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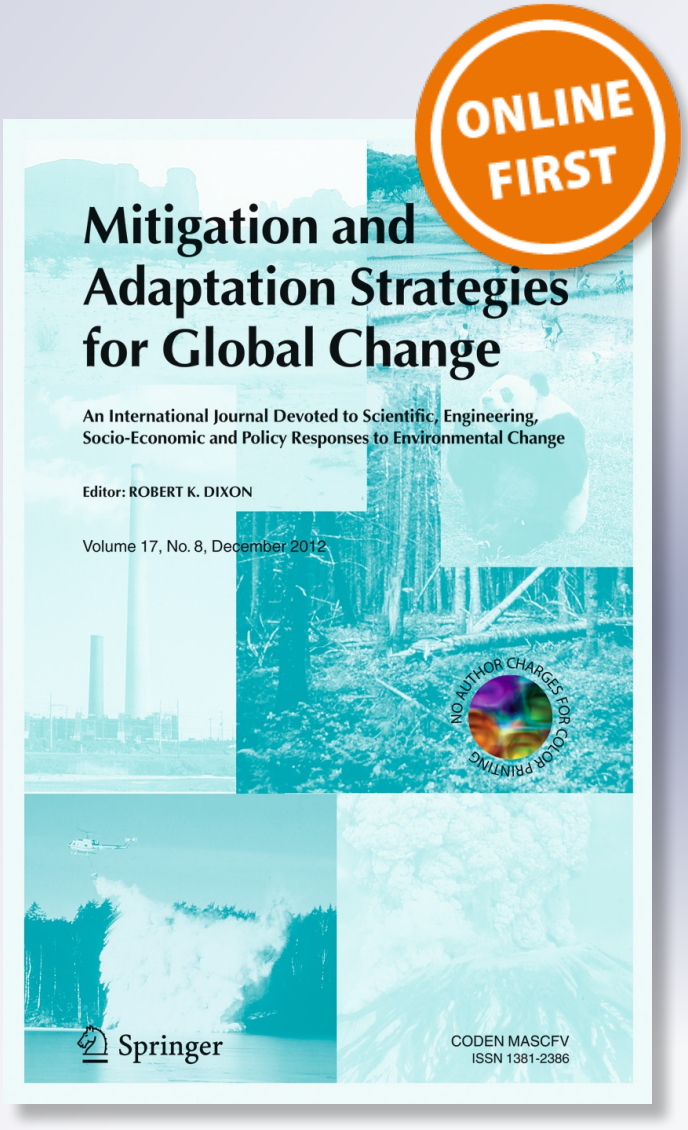

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ORIGINAL ARTICLE

Developing biofuels industry in small economies: Policy experiences and lessons from the caribbean basin initiative

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Abstract With increasing concerns about rising energy demand and cost, diminishing oil reserves, and climate change, Central American and Caribbean (CAC) nations have the opportunity to become producers of low-carbon sustainable biofuels for domestic consumption and foreign exchange earnings. While the region has a number of comparative advantages for developing a vibrant biofuels sector, including favorable climate and significant agricultural experience, the experience under the favorable Caribbean Basin Initiative (CBI) has exposed significant technical and non-technical barriers that must be overcome. Using information compiled through interviews with industry executives, government policy makers and civil society stakeholders, we provide a critical analysis of this experience focusing on non-technical barriers to investment. Survey results suggest that political uncertainty, poor regulatory frameworks, and lack of institutional commitment and business incentives are the main non-technical barriers. Having laid out the challenges, we propose potential policy positions to stimulate growth of the regional biofuels sector. Results point to the need to prioritize enhancing national legislation, developing risk prevention plans, creating supply and demand side incentives and increasing multilateral collaboration. While these findings are derived from the Caribbean Basin experience, they may also be applicable to small economies in other regions that are considering policies for biofuels industry development.

Keywords Biofuels · Ethanol · Biodiesel · Caribbean · Central America · Caribbean basin initiative · Trade and investment · Energy security

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1 Introduction

Biofuels have been promoted as a solution to a variety of public policy issues ranging from energy security and rural development to adaptation and mitigation of global climate change (Timilsina and Shrestha 2009; McFarlane and Philippidis 2008; Rajagopal and Zilberman 2007). The vast majority of countries in Latin America and the Caribbean depend exclusively on oil products, gasoline and diesel. Oil is imported mostly from the Middle East, Venezuela, and Africa, all of which face geo-political challenges. As future oil availability and price remain uncertain, local economies remain highly vulnerable to events and actions beyond their control. On the other hand, Brazil and Colombia have been successfully producing and using domestic biofuels in the form of ethanol and biodiesel. Ethanol is produced from cane sugar and molasses, whereas biodiesel is produced from African palm, castor beans, sunflower, and other oil-seed plants.

Table 1 reports each CAC country's biofuel potential by crop and fuel type, as percentages, based on that country's total crop production.[1] Production of crops such as soybeans (*Glycine max*), palm nuts (*Gypohierax angolensis*) and cassava (*Manihot esculenta*) in Latin America and the Caribbean is higher than the global average, which suggests a strong potential for biofuel production and utilization. Looking to Latin American biofuels leaders such as Brazil and Colombia, their success is based on instituted policies and regulations to tap their biofuel potential. In 2009 Brazil produced over 6.6 billion gallons of ethanol from its own sugarcane, whereas Colombia produced 83 million gallons (Renewable Fuels Association 2010). Both countries have long instituted policies and regulations promoting and/or mandating the use of biofuels, so they are mostly used in their domestic markets (Renewable Fuels Association 2008).

After the U.S. (10.6 billion gallons in 2009), Brazil is the second global powerhouse of biofuels, and they collectively account for almost 90 % of the world's ethanol production. Still, biofuels cooperation between the two countries to date has been historically hampered by the 54-cents/gallon tariff that the U.S. imposes on direct imports of most foreign ethanol imports, including those from Brazil. Thanks to the U.S. Caribbean Basin Initiative (CBI), several countries in CAC export ethanol to the U.S. tariff-free. However, this is not ethanol produced from local resources, but rather dehydrated Brazilian ethanol. It therefore provides limited economic benefits to the producing countries' economies.

CAC have not, to date, been able to exploit their biofuels production potential. Given that first generation biofuel (e.g. ethanol from sugar cane) cropping and processing technologies are well understood and available and second generation technologies (e.g. bagasse,[2] jatropha, switch grass) are moving to commercialization in certain parts of the world, the question remains as to what are the barriers to biofuels substitution for fossil fuels in CAC. Policy barriers stem from political, economic, social, technological, legal and environmental factors. Strategies to overcome these barriers should therefore consider all such aspects holistically (Blechinger and Shah 2011). Stavins (2001) and Perman et al. (2003) suggest that energy/environment public policies must consider, as fundamental criteria, political acceptability, feasibility of implementation (local conditions, technology, infrastructure) and environmental performance. This suggests that increasing our understanding of both technological and non-technological barriers is critical to moving the industry forward.

[1] Estimates are based on basic resource potential and assume that it makes economic sense to convert such feedstocks to energy.

[2] Bagasse is the fiber left over after the juice has been squeezed out of sugarcane stalks. As biomass, it is used to manufacturing cellulosic ethanol.

Table 1 Percentage of Biofuel potential by crop and fuel based on total current production in the Caribbean Region

Country	Ethanol			Bio-Diesel					Bio-Power				
	Sugar	Corn	Sorghum	Coconut	Cotton seed	Palm kernels	Sesame	Soy	Sugar cane	Rice	Coffee	Coconut	Wood
Antigua/ Barbuda	-	100	-	-	100	-	-	-	-	-	-	-	-
Bahamas	97.1	2.9	-	-	-	-	-	-	52.0	-	-	-	48.0
Barbados	99.7	0.3	-	100	-	-	-	-	95.0	-	-	1.1	4.0
Cuba	92.8	7.2	0	100	-	-	-	-	65.5	4.2	0.1	0.7	29.4
Dominican Republic	96.9	3.1	0	63.1	-	36.9	-	-	57.6	19.0	1.5	4.2	17.6
Grenada	83.6	16.4	-	99.4	0.6	-	-	-	33.0	-	-	67.0	-
Haiti	55.7	43.5	0.8	70.1	2.7	-	27.1	-	13.1	3.9	1.0	0.7	81.4
Jamaica	99.8	0.2	-	100	-	-	-	-	41.5	0.0	0.1	7.6	50.8
St. Kitts/Nevis	100	-	-	99.5	0.5	-	-	-	98.8	-	-	1.2	-
St. Lucia	-	-	-	100	-	-	-	-	-	-	-	100	-
St. Vincent/ Grenadines	85.5	14.5	-	100	-	-	-	-	74.4	-	2.0	23.7	-
Trinidad & Tobago	97.6	2.4	-	100	-	-	-	-	65.1	1.1	0.2	4.5	29.1
Caribbean Avg.	92.0	7.9	0	83.6	0.3	13.8	2.3	-	55.4	6.1	0.4	2.0	36.1
Belize	88.9	11.1	0	91	-	-	-	9.0	65.6	1.9	0.0	0.1	32.3
Costa Rica	98.5	1.5	0	3	0.02	96.9	0.0	-	18.6	3.8	1.7	0.2	75.6
El Salvador	63.4	36.5	0.1	89.3	2.6	-	6.4	1.7	25.8	0.4	1.1	1.2	71.5
Guatemala	78.1	21.8	0	16.4	0.2	60.4	20.7	2.2	26.5	0.2	0.9	0.1	72.3
Honduras	66.2	33.8	0	1.8	0.1	97.6	0.4	0.1	13.5	0.1	0.7	0.1	85.6
Nicaragua	65.9	34.1	0.1	10.3	1.5	45.7	37.9	4.6	17.5	3.2	0.7	0.1	78.6
Panama	81.5	18.5	0	24.2	-	75.1	0.6	0.1	24.7	15.1	0.4	0.5	59.3
Cent. Am. Avg.	74.6	25.3	0	9.1	0.2	84.2	5.8	0.7	22.1	1.6	0.9	0.3	75.1

UN Biofuels Initiative 2006

While these sets of barriers are highly interwoven together, we focus the present study on non-technological barriers to biofuels development in those CAC countries taking part in the CBI. Such barriers are critical to investors and, to a large extent, can be addressed effectively by the countries themselves. First, we report on the progress of regional and country-by-country biofuels policies in the Caribbean region. Next we analyze trade and investment within the CBI framework and regional progress in biofuel substitution. Based on this analysis, we suggest possible policy interventions that could move biofuels policy and the industry forward. Through this study we take the opportunity to highlight the constraints of such non-technical barriers as such as political uncertainty, poor regulatory frameworks, and lack of institutional commitment and business incentives. The literature to date is still heavily focused on technical barriers and so our focus on non-technical barriers adds another dimension to the existing research. Our study is also the first the take a broad scope, critical look at the actual implementation experience over time, of a particular policy instrument—the Carribbean Basin Initiative (CBI). Our contribution is therefore instructive to governments involved in biofuels policy making. We also hope our study contributes critical insight for the countries involved in the CBI, as they look towards the next steps in biofuels industry development.

2 A place for biofuels in sustainable development of the Caribbean

The potential role of an expanded biofuels industry in CAC countries has been highly debated by researchers, politicians, investors and development agencies alike. Many of the possible impacts of biofuels expansion in developing countries in general (see Table 2 below) become even more acute in small countries and island states that are naturally more vulnerable to changes in ecologies and economics (Blechinger and Shah 2011). These include adaptation to and mitigation of climate change, economic development, food security and allocation of land and water resources.

2.1 Climate change mitigation

A vibrant and productive biofuels industry can contribute to regional and international reduction in global greenhouse gas emissions. As countries of the Caribbean consider their next moves in tapping the potential trade opportunities emerging from the international biofuels market, they must also carefully consider how this industry will impinge on their own present and long term sustainable development. One concern in this regard, for small countries/ island nations is limited acreage of arable land. Sound energy and economic policies depend on critical analysis of the pros and cons of investment in the biofuels industry (Table 3). For instance, while biofuels substitution could provide substantial reductions in potential greenhouse gas (GHG) emissions especially in the transportation sector (Shah 2008), increased biofuels usage could cause the conversion of remaining forest lands and pastures to crop lands.

Quinteroa et al. (2008) found that for selected production volume of ethanol and according to the feedstock requirements (292,618 ton/h of sugarcane or 50,629 ton/h of corn), it would be necessary to plant 20,618 Ha of sugarcane or 27,002 Ha of corn to produce the same amount of anhydrous ethanol under Colombian conditions. For the Colombian case, results show that the fuel ethanol process from corn has worse economic indexes related to sugarcane. In addition, the corn (*Zea mays*) process has a greater environmental impact mostly due to the utilization of fossil fuels to produce the thermal and electric energy

Table 2 Potential positive and negative impacts of Biofuels in developing countries

Positive Impacts	Negative Impacts
Creation of new demand for agricultural products	Food security impacts
- alternative income sources in areas with depressed agricultural prices	- displacement of food producers
- alternative employment opportunities in the biofuel production chain (transport, transformation etc.)	- higher food prices on net consumers
	- poor, vulnerable and food-insecure households may not be able to cope with higher prices
Global trade in feedstocks (or biofuels) is an opportunity for developing agricultural economies	Binding environmental impacts
- a means of expanding markets for food, feed or biofuel feedstock crops	- competition for water (e.g. sugarcane in Central America and corn in China)
- higher prices for farmers	- here water might be available – might also be constraint on available land for expansion
-reduced environmental costs	- Extensive use of crop residues (by 2nd generation technology) would threaten sustainability of crop land resources.
	- Excessive use of fertilizer and other capital intensive methods of production—impacts on water quality, human health, the wider ecosystem
	- Clearing of tropical forest and cultivation on ecological fragile land.
Health and environmental benefits	
- displacement of wood fuel in household use	
- potential reduction in fuel emissions and greenhouse gases including carbon dioxide, hydrocarbons, sulphur and particulate matter	
Carbon sequestration	
Energy security	

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Table 3 Comparison of greenhouse gas emissions by crop-type

Fuel Sources	Used to produce	Greenhouse gas emissions[a]	Use of resources during growing, harvesting, and refining of fuel			
Crop			Water	Fertilizer	Pesticide	Energy
Corn	Ethanol	81–85	High	High	High	High
Sugarcane	Ethanol	4–12	High	High	Med	Med
Switch grass	Ethanol	−24	Med–low	Low	Low	Low
Wood residue	Ethanol, Biodiesel	N/A	Med	Low	Low	Low
Soyabeans	Biodiesel	49	High	Low–Med	Med	Med–low

Groom et al. (2008)

[a] Kilograms of carbon dioxide created per mega joule of energy produced

required during grain conversion. This may be debatable based on variations in natural conditions, technologies and economies of scale in different countries and geographies. Some researchers also suggest that differences in estimates are often attributed to differences in measurement techniques employed in the full life cycle assessment methodologies and the actual production practices employed (for example, "slash and burn" of sugar cane fields in Brazil) (see Tsao et al. 2012; Ketola and Salmi 2010; Fredga and Mäler 2010; Gustavsson and Karlsson 2006 for more detailed treatise on estimating biofuels greenhouse gas emissions through life cycle assessments).

2.2 Economic benefits

From the CBI can be maximized if Caribbean nations pursue domestic production of biofuels from local feedstocks. The region has long agricultural experience in growing sugarcane, both by small farmers and large estates. It also possesses sugar mills that have been processing for years cane to sugar and molasses, either of which can be used for ethanol production. Moreover, the Caribbean Basin enjoys climatic conditions that favor sugarcane and other crop production with the potential to reach high yields, if agricultural and processing practices are improved. Considering that sugar cane ethanol is cheaper to produce than corn ethanol (Philippidis 2008), ethanol production in those countries, if practiced efficiently, could be more competitive than U.S. corn ethanol. Hence, by capitalizing on their major competitive advantages, CBI countries can boost biofuel production for local use and trade thanks to their preferential tariff-free access to the U.S. market. However, with a possible end of the tariff recently announced, this window may close as CAC continue to be hampered by lack of proper policies (Fitch 2011).

2.3 Food security

The dilemma regarding the risk of diverting farmland or crops (such as commodities like corn (*Zea mays*), sugar cane (*Saccharum officinarum*) or vegetable oil) for biofuels production to the detriment of the food supply is international in scope, with arguments on both sides of the issue. There is disagreement about how significant the issue is, what is causing it, and what can or should be done about it. For instance one study suggests that that market-driven expansion of ethanol in the U.S. increased maize prices by 21 % in 2009, in comparison with what prices would have been had ethanol production been frozen at 2004 levels (Babcock 2011). Another recent study suggests that there is no statistical evidence to support the argument that growth in ethanol production is driving consumer food prices higher; but rather, retail food prices are determined by a complex set of inter-related factors, including supply chain costs for energy, labor, transportation, packaging and other marketing-related expenses (The Renewable Fuels Foundation 2011). All CAC countries import food products and in some, like Barbados, Belize, Jamaica and Guyana, food accounts for up to 15–20 % of all imports (Coviello 2010). The potential for energy crops largely depends on land availability, considering that a growing demand for food has to be met, combined with ecosystem protection, sustainable management of soil and water resources and a variety of other sustainability criteria (Faaij and Domac 2006).

2.4 Natural resources

In addition to land, water is another critical resource for both food and biomass production and a constrained resource in many CAC regions. While drought sometimes occurs in some

CAC countries, the tropical climate typically ensures sufficient water supplies. However, due to seasonal variations in rainfall, infrastructure for storing adequate water supplies for production purposes could be a limiting factor. Several island nations overcome this by using large-scale desalination plants (e.g. Barbados, Trinidad and Tobago), but again this has to be factored into the investment costs, given the critical role of water in improving agricultural efficiency (and hence crop yield per hectare) in developing countries. Moreover, vinasse[3] disposal has to be accommodated, since almost 13 l of it are generated for every liter of ethanol produced. Finding environmentally suitable disposal methods (e.g. combustion) or reuse (e.g. fertilizer), as already practiced in Brazil and Colombia, is a pre-requisite for any large-scale biofuel investment (Cortez and Brossard Perez 1997).

3 Approach to the study

Our intention here is threefold; first to review the evolution of biofuels activities that broad set of countries that are signatory to the CBI and pay particular attention to the experiences in the sub-set of smaller Caribbean nations; second is to identify common challenges to these countries and suggest a suite of recommendations and directions for policy makers to consider in moving forward, especially in terms of regional strategy; third to draw from the opinions of a broad spectrum of expert stakeholders including government, the private sector investors, multilateral development agencies and civil society players such as academia and non-governmental organizations. Countries that are signatory to the CBI are Belize, Costa Rica, El Salvador, Guatemala, Guyana, Honduras, Nicaragua, Panama, Antigua, Aruba, the Bahamas, Barbados, British Virgin Islands, Dominica, Dominican Republic, Grenada, Haiti, Jamaica, Montserrat, Netherlands Antilles, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, and Trinidad and Tobago.

Our review takes a descriptive tone and "wide angle" approach to paint a realistic picture of occurrences under CBI in the region—a story, the context of which has not previously told in the academic literature. Our methodology for gathering information and data consisted of (1) literature review of scholarly and industry reports and (2) primary data collection through interviews with industry experts and stakeholders as well as direct observation.

The researchers gathered primary interview and observational data between 2006 and 2010 through involvement in a series of high level annual conference events held by the Caribbean Central American Action (CCAA) organization headquartered in Washington DC, USA. Over the course of the five annual conferences held during this time period, twelve high level forums dealing with biofuels and renewable energy investment, energy geo-politics, regional energy security and supply and transitioning to low carbon strategies were held.[4] Speakers and attendees to these forums included top executives of energy firms and from the biofuels industry, government ministers of energy and senior public officials, leading academics and business association heads, senior managers of multilateral institutions and non-governmental organizations. Semi-structured, face to face interviews were held with speakers and prominent participants during each conference. Each interview ranged between 15 and 25 min and about one in every three interviewees followed up by

[3] Vinasse is a liquid residue generated during sugarcane ethanol distillation that represents an environmental concern for the ethanol industry. It is acidic with high biological oxygen demand.

[4] Information about Caribbean Central American Action (CCAA) can be obtained at http://www.ccaa.org. Reports on CCAA's Annual Miami Conference, listing these forums and speakers are also available online.

providing additional information or comments via email after the conference. Interviews were structured to gather information in three broad areas: (1) role/industry position of interviewee/ interviewee organization and history of involvement in regional biofuels issues; (2) opinion on market conditions, current operations and investments and government relations; (3) recommendations for future industry development, regional policy and implementation. In total 48 fulsome interviews were completed consisting of 19 industry executives, 16 government officials/politicians, 7 academics/researchers and 6 non-governmental organizations. This data provided the basis of the recommendations made in the study.

Data analysis consisted of examining, categorizing and collating interviewee comments to address regional biofuels industry opportunities, threats and policy framework strengths and weaknesses. This was done iteratively for each year's data collection and summarily for all 5 years between 2006 and 2010. Consistencies and differences in accounts by interviewees and in archival information were sought and discrepancies rechecked with appropriate stakeholders. Threats to reliability in the quantitative research approach were mitigated by using the semi-structured interview approach which allowed enough flexibility to capture the story but enough structure to build consistency and ensure quality. Reliability was also assured through the multiple year data collection triangulation of data sources (archival, interview and observational data were used) and the use of responses from multiple interviewees.[5]

4 Biofuel trade in the Caribbean and Central America

4.1 U.S. Biofuels policy

In 2005, the U.S. government set the Renewable Fuel Standard (RFS1) aimed at a 20 % reduction in domestic gasoline consumption over the next 10 years. This called for production of upwards of 35 billion U.S. gallons of ethanol and biodiesel by 2017. Two years later, the Energy Independence and Security Act of 2007 was passed amending the RFS1 provisions of the Energy Policy Act of 2005. The expanded RFS (referred to as RFS2) required the annual use of 9 billion U.S. gallons (34,000,000 m^3) of biofuels in 2008 and expanded the mandate to 36 billion gallons annually in 2022. The Act included the provision that of the 36 billion U.S. gallons used, no more than 15 billion U.S. gallons could be corn based ethanol. In addition, of the 36 billion U.S. gallons, no less than 16 billion must be from cellulosic biofuels. The RFS is subject to arguments both for and against the policy. Supporters of an RFS claim it serves several public policy interests. The RFS reduces the risk of investing in renewable biofuels by guaranteeing demand for a projected period. It enhances U.S. energy security by promoting production of a liquid fuel from renewable, domestic sources. This in turn results in a decreased reliance on imported fossil fuels. The RFS acts as a boost to the U.S. agricultural sector by providing an additional source of demand for U.S. agricultural products, and increases rural incomes and rural employment opportunities. Supporters argue that renewable biofuels go unrecognized for the full extent of their environmental benefits. Unlike gasoline and gasoline additives, biofuels are non-toxic and biodegradable, and emit substantially lower volumes of direct greenhouse gases than fossil fuels when produced, harvested, and processed under the right circumstances.

[5] Quantitative researchers point out social desirability bias (the inclination of the interviewee to say what he believes is the social expectation) is a problem in some studies; but can ultimately be minimized by agreements of anonymity between research and respondent (Shah and Rivera 2007).

In the U.S. ethanol receives a 45-cents-per-gallon tax credit and, to prevent foreign manufacturers from collecting the ethanol tax credit, the U.S. imposes a 54-cents-per-gallon import tariff on ethanol coming into the U.S. from most foreign countries, as outlined earlier. The amount of the tax credit and tariff historically were aligned to achieve a direct offset. Both the ethanol tax credit and the tariff expired in 2011 and on June 16, 2011, the U.S. Congress approved an amendment to the economic development bill to repeal both of them. Their eventual fate, however, still remains uncertain as several arguments and petitions from some members of Congress are being prepared to reinstate the credit and tariff. For intance, U.S. congressman Charles Rangel, in December 2011, introduced a bill to extend "other duty or charge" (ODC), a key component of the Caribbean Basin Economic Recovery Act (CBERA), that provides duty-free treatment to ethanol imports from the Caribbean for three years, until December 31, 2014.

4.2 The Caribbean basin initiative (CBI)

The CBI was established in 1983 to promote "a stable political and economic climate in the Caribbean region" (Yacobucci 2008) and to encourage economic growth and development in 24 designated Caribbean Basin countries by promoting increased production and exports of non-traditional products. Among its provisions it allows participating countries to export ethanol produced from foreign feedstocks (e.g. ethanol from third countries, including Brazilian) to the U.S. duty-free up to 7 % of the annual U.S. ethanol production. After the 7 % cap is reached, an additional 35 million gallons can be exported to the U.S. duty free, provided that at least 30 % of the ethanol is derived from "local" (Caribbean region) feedstocks. Anything above the additional 35 million gallons is still duty-free, if at least 50 % of the ethanol is derived from local feedstocks. If the local feedstock content is lower, limitations apply on the quantity of duty-free ethanol. To date, CBI countries have been dehydrating Brazilian ethanol in their plants and then exporting anhydrous ethanol duty-free to the U.S.

Despite this trade opportunity, CBI countries have never reached the annual dehydrated ethanol cap. For 2011, the 7 % volumetric cap on CBI ethanol duty-free exports to the U.S. is 870 million gallons, whereas the ethanol dehydration capacity of CBI countries is just 700 million gallons per year, consisting of three plants in Jamaica, two each in El Salvador and Trinidad and Tobago and one each in Costa Rica and St. Croix. In fact, the largest volume of CBI ethanol exports to the U.S. occurred in 2008 (340 million gallons) representing only 3.5 % of total U.S. consumption that year (Fig. 1).

Table 4 provides a breakdown of ethanol dehydration capacity in CBI countries. In 2008 Jamaica was responsible for some 80 million gallons of Brazilian-made sugarcane ethanol exports to the U.S. (Fig. 2). In 2009 Jamaica joined the U.S.-Brazil Memorandum of Understanding (MOU) in biofuels collaboration, which is intended to assist countries develop their biofuels industry and reduce dependence on imported fuels. The country has successfully implemented mandatory ethanol blending in domestically used gasoline. Based on its performance, Jamaica ranked as the 8th largest exporting nation with 2 % of global exports worth US$140 million annually (United Nations COMTRADE Database 2010).

Costa Rica exported just over 37.5 million gallons of ethanol to the U.S. in 2008. Domestically, its National Biofuel Program started in 2009 and introduced a 7 % ethanol blend in gasoline. The government hopes to increase the percent of ethanol mixed with gasoline to 12 % within the next 5 years in a structured effort to lower the country's dependency on foreign oil and to reduce GHG emissions (Inter American Development Bank 2006). Plans include increasing ethanol-producing crops and tax breaks for flex-fuel

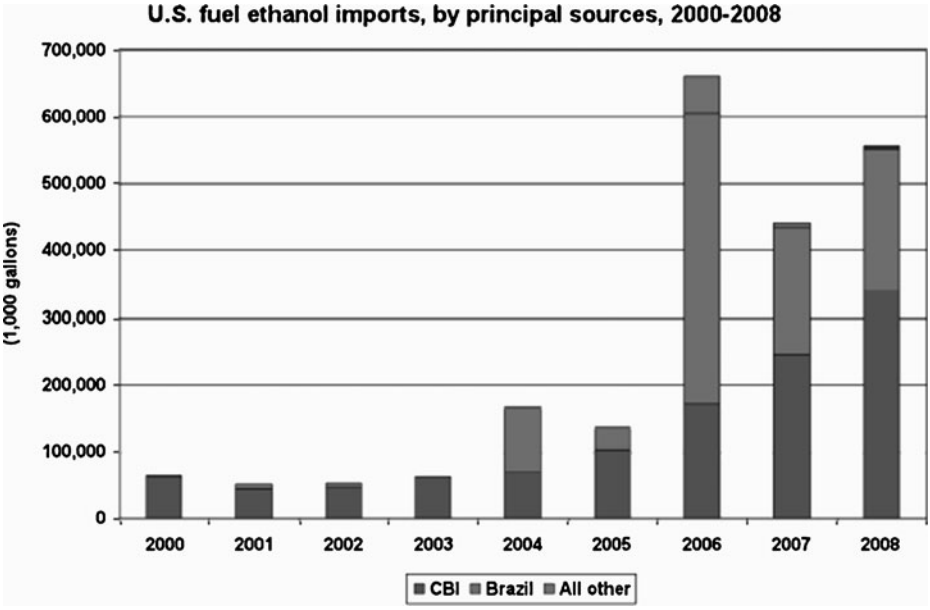

Fig. 1 U.S. ethanol imports, 2000–2008 (one gallon equals 3.8 l). U.S. International Trade Commission (USITC)

vehicles and other alternative fuel vehicles, as well as supporting the national association of fuel retailers to adapt their fueling infrastructure to biofuels.

El Salvador has made tremendous export strides with ethanol into the U.S. market doubling from 44.5 million gallons to nearly 75 million gallons between 2006 and 2007. As more investors enter the market, this upward trend may continue, but depends heavily on oil prices. Part of the success has been the U.S.-Brazil Memorandum of Understanding (MOU) in which El Salvador served as a pilot country for the introduction of biofuels policy and state-of-the-art technology to grow sugar cane for ethanol fuel production in Central America. We believe that this model of cooperative alliances can be replicated elsewhere in the Central American and Caribbean region to establish a robust biofuels industry.

Clearly, the U.S. ta1riff has proven essential to forcing Brazilian ethanol producers to use dehydration facilities located in CBI countries. The total impact of the CBI on the region is estimated at US$120–150 million/year with the value of products exceeding US$1.5 billion/year. There has been over US$300 million of investment in the nine Caribbean dehydration

Table 4 Dehydration capacity in CBI countries as of 2009 in million gallons per year (mgy)

Country	Capacity (mgy)	Operator
Costa Rica	60	LAICA
El Salvador	170	Gasohol de El Salvador; American Renewable Fuel Suppliers
Jamaica	215	Petrojam; Jamaica Broilers; JEPL
Trinidad & Tobago	200	TBTL; Ethylchem
U.S. Virgin Islands	100	GeoNet
TOTAL	745	

One gallon equals 3.8 l*USITC* U.S. international trade commission

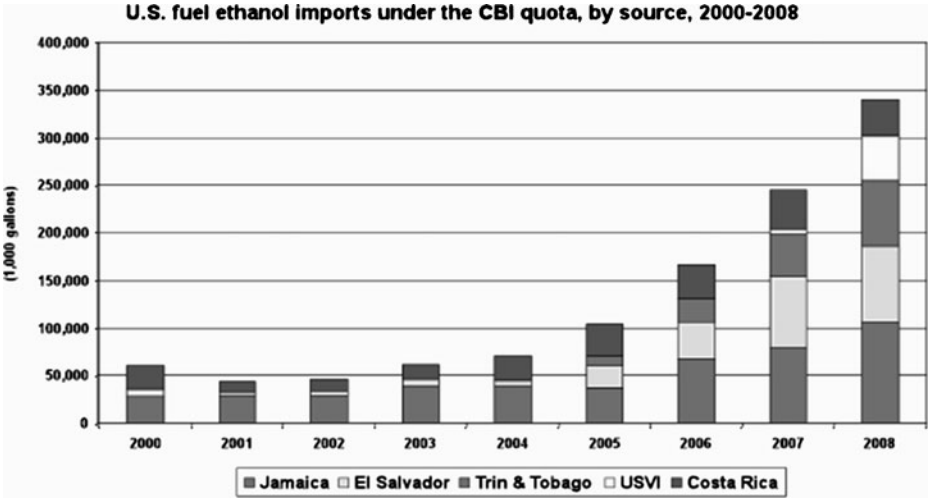

Fig. 2 U.S. fuel ethanol imports under CBI quota, by source, 2000–2008 (1 gallon equals 3.8 l). U.S. International Trade Commission (USITC)

facilities between 2007 and 2010. According to the Caribbean Ethanol Producers Group the projected cane ethanol potential of the region still falls under the 7 % CBI cap (Table 5) and could be supplemented through investment in additional CBI facilities built to meet U.S. demand, as dictated by the U.S. Renewable Fuel Standard (RFS2).[6]

It should be noted that Dominican Republic- Central American Free Trade Area (DR-CAFTA), the second largest free-trade zone in Latin America for exports to the U.S., does not increase overall access to the U.S. ethanol market. However, it establishes country-specific shares for Costa Rica and El Salvador within the overall CBI quota. El Salvador is guaranteed 5.2 million gallons in the first year, with annual increases of 1.3 million per year capped at 10 % of the quota, whereas Costa Rica is allocated 31 million gallons annually (Office of the United States Trade Representative CAFTA, 2005).

4.3 The U.S.-Brazil memorandum of understanding (MOU)

The U.S. and Brazil signed an MOU in 2007 to advance biofuels in the CAC region through techno-economic collaboration. Its goal is to accelerate the development and integration of biofuel feedstocks, production, and distribution systems. This cooperation has resulted in partnerships with Guatemala, Honduras, Jamaica, the Dominican Republic, El Salvador, Haiti, and St. Kitts and Nevis. In the initial tranche of countries, the U.S., Brazil, and MOU partners (Inter American Development Bank, Organization of American States, and United Nations Foundation) obligated over $4.3 million across 12 projects that are underway. Emphasis is placed on (1) the key role private industry should play in spurring innovation in biofuels technologies and in bringing the needed investment to grow the market, and (2) on the need for biofuel policy implementation by governments.

[6] The revised Renewable Fuel Standard (RFS2) is a mandate implemented by the U.S. Environmental Protection Agency (EPA) in 2010 under the Clean Air Act (CAA), which aims to boost biofuel production in the U.S.

Table 5 Collective projected sugar cane ethanol potential for the CBI region

Year	Potential cane ethanol (billion gallons per year[1])	CBI 7 % Cap
2011	0.294	0.87
2012	0.49	0.98
2013	0.7	1.06
2014	0.75	1.16
2015	0.8	1.3
2016	1.0	1.4
2017	1.2	1.6
2018	1.4	1.7
2019	1.6	1.8
2020	1.8	2.0
2021	2.0	2.1
2022	2.0	2.3

Caribbean ethanol producers group, 2011[1]One gallon equals 3.8 l

5 Progress in biofuels policy for selected countries

At the national level, several countries are drafting new policies and strategic plans to develop their biofuels sectors. There are ongoing efforts to transition from sugar cane strictly for sugar production to ethanol co-production and in terms of biodiesel new facilities are being built in countries like Costa Rica and Guatemala (IEA 2006). Detailed technical feasibility studies are ongoing or near completion in many smaller CBI states. The Inter-American Development Bank reports more requests for assistance and increasing demand from the region to develop Biofuel Action Plans including from El Salvador, Haiti, Dominican Republic, Jamaica and Nicaragua (Inter American Development 2006). Within the Caribbean Common Market (CARICOM) group of states, the Caribbean Renewable Energy Development Program is developing a regional policy approach to biofuels. Only five countries in CAC have national biofuels plans, while four more have plans in various stages of development. Countries with plans include Costa Rica, Honduras, El Salvador, Jamaica and Nicaragua; plans in development in Trinidad & Tobago, Dominican Republic, Belize and Nicaragua. The progress being made in selected Caribbean countries is reported below. An effort is made to highlight several CARICOM members within the CBI, since less information is available on them in the literature compared to DR-CAFTA member states.

5.1 Barbados

The draft Barbados National Energy Policy aims to mitigate the impact of high oil prices through a series of measures, including lower dependence on fossil fuels through promotion of renewable energy. As part of biofuel development, the government is constructing a 30 MW co-generation plant, and the feasibility of a second biofuel project using energy crops will be investigated. There are plans to implement a standard of 10 % ethanol in gasoline (E10) and to progressively raise it over the next 20 years as more ethanol becomes available. Approximately 14.7 million liters of ethanol will be produced annually to meet the initial requirement. The government also considers mandating 2 % biodiesel content (B2) in diesel fuel by 2012 and increasing it to B10 by 2025. Within the next 5 years it is anticipated that approximately 40 MW of electricity will be generated by renewable energy (30 MW from biofuels, 10 MW from wind), representing 17 % of the current capacity. The

government will promote the wider use of hybrid, flex-fuel and natural gas vehicles through a discriminatory tax regime that favors fuel diversification and fuel-efficient vehicles. The private sector will be encouraged through appropriate incentives to develop the biodiesel industry.

5.2 Guyana

The draft Guyana Agro-Energy Biofuel Policy provides a roadmap for the development of a competitive and sustainable agro-energy sector in Guyana, through targeted research, development, training, institutional enablement, technology transfer and investment. Land use, investment incentives, taxation and agricultural, and environmental and energy regulations will all be affected by this policy. It states the expectation that by 2020 Guyana will derive at least 65 % of its local fuel energy from agro-energy, and agro-energy exports will make a significant contribution to its Gross Domestic Product (GDP). Issues of significance are feedstock availability, availability of land and water resources, and competing uses for such resources. The policy emphasizes that agro-energy will not be developed at the expense of food production, will not be subsidized by the government and will ensure environmental sustainability, and in particular, protection of forested areas. The draft policy sets a target of substituting 10 % of nationally consumed gasoline with ethanol. Current pilot projects include the cultivation of 50,000 ha of crops for biofuel production, an ethanol project to look at sweet potatoes as feedstock and the commissioning of a biodiesel plant that will assess the use of African palm oil and jatropha as biofuel feedstocks. Several investment projects are underway, three for ethanol production from sugar cane, three for biodiesel production from palm oil, one for grass production for electricity and one for power co-generation from bagasse.

5.3 Jamaica

The National Energy Policy encourages the use of biofuels and ethanol blends as part of its goal of promoting social equity and environmental sustainability. It also stipulates policy and regulatory incentives, such as duty and tax exemptions on use of biofuel technologies. It incorporates an ethanol-blending mandate that lays out minimum percentages of ethanol to be added to gasoline and a mandate for minimum percentages of biodiesel to be mixed with diesel from 2010 to 2020. As noted earlier, there are three ethanol dehydration plants in Jamaica that have exported fuel ethanol to the United Sates under the CBI. The National Energy Policy Green Paper (2006–2020) sets targets for renewable energy sources in total energy use (10 % by 2010 and 15 % by 2020). Ethanol is earmarked for transportation energy needs from local feedstock sources (mainly sugarcane). Local feedstocks for biodiesel production would include castor, palm, jatropha, sunflower and rapeseed, and the government is developing partnerships with the government of Brazil for technical assistance to develop these feedstocks.

5.4 Organization of eastern Caribbean states (OECS)

St. Kitts and Nevis is presently considering its biofuels potential after the closure of its sugar industry as a result of changes to the European Union (EU) sugar regime. Several international investment proposals are being considered for using the sugarcane land for ethanol and other biofuel production. Feasibility studies suggest that under certain conditions

electricity and biofuels can be produced for the local market. The country is one of the CBI countries to benefit from the U.S.-Brazil MOU. The other Organization of Eastern Caribbean States (OECS) countries, Dominica, St. Lucia and Grenada, do not have biofuels policies in place, but are preparing sustainable energy plans that include the use of biomass and other renewable resources[7] through changes in the regulatory framework, tax concessions, energy efficiency measures and public education.

5.5 Suriname

Suriname has not developed a biofuels policy to date but has requested support for doing so from several international multilateral organizations, including the UN Economic Commission for Latin America and the Caribbean and the Inter-American Development Bank. Preliminary policy development research suggests that the vast availability of land and water along with an appropriate climate for biofuel feedstocks are among the positive drivers, while weaknesses that must be addressed include lack of incentives for biofuel production, weak research and development (R&D) support, inadequate transport infrastructure and lack of manpower.

5.6 Trinidad and Tobago

In 2011 the draft National Renewable Energy Framework was launched to address renewable energy development, strategy and technology choices (Blechinger and Shah 2011). It states that in the transportation sector the promotion of R&D in biofuels should be encouraged, particularly for ethanol production. A local biofuel industry is seen as a means for long-term energy security and sustainability, while the main concern is about land use for biofuels at the expense of food crops. It also notes technological considerations and the need to monitor R&D in gasification and other advanced processes used in the production of biofuels to determine their applicability to Trinidad and Tobago in the future. While private sector producers do export dehydrated ethanol to the U.S., the lack of production incentives is still seen as a major weakness to be addressed.

6 Regional progress in biofuel substitution

Ethanol is clearly the "Fuel of the Americas" with the U.S. and Brazil dominating the global scene. Independent life-cycle analyses have shown that sugarcane ethanol is significantly more sustainable than corn ethanol helping reduce carbon emissions by 80 % compared to gasoline (Worldwatch Institute 2006; Philippidis 2011). Thanks to almost 40 years of industrial and policy experience, Brazilian cane ethanol is the lowest-cost ethanol in the world, reportedly competitive with gasoline at oil prices as low as $50 per barrel. However, the U.S. ethanol import tariff and the lack of a biofuels policy in most Latin American countries prevent citizens of the Western Hemisphere from benefitting from the strategic, economic, and environmental benefits that biofuels "made in the Americas" offer.

Yet, there are signs of biofuels collaboration in advanced biofuels (Philippidis 2008). These biofuels are made from cellulosic biomass and algae without affecting food production or using agricultural land, since biomass is already generated as an agricultural byproduct and algae can

[7] It is part of the Global Sustainable Energy Islands Initiative (GSEII), which is a consortium of governments and NGOs supported by the Organization of American States, the United States Agency for International Development (USAID) and others.

be produced on non-arable land. While the U.S. is the leader in cellulosic biomass and algae technologies, CAC possesses the necessary resources for production including significant quantities of biomass, such as sugarcane bagasse, areas of underutilized land, plenty of sunlight, and warm weather to build a competitive industry. The opportunity to produce advanced biofuels at existing sugarcane mills in CAC can reduce significantly the capital and operating costs of the fuels and make them commercially cost competitive. Hence, the forthcoming commercialization of advanced biofuels represents an excellent prospect for biofuels production in CAC.

Biodiesel production, as a diesel replacement, has also increased throughout the Americas. The U.S. production of 700 million gallons comes primarily from soybeans, whereas Brazilian and other Latin American production comes from a diverse portfolio of plants, including African palm, sunflower, canola, and castor oil, as well as used cooking oil and animal fat. Because most of the biodiesel is produced and consumed locally, biodiesel has not experienced the trade obstacles of ethanol. Interestingly, Latin America has taken the lead in the production of biodiesel from non-edible oil-producing plants, such as jatropha, which is a native plant to CAC. Guatemala and Brazil are already producing small amounts of jatropha biodiesel on underutilized land. As biodiesel production does not require the large economies of scale of ethanol production, this biofuel looks promising also for the Caribbean island nations.

It should also be noted that the large agricultural sectors of Latin American countries generate an abundance of agricultural residues, such as sugarcane bagasse, wheat straw, African palm biomass and other byproducts. These low- or no-value materials can be used as solid fuel in power plants either co-fired with coal and other fossils or by themselves, as practiced by several sugarcane mills in Brazil and Colombia. Hence, investment in biofuels can also boost a country's power generation capacity in a sustainable way.

6.1 Biofuels substitution challenges and policy intervention options

CAC are well experienced in sugar production and exports and in agro-technical aspects. Only the end product, ethanol, is new and a departure from traditional sugar, molasses and rum production. The region must focus on producing ethanol competitively. Table 6 presents selected policies and measures for supporting biofuels investment in Caribbean Basin economies based on Wiesenthal et al. (2009).

The success of such policies and measures will vary depending upon social, economic, and institutional context. While policies and programs for expanding biofuel production are still in the infancy stage, the region's experience with production for export to the U.S. market under the CBI still allows several useful lessons to be learned. To maximize the CBI opportunity and indeed to maximize biofuel substitution for sustainable development, several constraints need to be addressed.

Table 6 Recommendations to improve biofuels investment policy

- Grants or soft loans provided by international donors
- Central Information Desk for investors
- State guarantees that facilitate bank lending
- Low-interest credits or income tax rebates
- CDM financing
- One-stop agency for contacts between investors and public entities
- Clear administrative responsibilities
- Stronger participation in international programs on regional or global level

First, developing a viable national biofuel program takes time. As international biofuel demand increases over the coming years and technological advancements continue, the economic viability of biofuels production and substitution will likely become more attractive. Hence, it is crucial that national programs consider medium and long term plans, including a well designed and coordinated strategy that engages all stakeholders, supports R&D to improve sugar cane varieties and processing methods, provides financial incentives to private investors and generates confidence among consumers. Second, the CAC region faces the challenge of luring international investment in general. Despite some instances of near misses,[8] foreign investment is still reluctant to make firm decisions for reasons we analyze later.

Third, the rather small size of the CAC countries deprives them of the advantages provided by economies of scale. Still, many of these islands have more arable land than is currently in use. For example, Cuba utilizes only 700,000 ha of its 6.6 million ha of arable land. Fourth, political instability reduces the appeal of some CAC countries to foreign investors. Finally, natural disasters, such as the recent catastrophic earthquake in Haiti, and seasonal tropical hurricanes, make foreign investors rather wary about unforeseeable risks to their investments.

Yet, there is a major opportunity for biofuel production and substitution in CAC, albeit it may be difficult to replicate the Brazilian success. Nevertheless, the region can still take full advantage of duty-free trading with the U.S. for access to large markets and hence economies of scale, wherever possible. Ramping up regional biofuels programs to a competitive stage in the near future requires policy considerations to be made now with future sustainable rural development and reduction of GHG emissions in mind. The following analysis suggests some of the key non-technical challenges for consideration by local governments.

7 Key challenges requiring policy interventions

There are several challenges requiring targeted policy interventions for wide-scale production, use, and export of biofuels in the CAC region. Even in developed countries, such as the U.S., where the market for ethanol is comparatively large due to demand in the transportation sector, the growth of ethanol output is primarily driven by fiscal incentives, such as subsidies, and regulatory instruments, like biofuel blending mandates (Timilsina and Dulal 2008).

7.1 Political uncertainty

Although CAC possess the right climate and agricultural experience to lead the world in biofuels production, they will require significant foreign investment from the private sector and from international development banks. However, such investment requires political stability. Energy production/distribution has always been a public-private partnership and as such it is vulnerable to political fluidity. Changes in government regimes through electoral process or otherwise is common and frequent. In just the last decade or so, there have been multiple regime changes in several CAC countries including Guatemala, El Salvador, Dominican Republic, Jamaica and Trinidad and Tobago. When political change is accompanied by drastic shifts in political ideologies there have been consequences on energy

[8] Although Infinity Bio-Energy and the Jamaican government failed to strike an agreement for the privatization of the country's sugar factories, the case illustrates a genuine effort to put adequate funds into Caribbean basin programs. Later, Kingston reopened its search for potential buyers (Liskey 2009) and successfully concluded the divestiture.

production and distribution policy in these countries (Arriagada 2006). This can, and has included dismissing of long term energy supply contracts, alterations to royalty agreements and exclusive exploration rights and shifts in subsidies for renewable energy. As a result, foreign investment will shy away from countries with a history of political unrest that affects energy policies. In particular, corruption and lack of protection for intellectual property and business contracts constitute tremendous barriers to the flow of U.S. and other foreign investment into biofuels (and other industries) in the CAC region. Hence, as of now, just a handful of countries, like Chile, Colombia, Costa Rica, and Panama, are most likely to attract the bulk of foreign investment in the energy sector. For this barrier to be removed, the whole continent needs to practice democracy, open market economics, and business transparency.

7.2 Absence of legal and regulatory framework

Most CAC countries lack an adequate regulatory and legal framework regarding the creation of public-private partnerships, protection of foreign investment, and repatriation of profits. These conditions can discourage investors. As biofuels represent a new industry, their production, distribution, and use need to be regulated under a clear and stable framework that transcends local politics. Quality standards for the produced biofuels need to be instituted or adopted from other regions of the world, such as the U.S. or the European Union (EU). Moreover, CAC countries need to institute expedient industrial permitting review and licensing procedures for new biofuel facilities, so investors can have a good understanding as to what it will take and how long before their investments generate profits.

7.3 Absence of long-term biofuels policy

A national energy vision revised to include long-term renewable energy and biofuels policy provides a strong incentive for investment. Consequently, 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 doing business in a country. The cases of Brazil and, more recently, of Colombia provide ample proof of the benefits derived from biofuels policy adoption. Since 1973, Brazil has had legislated, state-supported biofuels programs. Columbia implemented biofuels supporting legislation a decade ago, in 2001. This kind of strong long-term commitment has attracted domestic and foreign investment to the two countries enabling them to realize the numerous economic, social, and environmental benefits of domestically produced ethanol and biodiesel. Countries in CAC can follow the example of Colombia by providing incentives for the establishment of agricultural and manufacturing biofuels capacity and infrastructure in their economies and for the gradual adoption of gasoline-ethanol blends and diesel-biodiesel blends. Policy formulation should also be flexible enough to accommodate some of the uncertainties, like the future development of new feedstocks and novel conversion technologies (Ewing and Msangi 2009).

7.4 Lack of business incentives

The lack of business incentives for domestic production and use of biofuels remains a key obstacle to the success of the industry. 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, energy security and environmental friendliness. To counter

international trade restrictions, CAC countries need to develop and adopt policies promoting the local production and use of ethanol and biodiesel (and other future low-carbon fuels), such as revenue tax exemptions for biofuel-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.

Evidence from the EU shows that partial or total exemptions from fuel taxes for biofuels were vital in promoting them. Countries such as Germany (until the end of 2006), France, Sweden, and Spain with favorable tax regimes in place were the ones with a high penetration of biofuels. In the U.S. national tax incentives have played a major role in enhancing ethanol production. Biofuels can be tax-exempt by setting conditions, so that tax exemptions do not create perverse incentives. For example, according to Wiesenthal et al. (2009) the tax exemption or reduction must not exceed the amount of taxation payable on the volume of renewable fuel used; the exemption or reduction authorized should not be applied for a period of more than a specified number of years; and changes in feedstock prices must be accounted for in order to avoid overcompensation.

7.5 Trade barriers

Trade protectionism, in any form, remains a hindrance for biofuels production especially in the small countries of CAC, where small local demand may not justify investment or cannot accommodate the large economies of scale biofuels usually require. Agriculture in the developed world remains heavily subsidized leading to severe market distortions and trade constraints and making it difficult for developing countries to export to richer countries, while also producing enough food for their own populations (Greiler 2007).

In essence, protectionism prevents biofuels from becoming global commodities for the benefit of the consumer. Biofuel trade liberalization would increase competition in the sector and improve efficiency by bringing down costs and enabling developing countries to expand their share of the biofuels market. However, removal of trade barriers alone may not be enough. It must be accompanied by a commitment by rich developed countries to reduce or eliminate domestic protection of feedstock producers and their biofuels industries (Kojima and Klytchnikova 2008).

The root cause of these issues lies in the agricultural nature of biofuels. Countries around the world, including Latin America, have historically subsidized and protected their own farmers thus distorting the prices of crops. It would be naïve to expect that this centuries-old practice will change now. However, closer collaboration and coordination in the Western Hemisphere can minimize or remove such barriers over time and give CAC countries the opportunity to become biofuel suppliers.

7.6 Insufficient market information for investors

There is a lack of up-to-date, specific information available to identify particular locations, where biofuels can be developed in CAC. As the viability of any given ethanol or biodiesel project tends to be highly site-specific, potential investors need to have quality information on appropriate sites and resource potential. For example, mapping of biofuel and renewable energy suitability areas (including agricultural, environmental and social factors) will help decision-makers and investors quickly determine where to pursue viable and profitable projects. A critical constraint to biofuels development is the lack of awareness and experience among investors and financiers, which leads to a higher risk perception for taking on biofuels and other clean energy projects.

8 Biofuels policy interventions

8.1 National biofuels legislation

National plans must include several elements (see Table 6). These include privatizing or overhauling aging and inefficient government-controlled sugar mills "as Jamaica has already done"; the adoption of fuel specifications and mandates for environmentally and socially sustainable methods of feedstock cultivation and biofuels production; and the creation of incentives for production, such as tax breaks. Consideration must also be given to increasing domestic consumption through mandatory blending and use of biofuels by public vehicles and taxi fleets; public education campaigns; and tax structures which support the competitiveness of biofuels. Biofuel promotion instruments—mandatory blending quotas and tax exemptions— generate economies of scale via increases in demand (Peters and Thielmann 2008). Moreover, the potential benefits of the Clean Development Mechanism (CDM) has not been clearly understood by most regional governments and, hence, policies have not been developed to support CDM project sponsors (mainly from developed countries) and establish regulations that account for uncertainties regarding the Kyoto framework extending beyond the 2008–2012 commitment period.

Other areas requiring attention are policies for capacity expansion, infrastructure financing and innovation and R&D. Increasing biofuel supply will require strong and attractive financing sources (debt and equity), whereas mandatory blending regulations may require modifications to gas stations and vehicles (for blends over E10 and B20) and extensive consumer education. Perhaps the greatest immediate need for the region is infrastructure development for biofuels. This includes storage tanks and distribution transport, a network of dedicated pumps at fuel stations, transport pipelines (if possible), port infrastructure and dedicated terminals and storage facilities. Finally, all CAC country policies must address promoting technological advancement and providing labor training to support the development of competitive and efficient biofuels production region-wide. Collaborative inter regional policies, as well as agreements especially with industry leaders like Brazil and Colombia, should be prioritized (Fig. 3).

8.2 Supply side incentives

Supply side measures, such as agricultural feedstock support or grants to bioenergy production, can also play an important role. "Food vs. fuel" concerns can be addressed by only farmers and entrepreneurs willing to cultivate bioenergy crops on set-aside areas or on under-utilized land that is not suitable for crop production. State support could come in the form of policy and financial incentives, such as access to credit, tax benefits and greater use of the CDM. Also, achieving economies of scale via multi-nation collaborations will make production costs more competitive. Co-operative policies that cluster small producers and government-assisted access to technology should be given serious consideration. Technologies for sugarcane-based ethanol and oilseed-based biodiesel are already well developed and could be used to anchor industry development, whereas technologies for other types of feedstocks, such as jatropha and algae, are more futuristic.

8.3 Environmental and social risk prevention

Biofuel development can provide welfare gains that can improve purchasing power and decrease vulnerability to price shocks for food and energy by enhancing income generation

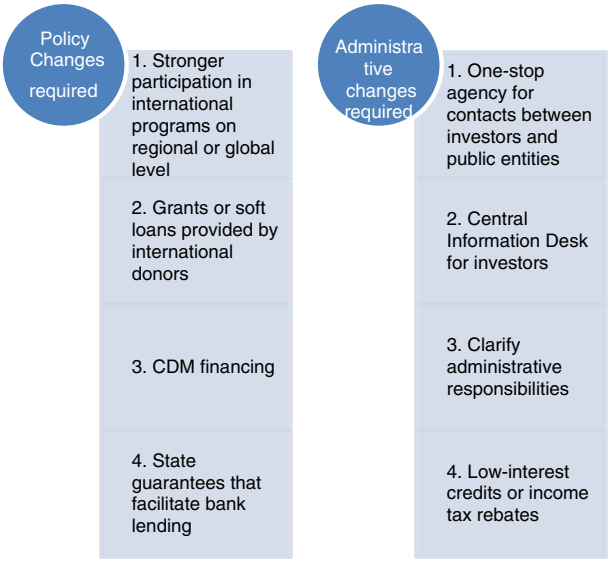

Fig. 3 Recommendations from industry executives to increase Caribbean biofuels investments

opportunities. As labor used in the planting and harvesting of biofuel feedstocks is mostly unskilled, there will be employment opportunities for rural laborers and small-holders, depending on local needs (Ewing and Msangi 2009). Peters and Thielmann (2008) argue that biofuel promotion contributes to rural employment and development through value addition in the agricultural sector. Expansion of biofuel industries in developing countries can also enhance job creation through planting of dedicated bio-energy crops (Memon et al. 2010). One of the social benefits of biofuel production is that it is much more labor-intensive than fossil fuels. Increased labor demand can have a substantial impact on unemployment reduction in rural areas. In addition to work in the fields, semi-skilled jobs, such as trucking, machinery operation and maintenance, will also be created.

As grid expansion and fuel distribution are prohibitively expensive in rural areas of developing countries, biofuel production provides them an opportunity to use their own fuel locally. The CAC will not have to dispose hard-earned income on oil products, whereas biofuels will help increase the household incomes of farmers (Lanely 2006). However, to what extent increases in agricultural income translate into improvements in income and welfare in the rest of the economy depends on the extent to which agriculture contributes towards GDP and on the percentage of the workforce employed in agriculture and related sectors. One of the ways of maximizing welfare benefit is through the use of small-scale biofuel production models, if economically feasible, which convert feedstocks locally (Ewing and Msangi 2009).

Attention must be paid to the impact of biofuels on natural resources, biodiversity and exacerbating social asymmetries. Jumbe et al. (2009) suggest that biofuel crops' adverse agricultural impact could be minimal if done carefully through strict monitoring and regulations. Policies must also consider direct and indirect impacts on social conditions, such as the labor market, concentration of wealth and social distribution of the gains. The proper national approach would be to develop rural development policies that meet each CAC nation's basic energy and food needs and address issues such as poverty, indigence and under-nutrition.

8.4 Multilateral collaboration in R&D

More support for cooperation in ethanol and biodiesel R&D between CAC and developed countries must be pursued through the U.S.-Brazil MOU and other hemispheric and multilateral mechanisms. Activities should include multilateral organizations facilitating technology transfer and measures to incorporate the private sector into funding and research activities. Specific issues, including the strengthening of regional trade agreements and patent-enforcement laws to facilitate the transfer of ideas and technology across borders have to be addressed in regional efforts. One main focus of R&D cooperation has to be development of productive crop cultivars, better agronomic practices, and next generation biofuels. Multilateral institutions, especially from the U.S. and Brazil, can be solicited to assist with improving national agricultural transportation and production systems and by helping conduct market and feasibility studies in close cooperation with research institutions in Caribbean Basin countries.

The Inter American Development Bank has been supporting the MOU by financing biofuels "blueprints" in Haiti and complementing its efforts in the Dominican Republic and El Salvador to determine suitability for domestic biofuels production; mapping of areas for feedstock development; and identifying key locations for production facilities. Action plans have been developed or are in development for Guatemala, Honduras and Mexico to determine regulatory issues and legislation; fiscal impact analysis; technical feasibility studies; and environmental and social assessments.

The Organization of American States (OAS) is a partner organization in the U.S.-Brazil MOU. It assists in implementing partnership activities in the countries that are beneficiaries of the agreement, including Jamaica, Dominican Republic, El Salvador, Haiti, Guatemala, Honduras and St Kitts and Nevis. The OAS also supports other sustainable energy activities in the Caribbean, such as the Caribbean Sustainable Energy Program for the development of national energy policies and implementation measures (in Antigua and Barbuda, the Bahamas, Dominica, Grenada, St Kitts and Nevis, St Lucia, and St Vincent and the Grenadines),

9 Conclusions

Based on the CBI experience of CAC countries, certain regional-level policies will benefit many, although there is no "one size fits all" approach to developing a biofuels industry, attracting investment and advancing oil substitution. There are differences between the region's countries in regards to political stability and corruption, production and use of biofuels, natural resources, previous experience and technological development, availability of alternative energy sources for transportation, degree to which the basic energy needs of populations are being met, poverty and under-nutrition. Policy interventions must be multi-dimensional and structurally managed in a centralized way. Policy formulation and implementation must move away from the relative norm of being commandeered solely by energy authorities. The process must include input from government agencies concerned with agriculture, industry, transportation, finance, natural resources, environment, social services and municipal governance.

Although the ethanol provisions of the CBI have benefited CAC countries that possess ethanol dehydration plants, the local ethanol industry realizes that it will become less competitive if the U.S. import tariff on Brazilian ethanol is eliminated or greatly reduced, as suppliers will likely ship anhydrous ethanol directly from Brazil to the U.S., hence

bypassing the Caribbean dehydration facilities. Establishing and expanding local markets for biofuels can help them create new business opportunities.

Increased food and fuel production can go hand-in-hand, especially when new agro-industrial biotechnology methods are deployed. To prevent large-scale displacement of food production because of biofuels production, it is vital that policies and institutions invest in greater agricultural productivity and/or address distribution issues related to the benefits accrued. Increased demand for biofuels could boost the economy of regional agricultural sectors with positive effects on rural development and poverty reduction (Rothkopf 2007), but there is a need to better understand the extent to which the production of some types of biofuel feedstocks could adversely affect the production of food crops. Studies to understand such trade-offs must also consider the impact of subsidies on the agricultural and energy sectors through a cost-benefit analysis for each country's entire economy (WRI 2008).

Another theme that policy makers should consider is the integration of national biofuels policies within the larger economic development portfolio. Marginalized or isolated energy and biofuels policies can potentially be counter-productive to investment, productivity, competitiveness and rural wealth-building objectives. For instance, agricultural policies may constrain feedstocks, making it increasingly difficult to meet mandates or may counteract pricing policies by limiting the range of cost-effective alternatives. Also, within the purview of environmental policies, a carbon tax can incentivize lower consumption of fossil fuels, which in turn could complement low carbon fuel standard compliance.

At the regional level, the entire Western Hemisphere has now moved into the realm of what has been deemed "ethanol diplomacy".[9] Negotiations and agreements made by the major producer-suppliers, the U.S. and Brazil, will have great ramifications on the energy security and sustainable development of the smaller economies of CAC. Collaboration agreements between the two biofuel superpowers would allow CAC countries to improve their productivity in both the fields and the biofuel plants. Brazil's voiced commitment to the region to promote, share and transfer Brazilian ethanol technology should be proactively pursued by national governments. Based on the U.S.-Brazil MOU, it is now up to CAC governments to exhibit the commitment and political will to expose their technical, business, and policy experts to Brazilian and U.S. experience and know-how from their public and private sectors.

CAC governments need to seize trade opportunities, while they last or when they appear. The immediate hurdle of deciding on suitable feedstocks based on technical feasibility as well as considerations of land availability and environmental impact must be pragmatic. While sugarcane ethanol may be best suited for highest profitability within the CBI context, there will also be future opportunities in second generation feedstocks from biomass and algae.

Before designing and implementing policies to promote biofuels, national governments need to have a clear understanding of the potential sustainable development benefits. Lessons from Brazil, India, Indonesia and Costa Rica among others, suggest that biofuel industry development requires a set of appropriate economic incentives and domestic policies. From a sustainable development perspective, biofuel policies should promote investment in environmentally suitable farming practices and technologies, as well as enable the fair participation of small farmers in the supply chain.

[9] This term first became prominent in 2007, when energy security was the main focus of U.S. President George W. Bush's Latin American tour, in which he met with Brazil's president Luiz Inacio Lula da Silva. They sought a common agenda to promote the production and use of sugar cane-based ethanol throughout Latin America and the Caribbean (Colitt 2007)

Most countries in Latin America and the Caribbean have large differentials between production potential and expected demand for biofuels, therefore creating significant potential to export to North America, Europe and Asia (Doornbosch and Steenblik 2007). The prospect of biofuels for the Caribbean's smaller economies holds the promise of energy security, foreign investment, economic growth, job creation, international trade, and protection from climate change. In short, a biofuel industry can be the catalyst to sustainable development sought by the region. The present study has also disclosed critical challenges and obstacles to the region's ability to maximize these opportunities. Interestingly, many obstacles are not directly related to technological deficiencies, but rather to domestic political, socio-cultural and institutional hindrances. It is, therefore, to a significant extent in the hands of CAC governments to systematically address these obstacles in order to take advantage of the economic opportunities that biofuels represent for the citizens of CAC within the CBI context.

We also suggest that there are lessons learned in the Caribbean experience that are applicable to other small economies with biofuels potential. First, the over dependence on the preferential arrangements of the Caribbean Basin Initiative made the region vulnerable to U.S. policy changes and minimized the emphasis on growing the domestic and regional markets for biofuels. Other countries should consider their underlying policy objectives for investing in biofuels energy development. These objectives could include being part of broader climate change adaptation and mitigation strategy, as a sustainable economic development mechanism especially for rural areas and to increase exports to earn additional foreign exchange. Second, countries should consider the constraints and limitations of their natural endowments of geography, land and water resources, infrastructure and competitive market positions in order to decide if they should embark on national biofuels programs or form alliances with neighbors to develop the industry as a block. This could lead to increased ability to negotiate exports with foreign markets, collate resources, spread investment risk, create economies of scale and open sharing of best practices in technology. But such regional alliances can also have long term political and socio-cultural implications that must also be considered. Thirdly, developing countries must understand that the investments being made in biofuels research and development including second and third generation sources can quickly alter the attractiveness to invest in particular or singular sources. National policies that broadly promote a portfolio of biofuels best suited to country conditions should be encouraged rather than policies singling out particular feedstocks or sources. This ensures avenues for future growth opportunities should market conditions, technologies or fuel preferences change.

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