important issue is the wide variation in the genetic material showing that this crop is not completely domesticated. When grown commercially, in larger areas, wide variations occur in productivity. As yet there is inadequate information to draw conclusions concerning longer term potential.

- **How it compares to castor as an option**

If all the advocates' reasons to plant jatropha are valid, the plant is potentially a better alternative to castor. In any case, it can be an option for marginal lands, including those with steep slopes, and trial plantings could be pursued in combination with castor in small hilly areas. As with castor, extensive field trails are needed over several years before deciding on introduction at large commercial scale.

<u>Other</u>

- **Sunflower**

This crop will compete for land with all other crops. Perhaps it can be used as crop rotation with sugar cane between ratoon replacements.

- **Tropical sugar beet**

Tropical sugar beet can be an option in very particular cases. Some tests are being conducted in inter-row systems, but there remain lots of gaps in knowledge to recommend it as an option for Jamaica. Sugar cane has much higher yield and seems a more appropriate "sugar" crop than sugar beet.

2.4 Biomass as supplemental fuel

To maximize the benefit of high efficiency cogeneration at sugar mills and ethanol plants, the cogeneration plants should be designed to run year round. While the cane cutting and milling season can be lengthened and some bagasse can be stored as means to reduce the time period when supplemental fuel is required, there is still likely to be a period of several months when supplemental fuel will be required.

Biomass crops vary widely, and the Petroleum Corporation of Jamaica has conducted fuelwood research jointly with sugar mills in the past and continues to work in this area today. Energy forests with eucalyptus could be an option as well as elephant grass and bamboo. In all cases they are quite marginal, as sources of biomass for electricity generation have to have a cost lower than conventional fuels to be economic. In Brazil, the eucalyptus is grown principally for cellulose production, and the wastes are used to recycle nutrients in soil or for energy. Large areas are also devoted to charcoal for the steel industry, and very little of the wood is used as fuel. It takes seven years for the first crop, followed by two additional harvests at seven-year intervals, and yields range from 160 m^3 to 260 m^3 of wood per hectare for each seven-year cycle, depending on crop, soil, management, etc. The quality and the caloric value of this material depend on climate conditions, variety and technology used. The amount of waste material depends upon the harvesting technology.

The annual yield of herbaceous grasses (e.g. elephant grass) can reach over 30 t/ha of dry mass with advanced technology and storage capability. Like bamboo (and cane), grass has a ripening period, and sugar accumulation may harm the tubes of boilers, so it has to be harvested "green" and then dried either naturally or thermally. Suitable timing for harvesting can only be determined after local studies. Usually harvest occurs once or twice in a year, and the material will have to be stored during the rest of the time, so the value of these options depends on timing in relation to local use, e.g., when sugarcane is not being processed.

In cultivating any of these crops, one must bear in mind that they will only be used during discreet time intervals, like the off-season for sugar cane, unless they provide fuel for dedicated boilers that operate year-round. The photosynthesis efficiency of eucalyptus is much lower than cane, sorghum, grasses and bamboo. Bamboo is a crop with some limitations similar to herbaceous grasses. It also has to be harvested green and left to dry before it can be used as a boiler fuel. In dry seasons it fits well but will compete with the sugar cane production that occurs in the dry season as well. The only advantage is that both bamboo and grass can be stored without problems of fermentation, as it would happen with cane because of their lower sugar content.

3. Human and Institutional Resources and Roles

3.1 Ethanol Industry

Since Jamaican cane ethanol capacity will be built on top of the existing (or an expanded) sugarcane infrastructure, a significant amount of agriculture and cane processing skills already exists in the country's sugar industry. The additional skills that will be required at the engineering and operating levels are related to the ethanol production portion of the process: (1) Fermentation and (2) Distillation. Both processes are off-the-shelf and hence well established and delivered as turn-key operations with adequate training available from the manufacturers.

Experience in industrial microbiology will be needed to operate and maintain the fermentation units of sugar and/or molasses to ethanol. It will be essential for the plant to have a microbiologist or chemical engineer with experience in a fermentation setting, such as beer, wine or spirits production in Jamaica or other countries. Yeast is the fermentative organism employed in ethanol production; hence, the microbiologist/engineer should understand thoroughly the field of yeast metabolism, inoculation, cultivation, harvesting, and contamination control.

Equally important is expertise in the operation and maintenance of distillation units consisting of distillation columns and molecular sieves. Ethanol produced during fermentation is dilute, usually 5-10% in water. As a result, distillation is necessary to remove large quantities of water and concentrate ethanol to 95.6% by weight, which is hydrous ethanol. The final step for production of anhydrous ethanol, which is the only appropriate form for blending with gasoline, requires the use of molecular sieves. Personnel with such skills can be recruited from other industries that employ distillation processes, such as Jamaica's three dehydration facilities or foreign cane or corn ethanol plants.

Power cogeneration and the necessary human skills are essential to the long-term success of the cane ethanol industry, as the Brazilian experience has demonstrated. Bagasse, which constitutes approximately 13% of the raw cane mass, is an excellent fuel for power generation. Power generation from bagasse is practiced extensively in Brazil and South Florida using low- or high-pressure boiler systems to satisfy almost entirely the power and steam needed for sugar extraction and refining. Excess electricity is exported to the grid. As emphasized throughout this report, cogeneration is essential to the long-term financial viability of the cane ethanol industry.

Cane trash, available in roughly equal amounts as bagasse, is an additional fuel, but it is currently left in the fields. As foreign sugar mills are evaluating the use of cane trash, Jamaica can benefit from future developments in this area.

3.2 Biodiesel Industry

The transesterification process, which converts crude vegetable or recycled oil (and fats) to biodiesel, is well established in Central America, Brazil, and the US. Several manufacturers deliver turnkey operations that can be run by a small number of trained staff members. The key types of expertise in biodiesel production are chemical (or related) engineering and chemistry, as it involves chemical reactions at elevated temperatures (50-60^{0}C), the use of chemical reagents (methanol and alkali), and phase separation. Personnel with proper experience can be recruited from other chemical operations in Jamaica and from the country's research institutions. Training provided by the equipment manufacturer should suffice to start, operate, and maintain a biodiesel production plant regardless of the feedstock used.

3.3 Role of Research Institutions

The development of the appropriate workforce for the country's ethanol industry should be served by the country's Universities and other research institutions, which offer education, provide training, and conduct research. If necessary, Jamaican institutions, such as the very capable CERE, SRC, and SIRI, should be encouraged to collaborate with US, Brazilian, Colombian or other international institutions to bring to Jamaica knowledge and practices regarding biofuels production. Regarding R&D, it is essential to support the ethanol and biodiesel industry, particularly in the area of agronomy and agriculture to develop plant varieties best suited for Jamaica's weather and soil and to support the local farmers with best practices in cultivation, maintenance, and harvesting of crops. Such programs in Brazil have resulted in phenomenal productivity improvements over the years, such as 33% increase in sugarcane yield (tons per hectare)[7]. Close collaboration with Brazilian and Colombian experts will also benefit the industry with fermentation, distillation, and vinasse handling (ethanol) and transesterification (biodiesel) improvements.

The research institutions, as well as PetroJam, can support the ethanol and biodiesel industries with analytical method development, chemical analysis, and quality control issues as they are possess appropriate expertise and instrumentation. Chemistry departments have the faculty expertise and student availability to establish the necessary analytical protocols. The analysis of methylesters (biodiesel), in particular, requires a battery of tests to ensure that the final product conforms to a certain standard that the industry will need to adopt. It could be the European biodiesel standard EN14214 or the US standard ASTM D6751, and the Bureau of Standards of Jamaica is considering recommendations to stipulate the ASTM standard in the Petroleum Quality Control Regulations governing biodiesel blends up to B5. Regardless of the standard adopted, a laboratory should be set up in Jamaica either at the biodiesel plant or at a University or other research organization to address this critical need. Training for equipment operators should be sought from qualified personnel in countries such as the US or Brazil.

[7] Isaias de Carvalho Macedo, Sugarcane's Energy, Unica, Sao Paulo, 2007.

Finally, Universities can also provide support in the evaluation of cellulosic biomass conversion to ethanol using 2nd generation technologies developed in the US and other countries. A thriving cane ethanol industry provides ideal conditions (co-location benefits) for the deployment of bagasse-to-ethanol technologies with the prospect of significantly increasing the amount of ethanol produced per ton of sugarcane.

As with sugarcane, R&D in plant agronomy and genetics will be valuable in identifying and improving promising varieties of castor beans, jatropha, and other biodiesel feedstocks and in supporting Jamaican farmers to ensure continuous and high-yield supplies of feedstocks. Because biodiesel production is not as energy intensive as cane ethanol, power co-generation is usually not practiced. However, given Jamaica's future needs of additional power and the fact that biodiesel feedstocks generate considerable amounts of biomass, the feasibility of a centrally located power generation plant should be examined. If the logistics make sense, a more economical alternative could be to have biomass from biodiesel plants transported to a cane ethanol facility equipped with cogeneration. There, such biomass can supplement bagasse for the production of energy and heat.

4. Economic Analysis

4.1 Pricing Formulae for Biofuels Compared to Petroleum Fuels

The first consideration should be a realistic evaluation of the cost of production of biofuels in Jamaica. A preliminary assessment should be carried out as soon as possible by organizations like CERE and SIRI, which must have in their possession all pertinent data, including land, feedstock, and labor costs. From a technology standpoint, both cane ethanol and biodiesel production plants can be obtained as turn-key operations from a number of manufacturers. The Brazilian company Dedini is the dominant supplier to the Brazilian sugarcane industry, whereas the Indian company Praj dominates in Southeast Asia and has made inroads into the Americas (e.g. Colombia). In the area of biodiesel, there are numerous manufacturers of modular transesterification units, which can handle a variety of feedstocks some of which may require a pretreatment step.

Once the capacity of a cane ethanol plant is defined, engineering and construction companies, such as Dedini and Praj, can be approached to solicit preliminary capital and operating cost information. Brazil has always been the lowest-cost producer of ethanol in the world. Even with the strengthening of the Brazilian currency in the last 2 years, the cost is estimated at about $1.40/gallon ($0.37/liter) making cane ethanol competitive with gasoline at oil prices of $40 or higher. However, the Brazilian ethanol industry has benefited from almost 40 years of hands-on experience. Moreover, Jamaica is facing low average sugarcane yields (55 tons/ha) compared to other countries in the Americas, such as Brazil (80 tons/ha), Guatemala and Nicaragua (over 90 tons/ha). Such inefficiencies need to be addressed immediately through agronomic and agriculture research and support to the Jamaican sugarcane farming community; otherwise the cost of production will be too high to compete with gasoline.

In the biodiesel sector, typically more than 80% of the cost of production is associated with the cost of the feedstock. This fact simplifies calculations, as it allows for a quick estimate of which feedstocks can be promising as cost-competitive with diesel in the country. CERE has already done a detailed preliminary assessment and concluded that castor beans and jatropha show promise.

Government support for locally produced biofuels exists in practically all biofuels-producing countries. It comes in various forms legislated through policies at the local, regional, and national levels. These policies include:

- Direct payments to producers or blenders of biofuels located in Jamaica
- Direct payments to farmers growing biofuels crops
- Exemption from or reduction in fuel excise taxes for biofuels
- Grants or low interest loans or loans guaranteed by the government for capital expenditures of biofuels facilities

- Exemption from import duties of capital equipment for biofuels facilities
- Exemption from or reduction in income taxes for biofuels producers for a period of time
- Grants for biofuels research and development
- Tariffs on imported biofuels

In most countries some of these incentives are accompanied by biofuels mandates, similar to the E10 mandate currently in effect in Jamaica. The mandates define the minimal market size and reduce the risk of investment in biofuels. As mandates come into effect, some countries (e.g. member states of the European Union) eliminate the excise tax exemptions of biofuels, thus passing the costs of biofuels directly to the consumers.

Below we review the biofuels pricing practices of countries considered global or regional leaders in production and use of biofuels.

Brazil

With all subsidies removed, ethanol in Brazil is priced based on its actual cost and the spread between production cost and the price of gasoline, always taking into consideration that ethanol has only 67% of the energy density of gasoline. In the case of biodiesel, this energy disadvantage differs from one feedstock to another, but in general biodiesel delivers over 90% of the energy of diesel.

In Jamaica we envision that one of the socioeconomic benefits of biofuels will be the opportunity an ethanol or biodiesel facility (most likely centrally located) to provide steady income to farmers who will grow cane or oil-seed crops on a long-term basis. The price paid for the feedstock should reflect the farmer's cost of production and any subsidies the government is willing to provide to the agricultural community to incentivize them. At the same time that price has to be reasonable enough to allow profitable or near-profitable production of biofuels. Brazilian sugarcane farmers and sugar/ethanol producers have negotiated a formula that determines what fraction of the sugar/ethanol revenues go to each party[8]:

- In the case of sugar production, 59.5% of the revenues to the cane farmers and 41.5% to the industry (sugar processors).
- In the case of ethanol production, 62.1% of the revenues to the cane farmers and 37.9% to the industry (sugar processors).
- Of course this issue does not exist for operations that are vertically integrated to include both production of sugarcane and conversion to ethanol.

Colombia

In Colombia the government guarantees ethanol producers a floor price for their product. Hence, at times when oil prices are low, the state is willing to subsidize the production of biofuels to sustain the industry. As mentioned earlier, although such subsidies represent a cost

[8] Produção e uso do Etanol combustível no Brazil, Unica, Sao Paulo, 2007.

to the national budget, the money is invested in the local economy and not spent on oil imports.

Thailand

Another pricing model that Jamaica can consider is that of Thailand, where – just as in Jamaica - ethanol is blended and distributed by both state-run and private companies[9]. Ethanol is priced based to the ethanol FOB price at the Brazilian Commodity Exchange in Sao Paulo. The price is adjusted for freight, insurance, loss, and additional costs (survey, testing, shipping) as calculated for a hypothetical shipment from Sao Paulo to Thailand.

The government subsidizes certain blends to advance its policy of promoting the use of domestic biofuels at the expense of imported oil. For example, the retail price of E20 is set 6 cents/liter (¢23/gal) lower than E10 and 18 cents/liter (¢68/gal) lower than gasoline. The table below shows the types and prices of fuels (per liter) available in the Bangkok Metropolitan Area on Oct. 17, 2009 (based on an exchange rate of 33.4 baht to the US dollar):

Table 3: Thai Fuel Prices (2009)

E10 (octane 91)	**$0.89**
E10 (octane 95)	**$0.91**
E20	**$0.85**
E85	**$0.56**
Gasoline (octane 95)	**$1.03**

USA

In the United States, mandatory E10 blending is practiced by several states, whereas biodiesel blending above B2 level remains optional. In Midwestern states, where practically all US corn ethanol is produced, E85 blends for use with flexible-fuel vehicles are widely available. Ethanol prices are largely set by free market dynamics, which take into account the cost of production and the varying price of gasoline. However, there is a subsidy in the form of a credit of $0.45/gal, which is paid by the federal government to the oil companies that blend ethanol with gasoline. The government also provides a credit of $1.00/gal to biodiesel blenders, reflecting the precarious financial viability of biodiesel production in the country, although diesel use in the USA is just 1/3 of gasoline use. The subsidies certainly enhance the cost competitiveness of locally produced biofuels and hence secure thousands of jobs associated with them, but they come at a cost. Just the ethanol subsidy costs the country annually an estimated $6 billion.

The ethanol credit, usually referred to as "blender's credit", is officially called the Volumetric Ethanol Excise Tax Credit (VEETC) and was instituted in 2005. It was recently extended for one year and will expire at the end of 2011, unless the US Congress takes further action. Efforts are underway to both extend the credit and block it. The extension is supported primarily by corn

[9] C. Boyd, An Update on Ethanol Production and Utilization in Thailand, PNNL, 2009.

farmers and Midwestern states, whereas the opposition is led by environmental groups and others who see the program as uneconomical for one reason or another.

The practical significance for Jamaica is that as a member of the Caribbean Basin Initiative, the country can take advantage of the credit without offsetting tariffs, but the future of the credit is highly uncertain and probably would entail significant risk for an investor who relied on it. On the other hand, a renewable fuel standard established by the Energy Independence and Security Act of 2007 requires 12.95 billion gallons from renewable sources in 2010, increasing to 36 billion gallons per year by 2022. Greenhouse gas and other environmental criteria may favor cane-derived ethanol over other sources.

European Union

In the EU both ethanol and biodiesel receive government financial support in almost all member states predominantly in the form of reduced fuel excise taxes for biofuels. A recent study[10] concludes that EU governments spent $4.8 billion in 2006 to support biofuels in an effort to reduce reliance on oil. By 2008 the financial support dropped to $3.9 billion on 1.68 billion gallons of produced ethanol and 2.33 billion gallons of produced biodiesel because excise taxes on biofuels were raised as mandatory biofuels blending policy gained popularity. This government support translates to $3.64/gal for ethanol and $2.46/gal for biodiesel (calculated at an exchange rate of $1.30 per euro).

Interestingly, the same study makes the following recommendations to European policy makers:
Institute a "polluter pays" principle, a form of carbon tax, to account for the consequences of fossil fuel use;

- Phase out biofuels support except for research and development (R&D) programs;
- Eliminate tariffs on imported fuel ethanol;
- Implement transparency concerning EU member states' biofuels policies to allow proper evaluation of their support measures.

Australia

In 2001 Australia set a production target (but not a mandate) of 350M liters per year (92 mgy) of biofuels by 2010. The country has so far assisted biofuels prices mainly through an excise tax rebate of $1.34/gal to producers (calculated at an exchange rate of A$1.07 per US$). The subsidy is provided to domestically produced ethanol and biodiesel, as well as – surprisingly – to imported biodiesel, but not to imported ethanol. As a result, biofuels will enjoy an excise tax-free status until June 30, 2011. Subsequently, the taxes will progressively rise to 50% of the level of those imposed on gasoline and diesel by 2015-16 on an energy equivalent basis.

[10] Jung, A. *et al.*, "Biofuels – At What Cost? Government support for ethanol and biodiesel in the European Union – 2010 Update", International Institute for Sustainable Development, Geneva, Switzerland, July 2010.

Moreover, producers of ethanol and biodiesel have received federal grants for capital investments through the Biofuels Capital Grants Program. The grants have been used to build ethanol and biodiesel facilities, restructure the sugar industry, and promote innovation.

Conclusion

Biofuels pricing will have to be based on actual production costs, but the government may wish to provide floor price support or other direct or indirect financial incentives, such reduced excise taxes and/or duty-free importation of biofuels equipment, to encourage the establishment of a domestic biofuels industry. Hence, the decision will rely heavily on political will.

4.2 Markets for Biofuel Products

Biofuel processing, especially sugarcane, results in an array of products, all of which have value in the marketplace and can generate revenue to pay the cost of the feedstock and the facility and its operation. Addressed below are ethanol, biodiesel and electric power.

Ethanol

Jamaica currently has had an established E-10 program in place throughout the island since late 2009. Motor gasoline sales amount to just under 200 million gallons per year, providing a potential market for nearly 20 million gallons per year of anhydrous ethanol. Currently, this ethanol is imported from the US at a cost of between $1.67 and $1.70 US per gallon, plus $0.10 shipping from Texas, according to Petrojam sources. (Slightly below the current US average. See http://www.dtnprogressivefarmer.com/dtnag/markets)

Prospective local producers enjoy no preference besides lower shipping cost in supplying this market, since Petrojam is required to purchase supplies on the world market through open tenders. On the other hand, Jamaican producers will presumably be free to export ethanol to other countries. In the US, where the blending tax credit (described earlier) is due to expire at the end of 2011, along with the corresponding tariff for sources outside the CBI, a renewable fuel standard established by the Energy Independence and Security Act of 2007 requires 12.95 billion gallons from renewable sources in 2010, increasing to 36 billion gallons per year by 2022. (See http://www.epa.gov/oms/renewablefuels/420f10007.htm) Greenhouse gas and other environmental criteria there may favor cane-derived ethanol over other sources. European countries also have a variety of incentives for ethanol and other renewable fuels, including Sweden, for example, where E-85 (from imported ethanol) is widely used. With the world demand for renewable fuels expanding as it is, Jamaica should be at an advantage if it can position itself as a net supplier of ethanol from cane. More on world prices at: http://www.icis.com/home/default.aspx.

Biodiesel

Plant lipids can be converted to fuel either by traditional petroleum refining, with minor process changes (See http://www.nrel.gov/docs/fy04osti/34796.pdf), or as described above to form methyl esters. The caloric value of the esters is approximately 10% less than traditional diesel fuel and the fuel has a variety of other advantages and disadvantages, including lower combustion emissions (except NOx), and shorter storage life. A by-product is crude glycerol (about 10 percent of the product volume; 80 per cent purity), worth 10 US cents per gallon or less, currently, due to a worldwide glut created by already ongoing biodiesel production.

The Jamaican market for biodiesel has several segments. A national plan currently under consideration calls for B-5 blends, analogous to the E-10 ethanol mandate, and Petrojam Limited has elected to adopt US standards for fuel composition and testing and has undertaken independent evaluations of engine performance on biodiesel blends. Based on information at the PCJ web site[11], total fuel consumption for road and rail transport was 5.8 million barrels in 2008. Of this about 4.3 million barrels was unleaded gasoline, leaving 1.5 million barrels (63 million gallons) of diesel, which represents a nationwide market of roughly 3 million gallons per year of plant methyl esters for B-5. This small volume may not justify a national campaign to introduce the blend, but an advantage would lie in the contribution of the plant esters to fuel lubricity, which is more difficult to achieve at 15 ppm sulfur levels projected for three years from now.

Another alternative market sector would be truck fleets, which could consume B-100. Diesel trucks represent nearly 90 percent of the 20,727 diesel vehicles on the island and no doubt a higher percentage of the fuel consumption. If a number of large fleet operators were to convert to B-100, as a trash collector has apparently proposed, biodiesel could displace a larger fraction of the 63 million gallons than the 5 percent upper limit of B-5.

Stationary engines represent an even larger market. Just over 6 million barrels (252 million gallons) of petroleum, including heavy fuel oil and auto diesel, are consumed for electricity generation. Assuming the 2.4 million barrels of auto diesel remaining after subtracting transport fuel from total production is for power generation that would represent 100 million gallons per year of potential market for B-100 for stationary diesel engines and combustion turbines. Biodiesel could also displace bunker fuel, but the value would be reduced.

In any case, the August 19, 2010 price of auto diesel at the Petrojam refinery gate was $95.86 US per barrel, or $2.28 per gallon. Accounting for the 10 percent lower calorific value, the equivalent value of biodiesel would be $2.05 per gallon.

Electric Power

Sugarcane processing can contribute renewable electric power through cogeneration fueled by bagasse. Power sales to the electric utility can defray production costs, and the utility system saves on fuel, at a minimum and possibly generating capacity and power transmission costs, depending on location and timing considerations.

[11] http://www.pcj.com/dnn/Statisticsbyproduct/tabid/144/Default.aspx,

In Jamaica, the Office of Utility Regulation (OUR) has an established policy regarding independent power and cogeneration, including incentives for renewable resources. While rates offered for cogeneration in the current regime are artificially low, OUR has recently published an updated expansion plan for power generation and is presently revising the policy to conform with the recent National Energy Policy and take into account plans by PCJ to import LNG for power generation and other purposes.

Part of the OUR expansion plan involves near-term acquisition of 480 MW of new generating capacity through a request for bids from prospective investors, due on March 31, 2011. The goal, according to OUR, is to replace five antiquated heavy oil-fired steam generating stations with new technology, preferably fueled with natural gas from imported LNG with a provision for oil as a fallback to offset supply risk. That would leave in place several low and medium speed diesels, combustion turbines and a 114 MW combined cycle unit, along with several independent power producers.

According to OUR's *Generation Expansion Plan (2010)*, Table 6.7-1, the heat rates for the remaining heavy fuel oil-fueled diesels, including the newer independent power producers', is 8,144 kJ/kWh or better, so they would likely be base-loaded in preference to the auto diesel-fueled combustion turbines, which JPS does not plan to retire (Expansion Plan, p. 54). The latter would likely be the marginal generators curtailed under a priority dispatch system if additional cogenerated power became available from sugar cane processing.

At 137,000 kJ per gallon, and Petrojam's August 2010 refinery gate price of $2.28, the diesel for the combustion turbines costs $16.60 per million kJ. At the lowest heat rate, 9,133 kJ/kWh, corresponding to the one combined cycle unit at maximum capacity, the fuel cost alone is 15 cents per kWh. The simple cycle units have efficiencies ranging from 11,807 to 14,908 kJ/kWh, so their fuel costs are between 20 cents and 25 cents per kWh at rated capacity. At lower outputs, the units are less efficient, so the fuel costs are higher. Even if one assumes that power from sugarcane cogeneration displaces power from a new combined cycle plant (Expansion Plan, Table 8.3-1) with a heat rate of 7,654 kJ/kWh, the avoided fuel cost would be 13 cents/kWh.

Obviously, the actual avoided cost depends on timing relative to system peaks, but the value to the Jamaican economy likely falls within a range of 15 to 25 cents per kWh. That does not include any credit for capacity, as power from cogeneration allows new generation capacity investments to be postponed and offsets risks due to delays, and power generated at sugar mills may also alleviate transmission and distribution costs in rural areas where transmission capacity is currently strained, as it appears it may be on the eastern end of the island, where some sugarcane is now produced.

Finally, the OUR Expansion Plan could have provided for sugarcane bagasse-fueled facilities to replace the aging oil-fired steam generators. These older plants, at 60-69 MW each, correspond roughly in scale to large sugar mills, which could operate year-round with supplemental fuel, possibly at lower total cost and financial risk than new LNG combustion turbines, tied, as LNG cost would be, to future world energy prices. As it stands, the plan devotes one page to renewable resources in Section 6.10, which indicates a potential contribution of ">100 MW" from biomass (Expansion Plan, Table 6.10-1). The bids for new capacity, to be submitted in March 2011, will provide a clearer indication of what new capacity will cost, and biomass-fueled generation could save.

4.3 Financial Requirements, Financing Regime, and Capital Development Options

The cost of developing a biofuels industry in Jamaica depends on a number of parameters, the most important of which are:

1. Use only existing sugarcane production or develop additional capacity on appropriate land.
2. Build one large centralized ethanol processing facility or several small decentralized ones.

The first issue is critical, as sugarcane plantations in Jamaica have shrunk over the years. At the present production level of 1.65M tons per year, the potential for ethanol production (using industry best practices) is just 36M gallons, even if all cane production was directed to ethanol. This is just 21% of current gasoline use, hence limiting the country's ability to replace considerable amounts of imported oil with domestic ethanol.

Putting additional land into sugarcane production requires both money and time. Pressure from land developers is expected to complicate matters, as it will certainly raise social and political issues even for land owned by the government. Eventually, it becomes a matter of policy and economics: a political decision about the country's sustainable economic growth will have to be made with agriculture playing a pivotal role. Independent farmers will favor sugarcane plantations only if they can be guaranteed reasonable long-term financial returns for their hard work and commitment to the country's biofuels vision.

The second issue – one centralized facility or several smaller ones - is equally important. Economies of scale are of paramount importance for ethanol production. Even a 36M gallon facility by ethanol industry standards is considered a small-size facility. If a decision is made to utilize only a portion of cane for ethanol production, then the ethanol facility will be even smaller. Similarly, if instead of a centrally located ethanol facility several smaller ones are built, they will suffer from higher operating costs and the total investment required will end up being higher for the country. Our advice is to opt for a single ethanol plant either located at the largest existing sugar mill or built in a central location that minimizes overall logistical costs.

Based on information from Brazil for 100M gallon facilities, the cost of new (greenfield) sugarcane ethanol plants is approximately $1.50 per annual gallon of ethanol capacity if the agricultural infrastructure already exists. The cost jumps to about $3.50 per annual gallon of ethanol if the sugarcane plantations need to be developed de novo. In Jamaica, based on current cane productivity for a new ethanol plant of rather small size (36M gal), a cost of around $2.50 per annual gallon of ethanol capacity may be a reasonable first estimate. Hence, the investment required for an operation of 36M gallons could reach $90M or more.

In the case of biodiesel, the challenges are more daunting as the agricultural infrastructure for feedstock production simply does not exist in Jamaica. We understand that castor beans and jatropha are considered the most promising feedstocks. However, practices in Central and South America indicate that African palm has the highest oil yield, whereas castor beans are cultivated extensively only in Brazil. Moreover, there is no large-scale commercial experience with jatropha anywhere in the world, hence developing a national program based on this crop, regardless of its promise, entails high risk and significant investment. On the positive side, capital requirements for new biodiesel production facilities are approximately $1.00 per gallon of biodiesel capacity, including storage tanks for feedstock, chemicals, and product. Furthermore, for biodiesel, economies of scale are not as critical as for ethanol. Biodiesel plants tent to be modular allowing for easy capacity expansion at any time.

Establishment of a biofuels industry in Jamaica will eventually depend on the success of project financing. Usually such financing is secured through a combination of debt and equity at a debt-to-equity ratio of 80:20 or lower. Equity will be sought from local and international investors, whereas the debt will be secured from regional and international banks provided that long-term contracts for key components of the plant's operation can be arranged:

- Cane or oil-seed supply contracts
- Ethanol or biodiesel off-take contracts
- By-product (e.g. molasses) off-take contracts
- Electricity sales agreements (if excess power is available)

Such long-term contracts, covering 10-20 years, reduce the risks of the project and make the return on the investment attractive. Fig. 6, which shows a typical project finance structure, demonstrates the complex arrangements necessary for a successful biofuels industry. Saleable by-products of an ethanol project include molasses, carbon dioxide (CO_2), fertilizer, biogas, and carbon credits, whereas for a biodiesel plant they are glycerin, fertilizer, and carbon credits. Excess electricity, if any, requires the operation of a cogeneration plant within the biofuels facility.

Procurement of the design and engineering of the plant should be done through an open solicitation calling for expression of interest in a turn-key operation to ensure that one entity can be held responsible for the entire facility. To help the Jamaican economy, terms of the solicitation should mandate the use of local labor, contractors, and fabrication to the extent possible.

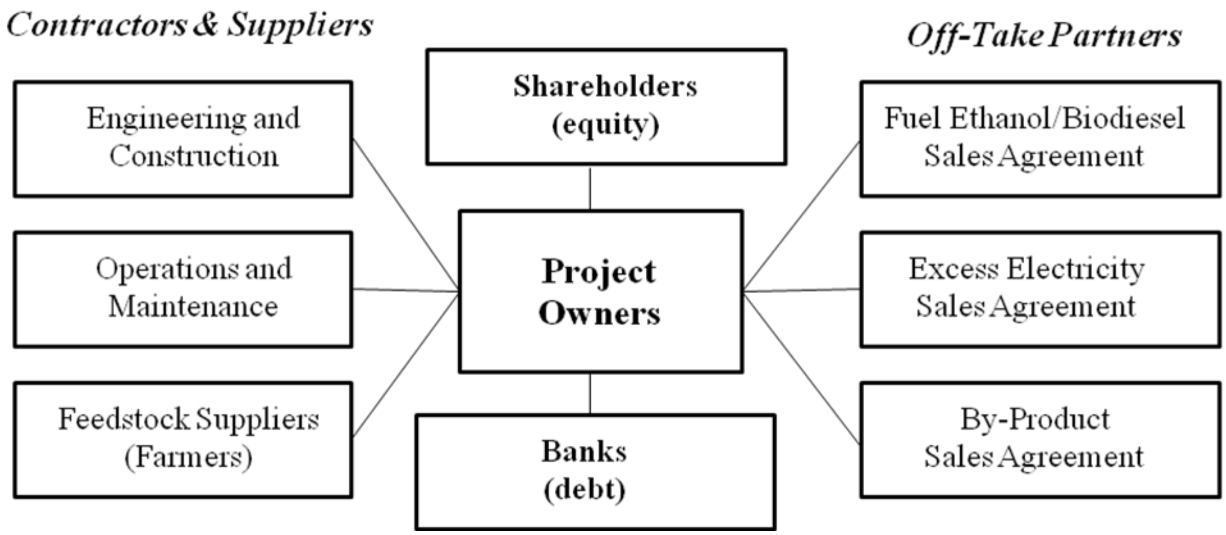

Figure 6: Typical financing structure for a biofuels project

In addition to the biofuels production facility itself, additional significant investment will be required:

- Road improvement and construction will be needed to allow for efficient transportation of sugarcane to the ethanol plant and ethanol fuel to Petrojam and other blending facilities around the island. In general, the condition of Jamaica's road infrastructure appears to be in urgent need of repairs and expansion.
- A public education campaign is sorely needed to inform Jamaicans about the properties, proper use, and benefits of biofuels.
- Sugarcane harvesters will need to be introduced, if cane harvesting will be partially or fully mechanized to enhance productivity at least on relatively flat land. Each harvester reportedly costs in excess of $250K. Even if large harvesters are out of the question, the use of other means to accelerate harvesting, such as hand-operated cane mowing machines used in Brazil, should be seriously considered.
- Tank clean-up at gas stations will be needed, if not already done, to remove gasoline deposits and preserve fuel quality, since ethanol has detergent properties. Moreover, repairs to or replacement of leaky gas station tanks will be needed to prevent water from entering E10 storage facilities and causing phase separation, which can damage car engines.
- If and when blends over E10 or B20 are introduced, adjustments to gas station tanks and pumps will be necessary to enable them to handle such biofuels blends (replacement of rubber components with neoprene or EPDM).

The costs of each of the above can be estimated only when appropriate data are available.

The financial and capital requirements for developing a biofuels industry in Jamaica will have to come from the private sector with the possible involvement of the World Bank and other regional and international development banks for a combination of equity and debt financing. For example, the Brazilian Export Bank is known to finance over 80% of sugarcane ethanol facilities as long as Brazilian equipment is procured.

5. Processing and Distribution

5.1 Technology-neutral processing regime required to activate the desired biofuel developments

Sugarcane Processing

The total amount of energy in 1 t of cane (aerials part) is about 7400 MJ, more than a barrel of oil (6000 MJ), but it is divided about 2400 MJ in sugars, 2500 MJ in the bagasse and 2500 MJ in the straw (mainly leaves and sometimes called cane trash). The efficiency of recovery of the sugar, in various final non-energy forms, and the balance as energy differs between each type due to the process differences. While sugar recovery reaches efficiencies of over 90% with current technology, the recovery of the energy in terms of process steam and electricity by using the bagasse as a boiler fuel is lower. Whereas modern high-pressure bagasse boilers can achieve thermal efficiencies of 85%, older lower pressure units have efficiencies often below 75%. In addition, the overall steam to electricity conversion efficiencies that for modern units can exceed 30% is often lower than 10% at older plants. In order to reduce the cost of ethanol produced from the cane sugar whether in the case of a combined granular sugar and ethanol plant or is a purpose built cane to ethanol with no granular sugar plant, the main approach adopted in the last 20 years has been to introduce higher energy efficiency in the processes such that surplus electricity can be maximized and sold to create additional revenue that can be used to reduce the price of the ethanol when this is needed for overall financial viability. Longer term research, development and initial pre-commercialization of advanced biofuel production processes that begin after the hydrolysis of the fiber (celluloses and hemicelluloses), offer the prospect of an approach that provided better overall returns and will make sugar cane almost unbeatable in terms of energy production. This new technology will place greater emphasis on developing varieties of cane that may be higher in fiber and or mature earlier or later. It will certainly increase the needs for well-managed operations in the field as well as in the process to maximize outputs and minimize unit costs.

Ethanol production can be built as an extension of current sugar mill operations with the addition primarily of fermentation and distillation capabilities, as the dashed section of Figure 7 shows. Sugarcane processing for ethanol production is a well-established commercial process that can be readily purchased and installed off the shelf as a turn-key operation by a small number of international suppliers. As seen in Fig. 7, sugarcane delivered to the plant is crushed to extract the sugar juice. The sucrose-rich juice is then concentrated and processed to sugar and molasses (for rum production) or fermented by yeast to ethanol in continuous stirred fermentation units. The dilute fermentation broth is directed to a distillation column, where ethanol is recovered as a 95.6% (by weight) aqueous solution. In Jamaica the molasses are turned into rum by the country's spirits industry.

The ethanol solution is further refined to anhydrous ethanol using molecular sieves to remove the remaining water. The sieves consist of zeolites, which facilitate the separation of ethanol from water at elevated temperatures and pressures. Although dehydration can be carried out via a number of processes, the use of molecular sieves is advised, since both of the existing dehydration facilities in Jamaica employ them.

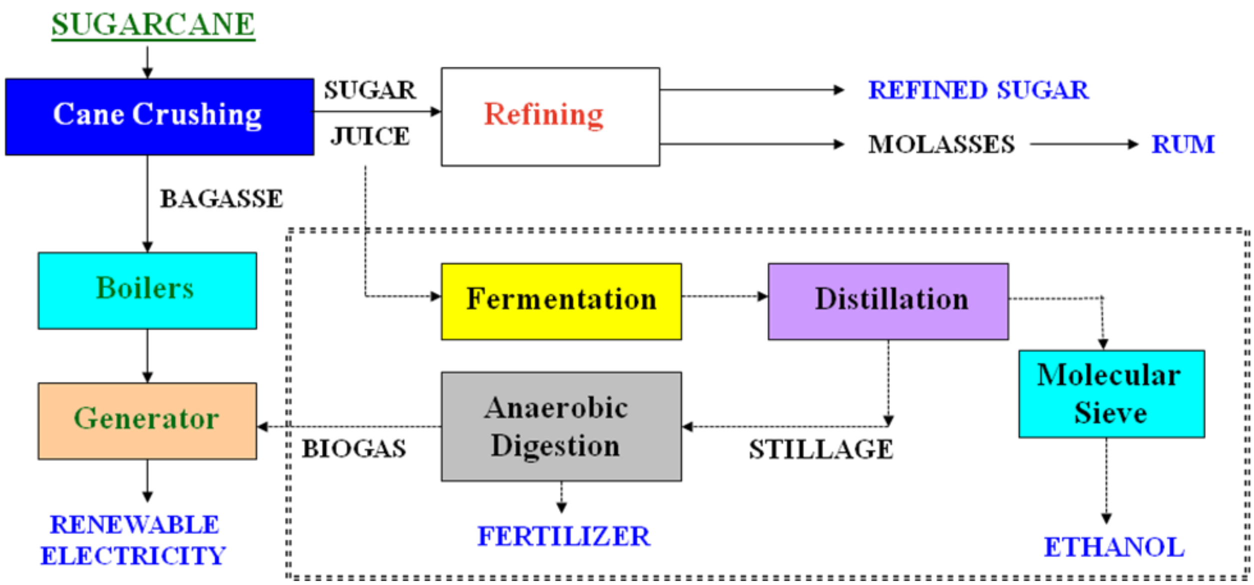

Figure 7: Schematic representation of ethanol production (within dashed lines) integrated in an existing sugar mill with cogeneration capability

Carbon dioxide produced during the fermentation (in a 1:1 molecular ratio to ethanol) is appropriate for use by the food and beverage industry, thus producing an additional revenue source for the plant. The stillage (vinasse), the solid-liquid mixture obtained from the bottom of the distillation column, is rich in potassium and other inorganic elements absorbed by sugarcane from the local soil. It has high BOD and COD loads that can be reduced via anaerobic digestion, while generating valuable methane-rich biogas, which can improve the energy balance of the whole operation. The digested solids can then be used as a natural fertilizer in the fields to provide soil nourishment. Indeed, in Brazil, Colombia, and other countries vinasse is used as a fertilizer that is applied to the cane fields via irrigation water ("fertirrigation") to replenish the soil of the sugarcane fields with essential nutrients cutting down on the use of fertilizers. A similar application is envisioned in Jamaica using the experience of other countries.

Finally, the bagasse residue recovered from the crushed cane should be treated as a fuel for cogeneration at the sugar ethanol plant. Medium (65 bar) or high (100 bar) pressure boilers are recommended to increase energy efficiency. Such power (and heat) generation can provide for the electricity and steam needs of the plant making the investment more attractive and shielding the plant from the high cost and uncertain reliability of grid power.

Most sugarcane producing countries, including Jamaica, have a rainy summer and fall, which interrupts harvesting and hence the operation of the mill. Because cane cannot be stored without degradation, this reality will also affect ethanol production. Unless surplus molasses are produced and stored for later processing, ethanol operations will have to coincide with cane operations, which in Jamaica means about 250 days a year during the January-June period. During off-season maintenance and repairs will be performed throughout the plant. It should be noted that the dehydration section of the plant can be available during off-season for production of anhydrous ethanol from imported hydrous ethanol, if the economics of gasoline vs. ethanol make dehydration profitable.

Oil-seed Crop Processing

In the absence of commercial oil-seed crops in Jamaica, large plots of land will have to be dedicated to cultivation of plants, like castor beans, to support a biodiesel industry. Just like the sugarcane-to-ethanol operation, the crop-to-biodiesel process is well established in many countries regardless of the feedstock used. Today, off-the-shelf biodiesel production units from numerous manufacturers can handle a variety of feedstocks.

From a processing standpoint, seeds will be harvested manually and/or mechanically and sent to a crusher for extraction of crude vegetable oil. Recycled oil can also be used, but depending on its free fatty acid (FAA) content, pretreatment may be needed (Fig. 8). However, such a unit can be ordered as a standard part of the integrated modular biodiesel unit to allow maximal flexibility in dealing with a variety of virgin and recycled feedstocks.

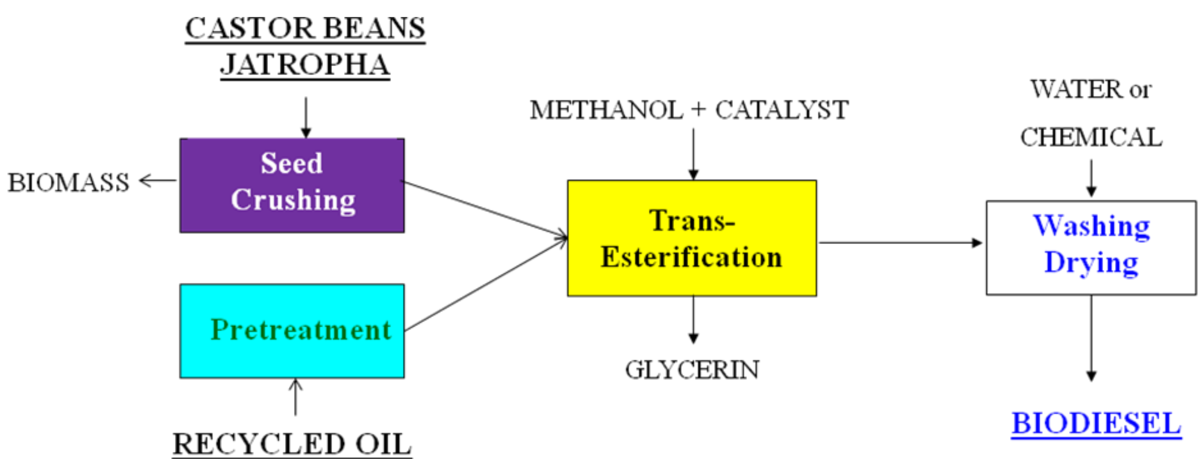

Figure 8: Schematic representation of biodiesel production from oil-seed plants and recycled oil

The oil is subsequently led through a series of vessels, where the transesterification process takes place at 50-60^{0}C in the presence of excess methanol and potassium hydroxide, which catalyzes the reaction. This standard process leads to the formation of primarily a mix of methyl esters (biodiesel) and glycerin in a weight ratio of approximately 10:1. After a series of washing and drying steps to remove impurities (methanol) and moisture, the biodiesel is ready for testing to qualify it as appropriate for commercial use through blending with diesel. The glycerin is generated as a dilute aqueous solution that can be used in a number of ways, such as:

- Subjected to anaerobic digestion for conversion to methane, which can be used as a fuel for power and/or heat generation.
- Mixed with animal feed (as long as it is methanol-free) as a carbon supplement.
- Upgraded through distillation to a high purity (and high value) product that has applications in the cosmetics industry.

The latter application requires the purchase and operation of a distillation column, whereas anaerobic digestion and animal feed are lower value, but also lower-cost, options with modest revenue-generating potential.

The solid leftovers from the crushing of the seeds, along with other plant material, constitute a steady source of biomass that should be considered as the basis for cogeneration or for use as a natural fertilizer. Although cogeneration is usually not practiced at biodiesel plants due to their rather small size (and hence limited quantities of biomass), this possibility should be re-examined in Jamaica particularly in coordination with the cogeneration plans of the sugarcane-to-ethanol industry.

5.2 Harvesting, storing, transporting, blending and distributing products

The vast majority of sugarcane operations around the world are based on manual harvesting for two main reasons:

- Mechanical harvesting requires a significant investment (as the cost of each harvester exceeds $250K) and rather flat landscape.
- Manual harvesting provides socio-economic benefits to communities in the form of employment.

Even in Brazil, the largest sugarcane producer in the world, only 30% of harvesting is done mechanically. In Jamaica manual harvesting is practiced by the industry and most likely will remain so in the foreseeable future. Sugarcane needs to be processed as soon as possible – preferably within 12 hours because the sucrose in cane is susceptible to fermentation by natural microorganisms. Such degradation represents a loss in sugar yield and quality (and will negatively impact the economics), as sugar is converted to organic acids and other metabolites, especially at the warm temperatures and humidity prevalent in the fields of Jamaica during harvesting.

As mentioned earlier, ethanol produced at the plant has to be in anhydrous form via molecular sieves that break the azeotropic 95.6% ethanol-water solution derived from the distillation column. Only anhydrous ethanol is appropriate for blending with gasoline. Because of ethanol's hygroscopic nature and Jamaica's mostly humid climate and aging infrastructure, anhydrous ethanol storage at the plant and E10 storage at gas stations should be done with precautions to prevent water absorption, which will cause undesirable phase separation between ethanol and gasoline. Arrangements will need to be made between the ethanol plant operator and PCJ (and other blenders) for the delivery of ethanol to appropriate fuel storage facilities, where ethanol will be blended in line or in tank with gasoline to form the desirable final blend(s), such as E5, E10 or other. The same is true for biodiesel blends with diesel. The blends are then ready for distribution to gas station tanks and from there for sale to the public.

It should be noted that blends of gasoline up to E10 and diesel up to B20 are in general considered compatible with vehicles manufactured after 1995. Higher blends should not be used, except in Flex Fuel Vehicles (FFV), without the original manufacturer's prior consent regarding the vehicle's warranty and operation.

6. Technology Assessment - economic & technical aspects of current and emerging biofuel technologies

As explained earlier, both cane ethanol and biodiesel technologies (so-called "1st generation") are fully commercial and available off-the-shelf. Skilled personnel will be needed to run and maintain such operations, and expertise from Brazil and other countries in the hemisphere should be sought to optimize industrial operations. In Jamaica improvements are sorely needed on the agricultural side, where yields of cane per hectare are simply not competitive and may make the cost of biofuels prohibitive. Assistance from sugarcane experts in Brazil and Colombia will be essential to close the productivity gap, as is research in Jamaican institutions to improve cane varieties and adapt them to the Jamaican soil and weather conditions. This is also essential for the biodiesel industry, which will need significant support in terms of identifying and improving appropriate feedstocks.

A promising extension of present fermentation technology involves organisms modified to produce butanol instead of ethanol from sugar-containing media. Advantages of butanol-gasoline blends over E-10 are higher calorific value, lower volatility and improved moisture tolerance. A 15 percent butanol blend also contains the same proportion of oxygen as E-10 for controlling exhaust emissions. Although processes are not yet available for licensing, large-scale industrial pilot facilities are in operation, and the technology may be an option for Jamaican producers within a year or two.

Beyond 1st generation biofuels, there are promising developments in advanced biofuels – biofuels derived from non-edible materials, such as ethanol from sugarcane bagasse. Biomass in general consists primarily of cellulose, hemicelluloses, and lignin. The two main technological pathways being pursued are the biochemical and the thermochemical.

In the biochemical path dilute chemicals and cellulase enzymes are employed to reduce the hemicellulosic and cellulosic fractions of biomass, respectively, to simple sugars - mainly glucose and xylose (Fig. 9). The sugars are subsequently fermented to ethanol, which is recovered via distillation and molecular sieves, as done in a conventional sugarcane ethanol operation. Lignin and other solids in the stillage can serve as fuel for power cogeneration.

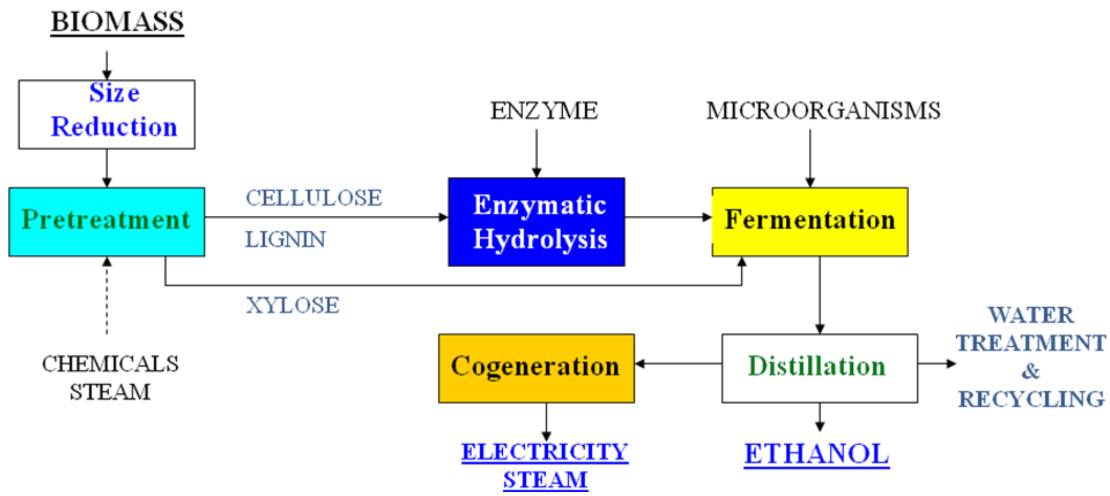

Figure 9: Schematic representation of the biochemical process for the conversion of biomass, such as sugarcane bagasse, to ethanol

In the thermochemical path all the organic components of biomass (cellulose, hemicellulose, and lignin) are turned into synthesis gas via gasification (Fig. 10). The syngas is conditioned to remove tars and is subsequently converted in the presence of catalysts to alcohols or hydrocarbons depending on the catalyst employed.

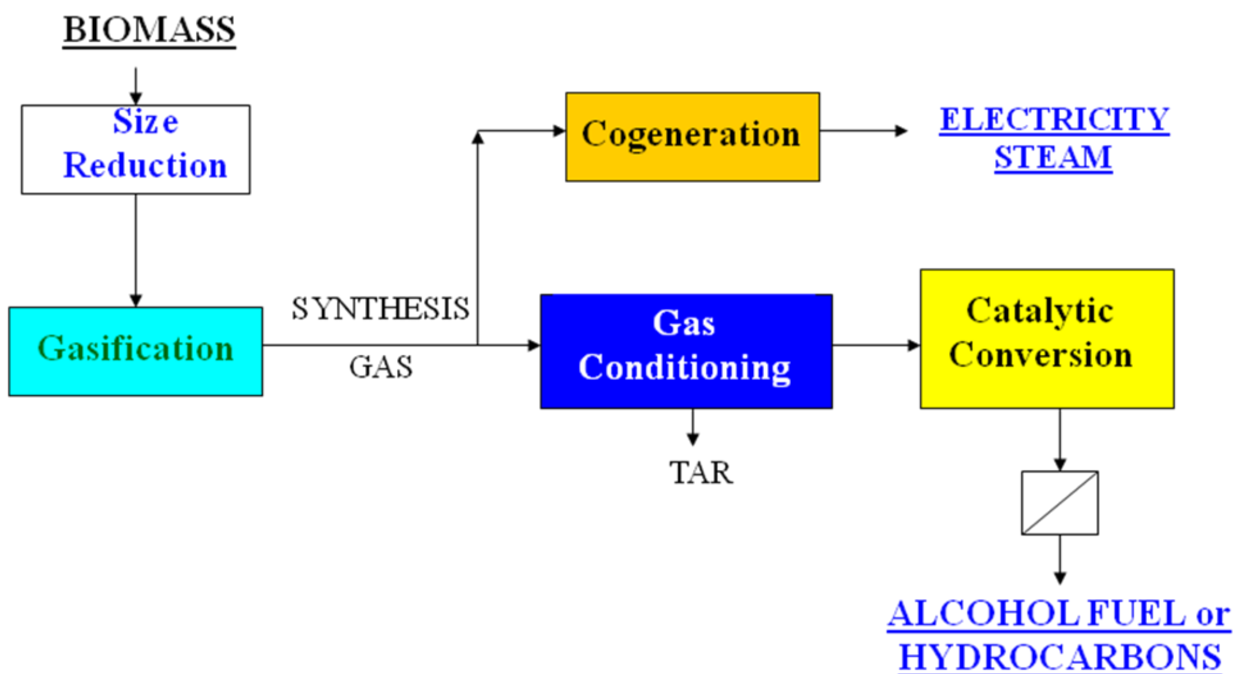

Figure 10: Schematic representation of the thermochemical process for the conversion of biomass, such as sugarcane bagasse, to alcohol or hydrocarbon fuels

Each technology has advantages and disadvantages. The biochemical technology requires costly cellulase enzymes and fermentation of two classes of sugars: (a) 6-carbon sugars consisting primarily of glucose derived from cellulose and (b) 5-carbon sugars consisting primarily of xylose derived from hemicellulose. Moreover, lignin cannot be utilized for ethanol production and is instead used as low-grade fuel in the boilers. On the positive side, fermentative microorganisms convert the sugars to almost exclusively ethanol.

The thermochemical technology has the advantage of using well-established coal gasification and Fischer-Tropsch (F-T) processes, although modifications are needed to adapt them to the peculiarities of biomass. Moreover, lignin is also converted to biofuels, along with cellulose and hemicelluloses, adding an extra 20% or more to the biofuels yield potential of biomass. Challenges, on the other hand, include the use of expensive catalysts in the F-T reactions and the production of hydrocarbon or alcohol mixtures, as opposed to a single fuel.

The ability to convert bagasse to ethanol could significantly increase the capacity of a sugarcane ethanol plant especially using the biochemical process, since it is compatible with existing sugarcane ethanol operations, as it involves fermentation and distillation. Bagasse typically constitutes around 13% of the raw cane's mass. Preliminary assessments of the biochemical technology indicate that approximately 80 gallons of ethanol can be produced from each ton of bagasse (dry basis). Thermochemical yields approach 100 gallons per ton because gasification makes use not only of cellulose and hemicelluloses, but of lignin (20-25% of bagasse) as well.

However, if the cane ethanol plant possesses a cogeneration facility, as we have recommended, another fuel will have to be identified for the boilers to replace any bagasse converted to ethanol. Possible solutions include:

- Cane trash left in the fields and generated in roughly similar quantities as bagasse.
- Wood waste from near-by forest operations.
- Biomass residues of any kind from agricultural operations, such as those for production of biodiesel.

No advanced biofuels technology has been commercialized yet. As the situation evolves in the US and other countries, Jamaica will be in a position to benefit at some point in the future.

Besides terrestrial biomass, another promising advanced biofuels technology involves algae cultivation in open shallow ponds, followed by cell harvesting and extraction of lipids. The lipids are either transesterified to biodiesel or thermocatalytically converted to diesel and other hydrocarbons (Fig. 11).

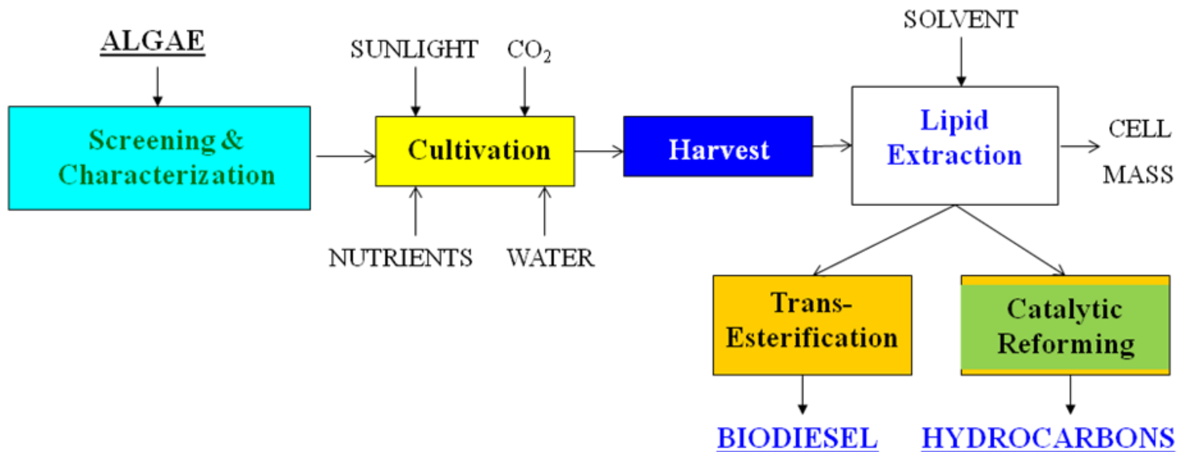

Figure 11: Schematic representation of algal cultivation for production of renewable fuels

The algal fuel technologies combine a number of advantages: use of marginal land to grow the algae in ponds, use of brackish or even saline water (instead of more precious process water), and absorption of CO_2 photosynthetically by the microorganisms. However, challenges abound as well:

- large plots of land to build an extensive network of ponds;
- exposure to inclement weather and contamination; and
- processing difficulties in algae dewatering and lipid recovery, as well as in conversion of the lipids to fuels.

Although Jamaica has plenty of sun exposure and favorable climate to pursue algal fuels, the technology is several years away from commercialization. In contrast, biochemical and thermochemical processes for conversion of biomass to biofuels, which have been intensively developed over the last 10 years, have entered the demonstration stage in North America and are likely to become commercial within a few years.

7. Risk Assessment

Although Jamaica possesses the right climate and agricultural experience for biofuels production, it is faced with significant challenges. Some of those challenges are within its control, whilst others are not. The main risks and means of mitigation are as follows.

Final Formalization of Biofuels Policy

A draft policy has been formulated and is currently undergoing stakeholder consultations prior to formal issuance. A national vision in the form of a long-term renewable energy or biofuels policy will provide a strong incentive for investment in Jamaica. Conversely, the absence of legislated renewable fuel goals or mandates is perceived as a lack of will to support the development of this new industry. A biofuels policy will provide the umbrella that stimulates investment by reducing the risk of investing and doing business in the country. The cases of Brazil and, more recently, Colombia provide ample proof of the benefit of policy adoption to the growth of biofuels. Brazil since 1973 and Colombia since 2001 have legislated state-supported biofuels programs clearly intended to reduce their exclusive reliance on imported oil. This kind of strong commitment has attracted domestic and foreign investment to the two countries enabling them to realize economic, social, and environmental benefits of domestically produced ethanol and biodiesel.

Jamaica can follow the example of Colombia by providing incentives for the establishment of biofuels capacity and infrastructure in its economy. It has already adopted gasoline-ethanol E10 blending and should also consider promoting biodiesel as well. Until recently, however, the ethanol has been imported in its hydrous form from Brazil and dehydrated in Jamaica with minimal positive impact on the country's economy. The biofuels policy has to focus on ways to spur domestic biofuels production.

Political Uncertainty

The creation of a biofuels industry and infrastructure in the country will require significant foreign investment from the private sector and from international development banks. However, such investment requires political stability that transcends party politics, since energy production/distribution has always been a public-private partnership and as such it is vulnerable to political fluidity.

In particular, civil unrest, corruption, and lack of protection for intellectual property and business contracts constitute tremendous barriers to the flow of US and other foreign investment in biofuels and other industries in the region. Democratic rule, open market economics, and business transparency are needed to secure investment.

Weak Legal and Regulatory Framework

As biofuels represent a new industry, their production, distribution, and use need to be regulated under a clear and stable framework that transcends political changes. Jamaica needs a strong regulatory and legal framework regarding the creation and operation of agroenergy/biofuels operations in the country. Jamaica needs to institute expedient industrial permitting review and licensing procedures for new biofuels facilities, so investors can have a good understanding as to what it will take and how long to see their investments generate profits. A single agency, such as NEPA, should provide a "one-stop-shop" to interested parties, coordinate with other government agencies, and streamline and accelerate the process. Moreover, quality standards for the produced biofuels need to be instituted or adopted from other regions of the world, such as the US or the European Union.

Lack of Business Incentives

The lack of business incentives for domestic production and use of biofuels will be a key obstacle to the adoption of biofuels in Jamaica. Just like every nascent industry, biofuels will need state support to establish themselves as a viable option, especially in light of their sustainable nature, economic contribution, and environmental friendliness. Jamaica should develop and adopt policies promoting the local production and use of ethanol and biodiesel, such as revenue tax exemptions for biofuels-producing operations, reduced sales taxes on biofuels compared to fossil fuels, reduced import duties on flexible fuel cars, and no import duties on equipment used for the manufacturing and R&D of biofuels. Such measures should remain in effect until the biofuels sector has matured to stand on its own. Colombia has set a great example in the region. Following in the footsteps of Brazil, the country implemented biofuels legislation (Law 693) since 2001 promoting the production of ethanol from agriculture and mandating its use throughout the country as a blend with gasoline.

Despite these challenges, biofuels constitute a major opportunity for Jamaica in terms of energy security, foreign investment, economic growth, job creation, international trade, and climate protection. In 2007 the US and Brazil signed a Memorandum of Understanding agreeing to jointly help certain Latin American and Caribbean countries, including Jamaica, develop a biofuels industry. Technical, business, and policy experts from the two countries have visited the region to offer biofuels guidance to governments and the private sector.

With policy, technical, and financial support from the US and Brazil, the country can boost the value of agriculture by co-producing food, biofuels, and renewable power. By focusing on systematically addressing the outlined challenges and obstacles, Jamaica can take advantage of the excellent economic opportunity that biofuels, current and future, represent for its people.

Low oil prices

This is a challenge beyond Jamaica's control, but a significant one as it affects the profitability of biofuels production in the country. Low oil prices will render biofuels more expensive and may create public backlash as blended gasoline and diesel will be more expensive. However, the country has already implemented E10 in both types of gasoline available (octane 87 and 90), therefore unblended gasoline is not an option at gas stations. The same should be done with diesel.

Mitigation of this risk lies in the pursuit of increased productivity by the Jamaican ethanol industry through high yields in both the field (tons of cane per hectare) and the plant (gallons of ethanol per ton of cane). Moreover, the probability of low oil prices is rather remote as global future predictions point to increased oil demand by developing countries, like China and India, and reduced oil reserves.

ANNEX I
Public Education and Outreach Plan

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1. Introduction

Agriculture-based fuels, such as bioethanol and biodiesel could be produced in Jamaica. Development of this local industry would boost the local economy and reduce greenhouse gas (GHG) emissions, among other benefits. In order to expedite this development, a biofuels policy is considered necessary and a draft policy has been produced. Essential to an effective biofuel policy is a corresponding, comprehensive education and outreach program to provide the necessary basic information, tools, and specialist knowledge needed to educate and raise awareness of biofuels among key stakeholders and to garner support and overcome key technical and social barriers. The program must contain a number of components addressing: broadly based education for a number of target audiences, more focused education related to capacity building and skilled-labor building, hands-on experience, workforce development, and community outreach. Above all it must create the opportunity for Jamaicans to become self sufficient in terms of the long term capabilities and skills needed for domestically-produced, sustainable biofuels.

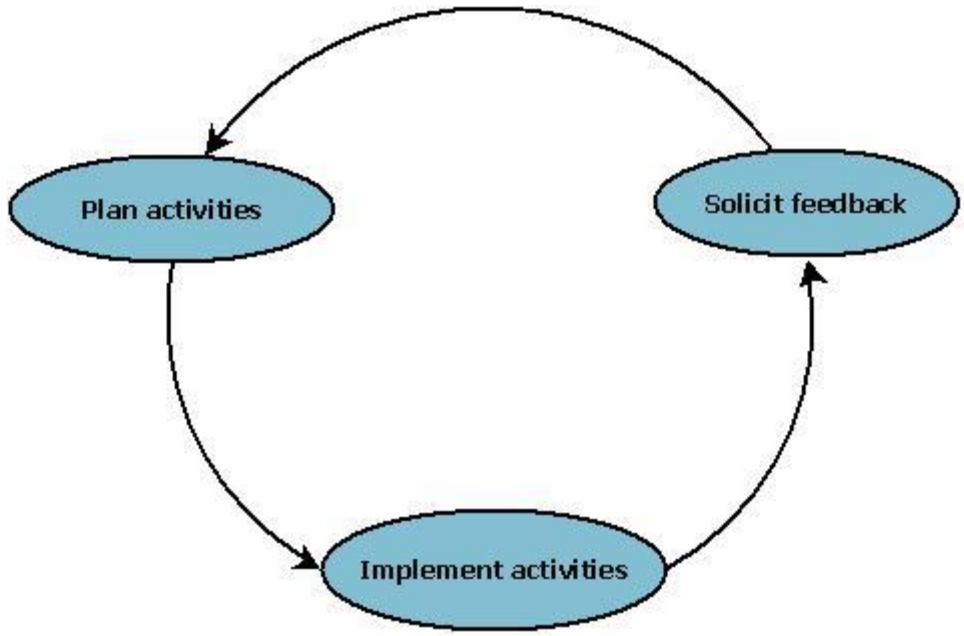
This document outlines such a campaign for biofuels education and awareness in Jamaica based on input gathered in meetings with stakeholder groups and government agencies, including regular communication with the Jamaica Biofuels Task Force. This document is presented as a proposed starting point for Jamaica's biofuels education and outreach campaign. Options are presented for management, targeted stakeholder groups, and activities that must be weighed against their different costs and the capacity to carry out each option.

2. Campaign Development

The development of this education and awareness campaign has three stages:

(1) Scoping Assessment
(2) Plan Development
(3) Implementation

The first stage, the scoping assessment, was conducted through a literature review and consultations with key stakeholders, between May and August, 2010.The information presented in this document is a first attempt at the second stage, the education and outreach plan development, and is based on information gathered in the first stage. Although this document is inherently static, the ongoing education and awareness campaign will need to be dynamic with continuous monitoring and adaptation based on feedback and results. As part of the plan presented here, it is recommended that the campaign return to the first stage to conduct a baseline investigation to assess the current level of awareness of biofuels in Jamaica. Furthermore, the education and outreach campaign is not independent from other biofuel development activities – it must be integrated with other developments in the biofuel industry as much of the information disseminated must come from studies on the biofuels industry in Jamaica and other research and development activities, so those aspects of the campaign cannot be prescribed until the studies and research have been completed. The information presented here should, therefore, be viewed only as a starting point in assessing the needs and options for a biofuels education and awareness campaign, with the understanding that revisions will be made as feedback is gathered and more stakeholders are consulted.



In the scoping assessment, input was collected from the individuals and organizations listed in Table 1 (conversations further detailed in Appendix 4) about the following questions:

- Who are the key stakeholders?
  - What do they already know? What are their concerns?
  - What are the main issues that this campaign should address for each?
- What education and outreach activities may be useful in reaching these stakeholders?
- Who/what organizations are already doing education and outreach on these issues?
- Who/what organizations may have local capacity to do education and outreach on these issues?
  - What resources/capacity do they have already?
  - What activities are they already doing?
  - What support would they need to undertake a new aspect of the campaign?

Contact	Organization/Role	Date
Dr. Betsy Bandy	Ministry of Energy and Mines	On-going
Dr. Leahcmin Semaj	The Job Bank – Ideators & Resultants in Human Behaviour, Productivity and Psychometric Testing	July 8, 2010
Alternative Energy Course Students	University of West Indies Alternative Energy Summer Programme	July 21, 2010
Taskforce Members	Biofuels Taskforce	July 21, 2010
Omar Azan **Imega Breese**	Jamaica Manufacturers' Association	July 22, 2010
Karl James	Sugar Industry Association	July 22, 2010
Michael Hewitt **Gladstone Ivey** **Nicole Smith**	PetroJam	July 22, 2010
Taniquea Callam - MEM **Nicole Smith -**	Participated in education and outreach for the E10 rollout	July 23, 2010

Petrojam **Marcia Browne – PCJ**		
Rex Demafelis	Worked on education and outreach campaign for biofuels in the Philippines. Consultant on Biofuels and Industrial Process Optimization with UN-FAO and USAID. Consultant on Biofuels, Solid Waste and Wastewater Management, Process and Plant Design to numerous institutions in the Philippines. Department of Agriculture- Bureau of Agricultural Research Technical Adviser on Biofuels. Convener of the UPLB Alternative Energy RDE and chair of the Department of Chemical Engineering in the College of Engineering and Agro-industrial Technology (CEAT).	August 8, 2010
Mr. Trevor Barnes	Jamaica Gasoline Retailers Association	August 23, 2010
Vicki Walker	Winrock International – Empowerment and Community Engagement Unit	August 24, 2010

2.1 Previous Biofuels Education and Awareness in Jamaica

An earlier education and awareness campaign for biofuels was carried out in Jamaica along with the rollout of E10. This campaign had two phases: the first phase lasted one year, beginning in November 2008 with the 87 octane rollout, and the second phase accompanied the 90 octane rollout the following year. This campaign consisted of several strategies for informing fuel consumers about biofuels and for addressing concerns that they had. The scope and experiences of this earlier campaign provide a good starting point and useful insights from which to develop the new public outreach program described in this document.

The Petroleum Corporation of Jamaica led the earlier campaign, which consisted of:

- A pilot study and public demonstrations of biofuel, specifically E10 and flex fuel vehicle use
- Distribution of technical information
- Stakeholder group meetings
- E10 hotline where consumers with questions and comments could call and get information
- Ad campaigns utilizing print and electronic media as well as billboards
- Media interviews
- Press conferences
- Sensitization workshops for specialized focal group
- Family fun day
- Posters, brochures and flyers
- Feature stories in the newspapers

In talking with both those involved with the campaign and stakeholders whom it targeted, the following themes arose as to how it might have been improved:

- Run over a longer period so that the initial awareness is well reinforced; engagement should be early and on-going
- Target a group of stakeholders broader than just consumers (although it is important to note that for both phases of the E10 rollout the JGRA, marketing companies, etc. participated in stakeholder meetings)
- Operate under a more organized structure with tasks and responsibilities assigned
- Get the media involved as early as possible by providing the basic facts, answering questions and countering misinformation
- Make the public more aware of what is going on before final decisions on policy and regulations are taken

The approach to developing stage two of the current campaign is to build off what has been done previously, both in the E10 roll out and other education and outreach activities, in order to use what capacity already exists in Jamaica and to strengthen it in order to meet the needs of such a campaign in Jamaica.

3. Barriers

Anticipating and planning for the barriers to public education and outreach is a critical step in the campaign development. Potential barriers are:

- Financial (the success of the campaign depends on a concerted, coordinated effort to educate and reach out to all stakeholders. This requires funding of many different activities and staff)
- Staffing (the campaign requires certain staff to coordinate and manage the multiple activities. Without enough staff and support for the staff, activities may fall to the side)
- Biofuels readiness (parts of the campaign cannot move forward until there is a market for domestically-produced biofuels, until there are technical solutions for problems that arose previously, or until incentives are in place)
- Misinformation and direct opposition from alternative interests (may cause confusion and misconceptions about biofuels in Jamaica, thereby counteracting the efforts of the campaign)
- Bureaucratic delays (biofuels development in Jamaica requires several political, technical, business, financial and education activities to move forward together. Bureaucratic delays may occur in any number of organizations critical to these activities which then delay several connected activities)
- Lack of monitoring (without adequate ongoing monitoring, feedback and adaptation of the campaign, the campaign will be less effective)

4. Stakeholders

The following section describes the stakeholders that the education and outreach campaign must address. While all the stakeholder groups listed here must be addressed, there should be a stratification of groups to ensure that priority stakeholders (e.g., the general public, government, and media) are addressed first. How these groups are stratified must be determined by the campaign leadership.

1. General public

The general public primarily refers to the collective group of fuel consumers, such as personal vehicle owners, large fleet operators industry, manufacturers, etc. The main opposition to biofuels from this group stems from concerns about vehicle performance when biofuels are used. A lot of these concerns were expressed at the initial E10 rollout, but they soon died down. There has also been some opposition to growing sugarcane for ethanol because of a preference for its use in rum. Acceptance by this group is critical to the success of biofuels in Jamaica as public resistance to biofuels could prevent successful deployment and misunderstandings about biofuel use and handling would be dangerous. Multiple strategies that target different populations and are implemented over different timeframes must be utilized in order to have a sustained and far reaching impact.

Issues to address:

- (a) **What biofuels are and how they differ from alcohol, gasoline and diesel;**
- (b) **Why biofuels/what the benefits of blending biofuels are, including the link between biofuel development and improved roads and infrastructure, direct and indirect jobs, investment and economic development, environmental impacts;**
- (c) **What changes they will see (e.g. costs, vehicle performance), problems that may arise/have arisen and how to address those problems;**
- (d) **Demonstrate an understanding of issues that have arisen with the E10 roll out and what has been/will be done to improve the situation. Also, how future potential issues are being preempted;**
- (e) **Biofuel developments in Jamaica and the course of action that is adopted;**
- (f) **How Jamaica can maintain and grow its existing granular sugar and rum production for domestic and export markets where profitable returns are possible while also producing bioethanol and biodiesel;**
- (g) **Information to control the spread of misinformation (prepare for and manage false information);**
- (h) **Where to go for more information.**

2. Sugar mill and estate owners

This is a relatively small group comprising sugar mill and estate owners who are either already in the private sector or all will be once the GoJ divestiture of its sugar cane mills and

estates is completed. The large mill and estate owner of Bernard Lodge, Moneymusk and Frome, will likely provide education and awareness within its own organization directed to their corporate planning objectives. However, it is possible that input from experts in bioethanol from sugar cane may be sought for guidance on, for example, extending the cane season and maximizing electricity revenue. The owners of the remaining smaller mills may need outreach regarding the decision of whether to participate in the ethanol industry and, if so how, to optimize their returns. Opening a dialogue with all of the mill owners early during the education and outreach campaign is desirable.

Issues to address:

- (a) **Options to produce ethanol along with granular sugar and molasses;**
- (b) **Options to become a year round supplier of electricity to the grid using energy crops out of the cane harvesting season;**
- (c) **Options to extend the ethanol production beyond the cane harvesting season;**
- (d) **Opportunities to attract investment (e.g. which organizations are experienced with this type of investment);**
- (e) **Biofuel policy developments;**
- (f) **How biofuels will affect business;**
- (g) **How to get information to make decisions about producing for ethanol;**
- (h) **Provision of feasibility studies for pilot plants;**
- (i) **How to maintain and improve yields (e.g., irrigation, fertigation, improved varieties, replanting, etc. – Occurs after research is done on the appropriateness of these techniques for the particular locations);**
- (j) **Varieties of sugar cane and sweet sorghum that mill owners may require under future scenarios;**
- (k) **Problems with cane burning and what alternative options exist;**
- (l) **Plant water requirements and best irrigation practices;**
- (m) **Fair labor practices and labor laws;**
- (n) **Sustainability (with emphasis on environmental impacts, labor and other social issues, and issues associated with best management practices);**
- (o) **Pest and disease management strategies (including organic approaches);**
  Benefits the sugarcane farmer will see from biofuels.

3. <u>Sugarcane farmers</u>

This category includes smallholders and large sugarcane farmers, as well as others involved in growing sugarcane. Outreach for this group of stakeholders aims to improve sugarcane yields, make growing it more efficient, and promote best practices (economic, environmental, and social – including labor laws and health and safety of workers). Trainings and information dissemination will build confidence in the expansion and longevity of the ethanol and sugarcane industries in Jamaica.

Issues to address:

- (a) **How to maintain and improve yields (e.g., irrigation, fertigation, improved varieties, replanting, etc. – Occurs after research is done on the appropriateness of these techniques for the particular locations);**

(b) **Varieties of sugarcane and sweet sorghum that mill owners may require under future scenarios;**
(c) **Problems with cane burning and what alternative options exist;**
(d) **Plant water requirements and best irrigation practices;**
(e) **Fair labor practices and labor laws;**
(f) **Sustainability (with emphasis on environmental impacts, labor and other social issues, and issues associated with best management practices);**
(g) **Pest and disease management strategies (including organic approaches);**
(h) **Benefits the sugarcane farmer will see from biofuels;**
(i) **Information on long term supply contracts and pricing structures currently being used in other countries;**
(j) **Information on bioethanol experiences in countries that produce ethanol domestically from sugarcane, such as Brazil and Philippines.**

4. Farmers growing biofuel feedstock other than sugarcane

As for sugarcane farmers, education and outreach for farmers who are considering or have begun growing other biofuel feedstocks involves training on best management practices and information dissemination to ensure profitability and build confidence in the biofuel industry as a long term market. In the case of crops new to the farmer, as many of the prospective biodiesel crops are, there is the added element of introduction of the feedstock and farming techniques. In addition to showing farmers how to grow the crops and supporting them as they become accustomed to them, there may also be a need for education to overcome cultural barriers to deciding which crops the farmer grows.

Issues to address:

(a) **Crop characteristics and guidance on the process from variety selection, land preparation and planting through harvesting and transport;**
(b) **How to maintain and improve yields;**
(c) **Sustainability issues associated with various agricultural practices;**
(d) **Pest and disease management strategies;**
(k) **Plant water requirements and best irrigation practices**
(e) **Benefits the farmer will see from biofuels;**
(f) **Information on long term supply contracts and pricing structures currently being used in other countries;**
(g) **Information on recent market failures (e.g., Some US based soybean refineries) and successes (e.g., Some Brazilian biodiesel refineries).**

5. Potential waste vegetable oil suppliers

The Draft Biofuel Policy speaks to percentage of biodiesel being produced from waste vegetable oil. Therefore, potential suppliers of this feedstock (e.g., restaurants, large hotel chains, etc.) ought to be engaged.

Issues to address:

(a) What waste vegetable oils are of value as a biofuel feedstock;
(b) Standards for waste vegetable oil that is supplied;
(c) Collection procedures for waste vegetable oil;
(d) Benefit to the supplier of providing or selling their waste vegetable oil (e.g., potential disposal cost saving, possible revenue from sale, and corporate social responsibility and corresponding advertising benefits).

6. Repair shop owners and mechanics

Vehicle repair shop owners and their mechanics must be kept up to date as to the problems that biofuels may cause in vehicles and how to remedy them. Their understanding of these issues is critical to ensuring biofuels work properly in vehicles. Their ability to communicate those issues to their customers is critical to the success of the general public campaign. This group has been very receptive to ethanol use in vehicles because it is cleaner to work with and this group has been valuable in educating their customers.

Issues to address:

(a) What problems biofuels may cause in vehicles (updated as discovered);
(b) How to fix those problems;
(c) Common concerns their customers may have and how to address them.

7. Used and new vehicle dealers

Vehicle dealers in Jamaica control the incoming vehicle fleet and their compatibility with biofuels.

Issues to address:

(a) Which types of cars can use biofuel;
(b) Details of the warranties for each vehicle when biofuels are used;
(c) What the state of the biofuel industry is and what opportunities it presents for them (e.g. increasing numbers of FFVs are being purchased).

8. Biofuel Producers

This applies mainly to biofuel producers who are expected to buy feedstock from a farmer or consolidator and produce biofuel to sell to fuel wholesellers. Biofuel refineries would primarily be involved in the education and outreach campaign from the side of conducting education and outreach and providing information to others doing so. Pathways for information sharing about biofuel refineries processes and technology improvements are already established and therefore outside the scope of this report. However, education and outreach must also be conducted to this group to establish a dialogue on the outreach

activities and what the concerns of other stakeholder groups are. Furthermore, they ought to contribute to the campaign what benefits they are creating for the communities around them and the country as a whole.

Issues to address:

(a) **What questions and concerns the public has that biofuel producers can help to address;**
(b) **Updates about the status of other components of the biofuel industry;**
(c) **Details of the education and outreach campaign.**

9. **Fuel distributors, gas station owners and managers, and pump attendants**

Training and education is necessary to build the capacity of fuel distributors and gas station owners and managers in order to control the quality of the fuel and maintenance of the equipment.

Issues to address:

(a) **What problems biofuels may cause in distribution and station equipment (updated as discovered);**
(b) **How to fix those problems;**
(c) **What the fuel standards are and how to test the fuel to see if it meets the standards;**
(d) **Common concerns their customers may have and how to address them;**
(e) **What are the fuel standards and how to monitor and meet them;**
(d) **What the state of the biofuel industry is and what opportunities it presents for them (e.g. increasing number of stations selling higher blends), including any programs that are available for them to participate in.**

10. **Elected officials and government agencies**

As those responsible for the development and implementation of policies, regulations, and legislation that affect biofuels through incentives, regulations, pricing schemes, land use policy, energy policy and so on, it is critical that elected officials are aware of the essential aspects of biofuels, their benefits for Jamaica, how they relate to other uses of crops and land, what barriers they face, and what the role of government can be in their successful development. Furthermore, a coordinated effort with open and on-going dialogue will result in more effective and efficient policy making.

Issues to address:

(a) **What biofuels are;**
(b) **How biofuels benefit Jamaica/rationale for biofuel development;**
(c) **What policies impact biofuels, including biofuel policy, land use policy, etc.;**
(d) **Balance of payments, financial and fiscal issues at the country level;**
(e) **How infrastructure improvements impacts biofuel industry, and other agriculture;**
(f) **Importance of a coordinated effort;**

(g) Information on long term supply contracts and pricing structures currently being used in other countries;
(h) Information on recent market failures (eg. Some US based Soyabean refineries) and successes (eg. Some Brazilian biodiesel refineries).

11. Potential investors, banks, and other approved financial institutions

While not the main focus of this campaign, potential investors in biofuels and related infrastructure are critical for overcoming financial barriers to biofuel development.

Issues to address:

(a) Preparation of summary descriptions of policies, regulations, and incentives that impact biofuel financing;
(b) Outreach to the investment community to provide a better overall understanding of the main components of a successful biofuel program;
(c) Information on long term supply contracts and pricing structures currently used in other countries.

12. Fishing community, boat owners, and coast guard

Education and outreach to this group will follow technical solutions to the problems that arose during the E10 rollout in the marine environment. It will have to build confidence that those issues have been resolved. In the mean time, education and outreach to this stakeholder group will consist of updates as to the advances of biofuels for marine vehicles.

Issues to address:

(a) How biofuels will affect them;
(b) How previous problems have been addressed;
(c) What potential problems still may arise and what to do;
(d) Why biofuel development is occurring;
(e) What the plan of action is, both in general, and as related to marine vehicles.

13. Motoring Clubs

Education and outreach to this stakeholder group will be similar to that of the general public and the marine community: what is happening with biofuels in Jamaica and how it will affect their vehicle fleet in particular.

Issues to address:

(a) How biofuels will affect them;
(b) What potential problems still may arise and what to do;
(c) Why biofuel development is occurring;

(d) **Demonstrate an understanding of issues that have arisen with the E10 roll out and what has been/will be done to improve the situation. Also, how future potential issues are being preempted;**
(e) **Where to go for more information.**

14. **<u>Academic and research community (Including universities, Bureau of Standards Jamaica, etc.)</u>**

There is a wide range of institutions involved with, or with the potential to be involved with, biofuels research and development. The biofuels industry would benefit from the creation of a forum for collaboration and information sharing amongst this community. Education and outreach to this community aims to foster collaboration and to create opportunities to build off of what others have learned.

Issues to address:

(a) **What biofuels research and development is occurring and what has come out of it;**
(b) **Areas of research and development that organizations are looking for collaboration on;**
(c) **What technological problems are arising in biofuels production, distribution and consumption;**
(d) **What the general public is concerned about with biofuels;**
(e) **What relevant research is happening globally.**

15. **<u>Media</u>**

As well as a channel by which to conduct public education and outreach, the media is also a stakeholder group on its own. As such, and due to its daily need to provide public information, it is important to keep the media informed of developments on a frequent basis and establish good lines of communication. By providing factual information and being responsive to enquiries that may well have a press deadline urgency associated with them, misinformation can be avoided and a consistent message achieved. The issues to address for the media are the same as for the general public, however they will be targeted slightly earlier and an on-going dialogue for information sharing will be established.

Issues to address:

(a) **What biofuels are and how they differ from alcohol, gasoline and diesel;**
(b) **Why biofuels/what the benefits of blending biofuels are, including link between biofuel development and improved roads and infrastructure, direct and indirect jobs, investment and economic development, environmental impacts;**
(c) **What changes they will see (e.g. costs, vehicle performance), problems that may arise/have arisen and how to address those problems;**
(d) **Demonstrate an understanding of issues that have arisen with the E10 roll out and what has been/will be done to improve the situation. Also, how future potential issues are being preempted;**
(e) **Biofuel developments in Jamaica and the course of action that is adopted;**

(f) **Information to control the spread of misinformation (prepare for and manage false information);**
(g) **Where to go for more information.**

5. Management of the Campaign

Before describing the proposed activities, the management of the campaign must be established. As an example, in the Philippines, biofuels education and outreach was initially run by several different agencies, including the Department of Energy (education on processing), Department of Agriculture (education on feedstock development), Department of Science and Technology, Department of Finance (education on financing), as well as several universities. These separate entities did not work together. Then, in 2006, a biofuels law was implemented which established a National Biofuels Board that took responsibility for coordinating and running a unified biofuels education and outreach campaign. Having this Board manage the campaign led to a more effective, concerted effort that complements and integrates all the information disseminated (Demafelis, pers.comm.).

As the campaign proposed here consists of many separate components that must be run by different organizations, targeting different stakeholder groups, the creation of a central biofuels education and outreach team is proposed. This team could fall under a government agency, such as the MEM. It must be comprised of at least one leading individual whose full time job is to manage the campaign activities. In addition to a team leader, recommended roles include a media and PR contact and a Fact Team leader. It is also recommended that PR firms be involved for soliciting feedback from targeted stakeholder group to determine effectiveness of the campaign and areas for improvement, recommend courses of action, and train the Media and PR Contact on messaging. Two PR firms could be involved, one with a technical focus, and one with a non-technical focus. There are several organizations and government departments that we propose could also participate in education and outreach activities based on their established connections with different stakeholder groups and experience or capacity for education and outreach.

The importance of having a coordinated effort and message that has consistent information and adapts uniformly in response to new concerns raised and developments occurring in the biofuel industry must be stressed. Development of a branding campaign and key messages was initially intended to be included in the plan development stage. However, as the education and outreach plan developed, it was decided that strategizing a biofuels education and outreach campaign and defining a management team was more relevant for this stage of work and that the branding and message development would best take place early in the implementation stage. To have the greatest impact, the branding campaign must take into account the beliefs, needs, and concerns of the target population and the local campaign management team would be best positioned to do this. Consequently, it should be developed after this team is established based on agreed upon objectives and approach, perhaps with the guidance of a local PR firm. A basic slogan and logo would be recommended. Some points that could be emphasized in the messaging include: domestic biofuels for the future of Jamaica, strengthening and diversifying the sugarcane sector, leadership in sugarcane, decreased dependence on foreign fuels, job creation, rural development, and cleaner energy. Key selling points include availability of land, technical expertise, history of sugarcane production, and demand for fuels. Some resources where examples of branding and messages developed for biofuels in other countries can be found in Annex Ic.

The positions and organizations to be involved in the campaign are described in the table below.

Proposed Position	Description
Education and Outreach Leader and Education and Outreach Officer **(new position)**	Oversees the entire education and outreach campaign, coordinates between leaders of different activities and keeps them aware of new developments or issues to address. Manages the budget.
Media and PR contact **(new position)**	In charge of involving the media early on, establishing connections with media outlets, and serves as point of contact for the media when news about biofuels arises.
Fact Team Leader **(new position)**	Responsible for communicating with researchers and technical experts in the field to compile the most up-to-date factual information about biofuels for outreach activities, in response to questions and concerns received from stakeholders, and to counter misinformation as it arises.
PR Agency/ies **(subcontractor)**	A reputable PR agency/ies with a solid track record in surveying public opinions, communicating social issues and social marketing in Jamaica. They would also be charged with soliciting feedback from the public and various stakeholder groups to understand public perceptions of biofuels in Jamaica and then recommend the most effective ways to communicate to different stakeholder groups.
Government Partners **Department of Cooperatives and Friendly Societies, of the Ministry of Industry, Investment, and Commerce** **Ministry of Agriculture and Fisheries** **Ministry of Education** **Ministry of Energy and Mining** **Ministry of Finance** **Ministry of Forestry** **Ministry of Labor and Social Security** **National Environment and Planning Agency** **National Land Agency** **Parish Councils** **Transport Authority of Jamaica** **Sugar Industry Authority**	Several government agencies and departments are responsible for activities related to biofuels production, distribution and consumption. These agencies and departments already have relationships with those directly involved with each of these processes and therefore can manage various biofuels education and outreach activities through activities they already manage or new programmes.
Energy Organizations	These organizations have experience managing public

Jamaica Broilers Jamaica Public Service Company Limited JEPCO (ED&F Man) Petroleum Corporation of Jamaica PetroJam Ltd. PetroJam Ethanol	education and outreach campaigns on energy issues as well as conducting technical trainings for those involved in fuel production, handling and distribution.
<u>Non-Governmental Organizations</u> Association of Women's Organizations in Jamaica Independent Jamaican Council for Human Rights Jamaica Conservation Development Trust JAMPACT National Environmental Societies Trust Northern Jamaica Conservation Authority	These NGOs and groups of NGOs have established relationships in communities across Jamaica and have experience with education and outreach that advocates for women, the environment, youth, and other groups/issues that an education and outreach campaign may need to target specifically.
<u>Research Groups and Universities</u> Bureau of Standards Jamaica Caribbean Maritime Institute Centre for Excellence for Advanced Agriculture College of Agriculture, Science and Education Mico University College Northern Caribbean University Sugar Industry Research Institute University College of the Caribbean University of Technology University of the West Indies	Research organizations and universities conduct research and development activities that may advance biofuels in Jamaica and provide the factual information that forms the basis of an education and outreach campaign. Universities can also train professionals and students who will become those working in all stages of the biofuel production process as well as different users (e.g., Caribbean Maritime Institute trains fishermen and boat operators).
<u>Trade Associations and Professional Organizations</u> All-Island Cane Farmers Association Chamber of Commerce Consumer Affairs Commission Gasoline Retailers Association Jamaica Agricultural Society Jamaica Association of Sugar Technologists Jamaica Cane Products Sales Limited Jamaica Estate Cane Growers' Association	Trade associations and organizations that represent a group that will be affected by biofuels can communicate messages of the campaign and keep their members updated about developments in the biofuels industry. They can also provide feedback on biofuels on behalf of their members. Additionally, many have experience conducting trainings for their members.

Jamaica Fishermen Cooperative Union Jamaica Manufacturers' Association Jamaica Millennium Motoring Club Jamaica Sugar Cane Growers' Association Jamaica Teachers' Association Jamaica Used Car Dealers Association Jamaica Yacht Club (and Montego Bay Yacht Club, Negril Yacht Club, Jamaica Yachting Association, etc.) Press Association of Jamaica Sugar Industry Association Sugar Manufacturers' Corporation of Jamaica Sugar Producers' Federation of Jamaica

6. Plan of Work

The activities of the Jamaica biofuels education and outreach campaign shall be built around the following principles, which were identified as critical in the needs assessment meetings as well as by previous Winrock experience with education and outreach campaigns:

- Early and on-going stakeholder engagement
- Regular monitoring and evaluation
- Skills building and development of human capacity

Engaging the public in the campaign early is a concept that was practiced to an extent in the previous biofuels education and outreach campaign. Meetings were held to get stakeholder feedback and a hotline was set up for anyone with questions or concerns to call to find answers. However, awareness faded after time as the campaigns' activities were reduced. This allowed opportunity for the spread of misinformation.

Similarly, those involved in the education and awareness campaign in the Philippines stressed the importance of early and ongoing public engagement. Rex Demafelis explained that while it may be easier at the start of a biofuels policy to not fully engage the public, it pays off it the long run to know the public concerns and be able to respond to them – this builds confidence both among the public and among agencies involved in the biofuels industry. He said that if he were to do one thing differently it would be to conduct a feasibility and viability study of biofuels production at the very beginning of the campaign because they received many questions that those studies would have been able to answer right at the beginning.

The Jamaica Manufacturers' Association also echoed this sentiment, saying that they are not particularly against any form of energy, they just are against using new energy sources without keeping the public informed of what is being considered and what developments are taking place.

Proposed activities to include in the education and outreach campaign are as follows:

Education and Outreach Activity	Objectives	Description	Target stakeholders	Leader of activity
Activity 1: Transparency - Status of biofuels policy and development	Explain what the government is doing, why there is a biofuel policy, what it consists of, and any developments that occur.	• Public meetings to introduce biofuels and biofuel policy developments. Conducted through community groups and associations. • Regular flow of information through newspaper and radio announcements, as well as the listservs of participating organizations and a central website. • TV and/or radio interviews to address questions publicly.	• General Public • Sugarcane Estate Owners • Farmers • Potential Investors	Media and PR Contact, working with: • Trade associations • Non-governmental organizations
Activity 2: Biofuel Basics	Explain what biofuels are (and how they are distinct from consumable alcohol), problems they may cause, ways to deal with those problems. *Note: Much of this information has already been created from the previous campaigns, so could be reused or updated and reissued.*	• Establish a unified message, image, and branding for the campaign. • Prepare and Distribute basic information to the public, specifically to road vehicle users (address marine vehicle users separately), elements of which include: >Marketing materials, such as posters, flyers and information sheets (as made in the previous campaign). >Media, such as radio, television and newspaper placements, as well as possibly a mobile phone messaging campaign. Also, skits, jingles, and Energy Expo for radio-based offerings. >Website center of information, could be modeled after JPS's: http://www.myjpsco.com/media_centre/index.php . >Questions and answers through	• General Public • Sugar Estate Owners • Farmers	Fact Team, working with: • Trade associations and industry groups who work with fuel consumers • Department of Education and individual schools • PR firm (for messaging)

		phone hotline and email address with answers made available online, website, public forums, and other methods for receiving and responding to concerns and questions. >Series of radio debates where questions can be called in and responded to while others listen. >Public forums with opportunities to have questions answered by experts. These could take place across the country, targeting different stakeholder groups. • Education "sessions" in primary and secondary school to introduce biofuels and safety practices. >Science competitions • Success stories from Jamaica (demonstrate vehicle use with a particular large fleet, have people share experiences at public forums, etc.). • Success stories from other countries by adding their stories to the other activities in this category. • Provide clear information about commonly occurring problems and how to fix them or where to go to have them fixed, through the other activities in this category.		
Activity 3: Ensuring Factual Accuracy	Control the spread of misinformation and false rumors and ensure that scientifically accurate information is distributed to ensure proper use of biofuels.	• Maintain awareness about misconceptions about biofuels that exist by studying monitoring survey outputs and hotline, email, and interview questions. • Research and provide factual information	• General Public	Fact Team, working with PR Agency

		to counter misinformation or clarify points of confusion. Incorporate this information into what is provided through the FAQ information.		
Activity 4: Media outreach	Involve the media early and establish a relationship between the media and the education and outreach leadership team so that the media knows what is going on and are an ally, rather than allying with the opposition groups.	• Establish a unified message and image for the campaign. • Engage media outlets in Transparency and Biofuels Basics and FAQs activities, ensuring that the issues are well understood. • Make Media and PR Contact readily available for questions from the media, to clarify any confusion, and address any misinformation that may come through the media. • Points to focus on for media outreach messages: >Price benefit (which was the focus in previous campaign) >Environmental benefit >Performance element of ethanol blends >Long-term benefits	Media (reporters, television and radio networks, newspapers and magazines)	Media and PR Contact with the Press Association of Jamaica
Activity 5: Best practices for biofuel agriculture and technological trainings	Improve feedstock production efficiency by improving yields and managing inputs, while improving soil quality and developing the skill set of farm workers and farmers.	• Initial training workshops in agricultural communities on what best practices exist for improved feedstock production (i.e., improved yields, reduced inputs, waste management and recycling, etc. The Sugar Industry Association has done this on a smaller scale already). >Explain why it is worthwhile to change their practices and increase production -	Small scale farmers, large scale farmers, sugarcane estate owners, and students of relevant degree programs.	MoA Outreach Program and the Centre of Excellence for Advanced Agriculture, with: • Sugar Industry Association • Jamaica

		but first, the necessary steps need to be taken to ensure that it will actually be worthwhile. • Initial training workshops to introduce new feedstocks. >Explain why it is worthwhile to grow new feedstocks - but first, the necessary steps need to be taken to ensure that it will actually be worthwhile. • Establish demonstration farms and learning centers where the trainings can take place, where best practices are demonstrated, and where research can be done on best practices specific to the regions. Can also demonstrate that agriculture can complement food and community enterprise. • On-going information exchange as best practices evolve. • Agricultural extension programs with specialists from the region hired as extension workers that visit farms that have participated in trainings to offer advice and answer questions. • Fora to share experiences and lessons learned. • International exchanges for those who will conduct trainings. • Bring in experts from other countries to contribute to trainings. • Incorporate best practices training and education into relevant university curricula, including classes, degree programmes, research opportunities,		Agriculture Society • Research institutions

		internships, and international exchanges.		
Activity 6: Technological trainings (non-agricultural)	Explain what the standards are for biofuels and how to monitor and control quality. *Note: a discussion must be had to determine whether this activity should be under public or private leadership. The activities listed here could be carried out by this campaign if it is publicly led, or could be supported by the campaign if it is industry-led.*	• Provide an up-to-date lists of vehicles which can use different blends of ethanol and biodiesel. • Provide kits to test fuel quality or incentives or mandate to buy them. • International exchanges on biofuel distribution and handling. • In-country training on biofuel distribution and handling. • Incorporate best practices training and education into relevant university curricula, including classes, degree programmes, research opportunities, internships, and international exchanges. • Could establish certification schemes for those working in fuel distribution and sales.	Fuel producers, distributors, gas station managers, and students of relevant degree programmes.	Ed. and Outreach Leader, working with Petrojam, Gasoline Retailers Association and universities (domestic and abroad)
Activity 7: Biofuels for communities	Ensure that socioeconomic benefits of biofuels are realized and address issues of project fatigue. *Note: It is necessary for the management team and relevant stakeholders to have a discussion on how best to ensure communities benefit from biofuel industry growth, ensure jobs and trainings reach a range of people (across genders, smallholder vs. large farmer, economic levels,*		Rural Communities	Parish Councils, Non-Governmental Organizations

	etc.), and that labour laws are complied with, in order to determine what will take place under this activity.			
Activity 8: Biofuels information for policy makers	Share knowledge between government departments, with the aim of supporting best outcomes from agriculture, energy industry, land use planners, manufacturing, and other industries. Coordinate efforts related to biofuels, energy, agriculture and land use.	• Interagency meetings and discussions to share knowledge and developments. • Targeted fact sheets. • Information sessions at offices/agencies.	Relevant government agencies and policy makers	Education and Outreach Leader, working with various government departments and agencies
Activity 9: Biofuels for the marine environment	With the E10 rollout there were significant challenges in the marine environment, hence, when/if technological issues are overcome and biofuels are reintroduced, education and outreach will have to boost confidence in the marine environment that the issues have been resolved as well as explain why they have been reintroduced and what vehicle owners and operators can expect.	• Distribute basic information on why biofuels, what changes they will see and how previous issues have been overcome. Information distributed through: - Marketing materials, such as posters, flyers and information sheets (as made in the previous campaign). - Media, such as radio, television and newspaper placements, as well as possibly a mobile phone messaging campaign. - Website center of information, could be modeled after JPS's: http://www.myjpsco.com/media_centre/index.php . - Questions and answers through same phone hotline and email address with answers made available online, website, public forums, and other methods for receiving and responding to concerns and	Water vehicle operators and owners	• Fisheries Division of the MoA • Fishermen Cooperative • Yacht clubs • Caribbean Maritime Institute • JDF Coast Guard

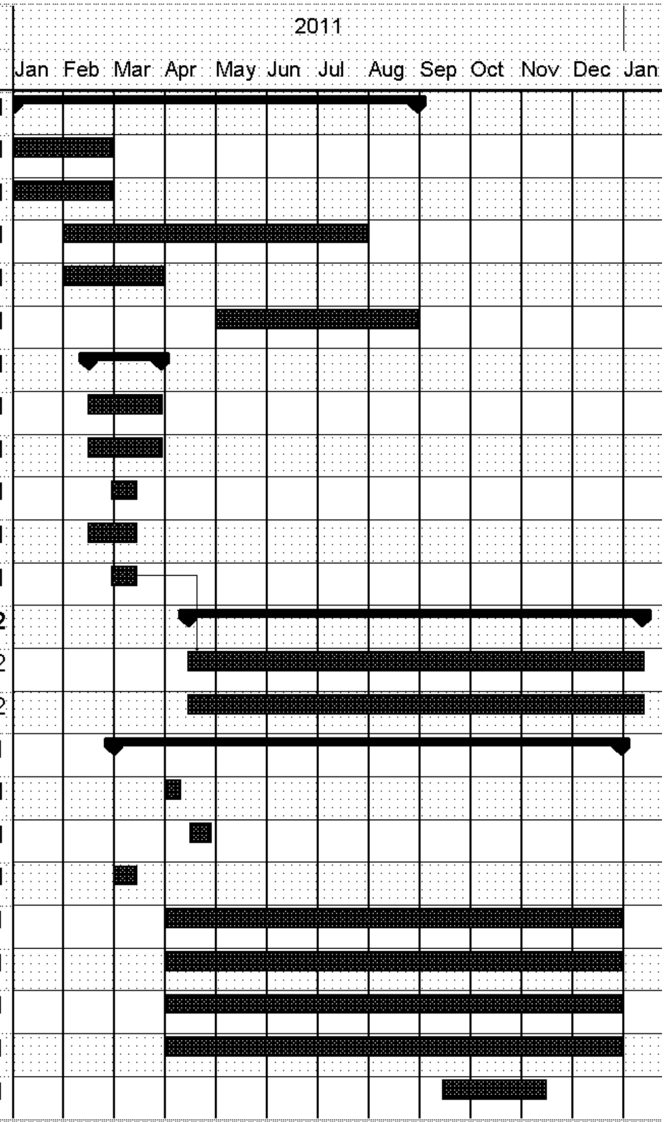
		questions. - Public forums with opportunities to have questions answered by experts, targeting water vehicle owners and operators. - Demonstrations at marinas. • Provide clear information on about commonly occurring problems and how to fix them or where to go to have them fixed, through the other activities in this category.		
Activity 10: Monitoring and accountability	Solicit feedback on public perceptions, what real problems are occurring and provide outside perspective of ways to improve outreach.	• Obtain feedback on what public perceptions of biofuels are, what real problems are occurring, what misconceptions exist, and the effectiveness of different outreach activities. - Survey end users on perceptions and experiences - Study questions received through hotline and other feedback mechanisms • Survey of farmers on adoption of best practices, resulting change in yields, how decisions are made, etc.		PR or polling or market research business that is not involved in the implementation of any of the other activities
Activity 11: Feasibility studies, Research and Development	To provide data and factual information for the campaign. The studies and research are not done as part of this campaign, but the results are integral to it. *Note: the leader of this activity must be determined by the*	• On -going research on the feasibility of biofuel feedstocks, technologies, use, etc. • Distribution of the results of feasibility studies by way of public forums and reference to them in the fact sheets and hot line responses. Make publically available on line.	To inform other campaign activities	

	campaign management team.			

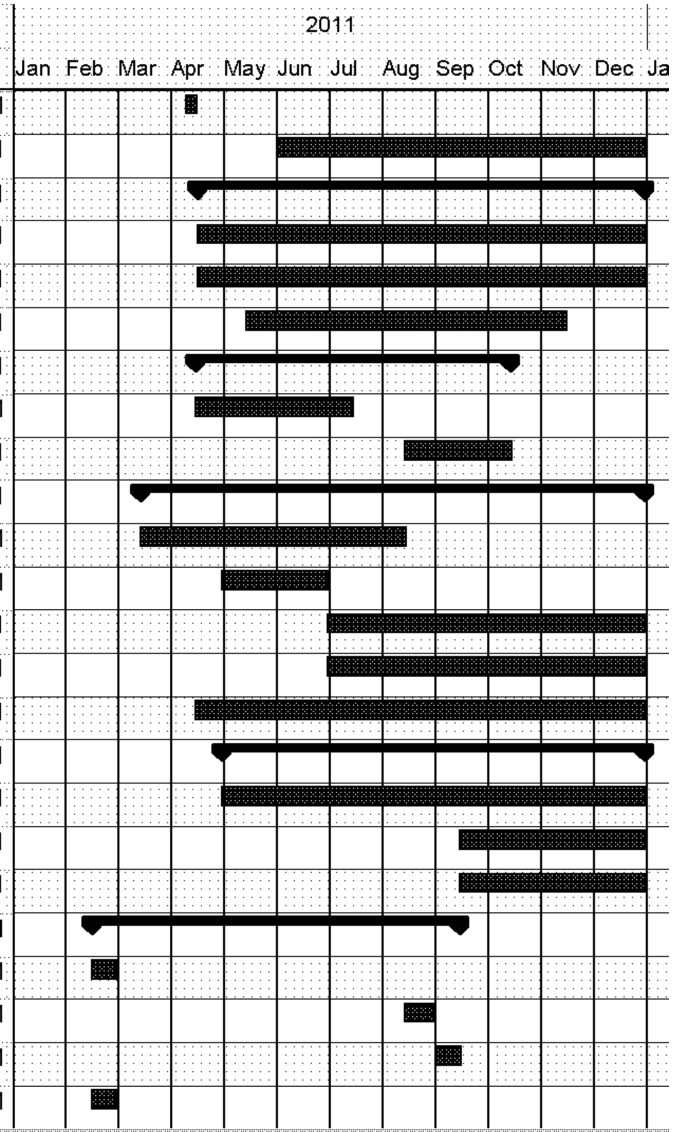
Annex Ia. Preliminary timeline for year one of the campaign

(to be reviewed/revised quarterly)

ID	Name	Start	Finish
	Initiation	**1/3/2011**	**9/1/2011**
	Identify individuals in org/agencies to run acti	1/3/2011	3/1/2011
	Finalize budget	1/3/2011	3/1/2011
	Secure funding	2/1/2011	8/1/2011
	Hire key staff	2/3/2011	4/1/2011
	Hire and train support staff	5/1/2011	9/1/2011
	Materials Preparation	**2/15/2011**	**3/30/2011**
	Create radio, newspaper and television ads	2/15/2011	3/30/2011
	Create factsheets, posters, flyers, etc.	2/15/2011	3/30/2011
	Factsheets for policy makers	2/28/2011	3/15/2011
	Create central website of the campaign	2/15/2011	3/15/2011
	Set up question hotline and email address	2/28/2011	3/15/2011
	Public Forums	**4/15/2011**	**1/13/2012**
	On-going public meetings	4/15/2011	1/13/2012
	Radio and/or TV Interviews	4/15/2011	1/13/2012
	General Information Dissemination	**3/1/2011**	**12/31/2011**
	Notify government and media contacts	4/1/2011	4/10/2011
	Press Releases and Listserv Notifications	4/17/2011	4/28/2011
	Publication of Biofuel FAQs on Websites	3/1/2011	3/15/2011
	Newspaper Ads	4/1/2011	12/31/2011
	Radio Ads	4/1/2011	12/31/2011
	TV Ads	4/1/2011	12/31/2011
	Distribution of Fact Sheets, Flyers, Posters	4/1/2011	12/31/2011
	Education sessions in primary and secondar	9/15/2011	11/15/2011



ID	Name	Start	Finish
	Inters-government agency information prese	4/10/2011	4/15/2011
	Inter-government agency biofuels meetings	6/1/2011	12/31/2011
	Question and Answers	**4/17/2011**	**12/31/2011**
	Hotline	4/17/2011	12/31/2011
	Email/website	4/17/2011	12/31/2011
	Radio call in	5/15/2011	11/15/2011
	Biofuel use demonstrations	**4/15/2011**	**10/15/2011**
	Use in some demonstration vehicles that are	4/15/2011	7/15/2011
	Adoption by a demonstration fleet of vehicles	8/15/2011	10/15/2011
	Agriculture best practices	**3/15/2011**	**12/31/2011**
	Establishment of demonstration farms	3/15/2011	8/15/2011
	Train extension workers	4/30/2011	6/30/2011
	Training sessions for farmers	6/30/2011	12/31/2011
	Agriculture extension workers visit farmers a	6/30/2011	12/31/2011
	Research and development	4/15/2011	12/31/2011
	University curriculums	**4/30/2011**	**12/31/2011**
	Research and discuss how to incorporate bi	4/30/2011	12/31/2011
	Incorporate biofuels into degree programs	9/15/2011	12/31/2011
	Connect students with relevant internships a	9/15/2011	12/31/2011
	Monitoring	**2/15/2011**	**9/15/2011**
	Survey of public perspectives - baseline	2/15/2011	2/28/2011
	Survey of public perspectives and outreach s	8/15/2011	8/31/2011
	Adjust campaign accordingly/if needed	9/1/2011	9/15/2011
	Survey of baseline agricultural practices	2/15/2011	2/28/2011



ID	Name	Start	Finish	2011
	Survey of farmers' adoption of best practices	8/15/2011	8/31/2011	
	Adjust campaign accordingly/if needed	9/1/2011	9/15/2011	

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

Annex Ib. Budget

The budget below is presented in two parts. The first part is a "core" budget that contains estimated costs required to initiate the education and outreach program but not to complete any of the activities, aside from Activity 10: Monitoring and Accountability. The costs are presented on an annual basis. They are indicative values and should be reevaluated before going forward. The second part of the budget is presented as a template, with only limited costs listed, containing the activities that the education and outreach team must plan further before developing a budget for. The budget for this second part should be developed by the team within the first few months of the program. The amounts will necessarily depend on what sources of funding can be established, the magnitude of the funds and the relative priorities that the team establishes based on it early work.

Annual Budget Part 1: Core activities

Staffing			
	Budget (Jamaican $)	**Quantity**	**Total (Jamaican $)**
Education and Outreach Lead	2,800,000	1	2,800,000
Education and Outreach Officer	1,500,000	1	1,500,000
Administrative Assistant	600,000	1	600,000
Media and PR Contact	1,800,000	1	1,800,000
FAQ Team Leader	1,800,000	1	1,800,000
Hotline and email question staff	700,000	1	700,000
Expert advisors	84,800/day	120 days worth	10,176,000
Office and travel costs	100% overhead		19,376,000
Total			38,752,000

Activity 10: Monitoring and accountability			
	Budget (Jamaican $)	**Quantity**	**Total (Jamaican $)**
Public opinion, every 6 months for first 2 years, annually thereafter – 1500 sample size	1,500,000	2	3,000,000
Agricultural practice, every 6 months first 2 years, annually thereafter – 1500 sample size	2,000,000	2	4,000,000
Total			7,000,000

Annual Budget Part 2: Illustrative template to be completed by Campaign Team

Activity 1: Transparency - status of biofuels policy and development			
	Budget (Jamaican $)	Quantity	Total (Jamaican $)
Meeting costs			
Radio ads	5,000-6,000		
Newspaper ads	50,000-200,000		
Television ads	65,000		
Total			

Activity 2: Biofuels Basics			
	Budget (Jamaican $)	Quantity	Total (Jamaican $)
Posters (printing and distribution)			
Fact sheets (printing and distribution)			
Radio ads			
Newspaper ads			
Television ads			
Creating and maintaining website			
Meeting costs	Combine with activity 1		
Materials for education sessions in elementary and secondary schools			
Hotline staff training			
Establishment of the hotline			
Initiation of a biofuels use demonstration project in a few vehicles			
Initiation of a biofuels use demonstration project in a fleet of vehicles			

Activity 5: Best practices for biofuel agriculture and technological trainings			
	Budget (Jamaican $)	**Quantity**	**Total (Jamaican $)**
Establish demonstration farms	50,000,000[12]		
Conduct farmer training workshops at demonstration farm or community center			
Extension workers training[13]			2,530,000
Extension workers salaries	800,000	4	3,200,000
Extension worker transportation to farms			
Community meetings/discussion forums on agriculture best practice topics			
International exchanges for students and extension workers			
Fund research opportunities and internships for students at the demonstration farms			

[12] Cost is estimated for 40 farmers at 2 locations, including the land lease and preparation, nursery establishment, equipment and machinery, water storage, construction/refurbishment of a classroom, 2 farm managers and a project manager, and classroom and office equipment.

[13] To independently establish a one-year training program for extension workers would cost in the region of $2.5 million. If the training were divested to the Ebony Park HEART Academy, in Toll Gate, Clarendon, it would cost more than $1.1 million. Ebony Park HEART Academy serves the parishes of Clarendon, St. Catherine, and St. Elizabeth, the country's "bread basket". It would cost $3,000 per annum per student, as the program is heavily subsidized by the government.

Activity 6: Technological trainings (non-agricultural)			
	Budget (Jamaican $)	Quantity	Total (Jamaican $)
Quality control trainings for fuel distributors			
Trainings for gasoline retailers			
Vehicle information sheets			

Activity 8: Biofuels information for policy makers			
	Budget (Jamaican $)	Quantity	Total (Jamaican $)
Fact sheets (printing and distribution)			
Conducting inter-agency meetings			

Activity 9: Biofuels for the Marine Environment			
	Budget (Jamaican $)	Quantity	Total (Jamaican $)
Posters (printing and distribution)			
Fact sheets (printing and distribution)			
Radio ads			
Newspaper ads			
Television ads			
Meeting setup costs			
Initiation of a biofuels use demonstration project in a few marine vehicles			

Annex Ic. Useful resources for education and outreach campaigns

The following table contains a list of websites from US trade associations, government agencies, private companies, and non-profits that provide examples of the type of information outreach conducted in the US (note that the organizations are working independently, not in a coordinated campaign as proposed in this document). Although this information is all available online, it provides a sense of what can be made available in print form, as well as on websites, as part of biofuels education and outreach activities and examples of public messages around biofuels.

Organization	Website	Target Audience	Comments
US National Biodiesel Board	www.biodiesel.org	US Biodiesel Industry	The "Resources" section of this website contains useful information for the biodiesel industry and the public on all aspects of biodiesel in the US. Of particular interest are their fact sheets (http://www.biodiesel.org/resources/fuelfactsheets/default.shtm).
US Renewable Fuel Association	http://www.ethanolrfa.org/	US Ethanol Industry	The "Resource Center" section of this website contains useful information for the ethanol industry and the public on all aspects of ethanol in the US, including a page of reports and studies (http://www.ethanolrfa.org/pages/reports-and-studies) and a guide for mechanics (http://www.ethanolrfa.org/page/-/rfa-association-site/ChangesinGasolineManualIV-UpdatedLogo.pdf?nocdn=1)
Growth Energy	http://www.growthenergy.org/		Contains an enormous amount of information that is publically accessible, including reports on research and policy (http://www.growthenergy.org/ethanol-resource-center/research-reports/) and informational brochures (http://www.growthenergy.org/ethanol-resource-center/informational-brochures/).
	www.ethanolretailer.org	US ethanol and gasoline retailers	This website by Growth Energy has many useful links targeted at this group, including a page of frequently asked questions (http://www.e85fuel.com/frequently-asked-questions/) and a checklist for installing or converting equipment for various ethanol blends (http://www.ethanolretailer.com/images/uploads/Pump_Checklist_Final.pdf).
	http://www.drivingethanol.org/ethanol_lane.html	US general public	This website is an example of an interactive educational website that is used to introduce the US general public to all aspects of biofuels.
US Department of Energy	http://www.afdc.energy.gov/afdc/etha	Biofuel stakeholders	Lists all of the Federal laws and incentives related to biofuels on their website, for those involved in the biofuel lifecycle to find out what impacts them.

	nol/incentives_laws_federal.html		
US Department of Transportation	http://www.phmsa.dot.gov/staticfiles/PHMSA/DownloadableFiles/Advisory%20Guidance%20Ethanol%20Gas%20MixturesSA16.pdf	Emergency Responders	Provides advice on how to handle emergency responses involving ethanol and gasoline fuel mixtures.
Ecology Center	http://www.ecologycenter.org/factsheets/biodiesel.html	Public	Pulls together resources and presents basic information about biodiesel for the general public.

ANNEX II
Pilot Project Identification

Pilot Project: Frome Estate – Electric Power Cogeneration

This pilot project entails a complete refurbishing of the Frome Estate to turn it into a modern sugar mill and sugar refinery equipped with a 29 MWe cogeneration power plant, as the schematic below shows. According to Mukherji Associates, who have inspected the estate, the current mill infrastructure is in disrepair and deemed obsolete, hence no effort to salvage it is recommended. Instead, new equipment should be purchased aiming at an efficient and cost-effective operation.

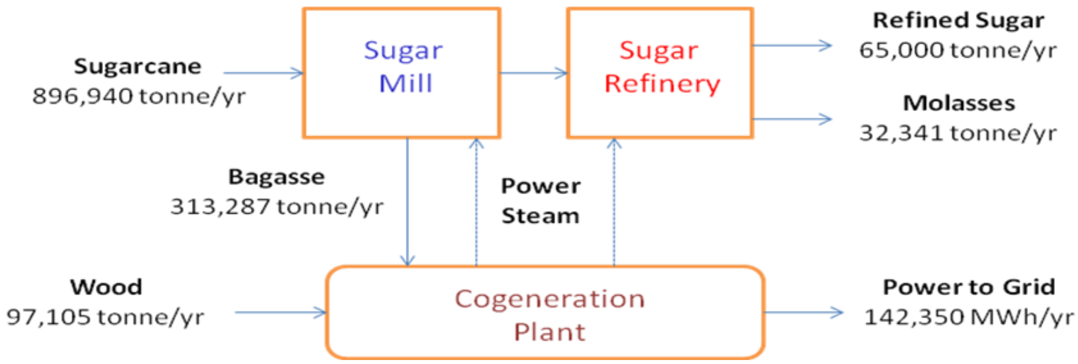


Figure 1: Electric Power Generation with refined sugar and molasses

At a glance, the key operating parameters of a refurbished Frome Estate are as follows:

<u>(1) Sugar Mill</u>

- Cultivated land: 4,800 hectares (ha)
- Sugarcane production: 408,000 tonnes/yr (average yield: 85 tonnes/ha)
- Sugarcane purchased: 488,940 tonnes/yr
- Crop period: 179 days/yr
- Harvest method: Manual (70%) and mechanized (30%)

<u>(2) Sugar Refinery</u>

- Refined sugar production: 65,000 tonnes/yr
- Molasses production: 32,341 tonnes/yr

<u>(3) Cogeneration Plant</u>

- Power production: 29 MW
- Power for export: 18 MW
- Electricity exported: 142,350 MWh/yr
- Boiler pressure: 65 bar
- Fuel used:
    - Bagasse: 313,287 tonnes/yr for 179 days/yr
    - Wood: 97,105 tonnes/yr for 186 days/yr

- Wood cost: $22.30/tonne (green basis)

Overview

Assumptions and Inputs to Financial Model

The mill will be supplied with sugarcane both from its own land and from independent farmers. More specifically, 45.5% of its cane supply (408,000 tonne/yr) will be harvested from land owned by the Estate and the rest from contracted farmers. An investment of almost $5.5M (in 2010 dollars) will be required for agricultural equipment, such as harvesters and trucks. Another $1.7M will be dedicated to installing an irrigation system in the estate's 4,800 hectares.

The new sugar mill, which will be processing a total of 896,940 tonnes/yr will require an investment of $24.7M, whereas the adjacent sugar refinery will need another $16.9M. The refined sugar is assumed to sell for $550/tonne ($0.25/lb) with an annual escalation factor of 5% due to increased future demand (global population growth) and land scarcity due to competing land uses. In addition, the refinery will be also producing molasses. The molasses are of vital importance to the country's economy, as they supply the rum industry. In our calculations we assume a selling price of $60/tonne for the molasses.

The major novelty of this pilot project is the cogeneration plant that will operate year-round using as fuel the mill's sugarcane bagasse during the crop season (179 days) and purchased wood during the off-season (186 days). A purchase price of $22.30/tonne of wood is the baseline in the proforma statements, but a sensitivity analysis has been performed to assess the effect of wood cost on the project's internal rate of return (IRR), as outlined later.

The cogeneration plant will be producing 29 MWe of power, of which 18 MWe will be exported at an assumed price of $0.10/kWh. The boilers of the cogen facility will be generating 65-bar steam. The capital cost of such a facility is estimated to be $44.8M. Although this is a significant investment, it will pay off: it will allow the mill to become completely self-sufficient in terms of power needs and to export annually 142,350 MWh of excess electricity to the grid to help Jamaica meet its increasing power needs, while reducing oil imports.

Overall, the investment required for such a new operation at Frome will be $94.8M (assumed 100% equity-financed), whereas its O&M will be costing $44.8M/yr. On the other hand, revenues from the sale of refined sugar, molasses, and electricity are expected to total $51.9M during the first year of operation.

Financial Model Results

As shown in the attached spreadsheet, assuming a straight-line 15-year depreciation of the capital cost (typical for this kind of operation), the Frome Estate is projected to finish the first year "in the black" with a net income of about $620,000 after taxes. The effective tax rate is assumed to be 20%, which is lower than Jamaica's 33.3% upper limit, but reflects better a leveraged financing investment, since interest expenses would offset income for tax purposes.

Over the 15 years of its depreciated life, the plant will generate a reasonable internal rate of return of 11.50% under the assumptions listed above.
The attached spreadsheet illustrates in detail the proforma statements for the Frome Estate pilot project under a set of assumptions that would justify the investment. While the authors feel the assumptions are realistic, the IRR is affected by a number of variables, some of which are beyond the mill's control and should hence be studied in more detail. Several crucial external variables are: (1) the cost of wood fuel purchased by the mill from farmers and used as fuel in the cogeneration plant during the off-season, when no bagasse is available; (2) the price and quality of the cane supply from the other plantations/farmers; (3) the value of sugar on the world market, which is currently high by historical standards; and (4) the price at which Jamaica's Utility Company is willing to purchase the mill's excess electricity (feed-in tariff).

Wood Fuel Supply

The critical issue for year-round cogeneration is the plant's ability to secure a sufficient supply of fuel at an acceptable price during the off-season. Wood (or other potential fuels) will have to be cultivated by farmers based on long-term contracts. In turn, the willingness of farmers to grow such biomass will depend on receiving a market-competitive compensation from the mill. The Mukherji report states that a land area of 7,000 ha will be required to generate the required 97,105 tonnes annually, but no further details are provided. This land size implies that the woody biomass that can be harvested sustainably is just less than 14 tonnes per hectare. This seems a reasonable assumption as higher rates of annual growth are achievable provided fast growing species are selected, the soils and rainfall are suitable and the plantation is well managed[14]. There is inevitably a time lag between planting saplings and reaching a steady state, where 14 tonne/ha-yr can be harvested. However, since the lead time to finance and then install the changes to the existing Frome sugar mill will realistically be at least 30 months, provided the planting of fast growing energy trees is given a priority, securing the funds needed for the first year operation of the plant may be possible. Other solutions that could help "bridge the gap" might be to bring the new plant into full year-round operation at full electrical output off-season over 1-2 years or to provide biomass to the cogen from some fast growing annual energy crops (high fiber sugar cane or sorghum) to cover that period. The optimum solution will need additional evaluation as part of a detailed feasibility study

The selling price for wood that will entice farmers to commit to supplying the power plant will depend on its competitiveness with other options (alternative crops) the farmers have in Jamaica. The Mukherji report assumes a price of $22.30/tonne of wood. To assess the effect of wood price on the economics of the Frome Estate operation, we performed a sensitivity analysis, as shown in Figure 2.

As the wood price is raised from $15/tonne to $30/tonne, the IRR drops from 11.50% to 10.65%. In other words, a doubling in wood expenses reduces the investment's performance by 7.4%. Hence, wood cost has a notable effect on the mill's profitability. Obviously even

[14] Based on a Winrock study of cotton wood grown for energy in the Mississippi, a climate somewhat less attractive to maximum growth than Jamaica, realistic sustainable removal rates of 23 tonne dry /ha-yr by year 3 and 31 tonne dry/ha-y by year 4

higher wood cost will have a detrimental effect on the rate of return making the investment less attractive.

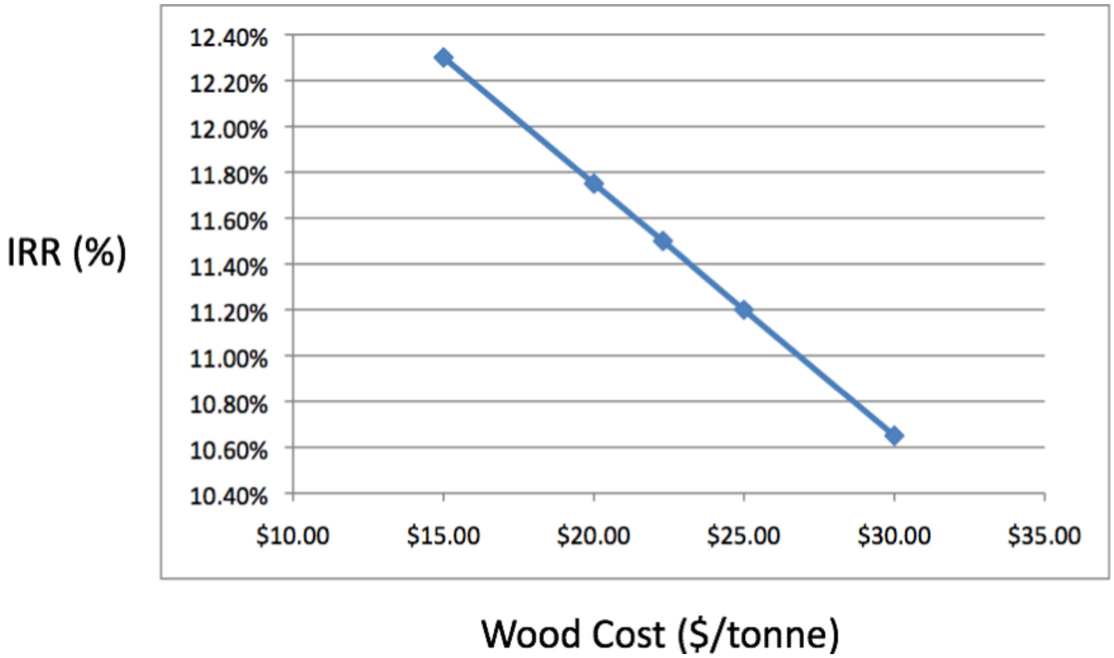


***Figure 2**: Effect of the cost of wood fuel on the internal rate of return (IRR) of the investment for the Frome Estate.*

Electricity Selling Price

Another crucial factor, as with any cogen operation, is the price at which excess electricity will be sold to the State-controlled Utility Company. The Mukherji report assumed $0.10/kWh, although the authors advocated higher prices to make the investment more attractive. For the purpose of the base case evaluation provided above we assumed $0.10/kWh, but assessed the effect of higher prices on the base case IRR of 11.50%. We performed a sensitivity analysis by varying the feed-in tariff between $0.10/kWh and $0.15/kWh. The results are shown in Figure 3.

The effect of the electricity selling price on the IRR is dramatic underlining the importance of this issue to prospective investors. As the feed-in tariff rises from $0.10/kWh to $0.15/kWh, a 50% increase, the IRR jumps from 11.50% to 18.73%, a 63% increase. This is not surprising, since the revenues from the sale of electricity represent a significant portion (27.4%) of the Frome operation's total revenues from the start.

It should be noted that when sugar prices fall, electricity from cogeneration provides a financial cushion to help maintain the overall profitability of the mill. Moreover, a year-round cogeneration plant at the mill largely eliminates any need for the mill to import electricity from the grid even in the out-of-season period. In addition, the cogeneration plant provides round year capacity to the utility company thereby avoiding the need for Jamaica to build such an amount of additional capacity under its expansion plans.

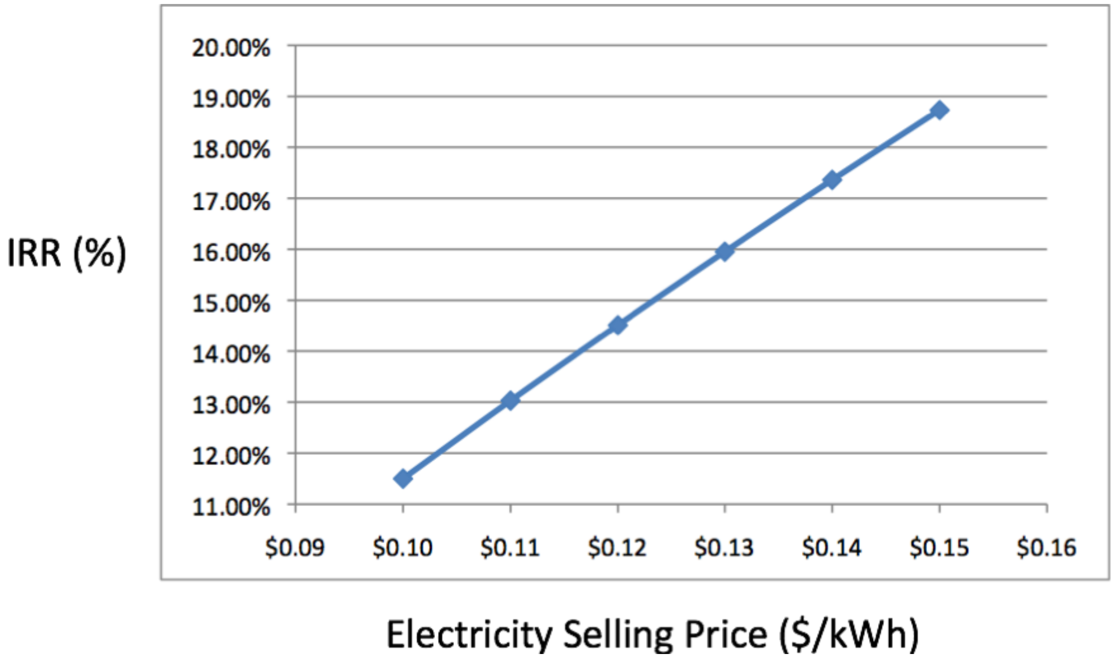


***Figure 3**: Effect of the selling price of excess electricity on the internal rate of return (IRR) of the investment for the Frome Estate.*

These ramifications for the Frome Estate project need to be studied and well understood by all parties involved as the country is seeking investments for its sugar and biofuels industries and striving to reduce its dependence on foreign oil.

Financial Simulation for Power and Sugar at the Frome Estate

	YEAR															
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Initial Investment	$ 94,833,372															
Product value																
Refined Sugar (per tonne)	$ 550	$ 550	$ 578	$ 606	$ 637	$ 669	$ 702	$ 737	$ 774	$ 813	$ 853	$ 896	$ 941	$ 988	$ 1,037	$ 1,089
Molasses (per tonne)	$ 60	$ 60	$ 63	$ 66	$ 69	$ 73	$ 77	$ 80	$ 84	$ 89	$ 93	$ 98	$ 103	$ 108	$ 113	$ 119
Exported electricity (per MWh)	$ 100	$ 100	$ 105	$ 110	$ 116	$ 122	$ 128	$ 134	$ 141	$ 148	$ 155	$ 163	$ 171	$ 180	$ 189	$ 198
Product Revenue																
Refined Sugar		$ 35,750,000	$ 37,537,500	$ 39,414,375	$ 41,385,094	$ 43,454,348	$ 45,627,066	$ 47,908,419	$ 50,303,840	$ 52,819,032	$ 55,459,984	$ 58,232,983	$ 61,144,632	$ 64,201,864	$ 67,411,957	$ 70,782,555
Molasses		$ 1,940,460	$ 2,037,483	$ 2,139,357	$ 2,246,325	$ 2,358,641	$ 2,476,573	$ 2,600,402	$ 2,730,422	$ 2,866,943	$ 3,010,290	$ 3,160,805	$ 3,318,845	$ 3,484,787	$ 3,659,027	$ 3,841,978
Exported electricity		$ 14,235,000	$ 14,946,750	$ 15,694,088	$ 16,478,792	$ 17,302,731	$ 18,167,868	$ 19,076,261	$ 20,030,075	$ 21,031,578	$ 22,083,157	$ 23,187,315	$ 24,346,681	$ 25,564,015	$ 26,842,216	$ 28,184,326
Total Revenue		$ 51,925,460	$ 54,521,733	$ 57,247,820	$ 60,110,211	$ 63,115,721	$ 66,271,507	$ 69,585,083	$ 73,064,337	$ 76,717,554	$ 80,553,431	$ 84,581,103	$ 88,810,158	$ 93,250,666	$ 97,913,199	$ 102,808,859
O&M Costs		$ 44,830,819	$ 46,175,744	$ 47,561,016	$ 48,987,847	$ 50,457,482	$ 51,971,206	$ 53,530,343	$ 55,136,253	$ 56,790,341	$ 58,494,051	$ 60,248,872	$ 62,056,338	$ 63,918,029	$ 65,835,569	$ 67,810,637
Depreciation (20 years)		$ 6,322,225	$ 6,322,225	$ 6,322,225	$ 6,322,225	$ 6,322,225	$ 6,322,225	$ 6,322,225	$ 6,322,225	$ 6,322,225	$ 6,322,225	$ 6,322,225	$ 6,322,225	$ 6,322,225	$ 6,322,225	$ 6,322,225
Net Income		$ 772,416	$ 2,023,764	$ 3,364,579	$ 4,800,139	$ 6,336,014	$ 7,978,076	$ 9,732,515	$ 11,605,859	$ 13,604,988	$ 15,737,156	$ 18,010,006	$ 20,431,595	$ 23,010,412	$ 25,755,405	$ 28,675,998
Taxes	20%	$ 154,483	$ 404,753	$ 672,916	$ 960,028	$ 1,267,203	$ 1,595,615	$ 1,946,503	$ 2,321,172	$ 2,720,998	$ 3,147,431	$ 3,602,001	$ 4,086,319	$ 4,602,082	$ 5,151,081	$ 5,735,200
Income after tax		$ 617,933	$ 1,619,011	$ 2,691,663	$ 3,840,111	$ 5,068,811	$ 6,382,461	$ 7,786,012	$ 9,284,687	$ 10,883,991	$ 12,589,725	$ 14,408,005	$ 16,345,276	$ 18,408,330	$ 20,604,324	$ 22,940,798
(add back depreciation)		$ 6,322,225	$ 6,322,225	$ 6,322,225	$ 6,322,225	$ 6,322,225	$ 6,322,225	$ 6,322,225	$ 6,322,225	$ 6,322,225	$ 6,322,225	$ 6,322,225	$ 6,322,225	$ 6,322,225	$ 6,322,225	$ 6,322,225
Cash Flow		$ 6,940,158	$ 7,941,236	$ 9,013,888	$ 10,162,336	$ 11,391,036	$ 12,704,686	$ 14,108,237	$ 15,606,912	$ 17,206,215	$ 18,911,949	$ 20,730,229	$ 22,667,501	$ 24,730,555	$ 26,926,549	$ 29,263,023
Discounted cash flow		$ 6,224,357	$ 6,387,610	$ 6,502,608	$ 6,574,975	$ 6,609,809	$ 6,611,724	$ 6,584,892	$ 6,533,081	$ 6,459,688	$ 6,367,774	$ 6,260,090	$ 6,139,107	$ 6,007,041	$ 5,865,872	$ 5,717,368
Cumulative discounted cash flow	$ (94,833,372)	$ (88,609,016)	$ (82,221,406)	$ (75,718,798)	$ (69,143,824)	$ (62,534,015)	$ (55,922,291)	$ (49,337,399)	$ (42,804,318)	$ (36,344,629)	$ (29,976,856)	$ (23,716,766)	$ (17,577,659)	$ (11,570,618)	$ (5,704,746)	$ 12,622

Annual Escallation Rate (products)	5%
Annual Escallation Rate (supplies)	3%
Annual Discount Rate	11.50%

Pilot Project: Duckenfield Estate - Ethanol from Cane Juice

In contrast to the Frome example described previously and due to the smaller cane catchment area, the Duckenfield Estate seems more suited as an opportunity, to produce alcohol in place of granular sugar and molasses. Under this scenario, the mill will grind the cane as it has traditionally, but the cane juice will then pass directly to a fermentation tank, where yeast will convert the sugars to alcohol, and from there to distillation columns to raise the ethanol concentration to 95%. The hydrous ethanol produced in this way would most logically be dehydrated to fuel-grade concentrations at one of the Island's two idle large facilities for this purpose. As in the Frome example, the mill will produce and sell surplus electric power to the utility grid. Section 5.1 of the main report describes the technology, and the diagram below illustrates the process and indicates the volumes of inputs and products corresponding to nine months of operation during the year.[15] As in the case of Frome, electric power generation would continue year-round with supplemental fuel from cane trash, biogas or other sources. The return on investment is highly sensitive to the relative prices of sugar and ethanol but under a plausible scenario could yield a blended (equity and debt) return of 16 percent per year.

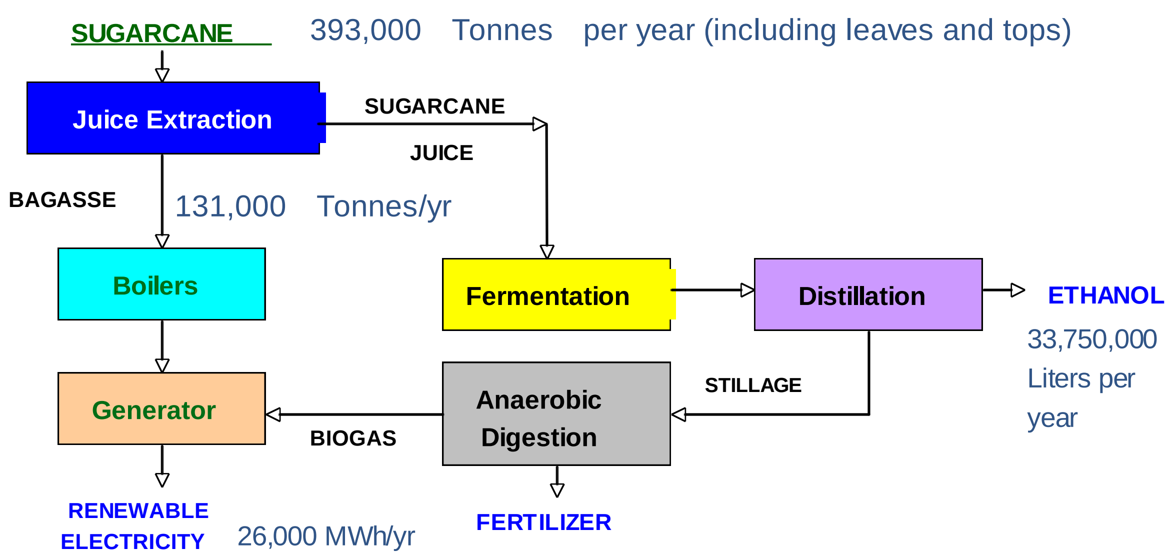


Figure 1: Ethanol and Electricity Production from Sugarcane

At a glance, the key operating parameters of a reconfigured Duckenfield Estate are as follows:

(1) Sugar Mill

- Cultivated land: 4,500 hectares (ha), including Jones and Golden Estates and small farmers
- "Clean" sugarcane consumption: 370,000 tonnes/yr (average yield: 82 tonnes/ha)

[15] Details of the project presented here are based on the San Carlos Bioethanol Project, a similar facility of comparable size constructed in the Philippines in 2007-2008.

- Total sugarcane consumption: 393,000 tonnes per year (including leaves and tops to supplement bagasse fuel)
- Crop period: 270 days/yr
- Harvest method: Manual (70%) and mechanized (30%)

(2) Fermentation and Distillation

- Hydrous ethanol production: 33,750,000 Liters/yr

(3) Cogeneration Plant

- Power production: 7.4 MW
- Power for export: 3.1 MW
- Electricity exported: 26,000 MWh/yr
- Boiler pressure: 67 bar
- Fuel used:
    - Bagasse: 131,000 tonnes/yr
    - Methane from biogas: 1.5 million cubic meters/yr

Overview

This pilot builds on plans by the Duckenfield Estate to increase sugarcane production by cultivating more land and improving yields. Currently, the mill counts on cane from approximately 3,000 captive hectares (Jones and Golden estates) and purchases from independent farmers, who cultivate an additional 500 hectares. Yields range from 44.5 tonnes/ha on small farms to 86.5 tonnes/ha on the Jones Estate. The plan is to expand the cultivated area to 4,500 total hectares, and assuming that the owners are able to achieve average yields of 82 tonnes/ha, the mill will have available 370,000 tonnes of cane per year to process. That amount corresponds with the capacity of a recently constructed facility that produces ethanol from cane juice in the Philippines and can thus serve as a model for a similar installation at Duckenfield.

The prospect evaluated here begins with the assumption that without an investment in ethanol, cane production and processing at Duckenfield would expand, reaching 37,000 tonnes per year of crystalline sugar and 3,700 tonnes per year of molasses. The pilot project would add ethanol fermentation and distillation equipment, upgrade the boiler house to generate sufficient high pressure steam, add turbine generators to supply electric power for on-site requirements and 3.1 MW for export to the grid, and install an anaerobic digester to treat wastes and produce methane as a fuel supplement. The resulting capability would permit the mill to sell 33.75 million liters of ethanol and 26,000 megawatt hours of electricity per year. Assuming the cost of cane and other operation and maintenance costs would be the same, whether the mill produced sugar or ethanol, the project amounts to a capital investment to be amortized by the higher revenues that energy products could command relative to sugar.

Additional assumptions involve extending the cane-harvesting season to 270 days per year, in order to take better advantage of processing capacity and reduce the time during which the mill will require supplemental fuel to continue generating firm electric power for export. Since fermentation is less exacting than sugar production in terms of the time intervals between peak sugar conditions and cane harvesting and also before crushing, and because concentrated cane juice can be stored and techniques used to promote early ripening, moving to a 270 day crushing season seems possible. However, this would need to be explored in more depth during a feasibility study. The analysis also assumes that, unlike the proposed arrangement at Frome, supplemental fuel will be in the form of 23,000 tonnes per year of cane tops and leaves delivered with the cane to increase the production of bagasse, which can be stored to fuel off-season power generation.

Specific features of the pilot appear below, and the spreadsheet at the end of this section outlines in detail the proforma statements for the Duckenfield pilot project. As in the case of the Frome example, the authors feel the assumptions are realistic, but the IRR is affected by a number of variables, some of which are beyond the mill's control and should be studied in more detail. Several crucial external variables are: (1) the price of sugar, assumed here to return to historic levels from its current highs; (2) the value of ethanol, which is tied closely to petroleum; and (4) The price at which Jamaica's Utility Company is willing to purchase the mill's excess electricity (feed-in tariff).

Added Component	Investment (US$)
Distillery	$4,011,593
Boiler plant	$3,947,051
Steam turbine	$2,128,594
Anaerobic digestion system	$1,197,110
Composting system	$74,471
Electrical system	$3,525,897
Construction and commissioning	$2,168,834
Total Investment	$17,053,549

Sugar Cane	Tonnes/y
Jones Estate (1,300 ha; 87 tonnes/ha)	113,100
Golden Estate (2,500 ha; 85 tonnes/ha)	212,500
Small Farmers (600 ha; 74 tonnes/ha)	44,400
Total clean cane (tonnes/yr)	370,000
Leaves and tops	23,000
Total "trashy" cane (tonnes/yr)	393,000

Ethanol Refinery	Liters/y
Ethanol production	33,750,000

Cogeneration	
Power production capacity (MW)	7.4
Surplus power (MW)	3.1
Boiler pressure (bar)	67
Bagasse (tonnes)	131,000
Power export (MWh/yr)	26,000
Days/yr	350

Table 1: Pilot Project Cost and Operating Characteristics

Product Prices

As indicated earlier, the upgrade could yield an internal rate of return (blended debt and equity) of 16 percent per year, assuming prices and revenues shown in Table 2 (below). "Internal rate of return" in this discussion refers to the financial performance of the incremental investment in ethanol production, and not the profitability of the mill as a whole. Variations in either the ethanol price or the value of sugar that would not be produced will cause significant changes in the predicted IRR. For example, at the current sugar price of US$0.37 per lb. (approximately $800 per tonne), ethanol is clearly uneconomical (See Figure 2.) On the other hand, as the graph in Figure 3 illustrates, sugar prices have been well below US$0.20 per lb. ($440 per tonne) for almost all of the past 30 years, and recent increases, due at least in part to weather in India and Australia, may be temporary, as they were in 1980.

Product Revenue	Price	Amount/yr
Ethanol	$0.50/liter	$16,875,000
Foregone sugar revenue @ 37,000 tonnes/yr	$480/tonne	$(17,760,000)
Foregone molasses revenue @3,700 tonnes/yr	$60/tonne	$(222,000)
Exported electricity	$150/MWh	$3,900,000
Total Net Revenue		$2,793,000

Table 2: Price and Revenue Assumptions

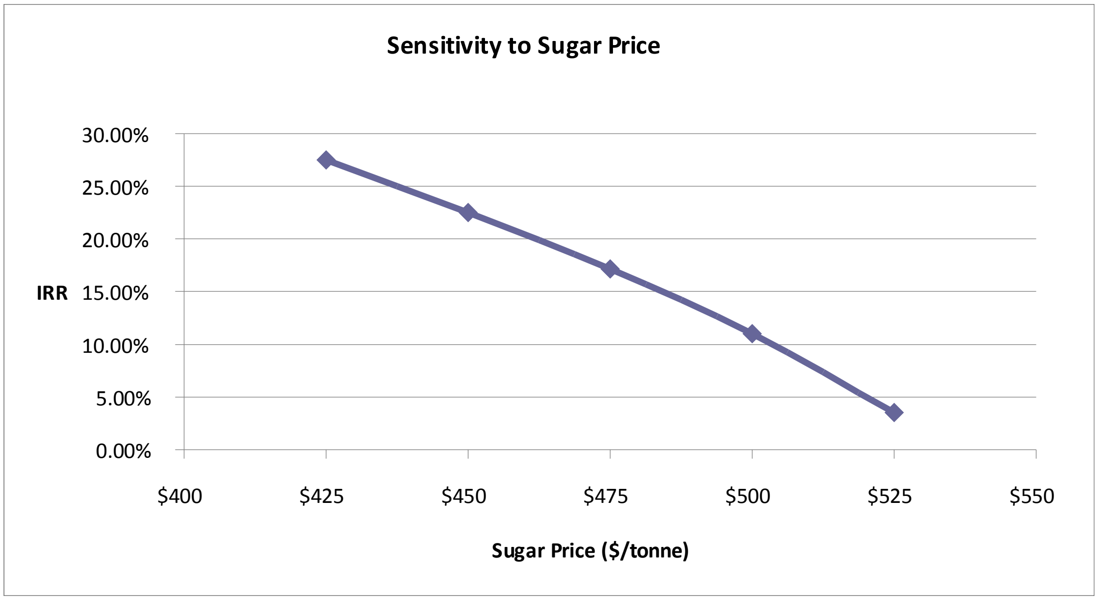
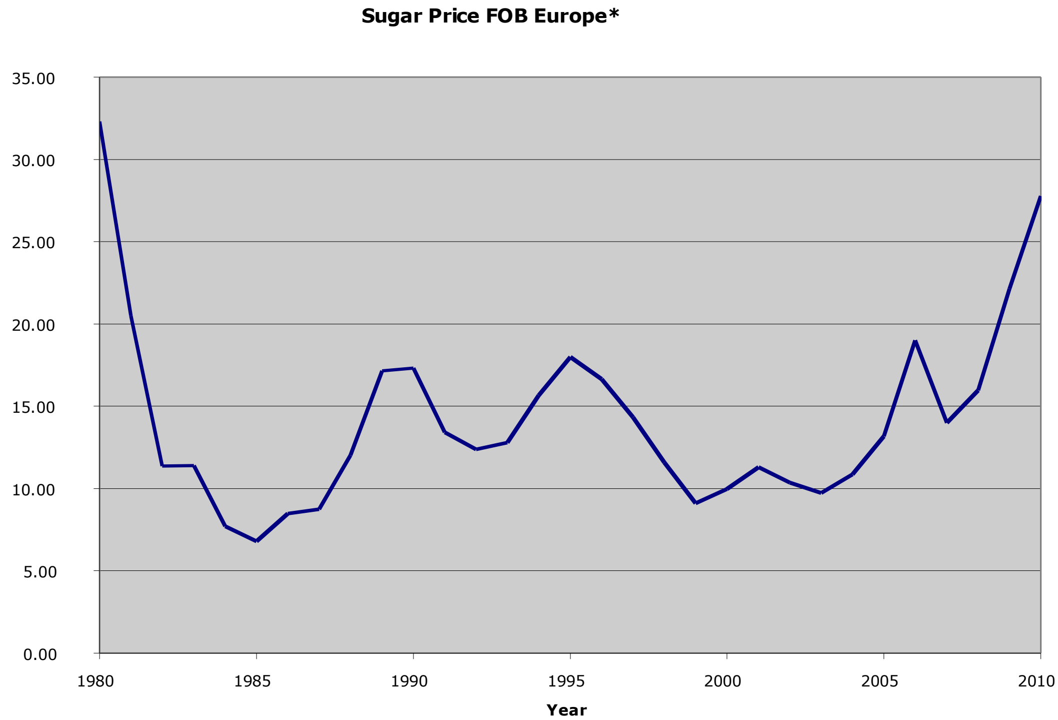


Figure 2: IRR Sensitivity to Sugar Price

Sensitivity to ethanol price at a fixed sugar price of $480 per tonne is shown in Figure 4. At this price, ethanol production offers an IRR of 15% and higher when ethanol is at or above US$ 0.50 per liter, comparable in terms of heating value to US$3.00 per gallon gasoline. However at US$0.45 cents per liter, only ten percent less, the IRR of the ethanol investment drops to 3.3 percent per year. This is clearly an inadequate long-term level. However,if sugar prices decline at the same time, and it is not unusual for sugar prices and crude oil process to be linked, a higher IRR would result (see Fugure 3). The key to an investment in an ethanol plant is the anticipated long-term future trends in sugar and ethanol prices. Although, one might expect petroleum prices to increase over time, that cannot be guaranteed. Similarly, one might expect from historical performance that current sugar prices will fall.

To offset pricing risks, the mill could retain its sugar production capacity as a hedge against high sugar and low ethanol prices. This would involve building the new ethanol distillery next to the adjacent sugar refinery and making provisions to "mothball" each plant when the other is operating. Some modest additional costs would be needed (e.g. ability to dry plant and, perhaps, an inert gas system to purge air from closed vessels). While combined operation is theoretically possible, designing an ethanol distillery to run at less than 75% full capacity is a challenge, and for the overall size of Duckenfield we believe this would be less attractive. Another issue is the need for a reliable source of ethanol to supply the Jamaican domestic market.



*Contract No. 407 (aka no.5), London Daily Price, for refined sugar, f.o.b. Europe, spot, through June 2006. Starting in July 2006, spot price replaced by average of nearest futures month for which an entire month of prices is available.
Source: US Department of Agriculture,
http://www.ers.usda.gov/briefing/sugar/Data/Table02.xls

Figure 3: Historical Sugarcane Prices

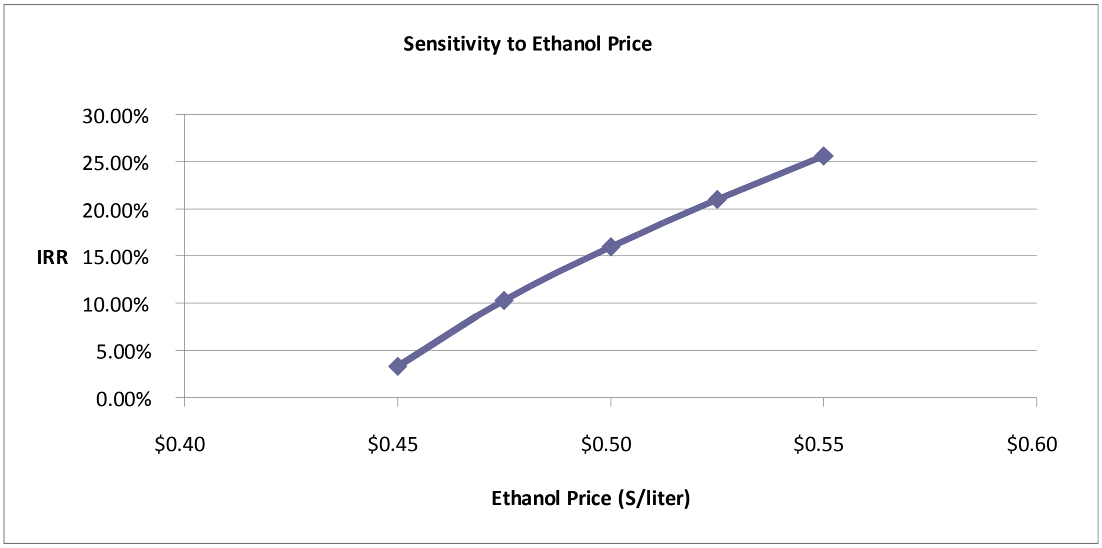


Figure 4: IRR Sensitivity to Ethanol Price

Financial Simulation for Ethanol and Power Production at Duckenfield

					YEAR											
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Initial Investment	$ 17,053,549															
Product values																
Ethanol (per liter)	$ 0.50	$ 0.50	$ 0.53	$ 0.55	$ 0.58	$ 0.61	$ 0.64	$ 0.67	$ 0.70	$ 0.74	$ 0.78	$ 0.81	$ 0.86	$ 0.90	$ 0.94	$ 0.99
Refined Sugar (per tonne)	$ 480	$ 480	$ 504	$ 529	$ 556	$ 583	$ 613	$ 643	$ 675	$ 709	$ 745	$ 782	$ 821	$ 862	$ 905	$ 950
Molasses (per tonne)	$ 60	$ 60	$ 63	$ 66	$ 69	$ 73	$ 77	$ 80	$ 84	$ 89	$ 93	$ 98	$ 103	$ 108	$ 113	$ 119
Exported electricity (per MWh)	$ 150	$ 150	$ 158	$ 165	$ 174	$ 182	$ 191	$ 201	$ 211	$ 222	$ 233	$ 244	$ 257	$ 269	$ 283	$ 297
Product Revenue																
Ethanol		$ 16,875,000	$ 17,718,750	$ 18,604,688	$ 19,534,922	$ 20,511,668	$ 21,537,251	$ 22,614,114	$ 23,744,820	$ 24,932,061	$ 26,178,664	$ 27,487,597	$ 28,861,977	$ 30,305,076	$ 31,820,329	$ 33,411,346
Foregone sugar revenue @ 37,000 tonnes/yr		$ (17,760,000)	$ (18,648,000)	$ (19,580,400)	$ (20,559,420)	$ (21,587,391)	$ (22,666,761)	$ (23,800,099)	$ (24,990,104)	$ (26,239,609)	$ (27,551,589)	$ (28,929,169)	$ (30,375,627)	$ (31,894,408)	$ (33,489,129)	$ (35,163,585)
Foregone molasses revenue @3,700 tonnes/yr		$ (222,000)	$ (233,100)	$ (244,755)	$ (256,993)	$ (269,842)	$ (283,335)	$ (297,501)	$ (312,376)	$ (327,995)	$ (344,395)	$ (361,615)	$ (379,695)	$ (398,680)	$ (418,614)	$ (439,545)
Exported electricity		$ 3,900,000	$ 4,095,000	$ 4,299,750	$ 4,514,738	$ 4,740,474	$ 4,977,498	$ 5,226,373	$ 5,487,692	$ 5,762,076	$ 6,050,180	$ 6,352,689	$ 6,670,323	$ 7,003,840	$ 7,354,032	$ 7,721,733
Total Revenue		$ 2,793,000	$ 2,932,650	$ 3,079,283	$ 3,233,247	$ 3,394,909	$ 3,564,654	$ 3,742,887	$ 3,930,031	$ 4,126,533	$ 4,332,860	$ 4,549,503	$ 4,776,978	$ 5,015,827	$ 5,266,618	$ 5,529,949
Incremental O&M Costs relative to sugar and molasses		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Depreciation (15 years)		$ 1,136,903	$ 1,136,903	$ 1,136,903	$ 1,136,903	$ 1,136,903	$ 1,136,903	$ 1,136,903	$ 1,136,903	$ 1,136,903	$ 1,136,903	$ 1,136,903	$ 1,136,903	$ 1,136,903	$ 1,136,903	$ 1,136,903
Net Income		$ 1,656,097	$ 1,795,747	$ 1,942,379	$ 2,096,343	$ 2,258,006	$ 2,427,751	$ 2,605,984	$ 2,793,128	$ 2,989,630	$ 3,195,956	$ 3,412,599	$ 3,640,075	$ 3,878,923	$ 4,129,715	$ 4,393,046
Taxes	20%	$ 331,219	$ 359,149	$ 388,476	$ 419,269	$ 451,601	$ 485,550	$ 521,197	$ 558,626	$ 597,926	$ 639,191	$ 682,520	$ 728,015	$ 775,785	$ 825,943	$ 878,609
Income after tax		$ 1,324,877	$ 1,436,597	$ 1,553,903	$ 1,677,075	$ 1,806,405	$ 1,942,201	$ 2,084,787	$ 2,234,503	$ 2,391,704	$ 2,556,765	$ 2,730,080	$ 2,912,060	$ 3,103,139	$ 3,303,772	$ 3,514,437
(add back depreciation)		$ 1,136,903	$ 1,136,903	$ 1,136,903	$ 1,136,903	$ 1,136,903	$ 1,136,903	$ 1,136,903	$ 1,136,903	$ 1,136,903	$ 1,136,903	$ 1,136,903	$ 1,136,903	$ 1,136,903	$ 1,136,903	$ 1,136,903
Cash Flow		$ 2,461,781	$ 2,573,501	$ 2,690,807	$ 2,813,978	$ 2,943,308	$ 3,079,104	$ 3,221,690	$ 3,371,406	$ 3,528,607	$ 3,693,668	$ 3,866,983	$ 4,048,963	$ 4,240,042	$ 4,440,675	$ 4,651,340
Discounted cash flow		$ 2,122,846	$ 1,913,651	$ 1,725,401	$ 1,555,956	$ 1,403,400	$ 1,266,017	$ 1,142,268	$ 1,030,776	$ 930,306	$ 839,749	$ 758,112	$ 684,501	$ 618,115	$ 558,236	$ 504,215
Cumulative discounted cash flow	$ (17,053,549)	$ (14,930,703)	$ (13,017,053)	$ (11,291,652)	$ (9,735,695)	$ (8,332,295)	$ (7,066,278)	$ (5,924,010)	$ (4,893,234)	$ (3,962,928)	$ (3,123,178)	$ (2,365,067)	$ (1,680,566)	$ (1,062,451)	$ (504,215)	$ (0)

Inputs	
Annual Escallation Rate (products)	5%
Annual Escallation Rate (supplies)	3%
Annual Discount Rate	15.97%

Pilot Projects: Discussion of Other Sugarcane Sites

Moneymusk

The pilot project evaluation for Frome has similar application to Moneymusk, where the sugar cane harvest in 2006 was 760,000 tons, compared to 897,000 tons at Frome. Since the new owners of Moneymusk, following divestiture by the Sugar Company of Jamaica, will also be able to supply cane from lands that were previously within the Bernard Lodge catchment area, the available sugar cane harvest after new investment and rationalization is likely to exceed that of Frome. As a result, and dependent on decisions by the new owners, a scheme similar to that described for Frome with comparable benefits and returns, is an option. As at Frome, lengthening the cane harvest season (213 days in 2006) and increasing biomass fuel supplies (bagasse and possibly purpose grown) for a new cogeneration plant will be desirable to maximise returns from the new investments. As the cane season is extended, water supply for irrigation will grow in significance. Options will need to be explored to use more efficient methods of irrigation (e.g. drip feeding) and possibly cultivation of sweet sorghum as an alternative to sugar cane in the early/late harvest periods. The other key factor is an appropriate payment for electricity sales that recognizes the full savings in imported fuel that electricity from a new cogeneration plant would provide. Both of the preceding are essential for a commercial success and hence for a decision by the new owners to invest.

Long Pond (Trelawny)

The Pilot project evaluation for Duckenfield, which had a total sugar cane harvest of 331,000 in 2006, is also applicable to Long Pond, where the 2006 sugar cane harvest was 338,000 ton. However, one important difference needs to be noted, and that is the longer and more pronounced dry season in the catchment area of Long Pond compared to Duckenfield, as shown in Figure 3. This is important, because in order to justify the investment needed to convert an existing a sugar mill to one producing ethanol and electricity (the pilot concept for Duckenfield), it is necessary to find ways to extend the harvest season to secure high availability from the new plant. Another problem at Long Pond is the loss of catchment areas due to its proximity to the rapidly developing tourist areas of the north coast. So even though Sweet Sorghum might be considered as an alternative to sugar cane and require less water, land for this crop will be less easy to obtain and secure in the long term.

An alternative that Long Pond may wish to consider is to just to invest in higher efficiency cogeneration based on sale of electricity to the Jamaican grid. This requires less investment, but again, it is most likely to be attractive when the operating period of the new plant can be extended to most of the year rather than being restricted to the current length of the cane harvest.

Worthy Park

This privately-owned site already has a highly integrated production of sugar and rum, and the cane catchment area has little room for expansion. As a result, the main option that Worthy is considering is investment in a more efficient cogeneration plant that would allow it to sell elecricity to the grid. This will only be possible if OUR finds a way to give full recognition to the value that this type of project would provide in terms of avoided imports of fossil fuel.

Duckenfield

As an alternative to conversion from sugar to ethanol production, Duckenfield could remain a sugar producer, but by adding a modern cogeneration plant, it could also become an electricity supplier to the grid. The economics of this is likely to require finding a way to extend the cane harvesting season and increasing available biomass (bagasse and bioenergy crops). The more regular rainfall in the Duckenfield capture area is an advantage. An indication of the overall economics can be estimated from the pilot case for Duckenfield by

Added Component	Investment (US$)
Distillery	**0**
Boiler plant	**$3,947,051**
Steam turbine	**$2,128,594**
Anaerobic digestion system	**0**
Composting system	**0**
Electrical system	**$3,525,897**
Construction and commissioning	**$1,000,000**
Total Investment	**$10,601,542**
Power export (MWh/yr)	**26,000**

Table 2: Investment Breakdown for Power Export at Duckenfeld

At a value of $150/MWh, the power would generate revenues of $3,900,000 per year, which would pay the initial investment back in less than three years.

Pilot Project: Biodiesel Refinery

Background

As the National Biofuels Policy indicates, development of biodiesel in Jamaica is in its infancy. The Petroleum Corporation of Jamaica's Center of Excellence for Renewable Energy is conducting exploratory research to identify promising crops and their potential under local conditions and likely productivity on marginal lands. Most of the recent effort has focused on jatropha curcas and castor, both of which have been the subject of small field trials.

Given the early stage of biodiesel feedstock development, determining the size and location of a processing facility is difficult, as is predicting the likely cost of raw material to the prospective processor. For this reason, the "pilot project" described here is a generic one, designed to illustrate the economic relationships among feedstock cost, processing plant scale and product selling price. The approach is to estimate what the processor could afford to pay for vegetable oils from jatropha, castor or other sources, since a target price in this form could be useful in designing and evaluating approaches to cultivation and harvesting.

Overview of options

Oilseed Production

Section 2.6 of the main report discusses sources of biodiesel in detail. Based on Brazilian experience, the cost of small-scale production of castor beans, for example, containing 48% oil, is US $0.50 per Kilo ($1.00 per Kilo of oil), which amounts to $3.40 per gallon, or roughly twice the cost of crude oil.

Large-scale mechanized production of castor or jatropha could be less costly, but it might also displace sugarcane. As a large-scale field crop, soy might be a better alternative, since it has food as well as energy value. Another solution would be higher oil-yielding palm trees, which would not compete with cane for land and could possibly provide solid fuel for off-season sugar mill operation.

Conversion Technology

From a processing standpoint, as illustrated in Section 6 of the main report above, oilseeds will be harvested manually and/or mechanically and sent to a crusher for extraction of crude vegetable oil. Recycled oil can also be used, but depending on its free fatty acid (FAA) content, pretreatment may be needed (Fig. 1). However, such a unit can be ordered as a standard part of the integrated modular biodiesel unit to allow maximal flexibility in dealing with a variety of virgin and recycled feedstocks.

The oil is subsequently led through a series of vessels, where the transesterification process takes place at 50-60^{0}C in the presence of excess methanol and potassium hydroxide, which catalyzes the reaction. This standard process leads to the formation of primarily a mix of methyl esters (biodiesel) and glycerin in a weight ratio of approximately 10:1.

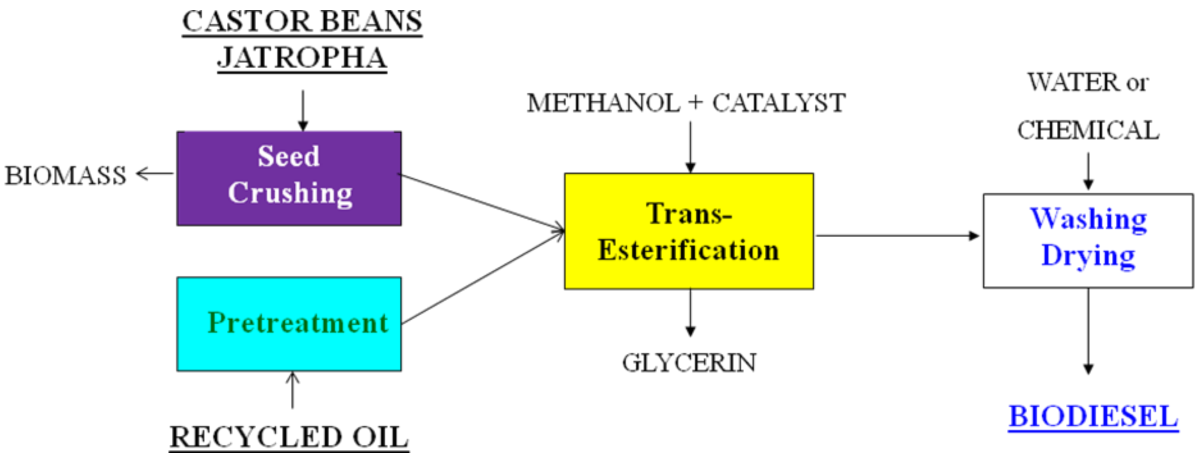


Figure 1: Biodiesel Production from Oil-Seed Plants and Recycled Oil

After a series of washing and drying steps to remove impurities (methanol) and moisture, the biodiesel is ready for testing to qualify it as appropriate for commercial use through blending with diesel. The glycerin is generated as a dilute aqueous solution that can be used in a number of ways, such as:

- Subjected to anaerobic digestion for conversion to methane, which can be used as a fuel for power and/or heat generation.
- Mixed with animal feed (as long as it is methanol-free) as a carbon supplement.
- Upgraded through distillation to a high purity (and high value) product that has applications in the cosmetics industry.

The latter application requires the purchase and operation of a distillation column, whereas anaerobic digestion and animal feed are lower value, but also lower-cost, options with modest revenue-generating potential.

The solid leftovers from the crushing of the seeds, along with other plant material, constitute a steady source of biomass that should be considered as the basis for cogeneration or for use as a natural fertilizer. Although cogeneration is usually not practiced at biodiesel plants due to their rather small size (and hence limited quantities of biomass), this possibility should be re-examined in Jamaica particularly in coordination with the cogeneration plans of the sugarcane-to-ethanol industry.

A more detailed discussion or processing technology and associated costs can be found in a report[16] by the US National Renewable Energy Laboratory. Process and cost data in the economic analysis that follows are generally from this source.

Revenue versus cost of feedstock

In general terms, the cost of processing vegetable oils into biodiesel are in approximately the same range as refining petroleum (US$ 0.50 per gallon), so the oil feedstock has to cost less than crude oil to be profitable without subsidies in some form. The crude oil price on the New York Mercantile Exchange was US$89.55 per barrel, or US$2.13 per gallon, on January 20, 2011. All countries with commercial

[16] Tyson, K Shaine, *et al.*, *Biomass Oil Analysis: Research Needs and Recommendations*, Golden Colorado, National Renewable Energy Laboratory, NREL/TP-510-34796, 2004. http://www.nrel.gov/docs/fy04osti/34796.pdf

biodiesel subsidize it one way or another, e.g., through lower excise taxes or mandatory use, and such a subsidy would probably be necessary, based on the analysis presented below.

Section 4.2 of the main report discusses possible uses for biodiesel and concludes that stationary applications represent the largest and most easily accessible market. As of January 20, 2011, Petrojam sells diesel fuel at the refinery gate, net of taxes, for J$64.5161 per Liter (US$2.85 per gal.). (See http://www.petrojam.com/index.php?q=latest-prices.) Taxes add another J$27.4041, bringing the total to J$91.9202 per Liter (US$4.06 per gal.). Biodiesel has a 10% lower calorific value per gallon, so the equivalent biodiesel price ex-refinery, without taxes, would be $2.57 per gallon. One way for Jamaica to encourage the formation and growth of a biofuels industry would be to exempt biodiesel from these taxes, which would bring the equivalent value to US$3.65 per gallon.

While agronomic trials are under way, and crops suitable for Jamaican conditions have not been selected, the scale and cost of vegetable oil supply remain difficult to predict. On the other hand, with values for the biodiesel fuel product and experience elsewhere with conversion costs, it is possible to calculate how much a processor could afford to pay for feedstock and realize an attractive return on investment under different price and scale scenarios.

With this in mind, results of four cash flow simulations appear below. These reflect plant capacities of 3 million and 15 million gallons per year and product prices equivalent to Petrojam's diesel with and without value-added and special consumption taxes, as shown in Table 1.

	Product Price	
Plant Scale	**US$2.57 per Gallon**	**US$3.65 per Gallon**
3 Million GPY	**Scenario A**	**Scenario B**
15 Million GPY	**Scenario C**	**Scenario D**

Table 1: Biodiesel Production Scenarios

The simulations reflected the following additional assumptions:

- Investment per annual gallon of plant capacity:
  - US$2.50 (3 million gpy)
  - US$1.00 (15 million gpy)
- Methanol and other reagents: US$0.25 per gallon of product
- Other plant operating cost: US$0.15 per gallon per year
- Sales, general and administrative costs:
  - US$100,000 per year (3 million gpy)
  - US$500,000 per year (15 million gpy)
- Depreciation: 15 years, strait line
- Taxes: 20 percent of net income
- Annual escalation rate: 3 percent per year (product price; feedstock and processing costs
- Hurdle rate of return on investment (discounted cash flow IRR): 15 percent per year

For illustration and simplicity, the 15 percent ROI assumes 100 percent equity financing. Debt leverage could improve this value for equity holders in an actual project. The implicit feedstock values corresponding to the four scenarios are as follows:

Scenario	Implicit Value of Vegetable Oil Feedstock
A	**US$1.68 per gallon**
B	**US$2.73 per gallon**
C	**US$1.93 per gallon**
D	**US$2.99 per gallon**

Table 2: Biodiesel Feedstock Values

From the two tables above, one can see that scale economies improve the economic prospects to a limited degree, while the effect of tax treatment is more than US$1.00 per gallon of feedstock at either scale. The detailed cash-flow simulations are presented in the tables below.

Financial Analysis for 3 Million Gallons per Year Biodiesel With Taxes

	Item	YEAR 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Initial Investment	$7,500,000															
2																	
3																	
4	Product Value per Gal. Biodiesel		$2.57	$2.65	$2.73	$2.81	$2.89	$2.98	$3.07	$3.16	$3.26	$3.36	$3.46	$3.56	$3.67	$3.78	$3.89
5	Feedstock Cost per Gallon		$1.68	$1.73	$1.78	$1.83	$1.89	$1.94	$2.00	$2.06	$2.12	$2.19	$2.25	$2.32	$2.39	$2.46	$2.54
6	Biodiesel Sales		$7,714,910	$7,946,357	$8,184,748	$8,430,290	$8,683,199	$8,943,695	$9,212,006	$9,488,366	$9,773,017	$10,066,208	$10,368,194	$10,679,240	$10,999,617	$11,329,605	$11,669,494
7	Feedstock cost @1.02 gal/gal prod.		$5,131,984	$5,285,944	$5,444,522	$5,607,858	$5,776,094	$5,949,376	$6,127,858	$6,311,694	$6,501,044	$6,696,076	$6,896,958	$7,103,867	$7,316,983	$7,536,492	$7,762,587
8	Gross Margin		$2,582,926	$2,660,413	$2,740,226	$2,822,433	$2,907,105	$2,994,319	$3,084,148	$3,176,673	$3,271,973	$3,370,132	$3,471,236	$3,575,373	$3,682,634	$3,793,113	$3,906,907
9	Gross margin per gallon		$0.86	$0.89	$0.91	$0.94	$0.97	$1.00	$1.03	$1.06	$1.09	$1.12	$1.16	$1.19	$1.23	$1.26	$1.30
10																	
11	Processing Cost																
12	Methanol and other reagents @ $0.25/ Gal.		$750,000	$772,500	$795,675	$819,545	$844,132	$869,456	$895,539	$922,405	$950,078	$978,580	$1,007,937	$1,038,175	$1,069,321	$1,101,400	$1,134,442
13	Other Plant Operating Cost @ $0.15/Gal.		$450,000	$463,500	$477,405	$491,727	$506,479	$521,673	$537,324	$553,443	$570,047	$587,148	$604,762	$622,905	$641,592	$660,840	$680,665
14	SG&A		$100,000	$103,000	$106,090	$109,273	$112,551	$115,927	$119,405	$122,987	$126,677	$130,477	$134,392	$138,423	$142,576	$146,853	$151,259
15	Total Processing Cost		$1,300,000	$1,339,000	$1,379,170	$1,420,545	$1,463,161	$1,507,056	$1,552,268	$1,598,836	$1,646,801	$1,696,205	$1,747,091	$1,799,504	$1,853,489	$1,909,094	$1,966,367
16																	
17	Depreciation (15 year)		$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000
18																	
19	Net Income		$782,926	$821,413	$861,056	$901,887	$943,944	$987,262	$1,031,880	$1,077,837	$1,125,172	$1,173,927	$1,224,145	$1,275,869	$1,329,145	$1,384,019	$1,440,540
20																	
21	Taxes (20%)		$156,585	$164,283	$172,211	$180,377	$188,789	$197,452	$206,376	$215,567	$225,034	$234,785	$244,829	$255,174	$265,829	$276,804	$288,108
22																	
23	Income After Tax		$626,340	$657,131	$688,845	$721,510	$755,155	$789,810	$825,504	$862,269	$900,137	$939,142	$979,316	$1,020,695	$1,063,316	$1,107,216	$1,152,432
24	(Add Back Non-cash Depreciation)		$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000
25	Cash Flow	-$7,500,000	$1,126,340	$1,157,131	$1,188,845	$1,221,510	$1,255,155	$1,289,810	$1,325,504	$1,362,269	$1,400,137	$1,439,142	$1,479,316	$1,520,695	$1,563,316	$1,607,216	$1,652,432
26	Discounted Cash Flow	-$7,500,000	$979,426	$874,957	$781,685	$698,402	$624,034	$557,620	$498,306	$445,328	$398,006	$355,734	$317,969	$284,229	$254,083	$227,146	$203,075
27	Cumulative Disc. Cash Flow	-$7,500,000	-$6,520,574	-$5,645,616	-$4,863,932	-$4,165,530	-$3,541,496	-$2,983,875	-$2,485,569	-$2,040,241	-$1,642,234	-$1,286,501	-$968,532	-$684,303	-$430,220	-$203,075	$0

	INPUTS	VALUES
1	Investment per Annual Gallon	$2.50
4	Product Annual Escallation Rate =	3%
5	Feedstock Annual Escallation Rate =	3%
12-14	Processing Annual Escallation Rate =	3%
26	Annual Discount Rate (IRR) =	15%

Financial Analysis for 3 Million Gallons per Year Biodiesel Without Taxes

	Item	YEAR 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Initial Investment	$7,500,000															
2																	
3																	
4	Product Value per Gal. Biodiesel		$3.65	$3.76	$3.87	$3.99	$4.11	$4.23	$4.36	$4.49	$4.62	$4.76	$4.91	$5.05	$5.20	$5.36	$5.52
5	Feedstock Cost per Gallon		$2.73	$2.82	$2.90	$2.99	$3.08	$3.17	$3.26	$3.36	$3.46	$3.57	$3.67	$3.78	$3.90	$4.02	$4.14
6	Biodiesel Sales		$10,950,000	$11,278,500	$11,616,855	$11,965,361	$12,324,321	$12,694,051	$13,074,873	$13,467,119	$13,871,132	$14,287,266	$14,715,884	$15,157,361	$15,612,082	$16,080,444	$16,562,857
7	Feedstock cost @1.02 gal/gal prod.		$8,367,074	$8,618,087	$8,876,629	$9,142,928	$9,417,216	$9,699,732	$9,990,724	$10,290,446	$10,599,160	$10,917,134	$11,244,648	$11,581,988	$11,929,447	$12,287,331	$12,655,951
8	Gross Margin		$2,582,926	$2,660,413	$2,740,226	$2,822,433	$2,907,105	$2,994,319	$3,084,148	$3,176,673	$3,271,973	$3,370,132	$3,471,236	$3,575,373	$3,682,634	$3,793,113	$3,906,907
9	Gross margin per gallon		$0.86	$0.89	$0.91	$0.94	$0.97	$1.00	$1.03	$1.06	$1.09	$1.12	$1.16	$1.19	$1.23	$1.26	$1.30
10																	
11	Processing Cost																
12	Methanol and other reagents @ $0.25/ Gal.		$750,000	$772,500	$795,675	$819,545	$844,132	$869,456	$895,539	$922,405	$950,078	$978,580	$1,007,937	$1,038,175	$1,069,321	$1,101,400	$1,134,442
13	Other Plant Operating Cost @ $0.15/Gal.		$450,000	$463,500	$477,405	$491,727	$506,479	$521,673	$537,324	$553,443	$570,047	$587,148	$604,762	$622,905	$641,592	$660,840	$680,665
14	SG&A		$100,000	$103,000	$106,090	$109,273	$112,551	$115,927	$119,405	$122,987	$126,677	$130,477	$134,392	$138,423	$142,576	$146,853	$151,259
15	Total Processing Cost		$1,300,000	$1,339,000	$1,379,170	$1,420,545	$1,463,161	$1,507,056	$1,552,268	$1,598,836	$1,646,801	$1,696,205	$1,747,091	$1,799,504	$1,853,489	$1,909,094	$1,966,367
16																	
17	Depreciation (15 year)		$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000
18																	
19	Net Income		$782,926	$821,413	$861,056	$901,887	$943,944	$987,262	$1,031,880	$1,077,837	$1,125,172	$1,173,927	$1,224,145	$1,275,869	$1,329,145	$1,384,019	$1,440,540
20																	
21	Taxes (20%)		$156,585	$164,283	$172,211	$180,377	$188,789	$197,452	$206,376	$215,567	$225,034	$234,785	$244,829	$255,174	$265,829	$276,804	$288,108
22																	
23	Income After Tax		$626,340	$657,131	$688,845	$721,510	$755,155	$789,810	$825,504	$862,269	$900,137	$939,142	$979,316	$1,020,695	$1,063,316	$1,107,216	$1,152,432
24	(Add Back Non-cash Depreciation)		$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000	$500,000
25	Cash Flow	-$7,500,000	$1,126,340	$1,157,131	$1,188,845	$1,221,510	$1,255,155	$1,289,810	$1,325,504	$1,362,269	$1,400,137	$1,439,142	$1,479,316	$1,520,695	$1,563,316	$1,607,216	$1,652,432
26	Discounted Cash Flow	-$7,500,000	$979,426	$874,957	$781,685	$698,402	$624,034	$557,620	$498,306	$445,328	$398,006	$355,734	$317,969	$284,229	$254,083	$227,146	$203,075
27	Cumulative Disc. Cash Flow	-$7,500,000	-$6,520,574	-$5,645,616	-$4,863,932	-$4,165,530	-$3,541,496	-$2,983,875	-$2,485,569	-$2,040,241	-$1,642,234	-$1,286,501	-$968,532	-$684,303	-$430,220	-$203,075	$0

	INPUTS	VALUES
1	Investment per Annual Gallon	$2.50
4	Product Annual Escallation Rate =	3%
5	Feedstock Annual Escallation Rate =	3%
12-14	Processing Annual Escallation Rate =	3%
26	Annual Discount Rate (IRR) =	15%

Financial Analysis for 15 Million Gallons per Year Biodiesel With Taxes

	Item	YEAR 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Initial Investment	$15,000,000															
2																	
3																	
4	Product Value per Gal. Biodiesel		$2.57	$2.65	$2.73	$2.81	$2.89	$2.98	$3.07	$3.16	$3.26	$3.36	$3.46	$3.56	$3.67	$3.78	$3.89
5	Feedstock Cost per Gallon		$1.93	$1.99	$2.05	$2.11	$2.17	$2.24	$2.30	$2.37	$2.44	$2.52	$2.59	$2.67	$2.75	$2.83	$2.92
6	Biodiesel Sales		$38,574,550	$39,731,786	$40,923,740	$42,151,452	$43,415,996	$44,718,476	$46,060,030	$47,441,831	$48,865,086	$50,331,038	$51,840,970	$53,396,199	$54,998,085	$56,648,027	$58,347,468
7	Feedstock cost @1.02 gal/gal prod.		$29,508,699	$30,393,960	$31,305,779	$32,244,952	$33,212,301	$34,208,670	$35,234,930	$36,291,978	$37,380,737	$38,502,159	$39,657,224	$40,846,940	$42,072,349	$43,334,519	$44,634,555
8	Gross Margin		$9,065,851	$9,337,827	$9,617,961	$9,906,500	$10,203,695	$10,509,806	$10,825,100	$11,149,853	$11,484,349	$11,828,879	$12,183,746	$12,549,258	$12,925,736	$13,313,508	$13,712,913
9	Gross margin per gallon		$0.60	$0.62	$0.64	$0.66	$0.68	$0.70	$0.72	$0.74	$0.77	$0.79	$0.81	$0.84	$0.86	$0.89	$0.91
10																	
11	Processing Cost																
12	Methanol and other reagents @ $0.25/ Gal.		$3,750,000	$3,862,500	$3,978,375	$4,097,726	$4,220,658	$4,347,278	$4,477,696	$4,612,027	$4,750,388	$4,892,899	$5,039,686	$5,190,877	$5,346,603	$5,507,001	$5,672,211
13	Other Plant Operating Cost @ $0.15/Gal.		$2,250,000	$2,317,500	$2,387,025	$2,458,636	$2,532,395	$2,608,367	$2,686,618	$2,767,216	$2,850,233	$2,935,740	$3,023,812	$3,114,526	$3,207,962	$3,304,201	$3,403,327
14	SG&A		$500,000	$515,000	$530,450	$546,364	$562,754	$579,637	$597,026	$614,937	$633,385	$652,387	$671,958	$692,117	$712,880	$734,267	$756,295
15	Total Processing Cost		$6,500,000	$6,695,000	$6,895,850	$7,102,726	$7,315,807	$7,535,281	$7,761,340	$7,994,180	$8,234,006	$8,481,026	$8,735,456	$8,997,520	$9,267,446	$9,545,469	$9,831,833
16																	
17	Depreciation (15 year)		$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000
18																	
19	Net Income		$1,565,851	$1,642,827	$1,722,111	$1,803,775	$1,887,888	$1,974,525	$2,063,760	$2,155,673	$2,250,343	$2,347,854	$2,448,289	$2,551,738	$2,658,290	$2,768,039	$2,881,080
20																	
21	Taxes (20%)		$313,170	$328,565	$344,422	$360,755	$377,578	$394,905	$412,752	$431,135	$450,069	$469,571	$489,658	$510,348	$531,658	$553,608	$576,216
22																	
23	Income After Tax		$1,252,681	$1,314,261	$1,377,689	$1,443,020	$1,510,310	$1,579,620	$1,651,008	$1,724,539	$1,800,275	$1,878,283	$1,958,631	$2,041,390	$2,126,632	$2,214,431	$2,304,864
24	(Add Back Non-cash Depreciation)		$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000
25	Cash Flow	-$15,000,000	$2,252,681	$2,314,261	$2,377,689	$2,443,020	$2,510,310	$2,579,620	$2,651,008	$2,724,539	$2,800,275	$2,878,283	$2,958,631	$3,041,390	$3,126,632	$3,214,431	$3,304,864
26	Discounted Cash Flow	-$15,000,000	$1,958,853	$1,749,914	$1,563,369	$1,396,805	$1,248,068	$1,115,241	$996,612	$890,657	$796,013	$711,468	$635,938	$568,458	$508,165	$454,291	$406,150
27	Cumulative Disc. Cash Flow	-$15,000,000	-$13,041,147	-$11,291,233	-$9,727,864	-$8,331,059	-$7,082,991	-$5,967,750	-$4,971,138	-$4,080,482	-$3,284,469	-$2,573,001	-$1,937,064	-$1,368,606	-$860,441	-$406,150	$0

	INPUTS	VALUES
1	Investment per Annual Gallon	$1.00
4	Product Annual Escallation Rate =	3%
5	Feedstock Annual Escallation Rate =	3%
12-14	Processing Annual Escallation Rate =	3%
26	Annual Discount Rate (IRR) =	15%

Financial Analysis for 15 Million Gallons per Year Biodiesel Without Taxes

	Item	YEAR 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Initial Investment	$15,000,000															
2																	
3																	
4	Product Value per Gal. Biodiesel		$3.65	$3.76	$3.87	$3.99	$4.11	$4.23	$4.36	$4.49	$4.62	$4.76	$4.91	$5.05	$5.20	$5.36	$5.52
5	Feedstock Cost per Gallon		$2.99	$3.08	$3.17	$3.26	$3.36	$3.46	$3.57	$3.67	$3.78	$3.90	$4.01	$4.13	$4.26	$4.38	$4.52
6	Biodiesel Sales		$54,750,000	$56,392,500	$58,084,275	$59,826,803	$61,621,607	$63,470,256	$65,374,363	$67,335,594	$69,355,662	$71,436,332	$73,579,422	$75,786,804	$78,060,409	$80,402,221	$82,814,287
7	Feedstock cost @1.02 gal/gal prod.		$45,684,149	$47,054,673	$48,466,314	$49,920,303	$51,417,912	$52,960,449	$54,549,263	$56,185,741	$57,871,313	$59,607,452	$61,395,676	$63,237,546	$65,134,673	$67,088,713	$69,101,374
8	Gross Margin		$9,065,851	$9,337,827	$9,617,961	$9,906,500	$10,203,695	$10,509,806	$10,825,100	$11,149,853	$11,484,349	$11,828,879	$12,183,746	$12,549,258	$12,925,736	$13,313,508	$13,712,913
9	Gross margin per gallon		$0.60	$0.62	$0.64	$0.66	$0.68	$0.70	$0.72	$0.74	$0.77	$0.79	$0.81	$0.84	$0.86	$0.89	$0.91
10																	
11	Processing Cost																
12	Methanol and other reagents @ $0.25/ Gal.		$3,750,000	$3,862,500	$3,978,375	$4,097,726	$4,220,658	$4,347,278	$4,477,696	$4,612,027	$4,750,388	$4,892,899	$5,039,686	$5,190,877	$5,346,603	$5,507,001	$5,672,211
13	Other Plant Operating Cost @ $0.15/Gal.		$2,250,000	$2,317,500	$2,387,025	$2,458,636	$2,532,395	$2,608,367	$2,686,618	$2,767,216	$2,850,233	$2,935,740	$3,023,812	$3,114,526	$3,207,962	$3,304,201	$3,403,327
14	SG&A		$500,000	$515,000	$530,450	$546,364	$562,754	$579,637	$597,026	$614,937	$633,385	$652,387	$671,958	$692,117	$712,880	$734,267	$756,295
15	Total Processing Cost		$6,500,000	$6,695,000	$6,895,850	$7,102,726	$7,315,807	$7,535,281	$7,761,340	$7,994,180	$8,234,006	$8,481,026	$8,735,456	$8,997,520	$9,267,446	$9,545,469	$9,831,833
16																	
17	Depreciation (15 year)		$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000
18																	
19	Net Income		$1,565,851	$1,642,827	$1,722,111	$1,803,775	$1,887,888	$1,974,525	$2,063,760	$2,155,673	$2,250,343	$2,347,854	$2,448,289	$2,551,738	$2,658,290	$2,768,039	$2,881,080
20																	
21	Taxes (20%)		$313,170	$328,565	$344,422	$360,755	$377,578	$394,905	$412,752	$431,135	$450,069	$469,571	$489,658	$510,348	$531,658	$553,608	$576,216
22																	
23	Income After Tax		$1,252,681	$1,314,261	$1,377,689	$1,443,020	$1,510,310	$1,579,620	$1,651,008	$1,724,539	$1,800,275	$1,878,283	$1,958,631	$2,041,390	$2,126,632	$2,214,431	$2,304,864
24	(Add Back Non-cash Depreciation)		$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$1,000,000
25	Cash Flow	-$15,000,000	$2,252,681	$2,314,261	$2,377,689	$2,443,020	$2,510,310	$2,579,620	$2,651,008	$2,724,539	$2,800,275	$2,878,283	$2,958,631	$3,041,390	$3,126,632	$3,214,431	$3,304,864
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	INPUTS	VALUES
1	Investment per Annual Gallon	$1.00
4	Product Annual Escallation Rate =	3%
5	Feedstock Annual Escallation Rate =	3%
12-14	Processing Annual Escallation Rate =	3%
26	Annual Discount Rate (IRR) =	15%

ANNEX III
Jamaica Biofuels Implementation Plan

After completion of a preliminary feasibility study and publication of a government policy, crucial steps remain to be taken to bring into being an economically viable and self-sustaining biofuels industry in Jamaica. Success will depend on a variety of actors outside the government, and the Ministry of Energy and Mining took the first step to engage the private sector at a workshop on November 23, 2010 in Kingston. Part of the discussion at the session concerned remaining actions required for development of a biofuels sector, and the deliberations provided a starting point for a series of steps described below. The necessary actions fall into six main groups: engagement of institutions and enterprises outside the government; public information and outreach (described separately); in-depth conceptual engineering design and financial feasibility studies; technology identification, screening and application; establishment of financing mechanisms; negotiation of prices acceptable to all parties for harvested sugar cane, independent electric power from sugar mills, and biodiesel feedstocks; and project implementation. An illustrative schedule, covering a five-year time frame, appears at the end of this annex.

Institutional Engagement

The successful formulation of a policy and the November workshop provide an opportunity to expand the existing Biofuels Task Force with broader membership to address implementation challenges. Added members, beyond those currently represented, should include sugar estate owners, the Sugar Divestment Enterprise, All-Island Jamaica Cane Farmers Association, Jamaica Cane Products Sales, Ltd., Ministry of Industry, Development Bank of Jamaica, Agricultural Support Services Project, Petrojam, Ltd., JB Ethanol, Jamaica Manufacturers' Association, Jamaica Promotions Corporation, Jamaica Public Service Co., and the Office of Utility Regulation. The list is not exclusive; others may be important to add as well.

In addition to an elected chairperson, such an expanded task force would benefit from a full-time coordinator, perhaps assigned from the staff of the Ministry of Energy and Mining. Among the roles the group could assume would be to identify needs for any future studies and oversee them, resolve disagreements and conflicts, coordinate members' independent activities, and monitor and report progress towards a biofuels industry. It could also conduct a public information and outreach effort, based on a plan developed separately, including public meetings and other means of communication with stakeholders.

The task force may also benefit from the formation of working groups or committees to address specific opportunities and challenges. For example, a sugar cane working group might be able to advance aspects of cane and ethanol production expeditiously without requiring participation of the rest of the members at the same level of activity. Another group might focus on how to advance the introduction of oil crops, looking at the main areas of crop selection and production, as well as at business models that could provide the framework for a commercially viable sub-sector for this biofuel.

Finally, the challenges of creating a biofuels industry are not unique to Jamaica. Many countries have successfully implemented programs to encourage sugar mills to become more energy efficient and sell surplus electricity to the grid, and some have established commercially successful domestic liquid biofuels programs. Other countries have been less successful, and biofuel programs have not thrived. With access to the experiences of countries that have been successful, as well as to those who have not, the task force can take advantage of valuable sources of "lessons learned" and guides to paths most likely to lead to success.

Research and Technology Surveillance

In order to take maximum advantage of the best available technology for growing feedstocks and processing them economically under Jamaican conditions, farmers and producers need access to expertise. Jamaica already has significant scientific and technical resources in the University of the West Indies, University of Technology and Sugar Industry Research Institute (SIRI), and the Center of Excellence for Renewable Energy (CERE), all of which are represented on the existing task force. Workshop participants recommended expanding SIRI's role to encompass other energy crops besides sugar cane, e.g., woody or oleaginous plants, with financial support from other sources to supplement the sugar industry funding, on which the institute currently depends. This would provide a source of scientific knowledge and a conduit for disseminating information derived from research activities, like the ongoing agronomic trials for *Jatropha curcas* under the auspices of the PCJ's CERE.

The task force might also consider seeking assistance with building technological capacity by promoting access to expertise through study tours and other activities aimed at transferring skills needed to take maximum advantage of any investment in modern processing facilities. Technical exchanges could help Jamaican professionals better configure and operate new mills for low process energy consumption to maximize sales of electricity, for example, plan and manage biomass fuel and feedstock cultivation so as to maximize operating time or take advantage of energy crops to generate power year-round.

Another workshop recommendation was to foster closer relationships between an expanded SIRI and the universities, where additional expertise resides but is not readily accessible to biofuel farmers and producers. An improved linkage would serve to identify real-world scientific challenges for faculty to address and at the same time, provide an efficient mechanism for applying results of their research in the field. University research focused on biofuels could possibly attract grant support from a variety of international sources, and with a level of core activity, faculty would be in a position to offer informed general advice and help on identification, screening and selection of alternative technologies and approaches from vendors and other sources outside of Jamaica.

In-Depth Project Feasibility Studies
In order to attract capital and secure government support for cane energy projects, especially, decision-makers will need the results of in-depth feasibility analysis of specific investment prospects. Studies at three prospective locations would likely be sufficient, covering at a minimum, options for sugar production and electric cogeneration without ethanol, production of ethanol and electricity alone, and flexible co-production of sugar, molasses, ethanol and electric power following the Brazilian model. The feasibility studies should include conceptual system designs, identification and sizing of major components, energy and mass balances, capital and operating costs, and revenue requirements.

Candidate mill sites could be selected on the basis of owner and management interest and willingness to cooperate with the studies, share costs, and proceed with projects if the results are favorable. Outside financial support would no doubt be needed for the studies, and the first step, perhaps to be undertaken by the task force, would be to secure grant support from interested entities like the Organization of American States, the Inter-American Development Bank, or the European Union.

If successful, the studies will identify and document viable investment opportunities, leading to financing, construction, and operation of new biofuel facilities in succeeding months (See Project Implementation below). At the same time, they will serve as concrete indications of the specific impacts of these facilities for policy makers.

Biofuels Financing
Expanding biofuels production will require substantial investments of capital in agricultural production and processing facilities. Under some circumstances, non-recourse project financing by foreign investors is a possibility, but not without firm raw material and product off-take agreements, which are unlikely in Jamaica, where among other things, the law prohibits exclusivity for domestic ethanol for fuel blending. While individual sugar estate owners may be able to raise capital on the strength of their own balance sheets, small farmers and other prospective biofuel enterprises may be too small or weak financially.

One way to address capital availability would be to establish a biofuels investment fund in Jamaica with the capability to lend to individual ventures and to attract and pool capital from private investors wishing to diversify their exposure within the sector, interested philanthropic foundations, the private sector windows of multilateral development banks, and other similar entities. The fund could then make loans to developers and farmers on terms appropriate to their projects, accompanied by technical expertise from SIRI and others. In the case of small farmers, loans could take the form of services and equipment to upgrade their productivity, to be repaid out of product sales.

Another role the fund could play would be to manage a price stabilization arrangement for fuels, similar to one that existed for sugar prior to privatization of The Sugar Corporation of Jamaica. When biofuel prices are high, a portion of sales proceeds could be set aside to support prices when they are too low to amortize investments in production. In that way, the fund would provide a hedge against investors' risk of fluctuations in world oil prices.

A funding mechanism along these lines would not have to be built in Jamaica from scratch. The country already counts on the Development Bank of Jamaica and the Agricultural Support Services Project, institutions that could play key roles in establishing and administering it.

Feedstock and Electricity Pricing

Two issues that arose in the formulation of the biofuels policy were pricing arrangements for sugar cane produced by independent farmers and for independent power exported to the electrical grid by processing installations. Although the feasibility study could estimate the costs and benefits of biofuel production, such an analysis cannot readily determine how the achievable benefits should be divided among interested parties. For example, the study estimated that, at least in the case of cogeneration at one Jamaican sugar mill, a price of $0.15 per kWh for cogenerated electricity would result in an annual return of approximately 15 percent. The study also estimated that the value of electricity to the national grid, expressed as avoided cost, was between $0.20 and $0.25 per kWh. Whether a return of 15% is sufficient to result in equity being invested in a new biofuel cogeneration plant, and how the potential net benefit of $0.05 to $0.10 per kWh should be distributed among the investor, the utility rate payer, and the public service company remains to be determined, presumably through negotiations among prospective producers, Jamaica Public Service, and the Office of Utility Regulation.

Similarly, cane prices paid to farmers by sugar mills have been based historically on the production of granular sugar and do not reflect any additional benefits associated with bioethanol or energy sales. As the sector become more multi-product oriented, a more sophisticated payment model will be needed to incentivize farmers to provide sugar mills with feedstock that maximizes overall value. These pricing arrangements will require negotiation between the cane growers and the sugar mill estates and possibly others.

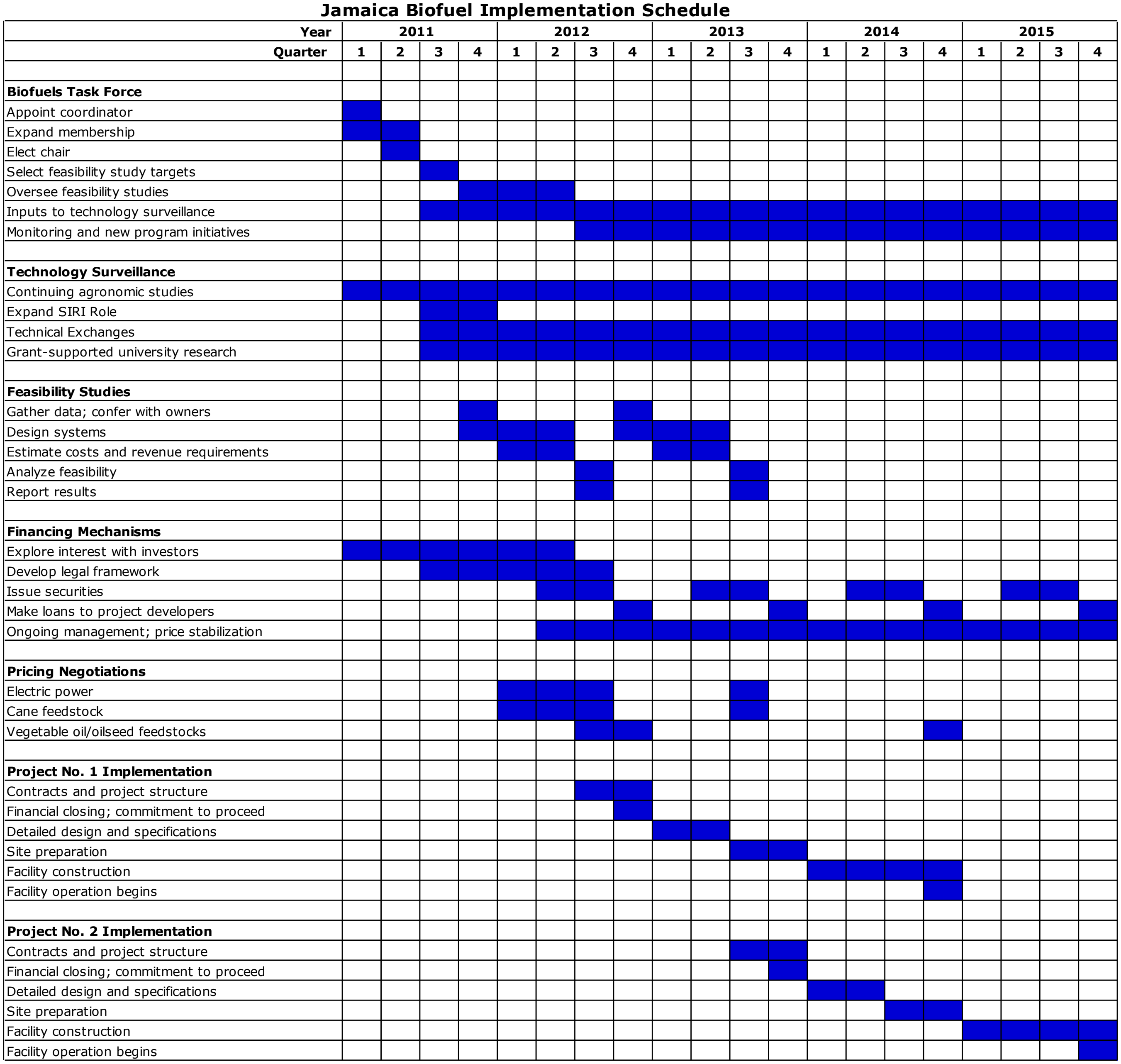
Finally, the study estimates based on Brazilian experience that biodiesel from plants like castor, and by extension jatropha, are unlikely to be produced economically without some form of subsidy. Such a subsidy may be justified as a means to slow urban migration or as an offset against other costs associated with rural poverty. How such a subsidy, if justified, might operate, and at what level is another feedstock price-related subject for agreement among the government and other parties involved in any prospective biodiesel industry.

An expanded biofuels task force could play a key role in identifying the parties, bringing them together, and providing a neutral forum for resolving differences and reaching agreement on how to distribute the benefits of biofuel ventures. The result would be to enlist the cooperation of all parties, so projects can move forward.

Project Implementation

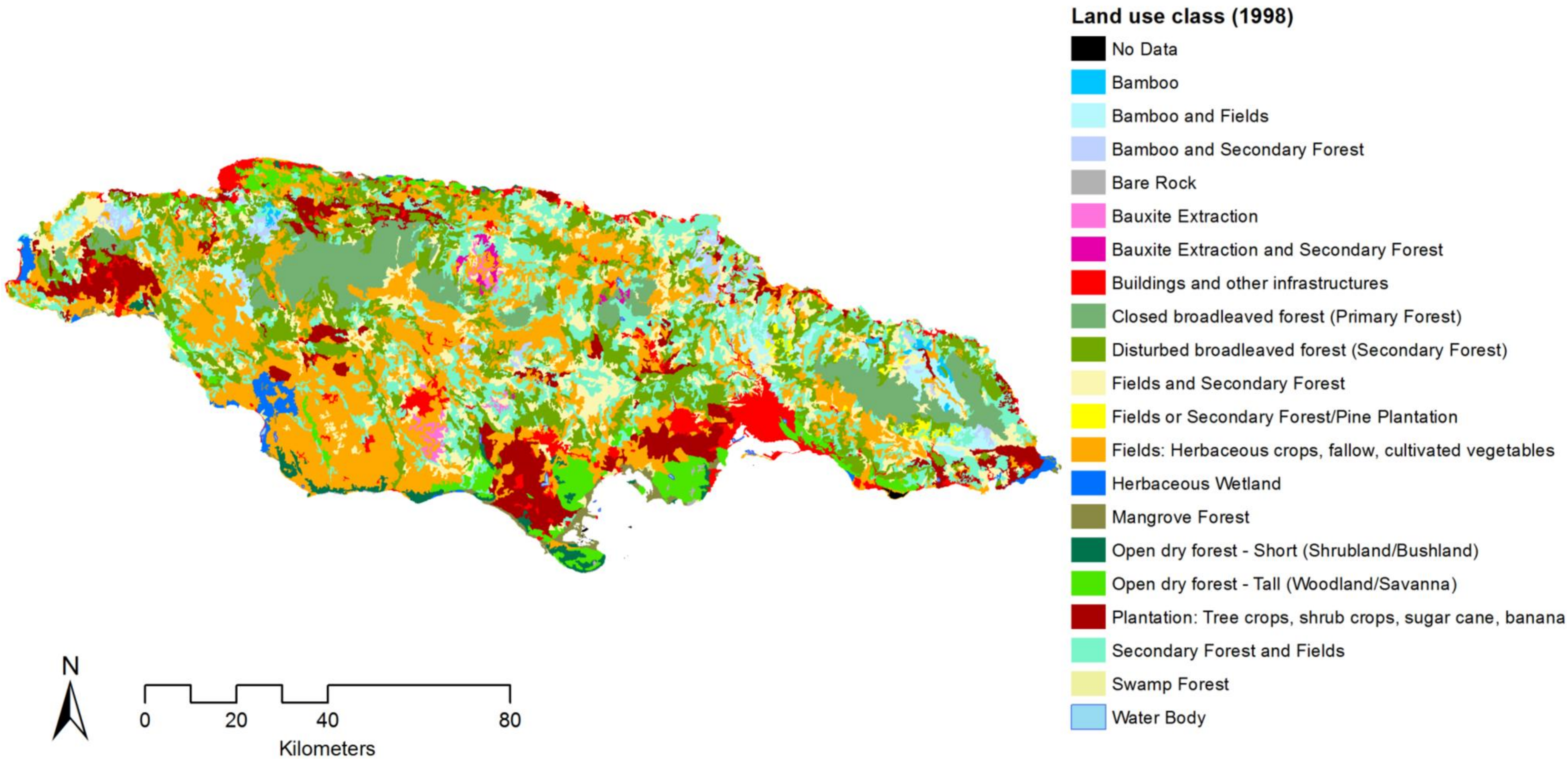
Task Force activities will focus on establishing the basis for project implementation and facilitating ensuing activity, which will be largely led by the private sector. If the feasibility studies' results are positive, pricing negotiations are successful, public support is forthcoming, and a financing mechanism comes into being, project developers should be in a position to move forward with major investments in biofuel facilities. The next steps would include final contractual and financing arrangements, detailed design and bid preparation, site preparation, facility construction and shakedown, and commencement of operation.

Jamaica Biofuel Implementation Schedule



ANNEX IV

Land Use Maps (1998) from the Forestry Department, Jamaica Ministry of Agriculture

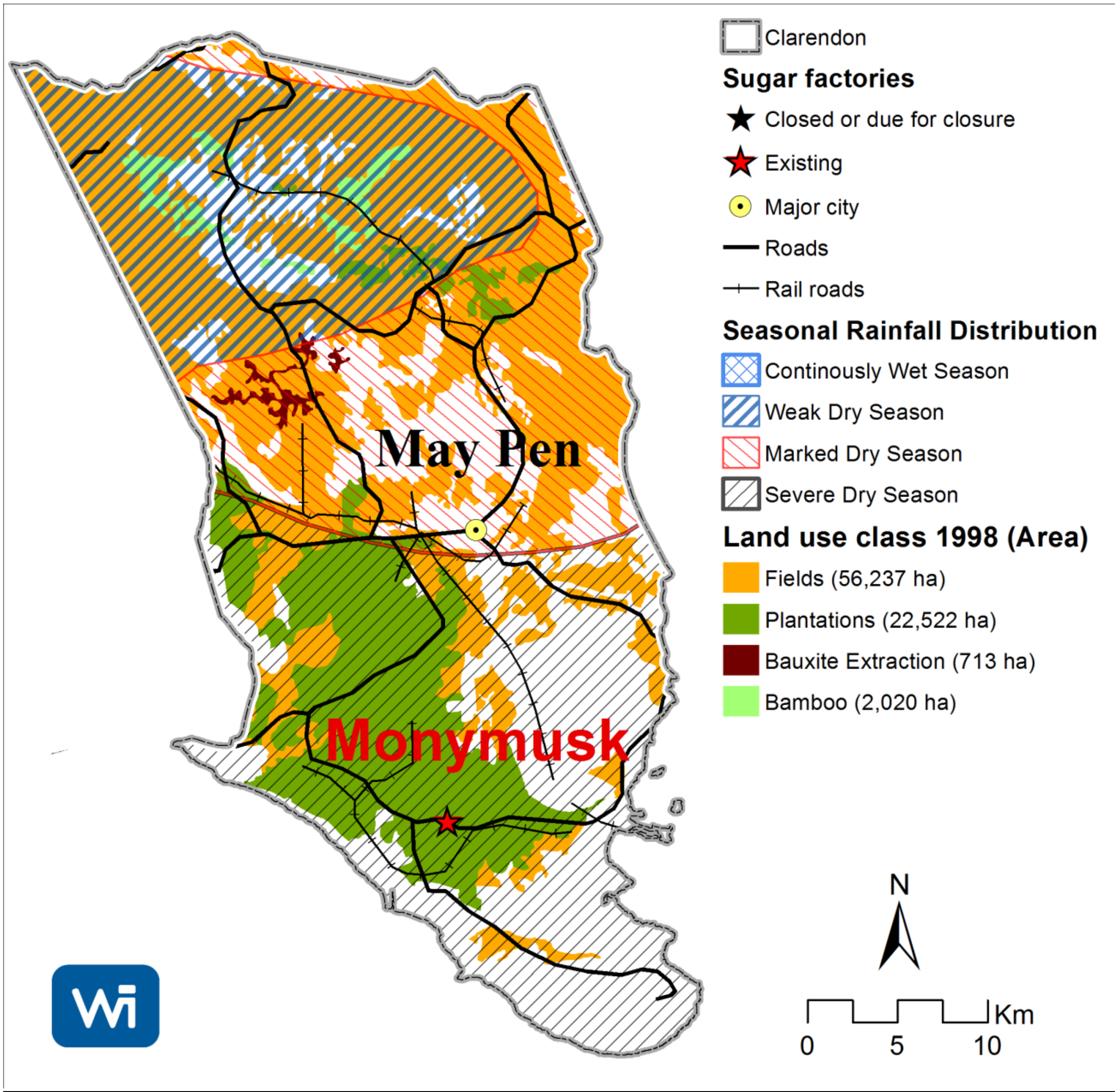


This table summarizes the area (ha) of each of the land use classes represented in the 1998 land use map for Jamaica. (Details in parish table and maps that follow)

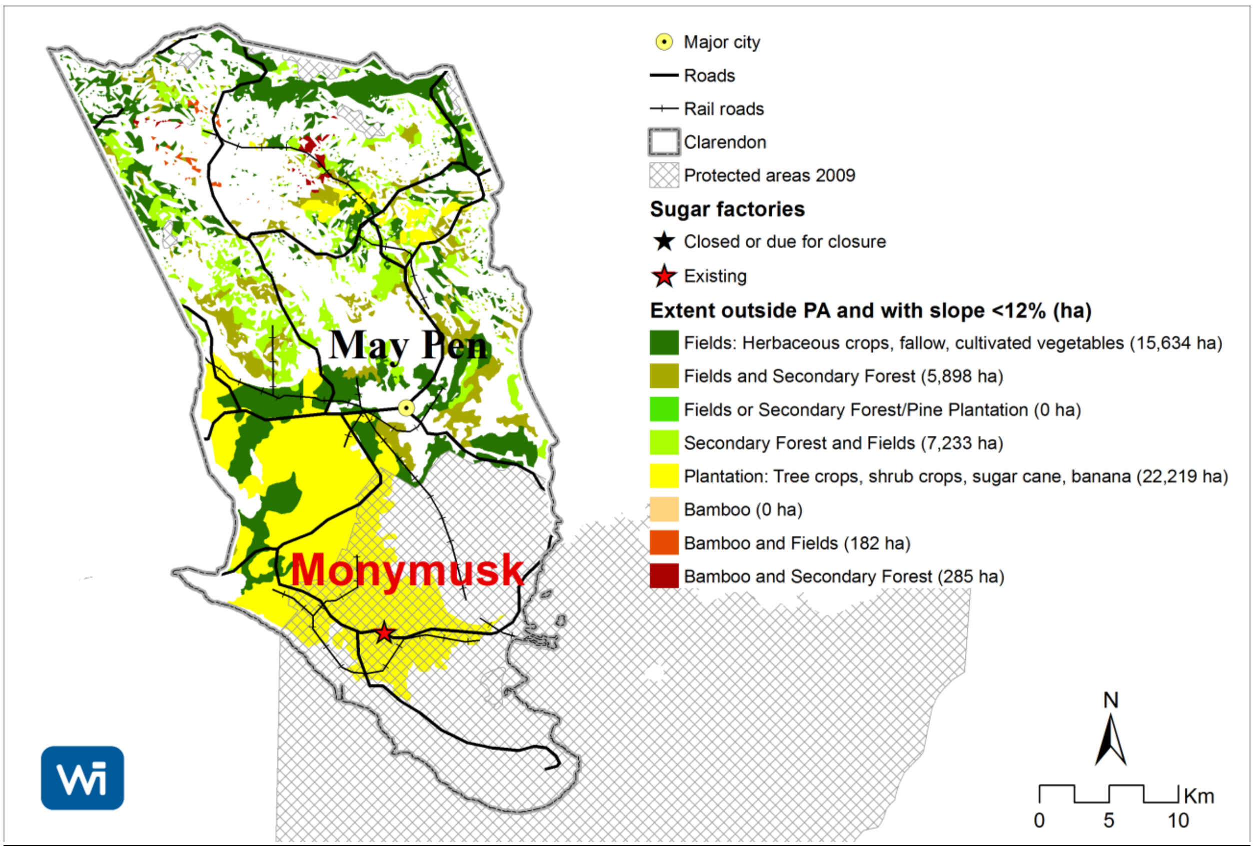
Land use category (1998)	Area (ha)
Bamboo	2,980
Bamboo and Fields	29,429
Bamboo and Secondary Forest	13,481
Bare Rock	934
Bauxite Extraction	5,104
Bauxite Extraction and Secondary Forest	2,819
Buildings and other infrastructures	52,292
Closed broadleaved forest (Primary Forest)	89,448
Disturbed broadleaved forest (Secondary Forest)	185,056
Fields and Secondary Forest	120,536
Fields or Secondary Forest/Pine Plantation	4,287
Fields: Herbaceous crops, fallow, cultivated vegetables	292,676
Herbaceous Wetland	12,785
Mangrove Forest	9,764
Open dry forest - Short (Shrubland/Bushland)	12,262
Open dry forest - Tall (Woodland/Savanna)	43,310
Plantation: Tree crops, shrub crops, sugar cane, banana	87,199
Secondary Forest and Fields	168,333
Swamp Forest	2,247
Water Body	1,070
No data	680

Area (ha) for disaggregated land use categories outside of protected areas with slopes <12% (Maps Figure 2)							
Parish **Land Use Category**	**Clarendon**	**Hanover**	**Man-chester**	**Portland**	**Saint Andrew**	**Saint Ann**	**Saint Catherine**
Fields: Herbaceous crops, fallow, cultivated vegetables	15,634	6,533	22,951	1,574	1,361	27,551	13,153
Fields and Secondary Forest	5,898	5,885	7,527	1,899	1,299	8,867	8,341
Fields or Secondary Forest/Pine Plantation	0	0	0	32	1	0	0
Secondary Forest and Fields	7,233	1,971	8,556	3,872	690	17,259	11,512
Plantation: Tree crops, shrub crops, sugar cane, banana	22,219	1,267	198	1,428	77	660	13,635
Bamboo	0	79	0	262	0	0	0
Bamboo and Fields	182	2,209	14	810	382	30	35
Bamboo and Secondary Forest	285	1,367	0	89	0	0	0

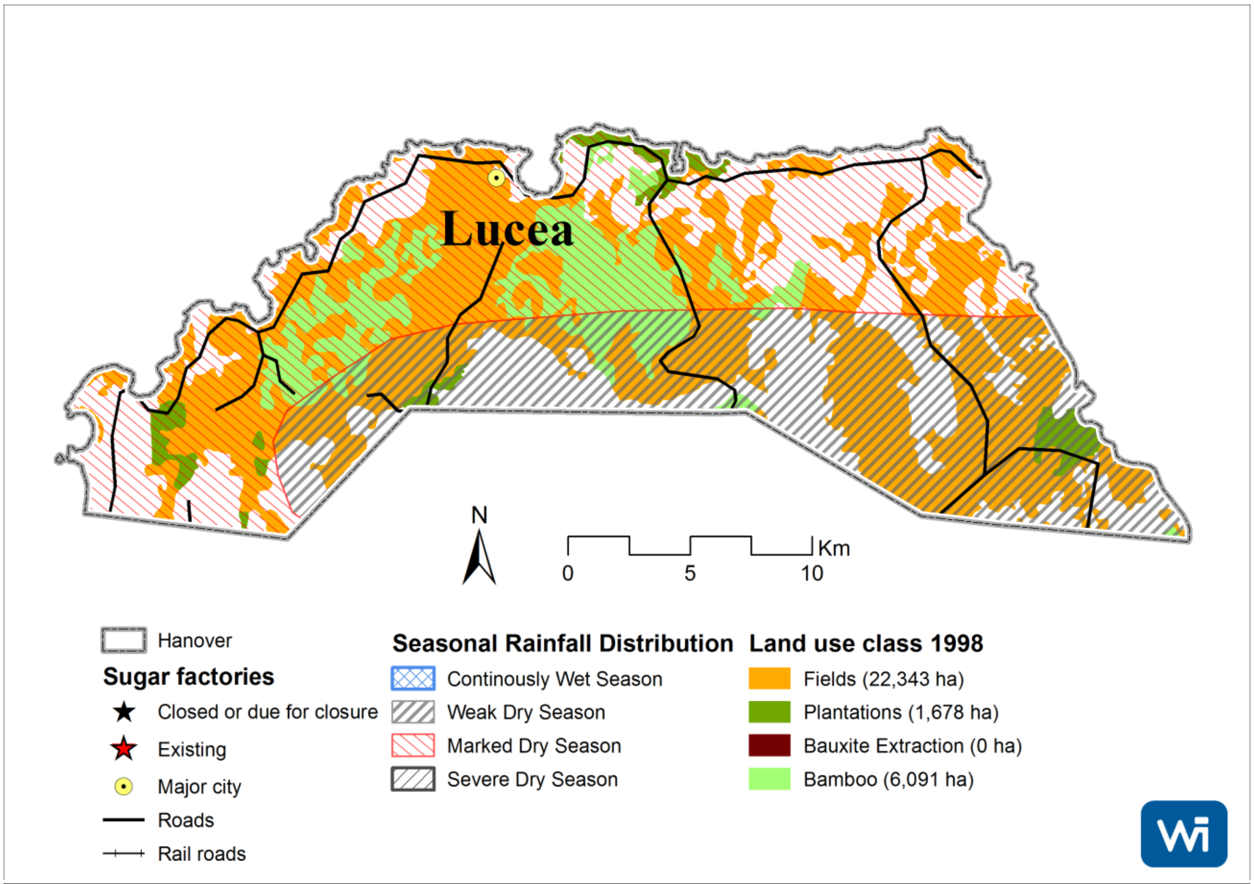
Parish **Land Use Category**	**Saint Elizabeth**	**Saint James**	**Saint Mary**	**Saint Thomas**	**Trelawny**	**Westmoreland**	
Fields: Herbaceous crops, fallow, cultivated vegetables	60,191	7,839	4,719	3,801	9,986	19,952	
Fields and Secondary Forest	3,240	1,864	5,323	4,941	1,824	3,138	
Fields or Secondary Forest/Pine Plantation	0	0	2	23	0	0	
Secondary Forest and Fields	5,597	2,488	6,645	4,046	3,677	5,967	
Plantation: Tree crops, shrub crops, sugar cane, banana	5,015	2,481	2,279	8,804	5,879	15,664	
Bamboo	0	510	0	0	0	0	
Bamboo and Fields	163	2,006	831	564	55	1,419	
Bamboo and Secondary Forest	0	1,157	2,962	37	0	5	



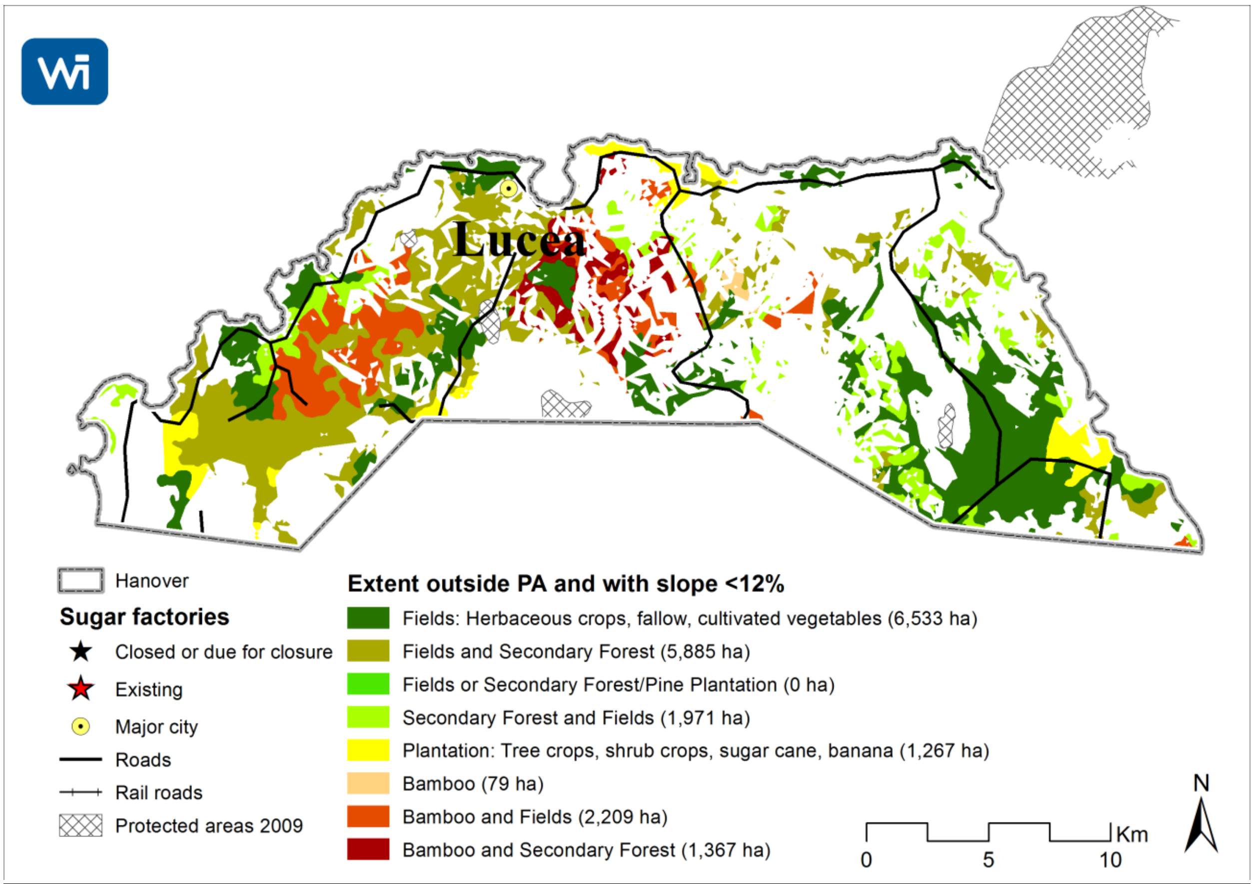
Clarendon Figure 1



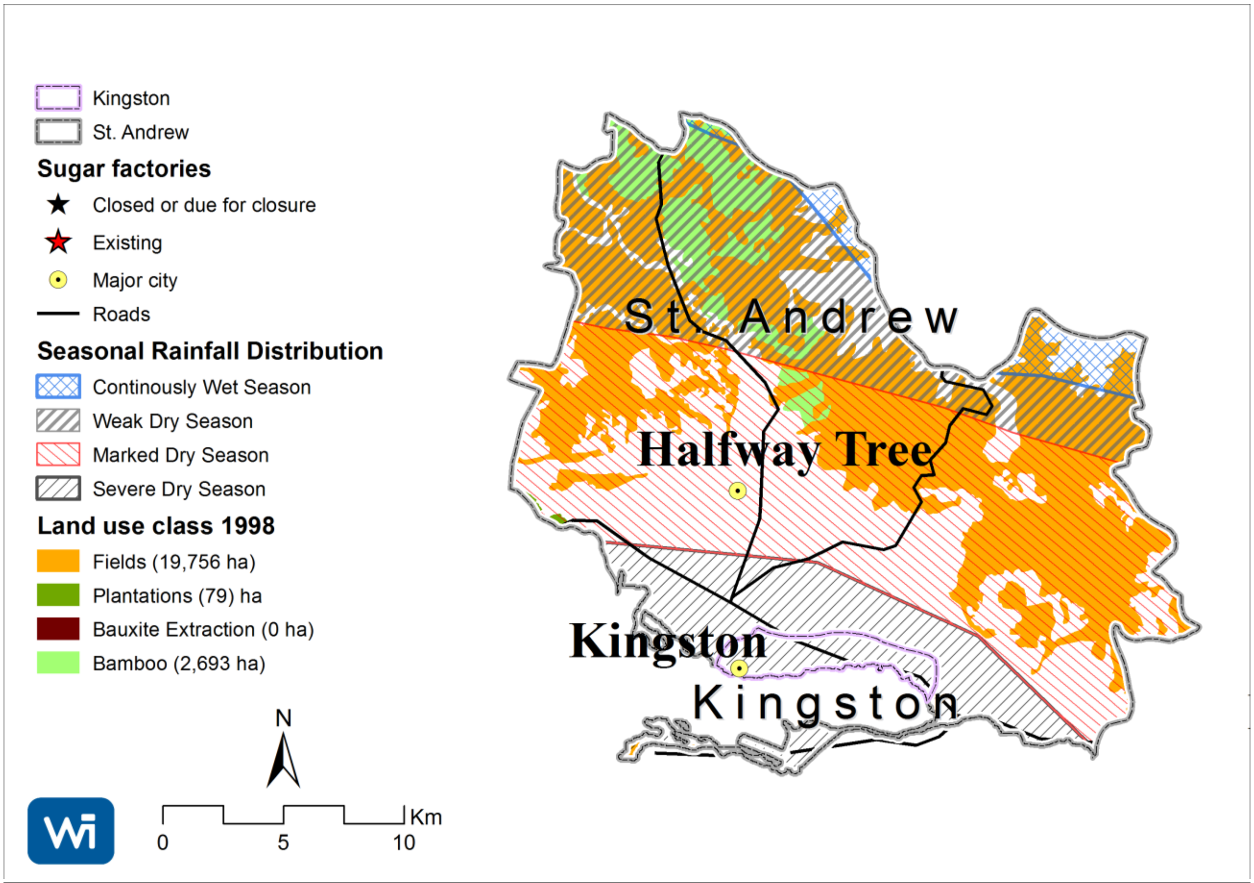
Clarendon Figure 2



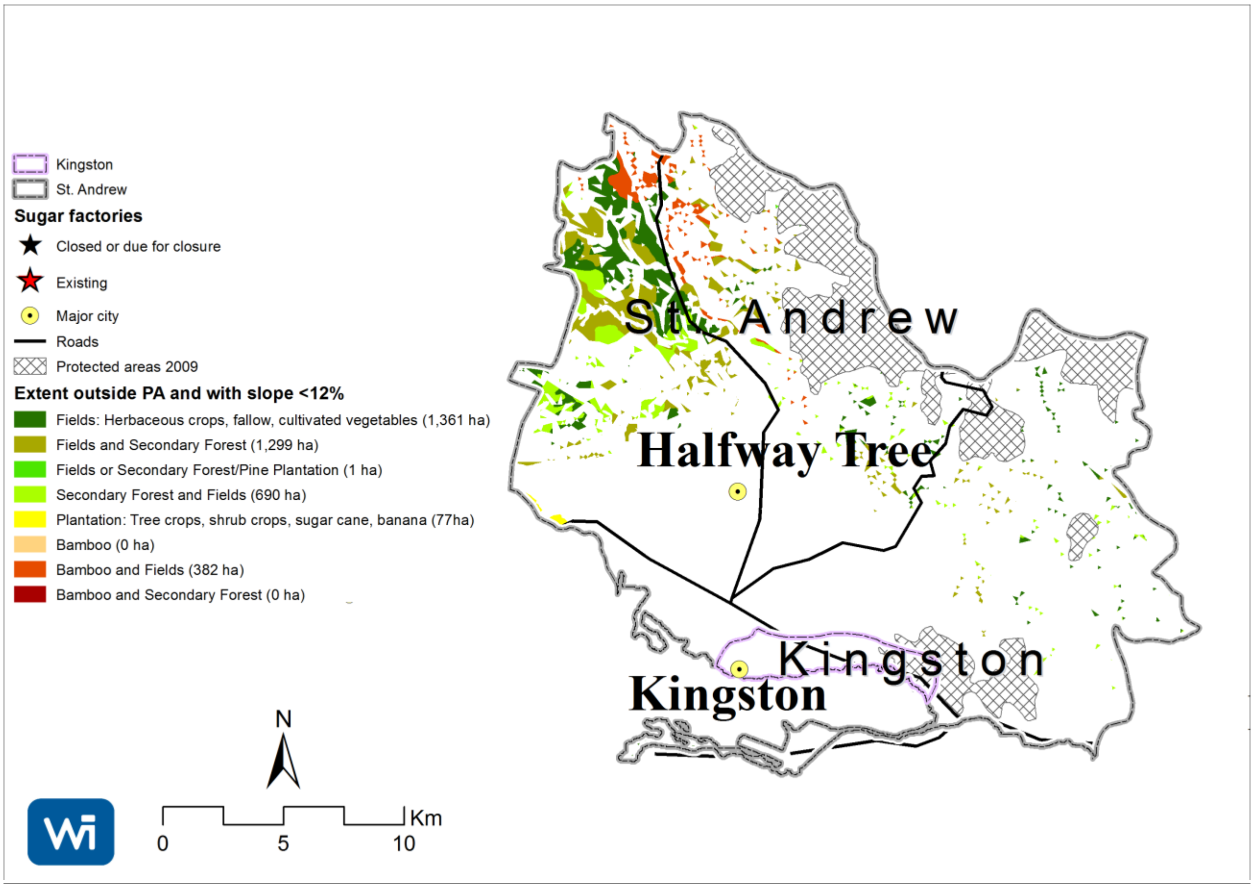
Hanover Figure 1



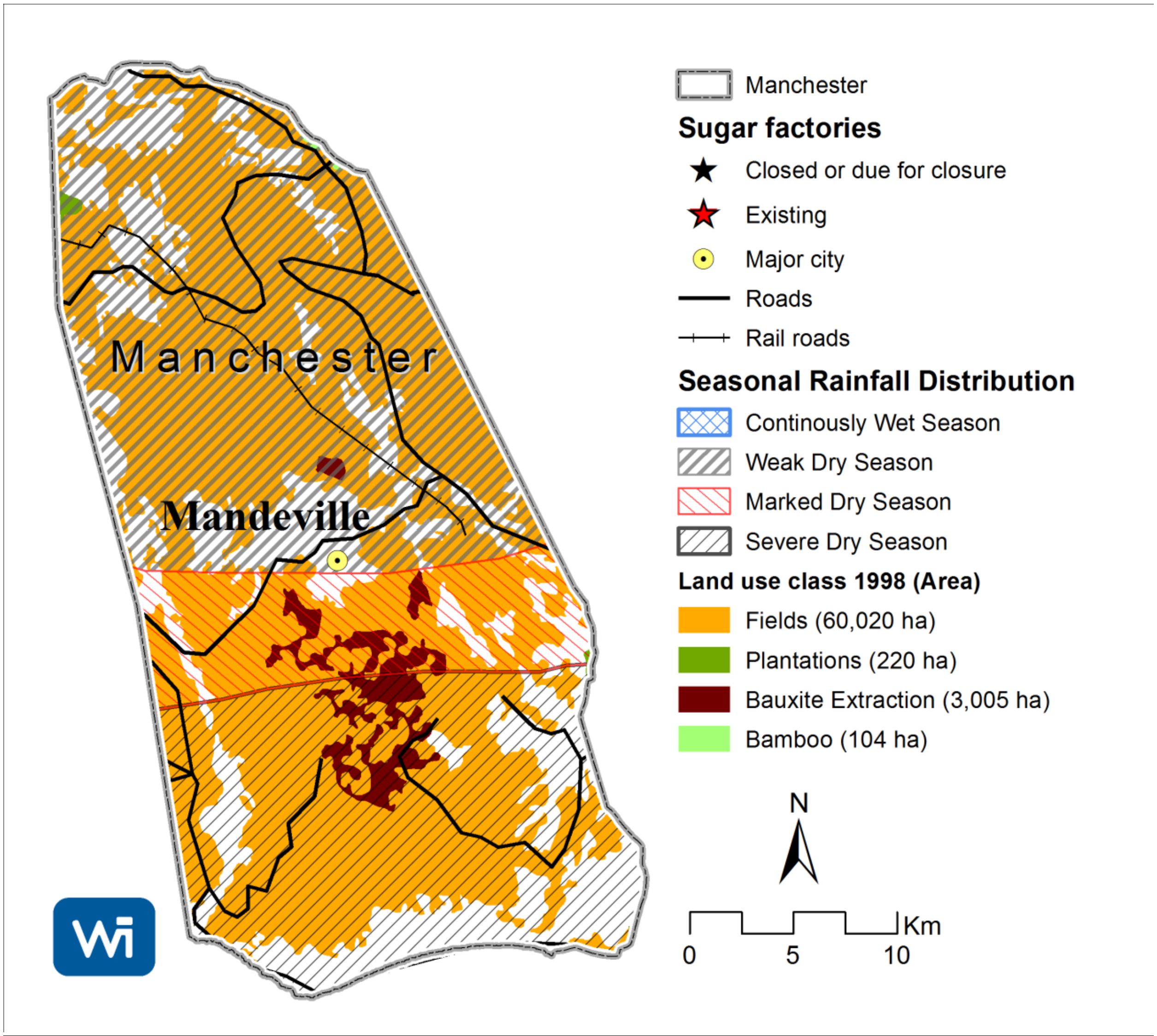
Hanover Figure 2



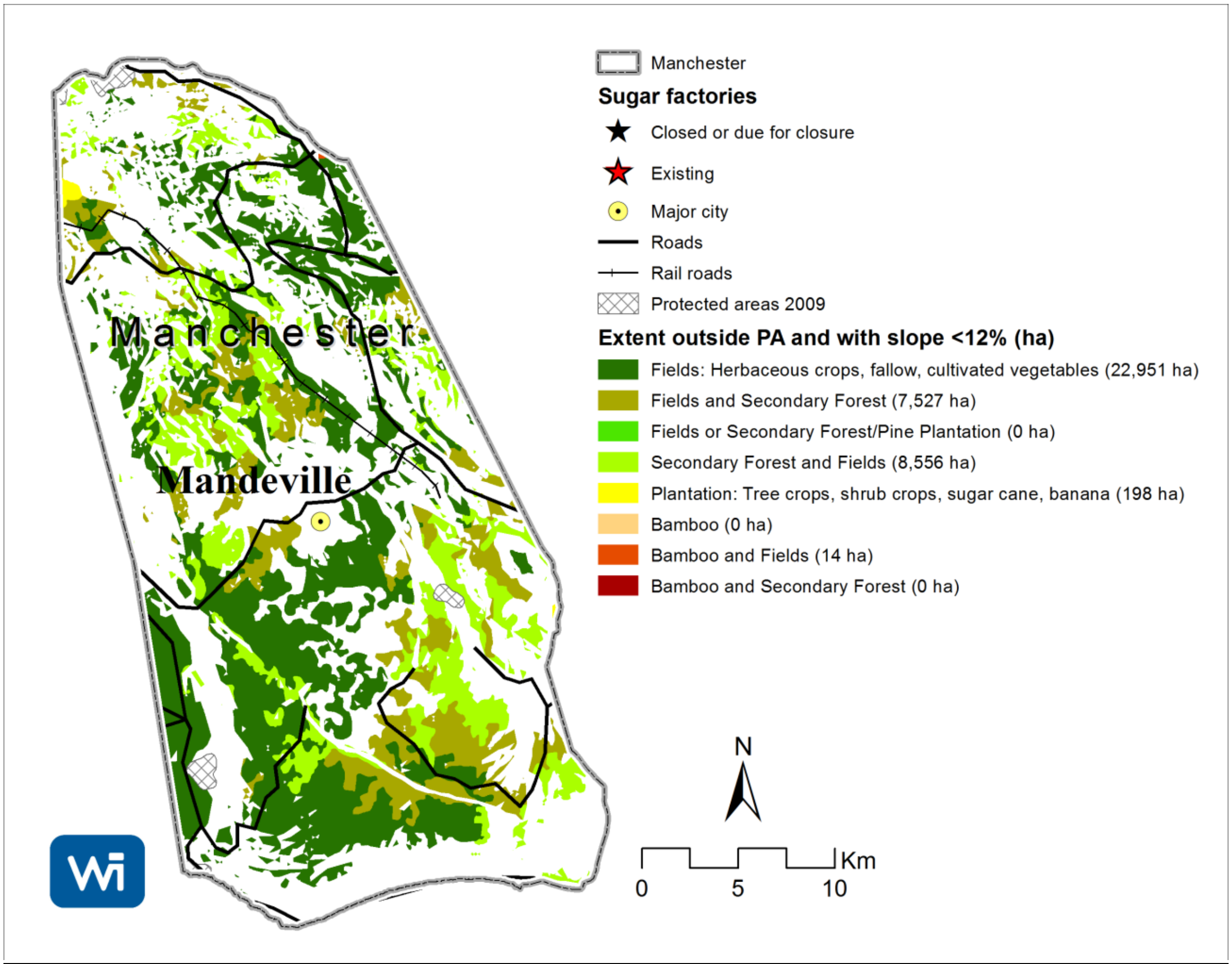
Kingston St. Andrew Figure 1



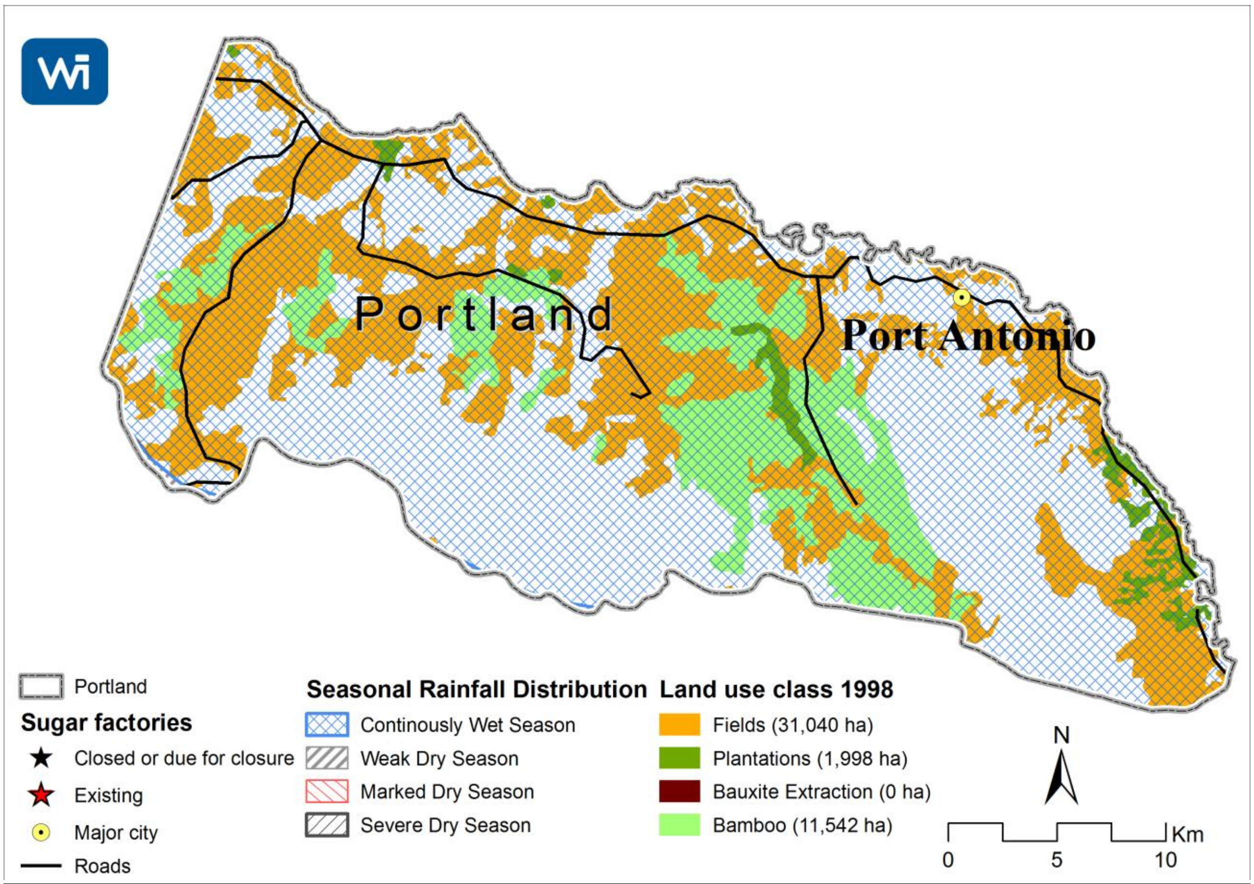
Kingston St. Andrew Figure 2



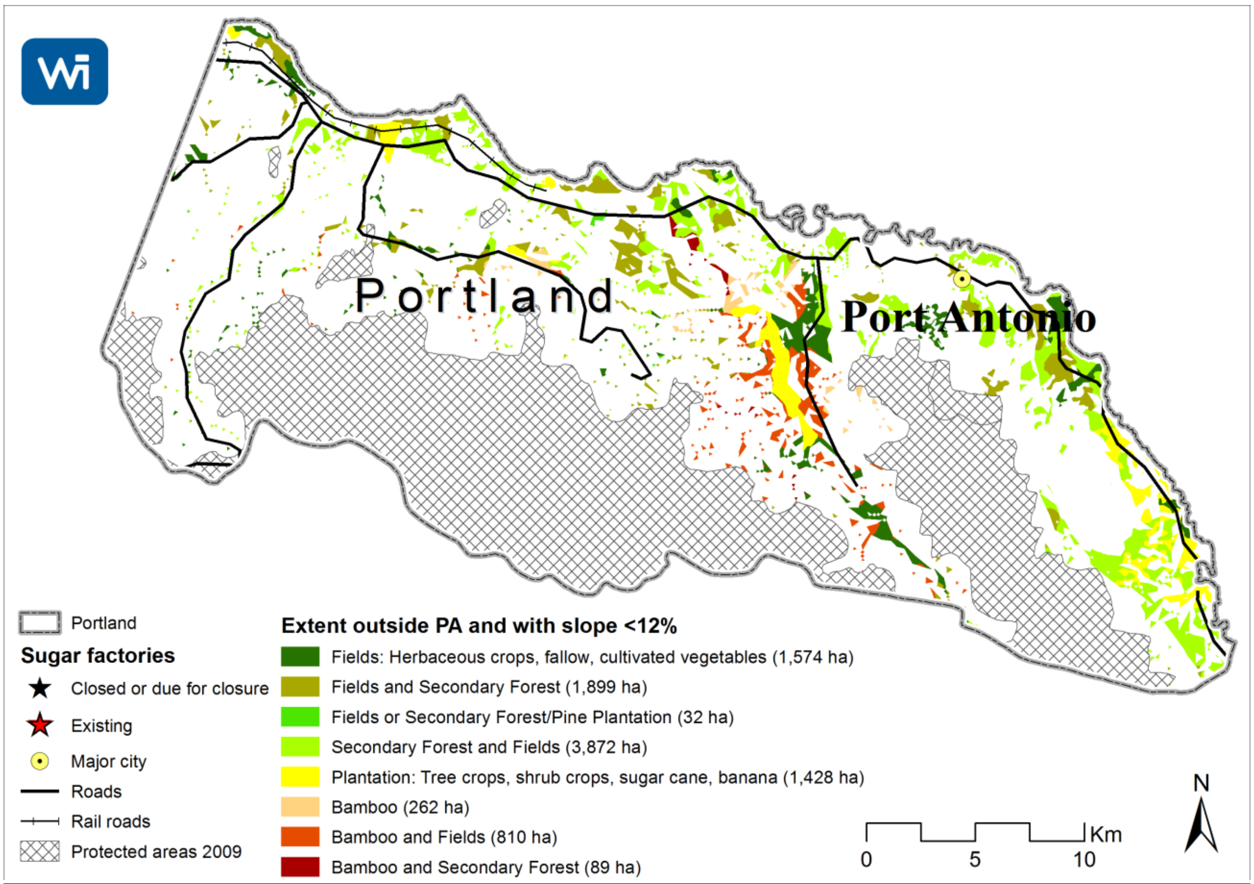
Manchester Figure 1



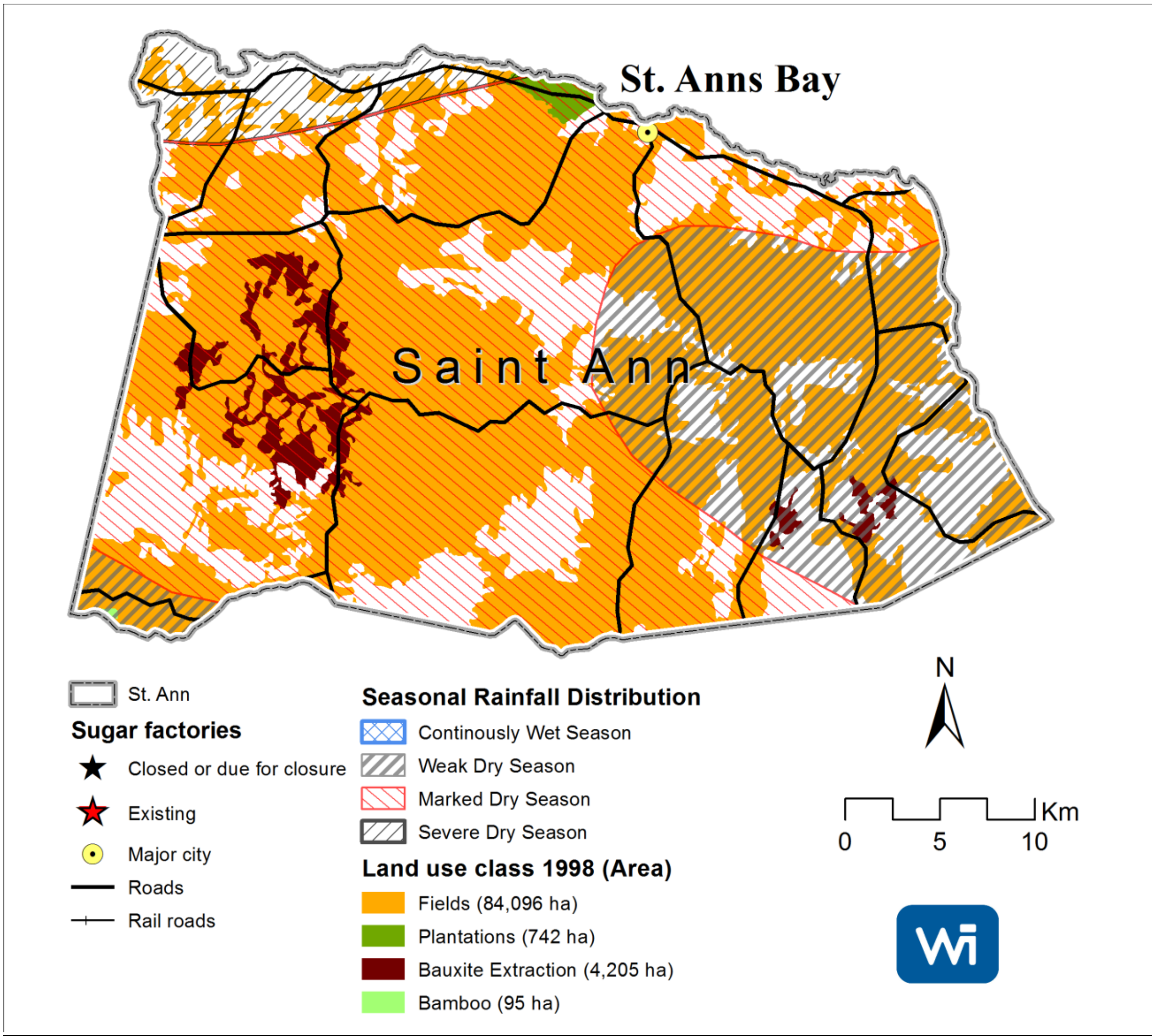
Manchester Figure 2



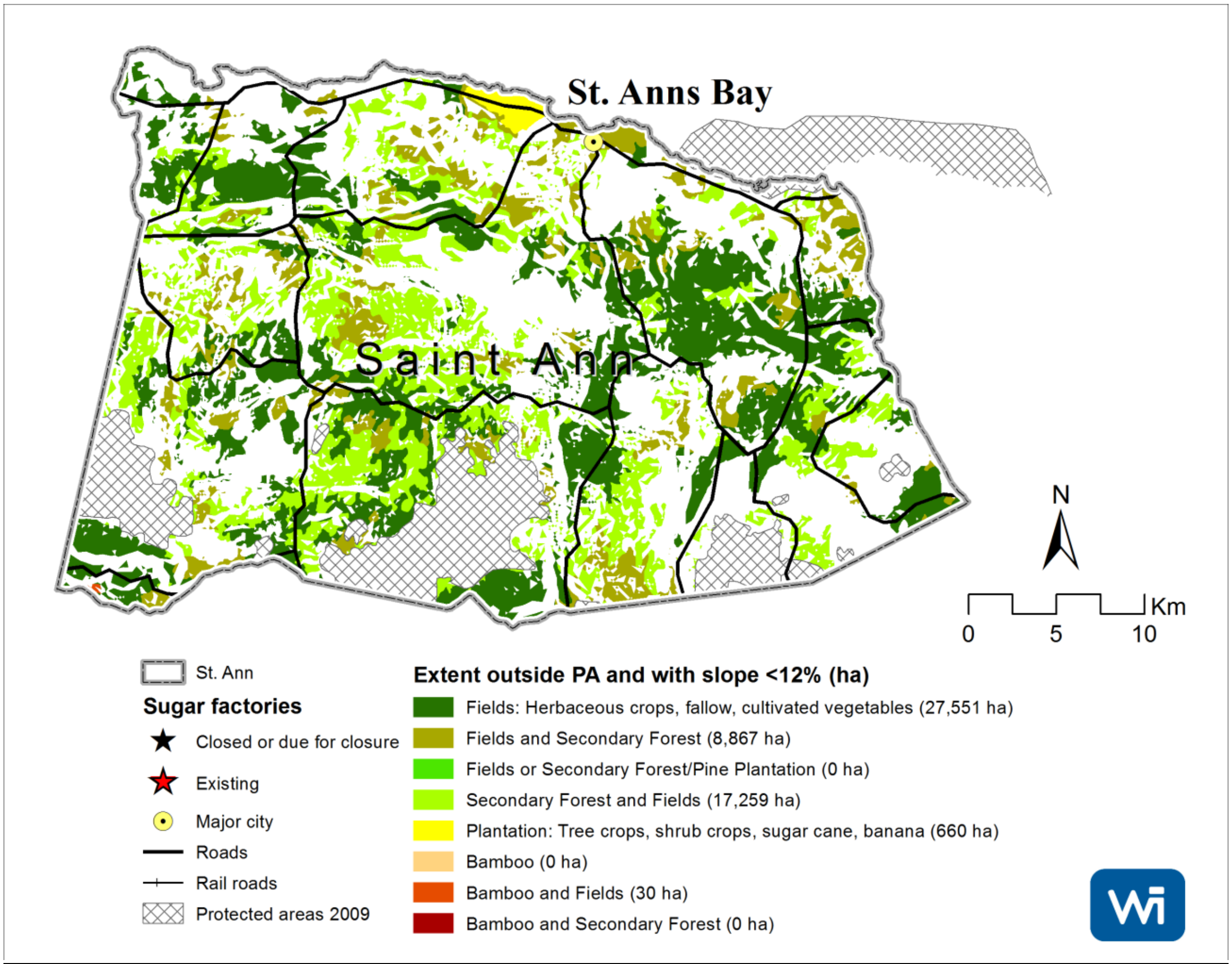
Portland Figure 1



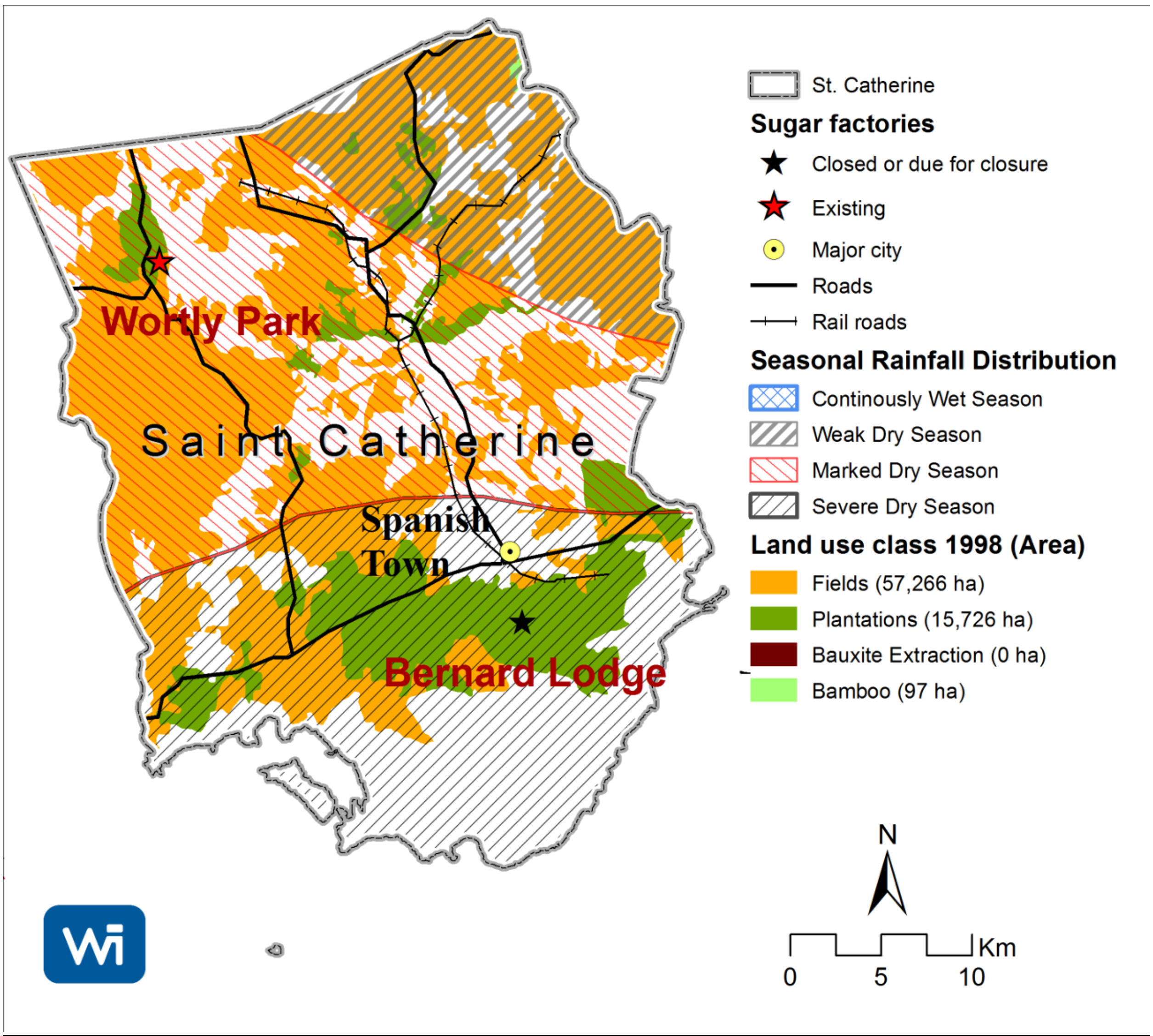
Portland Figure 2



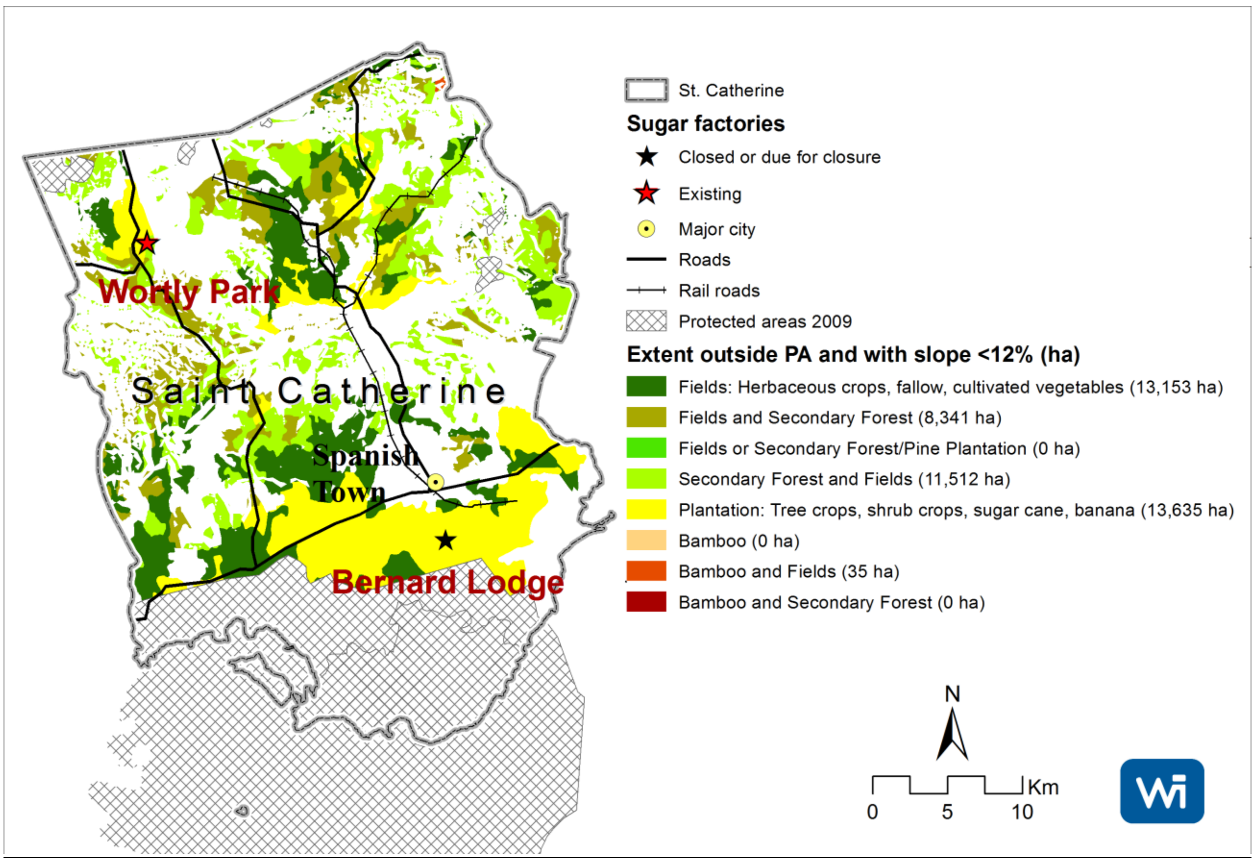
Saint Ann Figure 1



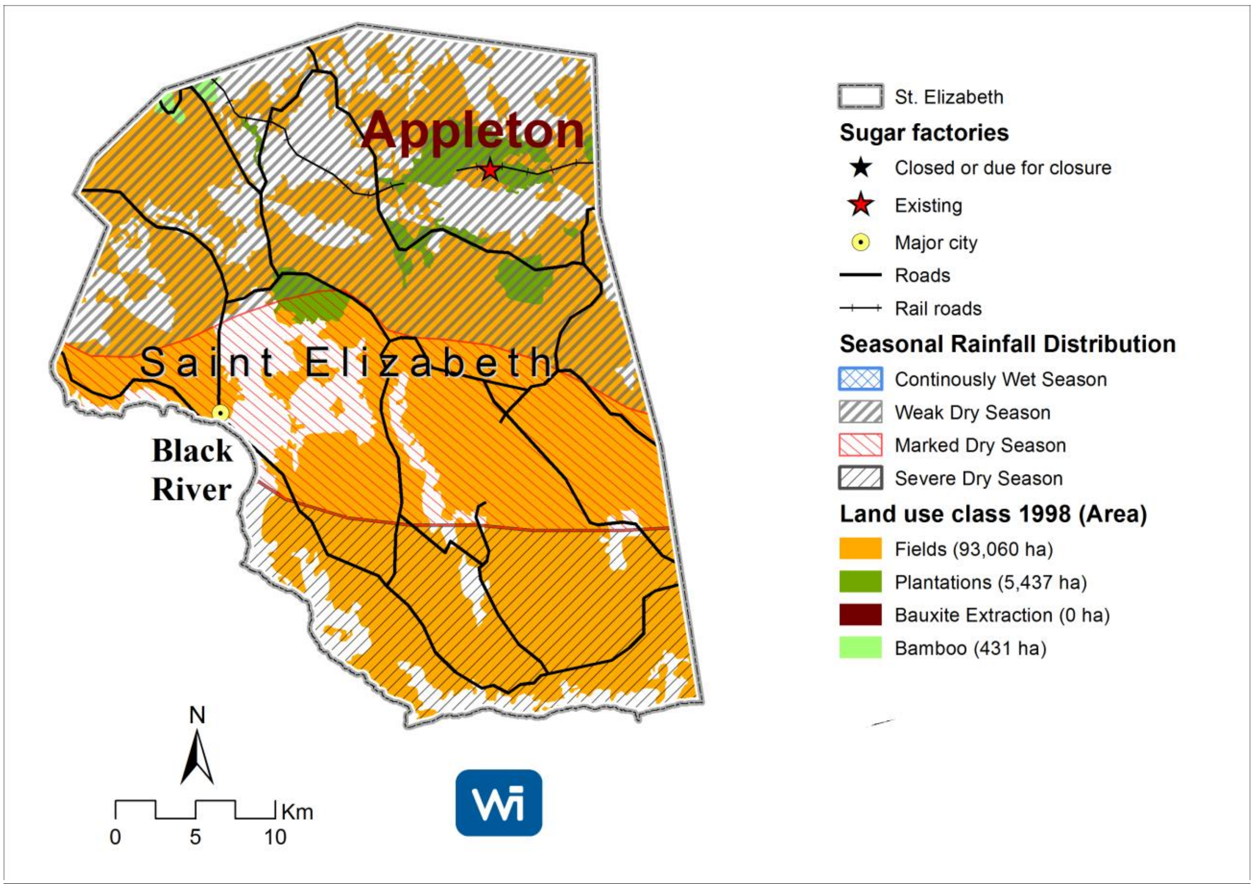
Saint Ann Figure 2



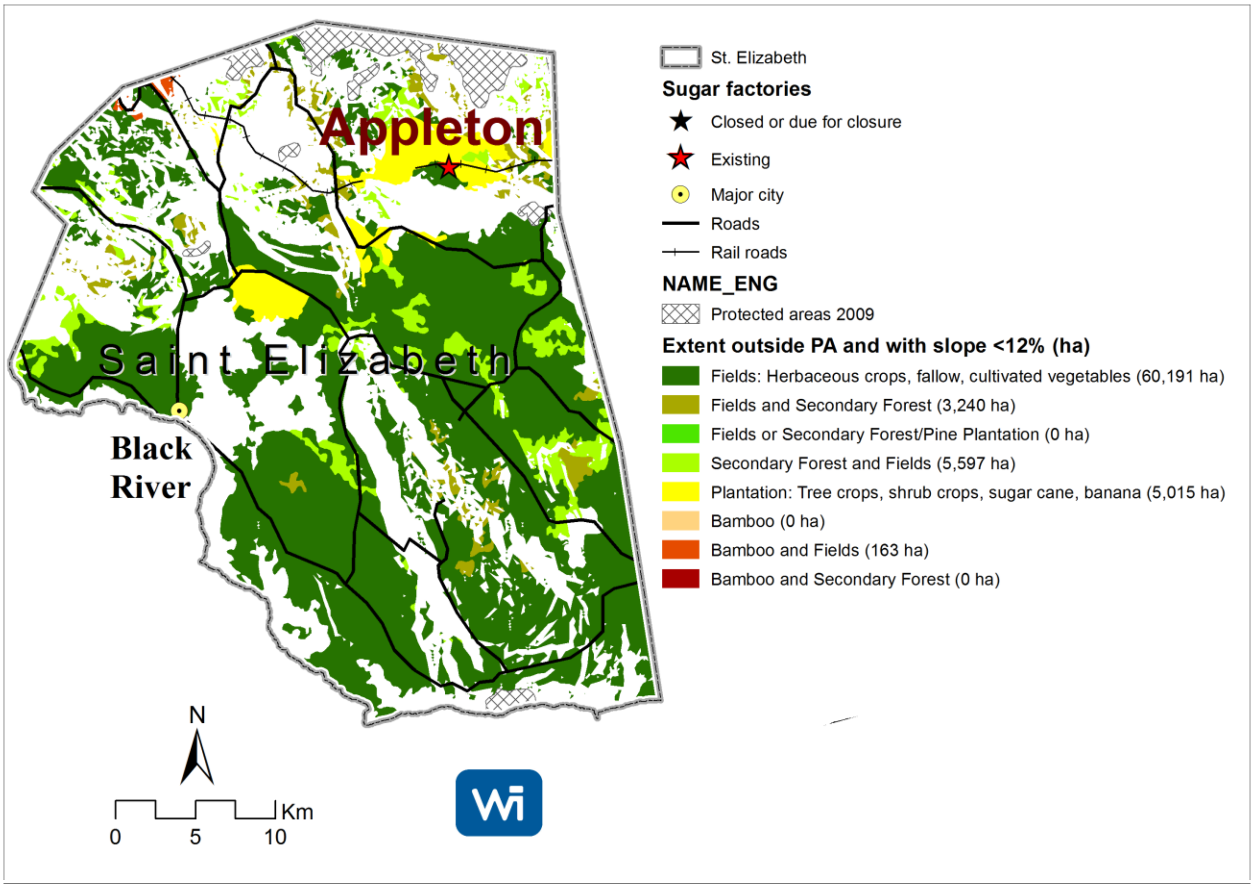
Saint Catherine Figure 1



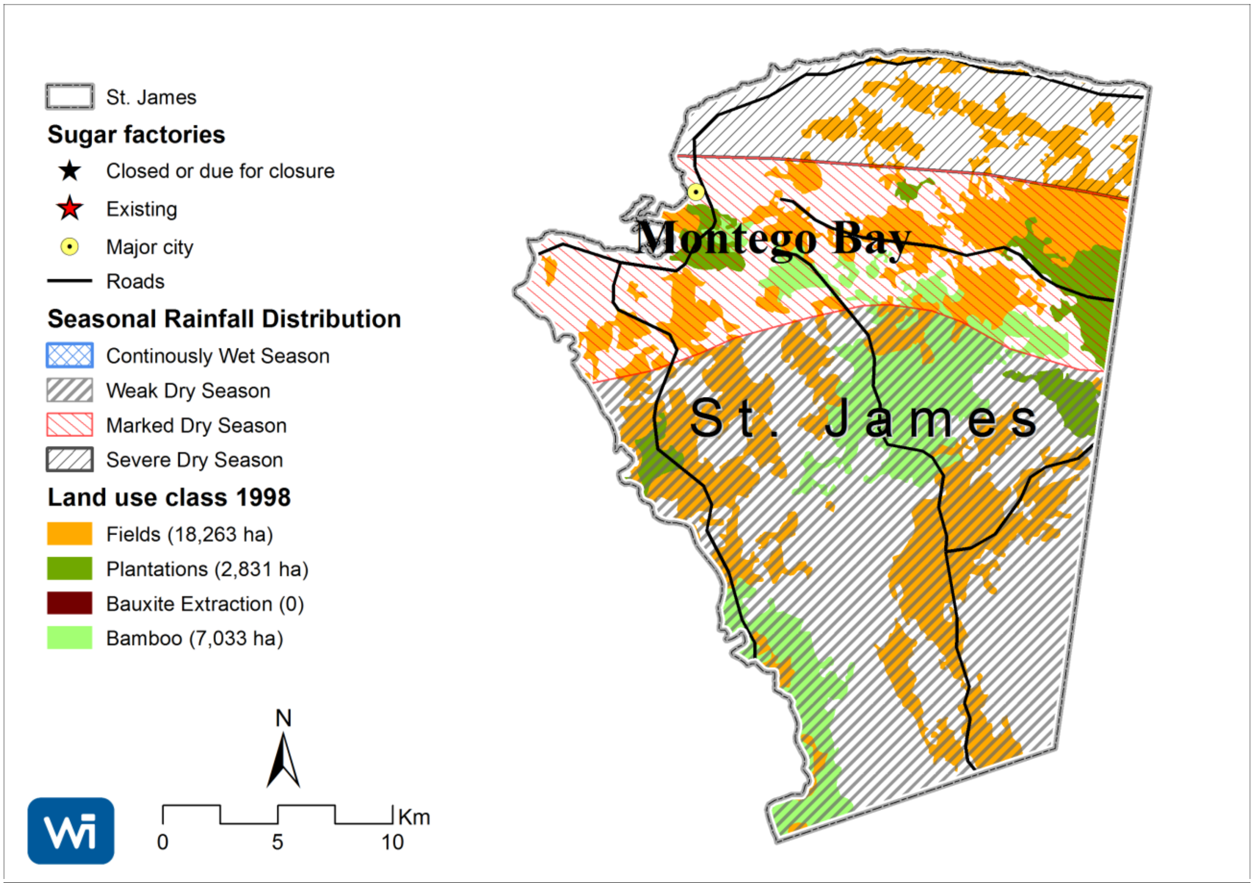
Saint Catherine Figure 2



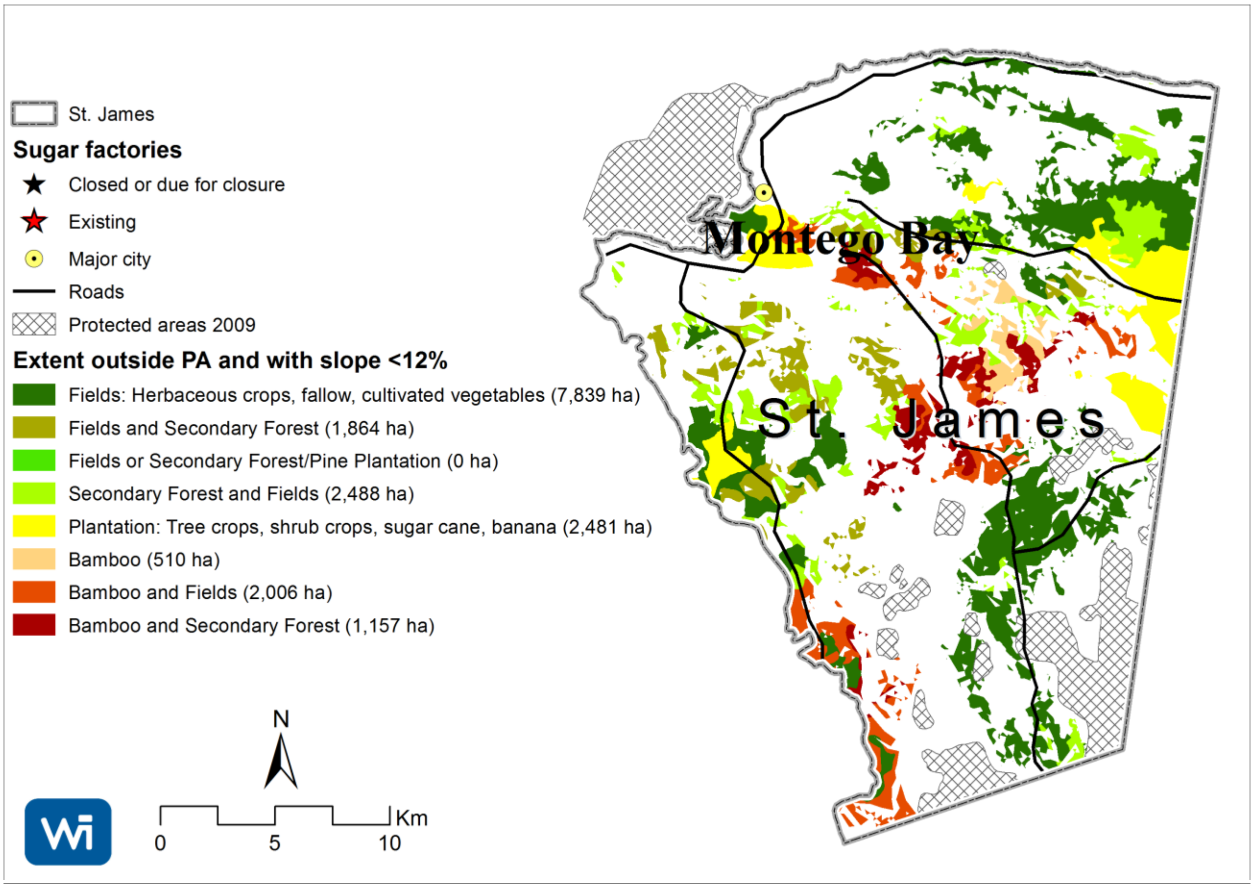
Saint Elizabeth Figure 1



Saint Elizabeth Figure 2



Saint James Figure 1



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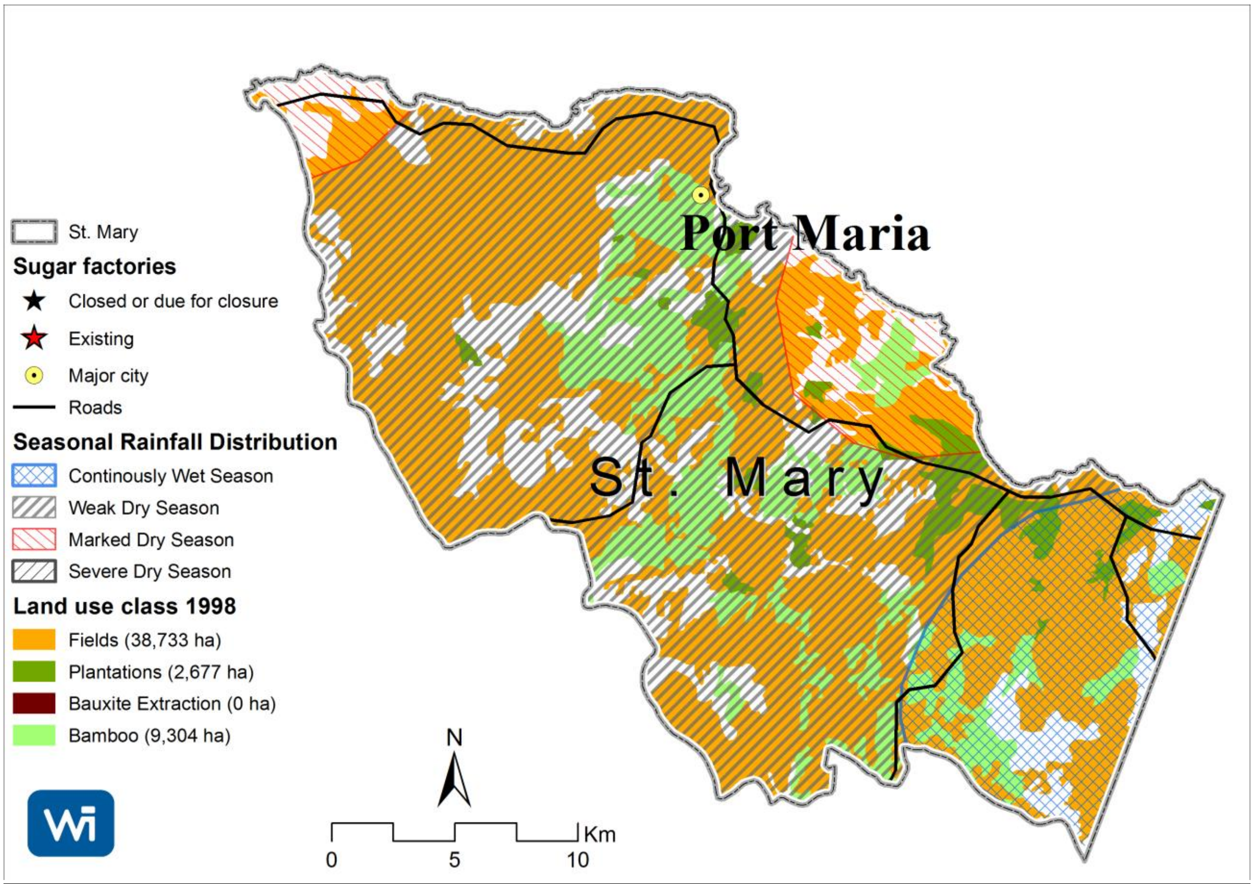

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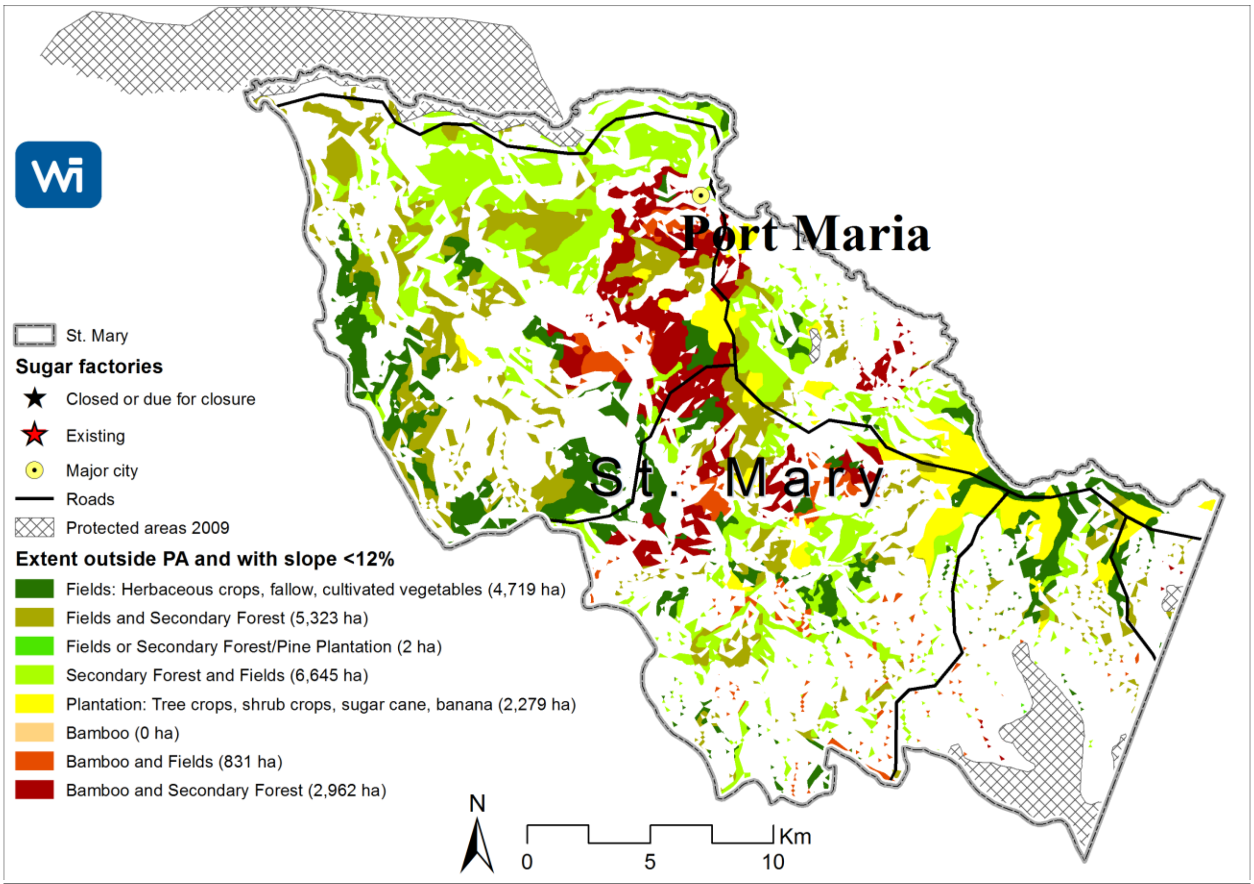

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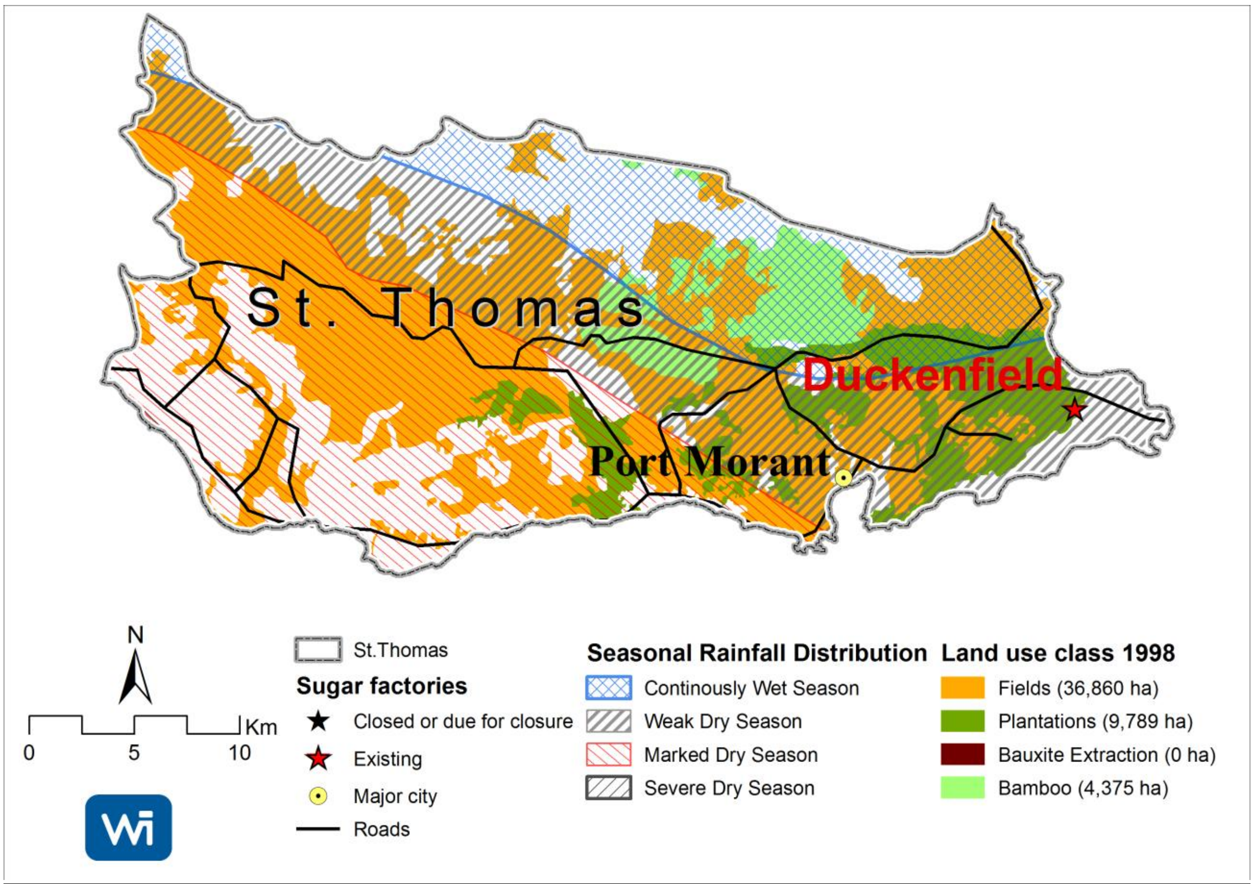
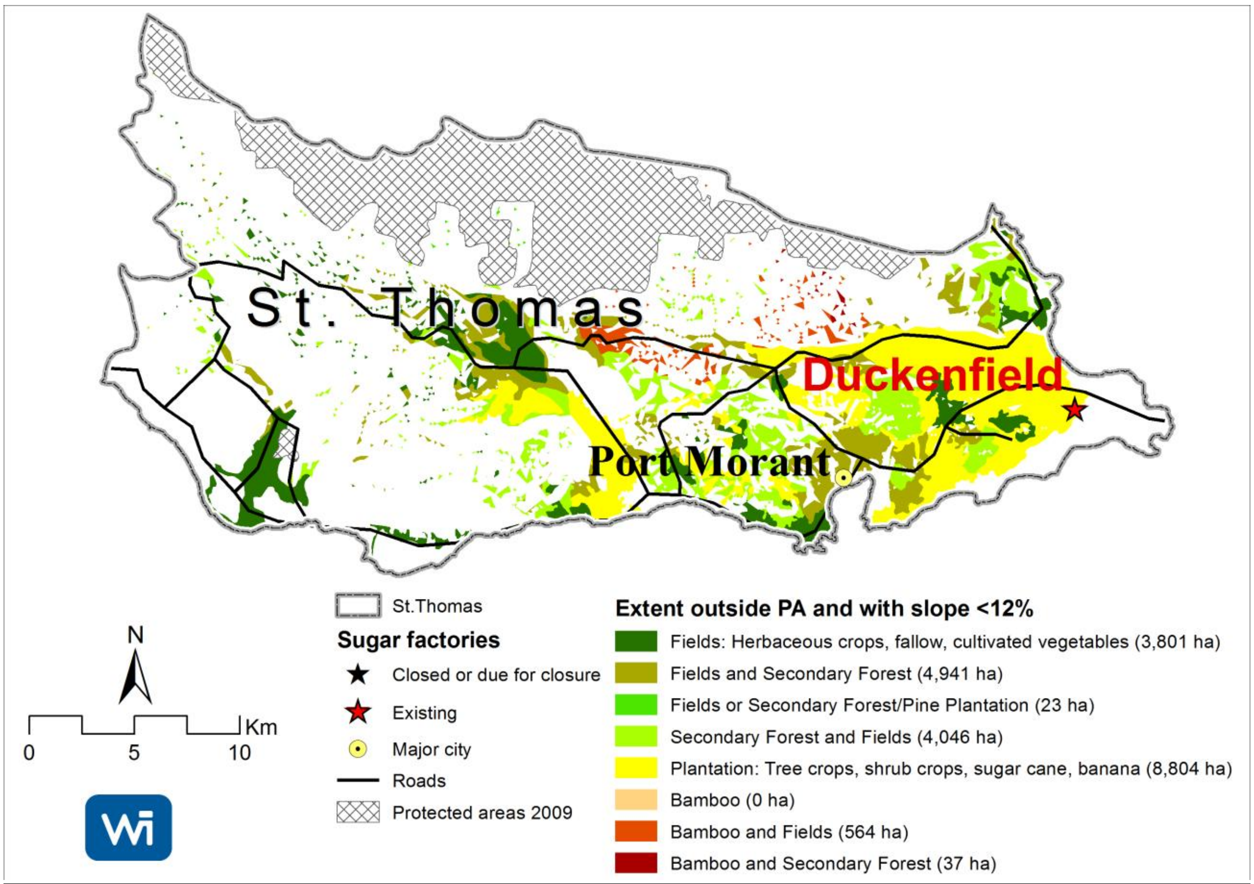


Saint Thomas Figure 1



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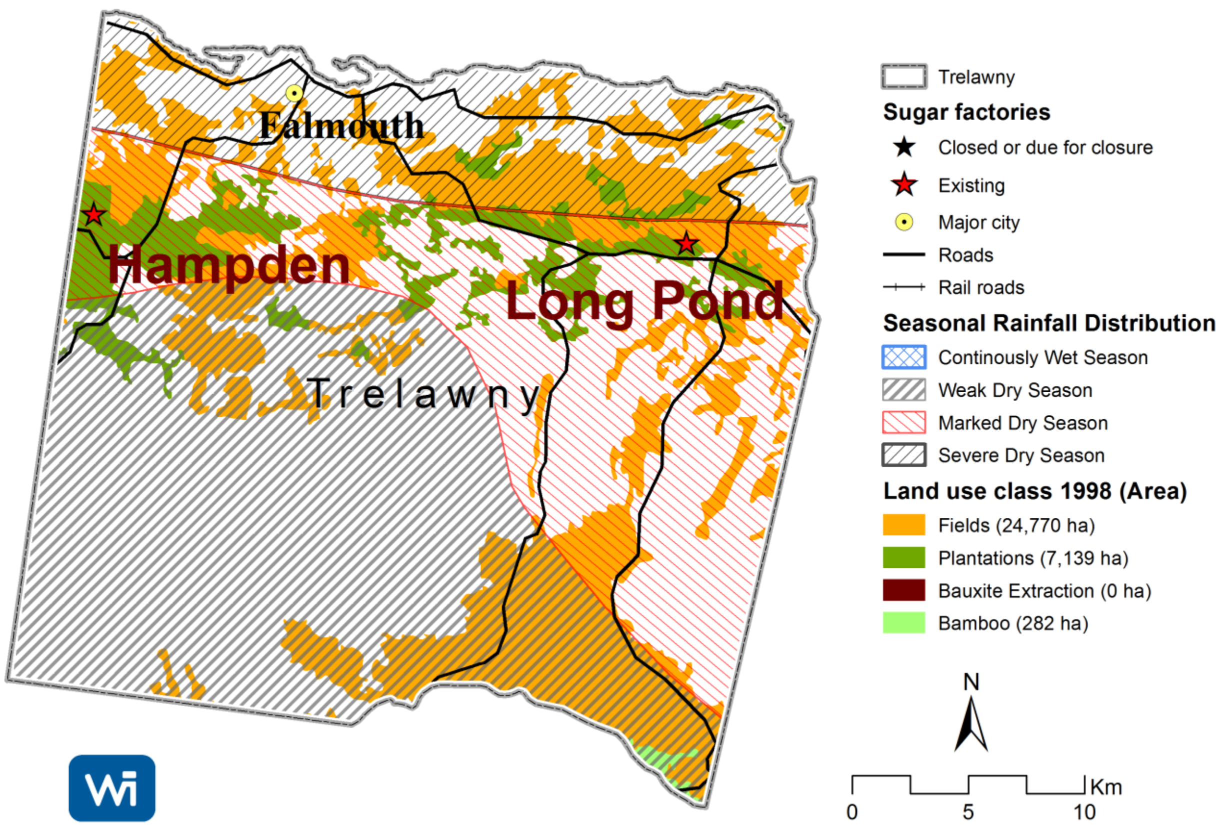
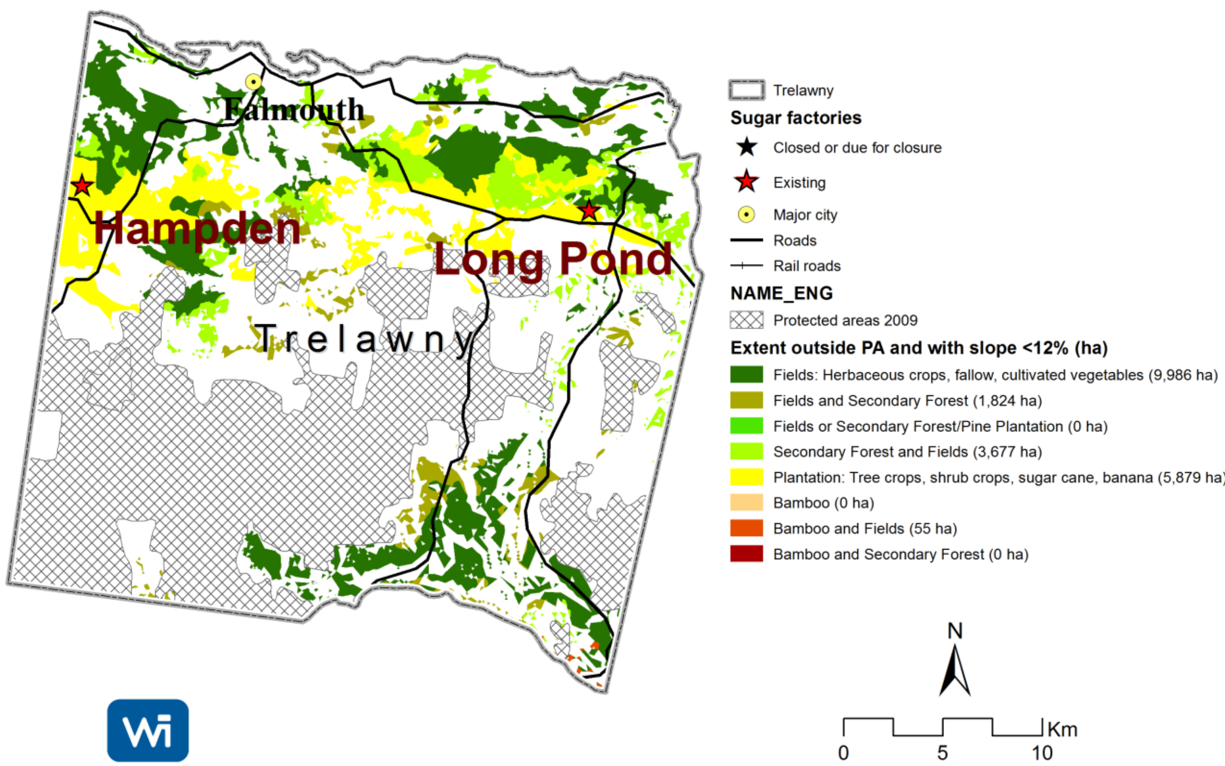
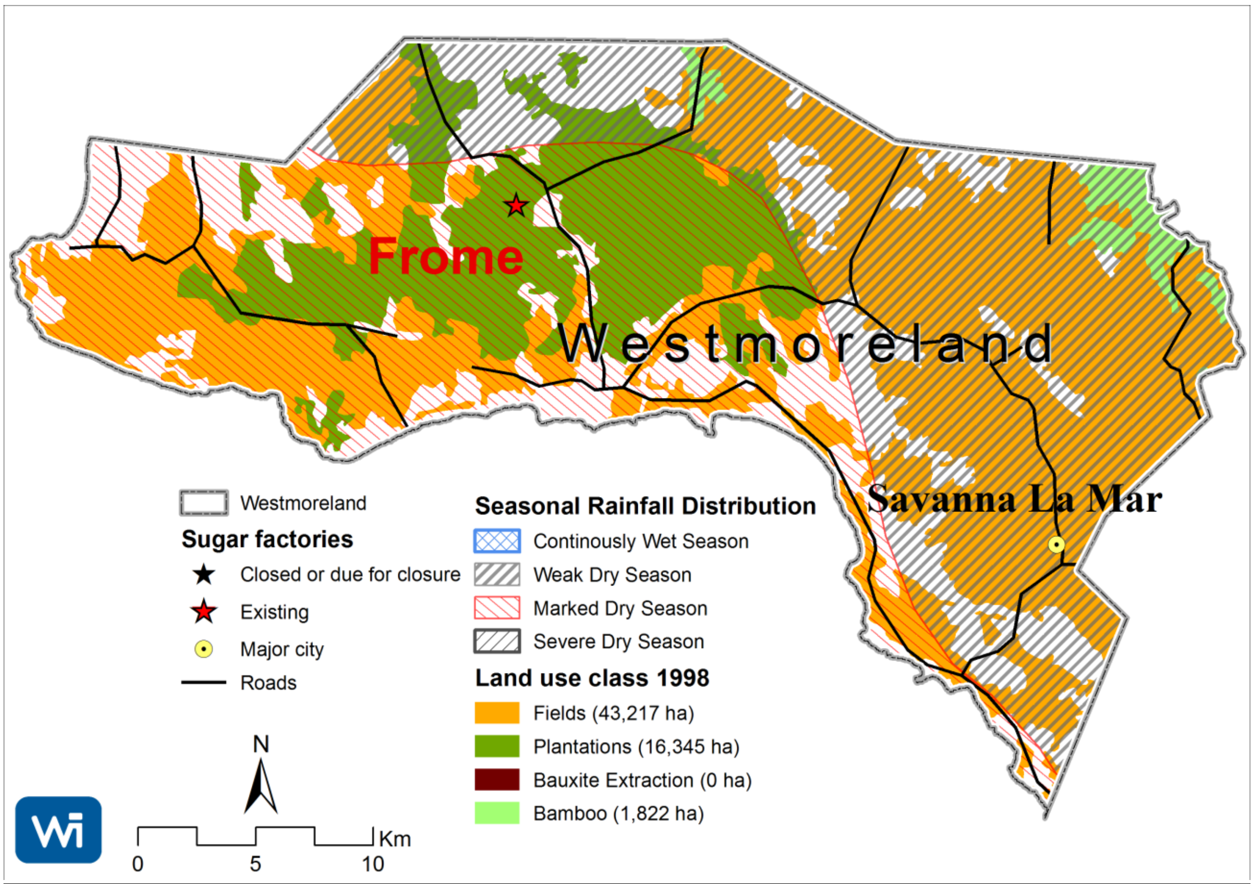


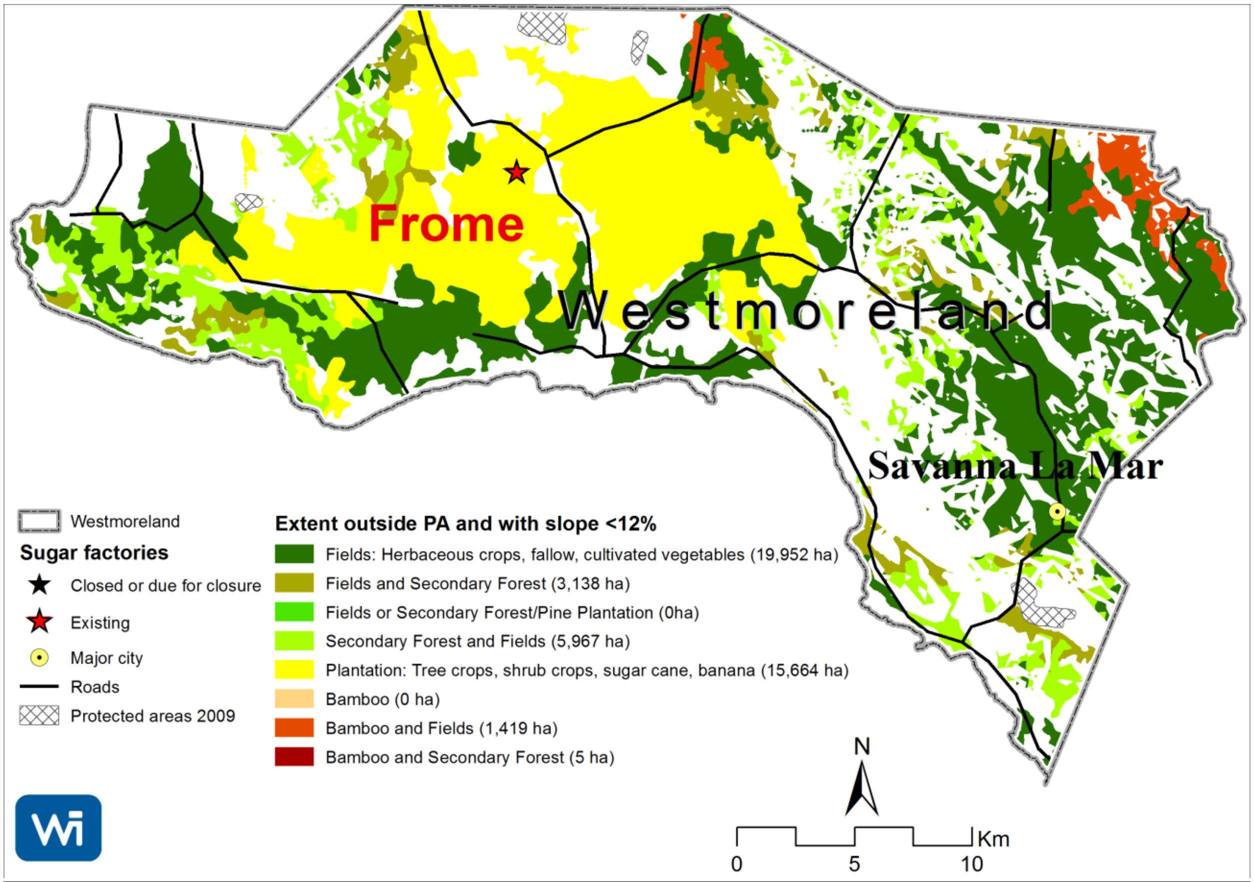
Trelawny Figure 1



Trelawny Figure 2



Westmoreland Figure 1



Westmoreland Figure 2

ANNEX V
Summary of Sugarcane industry Targets for 2010

Extract from work undertaken by Bradley Rein, Bradley K. Rein P.E., Director Processing Engineering and Technology, National Institute of Food and Agriculture, USDA

USDA National Institute of Food and Agriculture
www.nifa.usda.gov

Summary of JCS (I) Sugar Cane Industry Targets for 2010

Product	Production (tonnes/litres)		Cane Required (tonnes)		Land Required (reaped ha.)*	
	2010 Target	2009 Actual	2010 Target	2009 Actual	2010 Target	2009 Actual
Raw Sugar	200,000	126,000	1,900,000	1,300,000	25,000	29,000
Molasses (co-product)	67,000	40,000				
Additional Molasses for rum	67,000	0.0	400,000		5,000	0.0
Sub-total			2,300,000	1,300,000	30,000	29,000
Ethanol	70,000,000	0.0	1,000,000		13,000	0.0
Total			3,300,000	1,300,000	43,000	29,000

Notes:

Land required to be reaped under the JCS for 2010 assumed higher levels of productivity than actually achieved due to underperformance in replanting, maintenance, etc. actions proposed in the strategy.

The total cane required to meet these targets is 3,300,000 tonnes and 43,000 ha assuming a yield average of 76.74 tonnes/ha.

Source: JCS (I), SIA, SIRI