BIO-FUEL FOR SUSTAINABLE DEVELOPMENT IN A GROWING ECONOMY

G. U. Asonye, E. C. Abbah and S. N. Asoegwu
Department of Agricultural Engineering, Federal University of Technology, Owerri
Emails: u.asonye@yahoo.com, elochukks@yahoo.co.uk, asosab49@yahoo.com
Corresponding Author's E-mail: u.asonye@yahoo.com

ABSTRACT

Agricultural reform, climate change and energy security have been key drivers in renewed enthusiasm for biofuels. The production of biofuels has also been seen as providing stimulus for the economic revitalization of agriculturally unproductive rural areas both in developing and developed countries. Agriculture is heavily dependent on unsustainable non-renewable energy sources, especially petroleum. Abrupt abandonment of our reliance on these energy sources would be economically catastrophic and equally disruptive, hence the need for reduced reliance on non-renewable energy sources and a substitution of renewable sources to the extent that is economically feasible and sustainable. Sustainability rests on the principle that the needs of the present generation must be met without compromising the ability of future generations to meet their own needs. Therefore, stewarding of both natural and human resources is of prime importance to sustainability. This review surveys many dimensions of biofuel production and its sustainability, which is critical in a growing economy.

KEYWORDS: Bio-fuel, sustainable development, biomass

1. INTRODUCTION

Renewable energy in general and biofuels in particular, has begun to look like an increasingly viable mitigation option for addressing climate change. For rich countries they offer prospects for meeting emission reduction commitments. For low and middle-income countries they offer potential to reduce energy import bills as well as earn precious foreign exchange. The agricultural sector, which will always remain the mainstay of the economy in spite of the discovery of crude oil, is head in the area of energy demand. Energy needed for agricultural production ranges from the energy needed to drive equipment and machinery in and out of the farms to the energy needed in the milking house to that needed to preserve stored products. Fossil fuel have been the major contributors to agricultural energy use.

Liquid biofuels can provide the much needed substitute for fossil fuels used in the agricultural sector of the economy. They can contribute to climate change reduction and other environmental goals, energy security, economic development, and offer opportunities for other profitable ventures. Fossil fuels are the largest contributors of greenhouse gases (GHGs) to the biosphere with associated CO_2 emissions of about 29 Gtonnes [EIA, 2006]; and catastrophic climatic change projections and consequences on nature as well as human systems [IPCC, 2001].

African policy makers believe that developing liquid biofuels can transform Africa's traditional dependence on biomass energy sources, i.e., wood and dung. Biofuels contributes to climate and other environmental goals, energy security, economic development, and offer opportunities for private companies to profit.

There are social and environmental risks associated with biofuels such as cultivation of feedstock, land fertilizer use (Cohen *et al.,* 2008; Coyle 2007; Fargione *et al.,* 2008; Searchinger *et al.,* 2009) but as FAO (2009) points out, there are also considerable advantages for low and middle-income countries to nurture and expand their biofuel industries. Such advantages include infrastructural development, employment opportunities, qualitative and standard social wellbeing. Indeed (IEA Bioenergy, 2008) concludes that these potential drawbacks do not necessarily rule out biofuels as an option, as long as they can be

produced in a way that decreases poverty and does not have negative effect on biodiversity. It is projected that the growth in production and consumption of liquid biofuel will continue but their impacts towards meeting the overall energy demands will remain limited (Andrea and Yianna, 2008).

The development of biofuels will bring direct opportunities to developing countries through the creation of jobs from growing raw materials to biofuel manufacture, marketing and use. Furthermore, the production of biofuels by developing countries will help to decrease the dependency on costly fossil fuel [UN-Energy, 2007]. For many developing countries, biofuel production could promote economic development by providing new export opportunity. This paper reviews the positive impacts of biofuels in the sustainable development of a growing economy.

2. WHAT BIOFUELS ARE

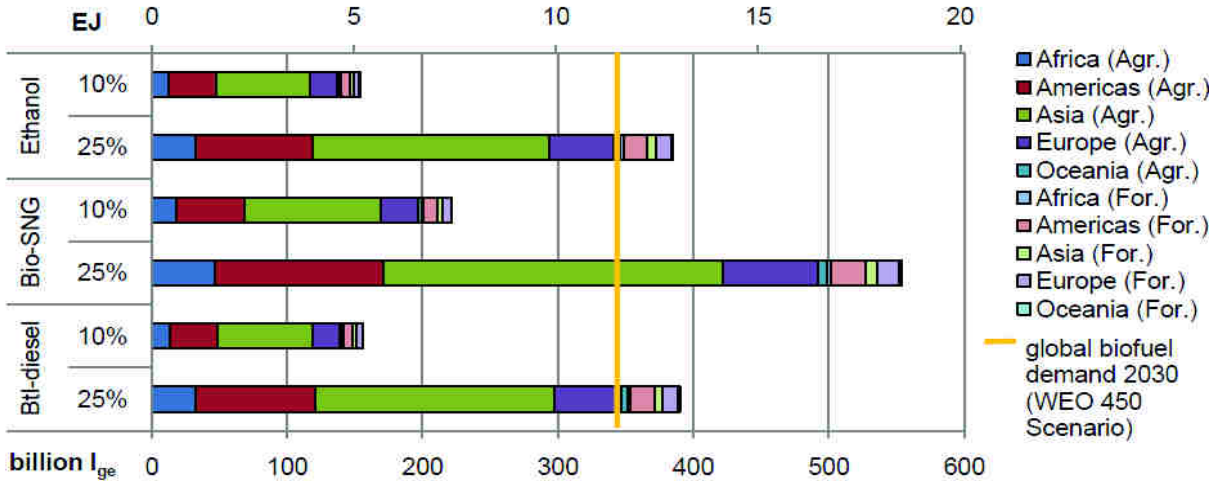
Biofuels are combustible materials directly or indirectly derived from biomass, commonly produced from plants, animals and micro-organisms but also from organic wastes. Biofuels may be solid, liquid or gaseous and include all kinds of biomass and derived products used for energetic purposes (Berndes *et al., 2003*). Biofuels are also defined as "fuels that can be produced from agricultural and forest products or the biodegradable portion of industrial and municipal waste" (Andrea and Yianna, 2008). The major sources of energy in rural Africa are biofuels such as wood, sawdust, palm kernel shell, palm fruit fiber, and dung. Liquid biofuels such as ethanol and biodiesel from grains and oil seeds have been used to power engines for transportation since the early 20th century. Biofuels being renewable liquid fuels derived from microorganisms, plant or animal material (biomass) can be used, in their pure form or as part of blends, to fuel transport vehicles as well as to generate heat and power.

Bioethanol, a liquid biofuel is used as a replacement for gasoline and biodiesel in place of diesel. It represents an immense growth area around the world in terms of research, production, development, marketing and use and has an important role to play in displacing the types of fuels the world has used in the past. They are presently mostly used as blends with the existing fuel types in some existing engine designs. Most importantly, it is imperative that developing countries like Nigeria have domestic energy security anchored on biofuels, as more than half of its liquid fuel needs are currently imported and the figure keeps rising. It is crucial that developing countries have their own energy supplies so that they are not dependent upon the supply and pricing dictated by world markets.

3. BIOMASS FOR BIOFUEL

Biofuels are fuels made from biological materials. These renewable fuels viz: biodiesel, biogas and methane, are derived from biological matter. Biofuels are based on ligno-cellulosic material, *i.e.* biomass, which is abundant virtually everywhere around the globe. Biomass can be derived from natural ecosystems (like forests, grassland or aquatic ecosystems), or can also be produced by cultivating bioenergy crops like perennial grasses, oil crops, root crops, grains or wood species. Table 1 shows the world biofuel production from feed stocks essentially agricultural and forestry residues.

Table 1: Theoretical second-generation biofuel potential from ligno-cellulosic residues in 2007



Note: Amounts cannot be summed up. Each bar indicates biofuel yields using all available biomass. 25% and 10% assume respective shares of agricultural and forestry residues to be available for biofuel production. Assumed conversion factors - BTL-diesel: 217 lge/tDM; Ethanol: 214 lge/tDM; Bio-SNG: 307 lge/tDM. Source: IEA based on FAOStat, 2009; FAO, 2003; IFPRI, 2001

In developing countries, over 500 million households still use traditional biomass for cooking and heating. However, already 25 million households cook and light their homes with biogas (displacing kerosene and other cooking fuel); and a growing number of small industries, including agricultural processing, obtain process heat and motive power from small-scale biogas plants. Biomass power contributed about 1% to the total global electric power capacity of 4300 GW in 2006 (REN21 2008).

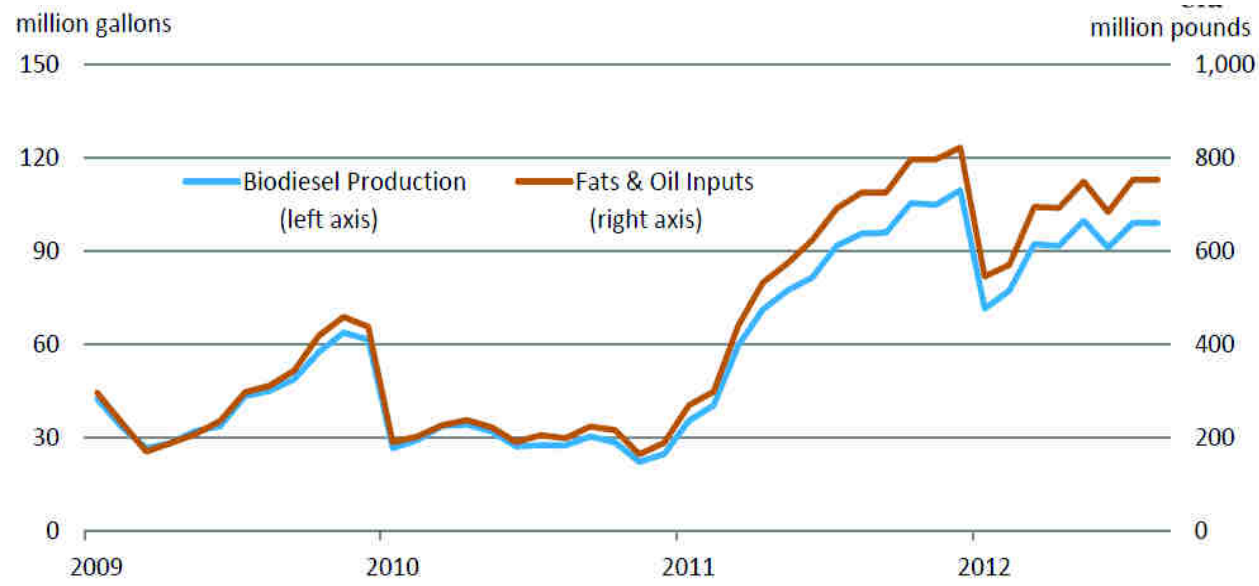


Figure 1: U.S. Biodiesel inputs and production, 2009-12
Source: EIA, Monthly Energy Review, August 2012

4. BIOFUEL IN WORLD ENERGY EQUATION

The world currently uses 86 million barrels of oil per day (BP, Statistical Review of World Energy, 2008) with forecasts that demand for liquid fuels will increase to 118 million barrels by 2030 (International Energy Outlook, 2007). Figure 2 depicts biofuel (ethanol) from 1982-2005. Most of incremental fuel will come from OPEC and specifically from the Middle East. In the last two years, the world's supply of oil has had difficulty keeping up with demand, and prices have skyrocketed to $140 per barrel and more. This has triggered economic hardship, especially among the poorest importing countries. As more and more funds are required to pay for oil products, importing countries find their current account balances eroding and the costs of producing and transporting goods and services increasing. Today, many forecasters predict that while prices will fluctuate, the era of low-cost oil is over and countries must adjust by seeking alternative energy options and strategies.

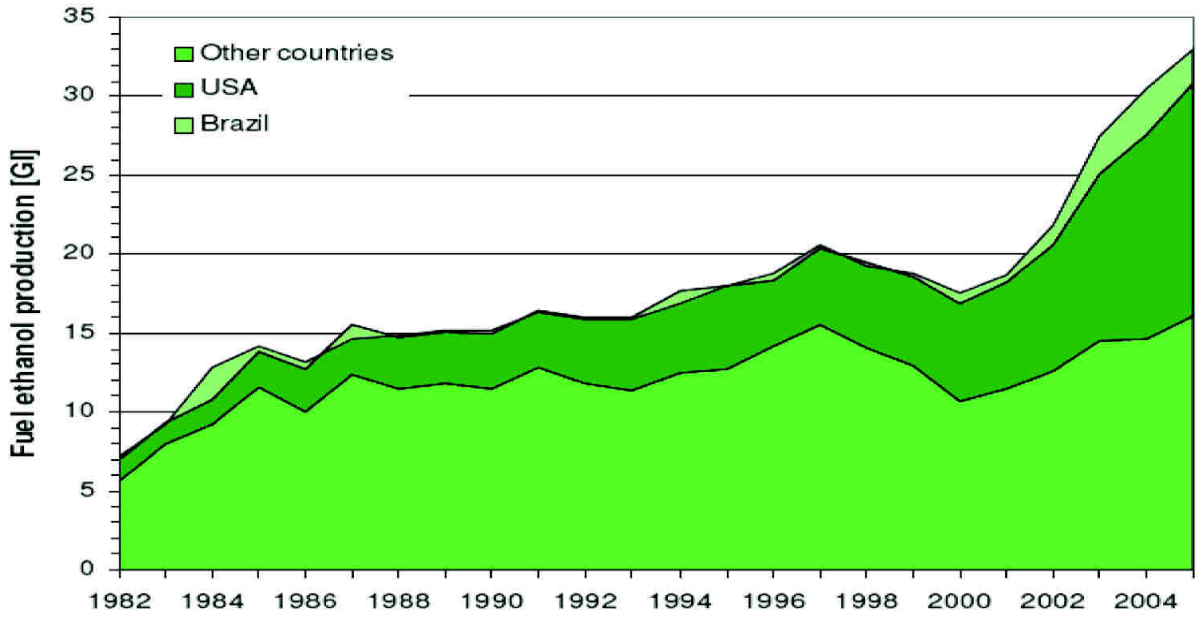


Figure 2: World ethanol production 1982–2005
Source: Walter et al. (2007).

Producing liquid fuels from biomass is one of the only alternatives to petroleum-based fuels. As a result, countries are looking at a menu of biofuel options to reduce their future reliance on petroleum. Since biofuels are likely to be produced in countries outside of OPEC, they may also allow fuel-consuming nations to diversify the sources of their fuels, and hence provide energy security benefits.

5. THE TYPES OF FUEL

5.1 Bio-Diesel

Biodiesel is a renewable and environmentally friendly fuel; made from various feedstock ranging from microalgae, edible oil seeds, non-edible oil seeds, waste vegetable oil, cellulose and the use of enzymes. Biodiesel production is a very modern and technological area for researchers due to the relevance that it is winning every day. It can be used neat, meaning 100-percent biodiesel, or it can be blended with petroleum diesel. Biodiesel is becoming widely available in developed economies and can be substituted for petroleum-based diesel fuel ("petrodiesel") in virtually any standard unmodified diesel engine. Biodiesel offers many advantages over petroleum-based diesel in that:

It is made from domestically produced and renewable agricultural products, mainly vegetable oil or animal fat.

- It is essentially non-toxic and biodegradable.
- It has a high flash point (over 300ºF) and is difficult to light on fire with a match.
- It reduces emissions of many toxic air pollutantslike carbon emissions.
- It functions as an excellent fuel lubricant and performs similarly to low-sulfur diesel with regards to power, torque, and fuel consumption.

Biodiesel offers environmental, economic and national security benefits. The combustion emits fewer regulated and non-regulated pollutants than petrodiesel. Furthermore, biodiesel is biodegradable and its lubricity extends engine life. Biodiesel could benefit farmers and rural communities, depending on ownership of production facilities and the mix and marketability of useful co-products. Also, biodiesel could reduce dependence on foreign oil and corresponding fluctuations in availability and price.

The non-edible vegetable oils such as *Madhuca indica, Jatropha curcas* and *Pongamia pinnata* are found to be suitable for biodiesel production under the experimental conditions (Meher *et al,* 2006; Sent *et al*., 2003). Meher *et al.,* (2006) found that the yield of methyl ester from karanja oil under the optimal condition is 97–98%. Oil content in the Castor bean, Hemp, Neem and Pongame seed is around 50, 35 30 and 40 % respectively.

5.2 Ethanol

This is an alcohol-based fuel derived from crops, usually corn, barley, and wheat. Ethanol can be blended with gasoline in varying concentrations. E85, for example, is a blend of 85 percent ethanol and 15 percent gasoline. Ethanol, or ethyl alcohol, is a high-octane fuel produced from the fermentation of plant sugars. Corn is the primary feedstock for ethanol production in the United States. Ethanol is also produced from other organic sources such as barley, wheat, rice, sorghum, sunflower, potatoes, cassava and molasses. Brazil is the world's largest ethanol producer and exporter, generating 4 billion gallons in 2004 representing 37 percent of the world's total. The United States is second, and is also the second largest ethanol importer. In August 2005, President Bush signed the Energy Policy Act of 2005 (EPAct 2005), which included the Renewable Fuels Standard (RFS) that established the first nationwide baseline for the use of fuels derived from renewable sources. RFS required petroleum refiners to use at least 4 billion gallons of renewable fuel beginning in 2006, increasing incrementally to 7.5 billion gallons per year by 2012.

5.3 Biogas

Biogas is methane produced by the process of anaerobic digestion of organic material by anaerobes (Redman, 2008). It can be produced either from biodegradable waste materials or by the use of energy crops fed into anaerobic digesters to supplement gas yields. The solid byproduct, digestate, can be used as a biofuel or a fertilizer. Biogas can be recovered from mechanical biological treatment waste processing systems.

Note: Landfill gas, a less clean form of biogas, is produced in landfills through naturally occurring anaerobic digestion. If it escapes into the atmosphere, it is a potential greenhouse gas.

6. ADVANTAGES OF BIOFUEL

6.1 Biofuels for Employment Opportunity

The contributions of biofuel in the area of job creation and income generation cannot be overemphasized

1) Biodiesel expands demand for those agricultural products which serve as its feedstock thereby bringing more money into the sector.
2) Farmers cultivating these crops get improved income.
3) The presence of facilities that creates energy from biological sources adds value to the nation's industrial and income base.
4) More jobs and increased personal income in rural communities.
5) Additional and more diversified markets for both starch-based and oilseed-based crops that can help production agriculture be more competitive.

6.2 Biofuel for Climate Change

Recent concern over global climate change has motivated growing interest in all manner of renewable energy sources, biofuels among them. Biofuels have been presented as a potential significant contributor to strategies for reducing net greenhouse gas emissions. When produced and used appropriately, biofuels can deliver lower net greenhouse gas emissions than fuels derived from fossil sources. This is particularly true when considering the amount of greenhouse gasses that synthetic fuels produced from coal or oil shale emits. However, the net greenhouse gas emissions of biofuels vary significantly depending on the feedstock and technologies used in their production and consumption. The overall impact of biofuel development on climate still tied up with differences in carbon stocks and solar reflectance between the biomass crops and the vegetation they replace. It seems virtually certain that biofuels will have a role in national and global strategies to address the dangers of climate change.

6.3 Biofuel for Economic Development

Biofuel production has enjoyed tremendous growth in recent years (Arndt *et al., 2009*). Between 2000 – 2007, global production tripled in volume (Coyle, 2007). In 2007–2008 alone, the share of ethanol in global gasoline increased from 3.8 to 5.5 percent, while the share of biodiesel in diesel increased from 0.9 to 1.5 percent (UNEP, 2009). More countries are setting higher biofuel consumption mandates (for example, 10 percent of transport energy in the European Union member states must come from biofuels by 2020), leading to consensus that the biofuels industry will grow even further. A recent study by the Food and Agriculture Organization of the United Nations (FAO 2009) reveals that only about one-quarter of land in Sub-Saharan Africa with potential for rain fed crop production is currently cultivated. This, together with the widely held perception that African agriculture has considerable scope for raising productivity (Diao *et al.,* 2007), means that biofuel feedstock may not necessarily displace food crops, and even where they do, food production can be maintained on less land through productivity enhancements.

Biofuels and their feedstock could be an important source of export income for developing nations. Participating in the global economy through export activity is a crucial part of the economic development process. In some tropical countries, biofuel production can bring with it "stepping stone" effects such as the extension of transportation networks, as well as job creation. In addition, countries can substitute domestically-produced biofuels for imported oil products, reducing the micro and macro impacts of the sharp escalation in oil prices. Also, biofuels present an opportunity for new entrepreneurial companies and small holders to emerge while simultaneously increasing activities in growing economies. The recent United Nations Report; (Sustainable Bioenergy, A Frame Work for Decision Makers, 2007) examined the implications of Bioenergy on agro-industrial development and job creation. The report found out that "Successful *bioenergy industries have great potential for significant job creation.*" And continues *"because the vast majority of bioenergy employment occurs in farming, transportation and processing, most of these jobs will be created in rural communities where underemployment is a common problem"*

6.4 Bio-Fuel Sustainability for Growing The Economy

Potential sources of bioenergy include agriculture and forest residues, organic waste, and dedicated energy crops grown on agricultural or marginal lands, all of which are major sources of feedstocks for biofuel production. Smeets *etal*., (2007) found that the long-term technical potential of bioenergy could be very large and they estimated that biomass resources could potentially supply up to two times the current global energy demand, without competing with food production. According to the authors, "if a type of agricultural management is applied similar to the best available technology in production of biofuel in undeveloped regions, the world would be capable of producing the demand for biofuel projected by 2050 using only a fraction of the present agriculture land" (Smeets *et al.,* 2007).

According to Ress (1989) "Sustainable development is positive socioeconomic change that does not undermine the ecological and social systems upon which communities and social systems are dependent". In relation to agriculture, sustainability means changing agricultural systems so that farmers are able to produce indefinitely (Rodale, 1988). The importance of sustainability of agricultural production system is becoming a major concern of agricultural researchers and policy makers in both developed and developing countries. Sustainability represents the last step in a long evolution that economic development must consider both in the protection of natural resource and the maintenance of environmental quality (Batie, 1989). Sustainable agriculture for biomass production should be based on approaches that reduce environmental degradation, conserve resources, and provide adequate and dependable farm income through poverty reduction and its associated problems. For the sustainable development of biomass for biofuel, farmers must change their strategies in production, processing and financing of the different biomass production systems. Enhanced biomass production ensures abundant raw materials for biofuels as an alternative source of energy, which in turn enhances the agricultural and other sectors that are indispensable for a sustainable system. Bio-fuels have shown the potential to fit into this category of a sustainable energy source.

Nigeria has pursued with vigor the exploitation of her natural endowment without taking a deep reflection on the challenge of maintaining its sustenance. Given her current international debt issues, it has become increasingly difficult to generate enough resources required for sustainable socioeconomic growth and access to capital to meet her obligations without exerting increased pressure on local resources. It is believed that with development and vigorous pursuit to the biofuel policy in Nigeria, considering its environmental, social and economic benefits, the Nation will scale out of her present economic doldrums.

7. CONCLUSION AND RECOMMENDATIONS

If several sustainability principles are treated seriously, Bio-fuel has tailpipe benefits that hold great promise as a sustainable energy source. Bio-fuels can among several advantages; Capture as much energy efficiency as possible on and off the farm ; reduce production costs and improve energy balance; Convert as much waste as possible into a useable resource, such as converting waste vegetable oil into fuel; Put oil-producing crops and high-quality agricultural lands to their highest and most sustainable use; Raise bioenergy crops that enhance soil and water resources; Create a range of diverse opportunities for biodiesel production in terms of the scale, design and ownership, so farmers and rural communities can share in the economic benefits and ultimately sustain development in a growing economy like Nigeria. Finally, it is important to point out that attaining the goal of sustainable agriculture is the responsibility of all participants in the system, including farmers, laborers, policymakers, researchers, retailers, and consumers who have their own unique contributions to make for a realiazable sustainable economy.

In summary, two major policy and practical changes must occur for biofuels to have a real effect on any country's energy future:

1) A national commitment to energy efficiency in every facet of the nation's life. This may include community redesign, broad changes in food production and delivery systems, greater commitment to mass transit.
2) A massive conversion from gasoline powered automobiles to cleaner-burning automobiles. Capturing energy efficiencies and making the best use of biofuels may be nearly impossible without redirecting current overdependence on fossil fuels, especially for powering our automobiles as is becoming the case in developed economies.

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