Biofuels: ACP's response to fossil fuel dependence

The role of Science, Technology and Innovation in Supporting a sustainable biofuel sector

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This policy brief outlines various opportunities for using local biomass resources to reduce dependence of ACP countries on fossil fuels and to improve the competitiveness of traditional and non-traditional agricultural-based industries.

1. INTRODUCTION

ACP countries with their biomass resource potential are well positioned to effectively use biofuels for partially meeting their energy needs. The continued increase in the cost of fossil fuels - a finite resource, coupled with the cut in world market prices for sugar and other traditional export commodities have forced many ACP countries to seek innovative ways of meeting energy demands and diversifying agricultural production.

Biofuels are products from biological origin that have been converted into liquid, solid or gas form, depending on the raw material base and the technology employed, for energy generation. *Liquid biofuels* are used for heating, cooking, lighting, transport and power generation. Bio-ethanol, bio-diesel and pure plant oils are the most common forms of liquid biofuels. *Solid biofuels* are plant matter such as wood chips, and other solid or woody biomass, that can be directly used as fuel. Two of the most widely used forms are wood chips and bagasse - the fibre remaining when sugar cane is crushed to remove the cane juice for sugar production. Bagasse has been used for centuries for electricity generation at sugar mills and excess power can be sold to the national grid. *Gaseous biofuels* include biogas, which is produced by digesting organic waste and is generally used for cooking, lighting and power generation at the village level.

Figure 1: Farmer harvesting cane for sugar and biofuel utilisation *(Source: Associated Press)*

2. WHY BIOFUELS?

Biofuels provide an opportunity for ACP countries to utilise their natural resources to attract the necessary foreign and domestic investment to contribute to achieving sustainable development goals including energy security. Promoting the use of biofuels, in a sustainable manner along with other non fossil energy sources such as solar energy can contribute to improved quality of life, economic development, job creation and poverty alleviation, especially in rural areas.

The sugar cane plant (Figure 1) which grows well in most ACP countries is considered the most efficient species of the plant kingdom in terms of biomass production and can be further engineered using traditional and modern plant breeding techniques to produce increased amounts of sugars and higher

percentages of fibre. Sugar cane juice and molasses are fermented to produce ethanol as is happening on a large scale in Brazil. Cassava (*Manihot esculenta*) and switch grass (*Panicum virgatum*) also serve as feedstock for the production of ethanol. Vegetable oils obtained from oil palm (*Elaeis sp*), coconut (*Cocos nucifera*) and *Jatropha curcas*, for example, can be used in their direct form (pure oils) or converted into biodiesel as is done in the EU, India, Indonesia and Malaysia. By-products from livestock and fisheries industries also provide a raw material base.

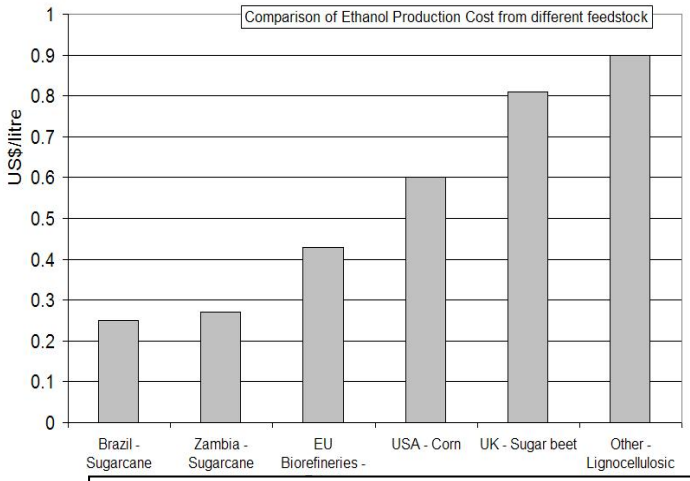
In the EU, USA and developing countries such as China, Malaysia and Thailand, much research work is underway to expand the range of conversion technologies. Enzymatic treatments and new strains of yeast are being developed at a rapid pace for producing ethanol from cellulose. Biomass production from algae seems promising. Systems to reduce the amount of energy used in producing bioethanol are also being designed. However, the key impediments to accessing these newer technologies may not be patent and licensing arrangements but tariffs and other restrictions (ICTSD, 2007). ACP scientists and engineers must be encouraged and facilitated to contribute to the global knowledge system that is working on improving the conversion technologies and expanding the feedstock base.

Producing biofuels can provide alternate fuels for ACP countries to respond to increasing demand in local and international markets. However, the social, scientific and technological challenges must be overcome to increase production efficiencies, ensure adequacy in food supply at affordable prices and safeguard the environment and livelihoods. A concerted effort of the scientific community, governments and regional bodies, international agencies and donors, engineers and society is needed.

3. CHALLENGES

3.1 Economics

Market prices of feedstock and fossil fuels are the main determinants of biofuel competitiveness. Given that these prices are highly volatile, investing in biofuel requires closer examination of the long term market potential and other determinants to minimize the risks. Economies of scale are crucial and in this regard, it is important that knowledge and capacity are available to select the appropriate feedstock and technology. Lessons can be learned from economic analyses undertaken for selected feedstocks in various countries (Figure 2: Ethanol; Figure 3: Biodiesel, from selected feedstock).



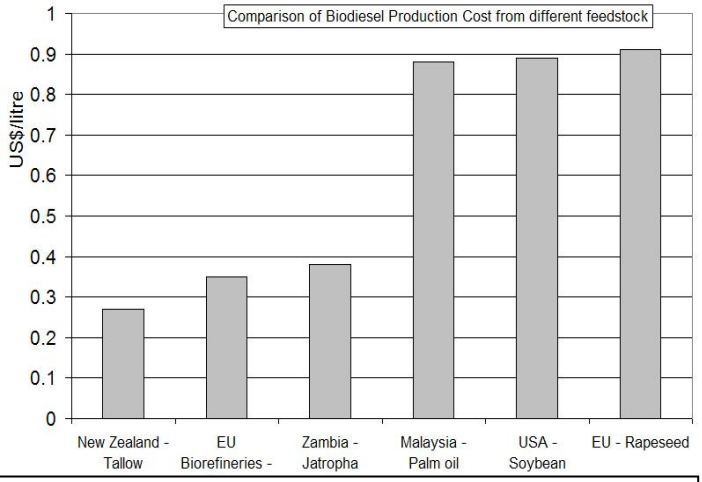


Figure 2 and 3: Production cost of ethanol (left) and biodiesel (right) in selected countries *(Source IEA 2004 Energy Outlook, CEEEZ 2006)*

Most ACP countries presently import more than they export and, a recent study by Woodruff (2006) showed that while there are economic benefits to import substitution of fossil fuels in Pacific island countries, this will reduce exports of copra, coconut oil and sugar. For example, to replace 10% of imported petrol, 20% of the exported agricultural commodities may be required; therefore, the trade balance (at equal price levels) worsens. In addition, subsidies for market penetration may be required, with further potential negative impact on government coffers. It is thus important that countries consider the total impact of a growing biofuel industry on their economy, including economic resilience, job generation, rural-urban drift and support for local agricultural production and export.

There is a strong case for increased economic resilience; Levantis (2007) found that an increase in price of US$10 per barrel of oil on the world market corresponds to a 2% decrease in the average economic growth in the Pacific.

3.2 Feedstock

The biggest challenge hindering viability of the biofuel industry in many ACP countries is the availability of feedstock in sufficient quantities at reasonable prices. Although production of a range of feedstock is possible, guaranteeing the volume to make the economic transformation competitive even at high prices of fossil fuel (US$90 - 100) is not possible. In some cases, the feedstock is insufficient to produce adequate amounts of biofuel to satisfy technically acceptable blending ratios, such as 10% ethanol in petrol (E10) or 10% biodiesel in diesel (B10).

ACP countries should aim to produce crops that are well adapted to the local conditions. Thus, sugar producing countries, can consider bio-ethanol and vegetable oil producing and exporting countries, can focus on coconut, oil palm and jatropha, among others for the production of biodiesel. Restricting the use of edible root crops such as cassava and grains for feedstock, to avoid food price shocks and minimize the conflict between food and fuel, as is done by a number of countries including China and India, is recommended. Although jatropha has commercial potential as a feedstock for biodiesel and requires little water, additional research is needed to determine commercial viability under a range of agronomic conditions. Development of improved varieties, enhancing productivity and minimizing toxicity and potential negative environmental impact given its potential to become an invasive species are priority research areas. Effective environmental and management plans are important for the commercial production of all feedstock.

3.3 Industry

3.3.1 Restructuring

With the implementation of the new EU sugar regime (2007-2009), industries started restructuring in an attempt to stay competitive. The common strategy is to use bagasse to satisfy industry demand for energy and diversify into ethanol production. Other options include the production of ethanol from molasses for the local or export fuel markets.

3.3.2 Standards

In most ACP states, biofuels have not been standardised for use as a recognised fuel or fuel blend, neither have national standards been developed. This reduces the acceptability of biofuels to domestic and industrial consumers and makes the industry unattractive to investors and venture capitalists. ACP countries can adopt or modify established EU standards for both bio-ethanol and bio-diesel, and can also draw lessons from existing biofuel standards in Brazil, Philippines, and

Malaysia. Standards for the quality of pure plant oils in adapted engines can also build on the existing German standard for vegetable oils as a fuel in transport and power generation.

3.3.3 Fuel Blending

Biofuels can completely displace the fossil fuels used in cars, trucks or generators, if these are adapted to accommodate the new fuel, for example, the 100% ethanol Brazilian "flex fuel" cars. To avoid the costs of switching or having to make engine adaptations, it is generally simpler to blend the proposed biofuel with the existing fossil fuel, such as is done so that vehicles can use E10 (ethanol blend), or B10 (diesel blend) fuels. The ACP region must put the policy and legislative framework in place to accommodate fuel blends and provide incentives to encourage oil distribution companies, car manufacturers and other entrepreneurs including farmers to invest.

3.4 Trade

International trade in biofuels and biofuel feedstocks has increased rapidly and is expected to increase further in the coming decade (FAO 2007). Increasing demand for vegetable oil, under pressure of the EU biofuel mandate, for example, has resulted in a rapid increase in vegetable oil prices (Figure 4) with negative impacts on the viability of biofuel and food prices.

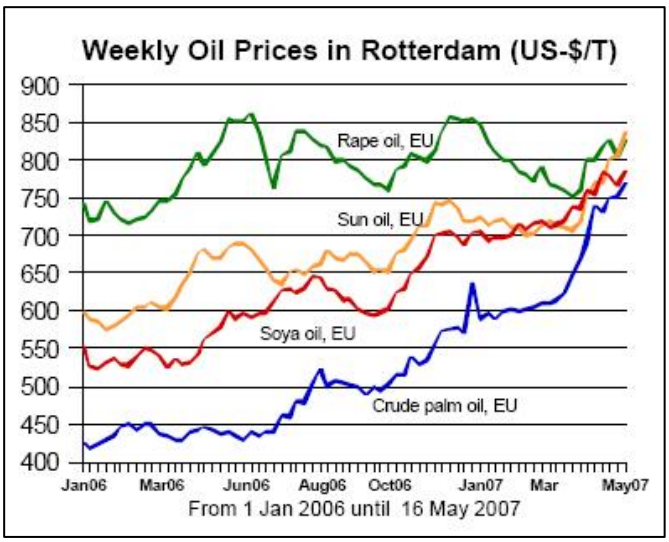


Figure 4: Vegetable Oil prices (source OilWorld, May 2007)

Figure 5 shows the major areas for sugarcane biofuel production (around the equator), but these are not the immediate potential markets, which comprise countries with Kyoto Protocol Annex-I signatories and the US with an active strategy to become less dependent on fossil fuel imports.

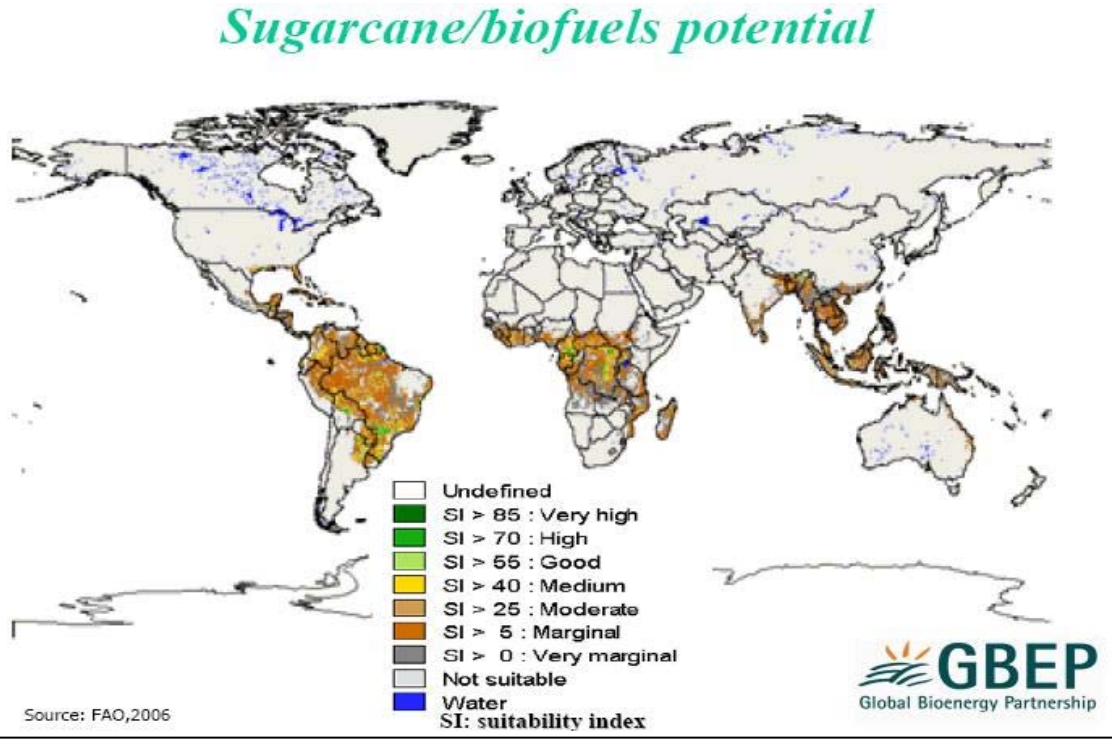


Figure 5: FAO world wide estimation on biofuels potential (Source: Global Bioenergy partnership)

Other ways of securing the industrial and financial viability of the biofuel industry would be to increase the production capacity, where feasible, to satisfy local needs and to compete on the export market. Right sizing of the industrial complex, in addition, to close examination of export taxes, transport charges as well as import duties in the targeted countries are important for guaranteeing price competitiveness at the delivery site.

3.5 Policies

Most Caribbean states in the past years, have updated their energy policy to include renewable energy. However, although many other ACP states have energy policies, some are outdated and do not actively support the use of renewable energy. Many countries subsidise the use of kerosene for lighting and cooking and other diesel for power generation and transport in remote areas to support rural communities. In addition, some countries still offer support mechanisms to stabilise the prices of farmer produce. These mechanisms do not necessarily take into account the role that biofuels can play, especially in remote places, as a substitute for or to complement fossil fuels. Therefore existing energy, agricultural and rural support policies may need to be carefully reviewed in the context of any programme to promote the use of biofuels.

The absence of updated policies, legislation, standards and tax incentives to support sustainable biofuel production can lead to failure and or stagnation in the development of this industry. For example, the copra subsidies that Kiribati, an island nation in the Pacific, uses to ensure income of outer island farmers, combined with fossil fuel subsidies to outer islands completely rule out the viability of a local biofuel industry. New energy policies need to address the issue of biofuels and other alternative fuels in a more holistic way, so as to optimise the total net benefits on a national level.

3.6 Socio Environmental Issues

There is a potential conflict between using land and water for growing crops for food and livestock feed, rearing livestock, aquaculture, and for biofuel. In addition, destroying tropical forests for large-scale unregulated plantations can result in loss of biodiversity and livelihoods. The production of crops for biofuel requires improved efficiencies in land and water management practices. Soil fertility management is critical and removal of crop residues, such as leaves and stalks, for use in co-generation, can negatively impact on soil structure, promote erosion and affect eco-system sustainability. Therefore strategies for managing crop residues and fertilization treatments must also be developed for eco-system sustainability.

The potential of biofuels in poverty reduction appears to be significant, it is also fragile: yet, its success can be undermined by many of the same policy, regulatory or investment shortcomings that impede agriculture (ODI, 2007). Consideration should be given to using marginal lands to grow crops such as jatropha although they have not been used for large scale investment in biofuel in recent years (OD1, 2007). Stringent management is necessary to achieve high productivity and maximum yield. High prices of fertilisers and failure to employ sound agronomic practices can hinder the proper growth and development of crops grown for biomass and negatively impact small budget operations as has occurred in traditional agricultural production systems.

3.7 The role of Science Technology and Innovation

To increase the availability and improve the quality of feedstock produced under local conditions, more data is required on the characterisation and optimisation of feedstock life cycle. In addition, economic analysis of the productivity and suitability of the various feedstock and the technological options for conversion should provide direction towards cost-effective solutions.

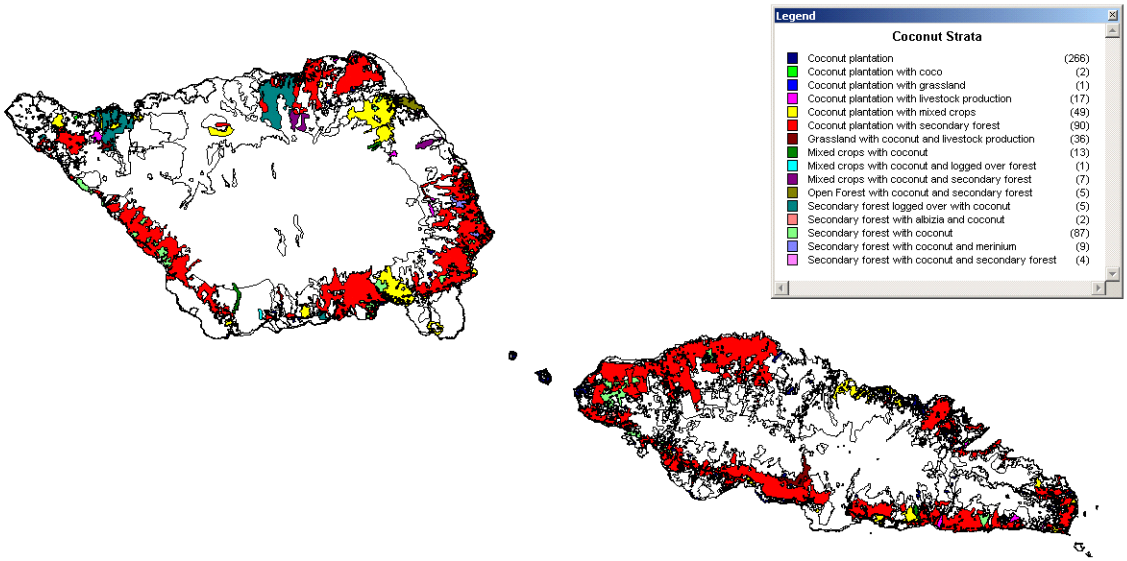


Figure 6: GIS Coconut Resource Assessment for Samoa (Source: SOPAC)

The use of GIS technology (Figure 6) to identify feedstock availability provides opportunities for resource assessment in a comprehensive way. Harvesting and storage of the raw material for feedstock requires improvement in dehydration /compaction techniques to increase the energy density. As an alternative to biodiesel esterification, requiring imports of extra-ACP methanol, pure plant oil applications in adapted engines should be further investigated, as well as other alternatives to esterification. The prospect of joint ventures using methanol from ACP sources should also be considered. Appropriate logistical issues for transporting biofuels must be addressed to ensure compatibility with the existing infrastructure, equipment capacity and capability. National biofuel quality standards may require adaptation to suit local requirements.

To answer such questions, greater investments in research and developing human capital and physical infrastructure are required, however these are often lacking in ACP countries due to financial constraints.

Figure 7: CTSAV Bagasse / Coal Power Plant in Mauritius *(Source: Raymond Rivalland)*

4. OPTIONS

4.1 Power Generation

The largest contribution by biofuels in the energy mix can be obtained through industrial heat and power generation (Figure 7).

4.1.1 Industrial Power Generation

Burning solid biomass releases a considerable amount of energy, which is used to fire a high pressure steam boiler, to produce electricity with a steam turbine. New high pressure technology is now available with higher efficiencies of electricity generated per unit of biomass, thus allowing excess electricity to be sold to the national grid. In addition, other woody biomass such as short rotation crops e.g. willow, eucalypts, poplar and agricultural waste may also be used during the out of crop season, to ensure power generation all year round and thus provide a good return on investment.

4.2 Bioenergy for household and village applications

Apart from energy production on an industrial scale, biofuels also play a large role in reducing fossil fuel demand and in improving the quality of life at a household level in ACP countries.

4.2.1 Liquid Biofuels

Remote areas in ACP countries can competitively use locally available raw material such as oil palm, jatropha and coconut to produce biodiesel for village power generation. Generators that have been adapted for the purpose and conversion equipment such as mills and filters are needed to complement existing rural electrification programmes.

4.2.2 Biogas

Biogas can be produced from domestic and livestock waste through anaerobic biogas digesters. The gas thus obtained can be used for cooking, heating both for households and light industrial applications and power generation. This requires cultural sensitivity analysis to ascertain its acceptability for use in the local context.

4.2.3 BioGel

BioGel is made from low grade ethanol and mixed with a gelling agent. It has the potential to replace wood for cooking, lighting and heating. Its solid form makes it easy and safe to distribute and the use of this fuel can contribute to reduction of forest depletion caused by widespread firewood use.

4.3 Promotion Policies

The use of biofuel can be made fiscally attractive based on the rationale of improving the balance of payments, decreasing dependence on fossil fuels and improving the local air quality by including these externalities into the price of fossil fuels through taxation. In addition, duties on biofuel-related equipment, partial duty exemption for biofuel blends and investment subsidies have been

Box 1: Success story: "Mauritius cane hub"

Facing a most severe price reduction of 36% of its raw sugar, traditionally sold to the EU, the Mauritius sugar industry restructured its activities in order to add value to every product related to crystal sugar manufacture.

Cane biomass utilization – bagasse from the milling activities, and cane trash originally left over in the fields – are thus burnt in most efficient boilers in order to generate high pressure steam used in cogeneration to satisfy the factory requirements, and to produce electricity exported to the local grid. Cane biomass presently satisfies 50% of the country's electricity requirements during the crop season.

Molasses, the residue from the crystallization process, - traditionally exported for cattle feeding mainly – is now fermented and distilled to bio ethanol. Bio ethanol may be blended, as it is currently done in Brazil, up to 20% to gasoline for the transport industry. This brings substantial savings to the country's foreign exchange balance, avoiding the import of ever increasing petroleum products.

Raw sugar, traditionally exported to the EU for refining will now be refined locally in state of the art refineries working all year round and fuelled from the cogeneration power plant installed nearby on the cane hub complex. The country will thus benefit from the refined sugar higher selling price as a partial compensation of the 36% raw sugar price drop.

In line with the success of the cane hub, the local research station (MSIRI), is currently breeding new high fibre canes which will ultimately practically set Mauritius as a self-sufficient energy producer all year round!

shown to boost the development of biofuels in developed countries. ACP Governments should consider setting targets for meeting national fuel needs from biofuels based on their particular circumstance. This strategic approach is being applied in the EU and other developed countries (COM, 2008).

Figure 8: Coconut Oil Retail in Vanuatu *(Source Tony Deamer)*

4.4 Biofuels for Transport

Blending ratios are determined by technical, economic and market considerations. However, the final blending ratios are influenced by the market for conventional fossil fuels and availability of feedstocks. To set optimal national blending ratios requires research on feedstock characteristics vis-à-vis environmental and socio-economic considerations. To support market development, national quality standards are imperative. Locally appropriate standards for a dedicated fleet of vehicles with adapted engines operating on pure plant oils (Figure 8) can also be considered.

5. CONCLUSIONS

ACP countries have a comparative advantage in biofuel production, because of their natural endowment – climate, arable land and water resources. Well researched national strategies can ensure biofuel benefits will accrue to the producer countries; producers, manufacturers and exporters in the ACP region. This requires that ACP governments invest in a competitive agricultural sector, taking into account the linkages between agriculture including livestock and fisheries, biofuel production, trade, economic development and environmental sustainability.

ACP Governments must act to increase investment for sustaining science, technology and innovation infrastructure with emphasis on building a critical mass of scientists and engineers and physical infrastructure to support the product development and technological breakthroughs that are relevant to a competitive agricultural sector that can sustain biofuel production that does not compromise food security goals. Scientists must be mindful of the linkages between achieving economies of scale in biofuel production, and societal goals of food and nutrition security and economic prosperity. Finally, it is envisaged that through policy coherence for development (PCD), which highlights the EU's commitments to improving the effectiveness of development assistance, ACP national governments should be able to access policy, budgetary and technical support in the areas of environment, energy, and agriculture and food security (COM, 2008).

6. POLICY RECOMMENDATIONS

The observations and analysis in this paper lead to the following recommendations.

- **Implement National Biofuel Strategies**

  ACP Governments in consultation with scientists, engineers, economists and the general public should formulate policies and strategies aimed at addressing critical issues such as promoting and sustaining local demand for alternative energy including biofuels. Targets should be set so that biofuels

account for a share of the fossil fuel market – a phased approach can be considered. In addition, blending ratios should be determined; biofuel standards and production modalities should be established, and consideration should be given to addressing environmental and social concerns while providing appropriate investment and consumption incentives.

- **Institute Legal and regulatory framework**

ACP Governments in consultation with scientists, engineers, economists and the general public must set up a legal and regulatory framework aimed at guiding and regulating the biofuel industry to avoid any negative environmental impact. There is need to find a balance between biomass and or biofuel commodity export and requirements for national consumption.

- **Promote integrated agro-energy farming policies**

ACP Governments in consultation with scientists, engineers, economists and the general public must take into account the interconnectedness of the biofuel industries with crop and livestock husbandry, fisheries and aquaculture, and the conservation of forests and watershed areas and the need to maximize national benefits while meeting food and nutrition security goals and ensuring sustainable development. This integrated approach is important to ensure coherence with a biofuels push and alternative energy, agriculture and rural development and sustainable water and land management policies.

- **Support ACP Biofuel Research**

ACP Governments in consultation with scientists, engineers, economists and the general public and regional and international partners such as the EU should support local and regional research and international collaboration and knowledge networking for evaluating and producing suitable quantities of feedstocks; process and logistics optimisation; finding cost effective solutions; accessing, adapting and transfer of technologies, contributing to advancing technological solutions such as ligno-cellulosic conversion; searching locally appropriate alternatives to existing biofuels; resource assessment, including the use of GIS and supporting the development of laboratory capability for the analysis of biofuels produced to ensure compliance with quality standards.

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