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Accessing the Impacts of Contemporary Development in Biofuel on Agriculture, Energy and Domestic Economy: Evidence from Nigeria

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ABSTRACT

The recent volatility of the conventional energy output owning to fluctuations in the supply chain in the fossil fuel cum with its finite supply nature has necessitate the integration of biofuel into the global energy needs. Biofuel as a type of renewable energy has the ability to reduce global warming resulting from greenhouse gas (GHG) emissions, thus offers a relatively healthy energy option for both the consumers and producers in global space. This notwithstanding has some implications on agriculture and food security. This paper examined the impact of biofuels development on agriculture, energy infrastructure and domestic wellbeing in Nigeria. The study identified a potential rivalrous relationship in terms of space and cultivation mechanism when sustainability is in view. We reviewed existing policies and sustainability practices in other economies and concludes that Nigeria needs a deliberate effort aimed at developing institutional structures that will facilitate building and expansion of the biofuels sub-sector at the same time enhance rural livelihood.

Keywords: Biofuel, Agriculture, Energy, Wellbeing, Nigeria
JEL Classifications: E22; G13; G22

1. INTRODUCTION

Biofuel integration into the already established energy amalgam came about as a result of global energy security concerns, often associated with the rising volatility in the supply of fossil fuel and its finite existence. Biofuel as a kind of renewable energy has the ability to reduce global warming resulting from greenhouse gas (GHG) emissions. A condition that has occasioned an increased demand for biofuels mostly from the transport sector, particularly road automobiles, which utilizes biofuels either in its pure form or synthesized into the usual fossil fuels (e.g. AGO or gasoline). Road biofuels accounted for 4.7% (13,985 ktoe) of total energy consumption in 2013 alone, including biodiesel (10,644 ktoe), biogasoline (2,892 ktoe) and other liquids (422 ktoe) (European Commission, 2013). Similarly, the development of biofuels usually add value to agricultural activities by advancing scenarios leading the provision of green jobs in the economy's non-carbon demanding sectors UNCTAD, 2008; (UNCTAD, 2014); Indexmundi (2013); Wisner, (2012); Dahunsi et al. (2019a); Lawal et al. (2018a).

The United States (US) is preeminently the world's leading biofuel manufacturer while Brazil significantly also leads in the production of biofuels. Brazil produces approximately 21 billion litres of ethanol a year and domestically consumes more than 90% of it (Sielhorst et al., 2008). In addition, Asian countries such as Japan and China also had audacious biofuel goals. China specifically aimed the use of over 6billion litres of bioethanol in 2012, as against the 3.8 billion liters of bioethanol in 2006 (SWAC/OECD, 2008; Yano, Blandford, and Surry, 2013).

Nigeria has also taken the same road as the country's growth needs warranted such an initiative. Even though Nigeria is the Africa's largest exporter of crude oil with tremendous revenues generated by the selling of oil and production licenses and the issuance of royalties, the nation has faced many challenges, including: insecurity of oil supplies and prices with acute scarcity; soil degradation, ecological and environmental hazards, air and oil pollution and the loss of biodiversity arising from oil activities, serial community conflicts, loss of means of daily income thereby leading to endemic poverty in the resource-rich Niger-Delta, food crisis, deficiency of essential and critical services and a total breakdown in the financial sector of the economy. Ishola et al. (2013) opined that biofuel processing (biodiesel, biogas and bioethanol) can mitigate these issues, however experience to date has shown that many obstacles remain implicit in the process towards its implementation.

The challenges and fears regarding the development of biofuels from the public perspective here in Nigeria are focused upon the premise that the production of biofuels would contribute to the displacement of food for fuel and agricultural lands (Galadima et al., 2011). In sub-Saharan Africa in general, the potential issues and drawbacks of biofuel as hinted in some research works (German et al., 2010, Laborde, 2011, Isola et al., 2015, Feintrenie et al., 2010, Lawal et al., 2018b) are the social challenges of poor land tenure stability for indigenous communities, worries about forest degradation, and depletion of biodiversity, as well as the low overall benefits to sustainable development. A daunting task and serious challenge it this is, as authorities try to implement positive and sustainable environmental policies into their biofuel markets, while trying to appeal to other competing demands such as green jobs, energy stability and exponential rise of agricultural yields, which in many emerging and least developed countries are much required.

It is upon this premise that this paper examined the influence of biofuels on agriculture, energy infrastructure, and domestic wellbeing. Adequate understanding of this situation in Nigeria would enable the country in learning sufficiently in this regard and as such provide a precondition for its management. Section two of the chapter provides background information on biofuels with emphasis on policy, incentives and institutional frameworks in Nigeria. Also, the section provides information on global experience as relating to policy issues, while assessing biofuel performance in terms of its production and consumption. Section three reviews some relevant literature with a specific emphasis on sustainability of biofuel production with specific concerns on Agriculture, energy and domestic economy. Section four evaluated the potential feedstocks for biofuel production in Nigeria. The last section provides conclusion and recommendation.

2. DEVELOPMENT IN BIOFUEL PRODUCTION

To fully understand how biofuels evolved in the Nigerian market, it is essential examine the existing policy document, incentives and institutional framework set up for biofuel production in the country. While also highlighting policy changes and market fundamentals that led to the global increases in biofuels production.

2.1. Nigerian Biofuel Policy, Incentives and Institutional Framework

Nigeria has established a policy document on biofuel production aimed at promoting the adoption of biofuels and to stimulate investments in this field. Nigerian Biofuel Policy gazetted as The Nigerian Biofuel and Incentives No. 72 Vol. 94 dated June 20, 2007 (Oniemola and Sanusi, 2009). The Nigerian National Petroleum Corporation (NNPC), in collaboration with other partners is responsible for the implementation of the policy objectives. The key components of this policy involve authorizing a 10% ethanol inclusion threshold, and 20% biodiesel with the sole purpose of inducing national demand; designating/classifying biofuel as an industrial sector linked to Agriculture, fiscal measures that include duties and VAT reduction and exceptions; setting up a biofuel energy commission tasked with the role of regulating the industry while liaising with relevant ministries, departments and agencies and lastly the creation of a Biofuel Research Agency (SWAC/OECD, 2008).

Nigeria's biofuel sector has provided numerous benefits and inducements and the Biofuel Energy Commission is charged with the responsibility of regulation of biofuel production activities, implementing the strategies for biofuels and several other related activities. The Biofuels Research Agency also serves as the central coordination body for biofuel research in the country as the agency coordinates biofuel crop production optimization program and collaborates with the research and development agencies.

2.1.1. Regulatory measures affecting biofuel development: Global experience

The AETS Consortium (2013) identified four broad groups of biofuel regulatory measures aimed at encouraging the integration of biofuels into the existing energy mix globally: (1) budgetary support; (2) consumption targets (nonbinding) or mandates (binding), which set a minimum market share for biofuels in total transport fuel; (3) trade measures, in particular import tariffs; and (4) measures to stimulate productivity and efficiency improvements at various points in the supply and marketing chain.

Table 1 summarizes biofuels policies in some selected key producing countries and regions.

Although general activities in biofuels is still at infancy in most African countries, due to weak regulatory framework for effective integration of biofuels into the available renewable sources; but increasing interest are evident in some African countries. This has given rise to some policy options to scale up both production and investment in biofuels. Table 2 highlights some of the policies measures.

Table 1: Biofuel policies in major producing countries and regions

Country	Mandate or target	Production incentives	Trade policy
United States	Mandate: 36 billion gallons of biofuels by 2022, of which no more of 15 billion gallons come from conventional sources and no less of 16 billion gallons come from cellulosic ethanol	Tax credit of US$0.45/gallon ($0.12/litre) for ethanol blenders and US$1.00/gallon ($0.26/litre) for biodiesel blenders, biodiesel tax credit biodiesel tax credit biodiesel tax credit agricultural feed stocks	Ethanol tariff of US$.54/ gallon ($0.143/litre) plus ad valorem duty of 2.5 %; Ad valorem duty of 1.9% on bio diesel
European Union	Mandate: Minimum of 10% of transport fuel from renewable fuels by 2020.	Member states can apply tax reductions on biofuels as well as provide production incentives.	Specific tariff of €0.192/litre of under-natured ethanol and €0.102/litre of denatured ethanol; Ad valorem duty of 6.5% on biodiesel
Brazil	Blending mandate for ethanol of 20–25%; Biodiesel use mandate set at 5% (B5) since 2010 (proposal to increase to up to 10% by 2020	Tax incentives on fuel ethanol and biodiesel. Tax incentives on flex-fuel vehicles.	Ad valorem duty of 20% on ethanol imported from outside the Mercosur area (temporarily in the list of exceptions); Ad valorem duty of 14% for biodiesel
India	Indicative 20% target for blending for both ethanol and biodiesel by 2017	Minimum price mechanisms for feedstocks tax incentives for ethanol or biodiesel.	Ad valorem duty of 28.6% both on ethanol and biodiesel
China	E10 for 2020 (12.7 Bnl ethanol) Target of 2.3 Bnl biodiesel consumption in 2020; Target of 15% of fuel consumption to be non-fossil fuel by 2020	Production subsidies on ethanol and biodiesel.	Ad valorem duty of 5% on denatured ethanol (30% until 2009) and 40% on under natured ethanol
Thailand	Ethanol: E20 mandatory since 2008; Biodiesel: B2 mandatory since 2008 and B5 since 2012	Tax exemption for ethanol. Investments subsidies for ethanol plants; Soft loans for biodiesel	No export duties on processed palm oil or biodiesel

Source: AETS Consortium (2013)

Table 2: Biofuel policies in selected African countries

Country	Strategy	Policy instruments	Primary feedstock(s)
Angola	Biofuels Policy 2010	Investment incentives	Sugarcane
Botswana	Energy Policy 2009		
Ethiopia	Biofuels Strategy (2007)	Blending target	Sugarcane, Jatropha
Ghana	National Bioenergy Policy (2005)		Jatropha
Kenya	National Biofuels Policy (2011)	Pilot E10 blend	Sugarcane, cassava, sweet sorghum, Jatropha
Malawi	Malawi Energy Regulatory Authority 2009	Blending mandate Subsidies and tax exemptions	Sugarcane, Jatropha
Mali	National Biofuel Development Strategy (2009)	Research and pilot studies	Jatropha
Mozambique	National Biofuel Policy and Strategy (2009)	Biofuel targets Fiscal incentives	Sugarcane, Jatropha, sorghum
Senegal	National Bioenergy Strategy (2007)	Production and investment incentives	Sugarcane, Jatropha
South Africa	Biofuels Industrial Strategy		Jatropha
Tanzania			
Zambia	National Energy Policy		

Source: AETS Consortium (2013)

2.2. Performance of Biofuels (2000-2015)

Total world biofuel production from 2000 to 2015 was basically dominated by production from North America and South and Central America (Figure 1), especially the United States and Brazil. For instance, total growth rate of 13.8% in 2010 was driven largely by the United States 42.8% and Brazil 26.3% contributions. While in 2015 world biofuel production increased of 0.9% was mainly due to United States 41.4% and Brazil 23.6%. A major feature from the trend revealed that 2015 recorded the lowest rate of growth after production dropped in 2000, a situation arising from 4.9% decline in biodiesel production, with decreased production in all major producer regions (BP,2016; EIA, 2009; EIA, 2012). Biofuels production in the Middle East and Africa (Nigeria inclusive) were minute during the period under review, implying that biofuels are still at infant stage in the two continents. Despite the slow growth in biofuels, there was a modest increase in global production overtime mainly due to bumper harvest of maize and sugar cane and low oil prices, which have sustained low production costs.

Bioethanol largely dominates biofuel production, accounting for about 95% and 76% of the total production of biofuel in 2000 and 2012 respectively (International Energy Statistics, 2015). This however still reflects a very minute fraction as this increased Biofuels production only accounts for a very tiny portion of the world's energy outlook. Biofuels constitute about 0.5% of overall demand for energy and about 1.5% of the fuel consumption by the transport sector (IEA WEO 2009).

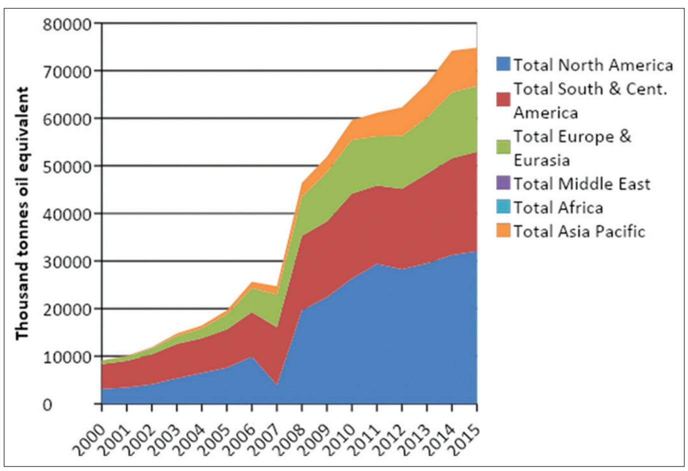
Biomass forms the primary energy source for over 50 % of humanity, reflecting a little above 90% of energy use in impoverished developing countries (FAO, 2005a). Biofuels also accounts for about 0.8% of electricity used globally by the end of 2011 (REN21, 2013; Renewable, 2015). The estimated total world energy usage of biofuels is as shown in Figure 2. Biofuels constituted 4% of the global fuel for transportation by road in 2014 and is deemed to gradually increase, hitting about 4.3% in 2020. As a consequence of the significant decrease in prices of crude oil in 2014, the global environment of biofuels is gradually shifting.

3. LITERATURE REVIEW

3.1. Conceptual Clarification

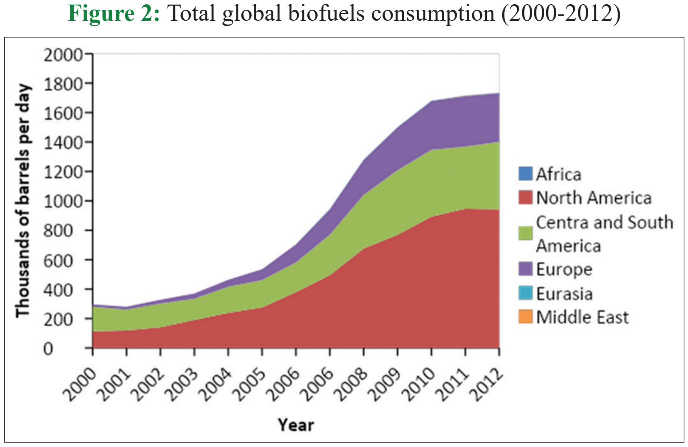
Biofuel is one among wider portfolio of renewable resources. Ethanol (mostly from fermenting sugar and cereal crops) and biodiesel (mainly from plant oils by transesterification) are the major biofuels of today. These traditional and modern biofuels are the two biofuels categories Conventional biofuels (the former generation) are sugar or starch-derived through the process of fermentation or from transesterified vegetable oils. Biofuels from feedstock that can also be used for food and food, including cotton, starch and vegetable oils, are also included. Sugar, starch and palm oil-based biodiesel are also biofuels. The most widely used feedstocks of this method involve sugar cane and sugar beet, stuffed grains such as corn and wheat and oil cultivations such as cotton, soya and oil palm. Biofuels of first generation are readily commercially available. (Yusoff, 2006; Searchinger, Heimlich, Houghton, Dong, Elobeid, Fabiosa, Tokgoz, Hayes and Yu, 2008).

Figure 1: World biofuels production (2000-2015)



Source: Author's computation from BP statistical review of world energy (various issues)

Figure 2: Total global biofuels consumption (2000-2012)



Source: Author's computation with data from international energy statistics, 2015

Highly developed (second generation) biofuels are fuels and substances not included in the aforementioned group are also a product of developed technologies. These include organic fuel derived from feedstocks not specifically comparable with feed crops, such as manure and farm residue (i.e., grains and wheat straw, used vegetable oils, municipal waste), non-food crops such (i.e., miscanthus and short rotation coppice and algae. For research and development, pilot or test stages, much innovative biofuel technology persists. A simple schematic of biofuel value chain is depicted in Figure 3.

3.2. Biofuels Sustainability: Food, Energy and Domestic Economy Concerns

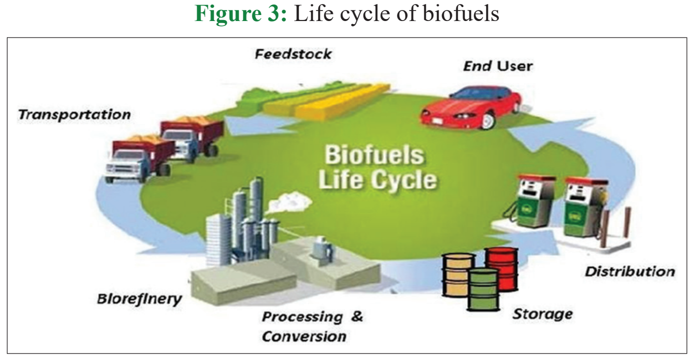
Considering the massive development in biofuels production since the early 2000s, there are many concerns on its sustainability. Specific concerns have been raised in the areas of agriculture, energy and domestic development. It becomes pertinent to carefully characterize the concern raised about biofuels in order to adapt effective policy, especially for developing country like Nigeria.

3.2.1. Biofuels versus agriculture

The first-generation development of biofuels is mostly based on plants used for both energy and food, increasing food safety risks and accessibility and affordability. Whilst first-generation processes may improve employment in development areas, low or high remuneration of such jobs is highly dependent on the level of training and the complexity of agro-industrial processes (Neves and Chabbad, 2012; Tyner, 2013; Lawal et al., 2017a). A massive economic risk associated with the expansion of first-generation biofuels production is another possible risk due to the competition existing between the food and energy markets.

The prices of agricultural commodities have been inconsistent for over a decade, and became noticeably on the high especially in 2007/08 (UNTCTAD, 2008). Quite a number of dynamics influence them including a rise in fossil oil prices, poor crop yields (as a consequence of harsh climatic conditions), increasing demand of food due to the consequent change in the eating habits of an equally increasing population, dawdling advancements in efficiency and outputs as a result of very low capital investments in agriculture in general and the biofuel production in particular (FAO, 2007). Studies on the correlation between biofuels and agricultural production founds that the relationship varies upon food costs and locations; and that certain biofuels such as the

Figure 3: Life cycle of biofuels



Source: http://www.europarl.europa.eu/studies second generation biofuels do not in a way compete for land with food production resulting in lower impact on commodity prices. However, several reports have emerged with mixed evidence on the implication of biofuels for agriculture, especially the first-generation biofuels.

A study conducted by ECOFYS (A Consulting company for energy and climate policy issues) in 2013 indicated that production of ethanol has not in any way led to noticeable hike in the prices of food items. This same study suggested that the actual effect of production of biofuel on the prices of food was below 1%. The Institution of Mechanical Engineers in the UK published a report also in 2013, which submitted that between 30% to 50% (or between 1-2 to 2 billion tonnes) of foodstuff items were affected by unhealthy harvesting practices, transport and storage deficiencies and market/consumer wastages, all leading factors of the food shortages. In a summary report published in 2013 by WBA (World Bioenergy Association), it was revealed that there seem to be adequate land open for more food and feed production process as well as more biofuel and bioenergy feed stocks.

An FAO study in 2008 studied the effect of increased prices of food on the accessibility to, and availability of, food at both levels. Increased food prices, according to the report, would have negative impacts for emerging net food-importing countries, in particular for countries with low income and a food shortage. At household level, the effect on food security would be generally negative. Poor urban households and low net food consumers in rural areas, which are the plurality of rural poor, are particularly at risk according to empirical evidence. Long-term, it has been hypothesized that increasing demand for biofuels and improved commodity prices may offer opportunities to improve agriculture and rural development. Unlike other agricultural crops, the production of biofuel crops in impoverished developing countries has the ability to stimulate economic growth (Lawal et al., 2017b).

Research on Sub-Saharan African nations (SSA) find that commercial crops would help farmers obtain access to loans and improve private investment in production, manufacturing, business development and human capital (FAO, 2008). Such patterns can provide farmers with the conditions for growing their income and the production of food in their fields. However, the study noted the need for active government initiatives to promote the involvement of smallholders (Lawal et al., 2016; Dahunsi et al., 2019b; Otekunrin et al., 2018; Okere et al, 2019). PANGEA (2012) report that low and decreasing agricultural productivity, combined with extremely bad climatic conditions and rising world oil prices, are further drivers of food price rises in the context of the 2010/2011 food insecurity in the Sub Saharan Africa.

On the contrary, Cotula et al. (2008) opined that land tenure security was an important component and that where land tenure policies are not enforced efficiently, as in Africa, the expansion of commercial biofuel production can result in loss of land access for poorer households, which could have a negative impact on local food safety and economic growth. EuroAfrica (2011) estimates, with Senegal and Mali as case studies that 66% of land purchases in Africa, or some 18.8 million hectares, were designated for biofuel production.

Other studies have also questioned the effectiveness, in supporting agricultural diversification and rural development, of first-generation biofuel crop production in developing countries. The OFID/IIASA research found that in developing countries, only small rural development benefits would be obtained. Furthermore, in terms of percentage increase in value added by 6-8% in the former and only 3% in the latter, by the year 2030 estimates, agriculture in highly industrialized countries profit comparatively more than in developing countries (Lawal et al., 2019).

While it is clear that mixed evidence exist on the role of biofuels on agricultural commodities, more important is the role of government in formulating good policies that will enhance the production of biofuels without negatively impacting on food production.

3.2.2. Biofuels versus energy

The technological feasibility is the primary fundamental factor of the biofuels development in relation to energy. The major technological parameters of the biofuels, given that it is an energy source, are efficiency of energy and energy balance specifically in production and also consumption. A methodology is used for assessing the energy balance and associated environmental considerations of biofuels for the life cycle assessment (LCA) method. When contrasting the amount of energy in the fuel production process to the amount produced in use, the energy balance of biofuels is achieved. The LCA methodology analyses the substance and the energy movement of a commodity to create an energy balance, which is correlated with the output or use. LCA can be supply-chain focused (the LCA approach that consider only direct effect), Economic Input Output LCA approach (the one that consider some type of indirect effects) and policy-focused LCA (one that use the calculable general equilibrium modelling to estimate effect of mandates and other economic policies).

Rajagopal and Zilberman (2007) claimed that the maximum energy and carbon dioxide benefits were only provided by sugarcane ethanol. The extraction of energy and carbon dioxide, although not as efficient as sugar cane, also has been found to be cassava ethanol. On the contrary, the energy and environmental benefits from corn ethanol were found to be lower than sugar cane and cassava according to Rajagopal and Zilberman. The writers have emphasized the essential biofuel LCA considerations such as environmental principles of crop rotation, intercropping and use of co-products.

The increased productivity of biofuel feedstock is an extenuating factor for the food and fuel problem. For starters, Sexton and Zilberman (2012) supported the substantial increase in prices at the peak of the global food crunch of 2008 by introducing genetically engineered crops. However, they claimed that Genetically modified crops of the First Generation enable cultivation to accelerate, thus potentially freeing up land for bio-fuel production or at least reducing the demand for new cropland caused by increased grain and combustible requirements.

The transfer from the feedstock to the final product poses a major concern over the partnership between biofuel and energy production. However, the costs associated with studying in refineries are significantly reduced. Hettinga et al. (2009) estimated, for example, that since 1975, sugar cane ethanol processing costs (including capital costs) have declined by 70% and maize ethanol has decreased by 49% since 1983. Such cost reductions coupled with expected rises in sugar cane and maize ethanol yields further boost their economic feasibility, particularly in view of high fuel prices.

Biofuels are significantly used also for the purpose of converting originally captured energy from solar technology making possible the ability to compare biofuel with the substantial use of solar energy. The contrast between the performance of solar energy production for automobile uses was carried out by Reijnders and Huijbregts (2007, 2009). It was concluded that the transition of lignocellulosic biomass to electricity from electric vehicles could be greater than the use in the conversion of solar power into automotive energy of the most energy-efficient first generation biofuel (sugar cane ethanol). This implies that solar energy is more effectively transferred to automotive fuel on the basis of solar cells.

3.2.3. Biofuels and domestic economy

When focusing on the involvement of biofuels to sustainable development, the connection between biofuels and the domestic economy is better understood. The conclusion arising from most studies on the effect of biofuels suggests that if GHG emissions from direct and indirect land use charges influenced by production of biofuel feedstock are excluded, biofuel offers a somehow reduced fossil-fuel emission (Timilsina and Shrestha, 2010). The Brazilian sugarcane ethanol, as shown by Macedo et al. (2008), is the largest reduction in GHG emissions due to high yields and the use of plant energy sugarcane waste, as well as electricity cogeneration. Certain products that save GHG emissions include palm oil, sugar beets, maize, sunflower, soya and rape seed, all of which save GHG in the mean range (Janda et al., 2012). Janda et al. reported in 2012 that maize has GHG emissions as the worst biofuel feedstock. Hill et al. (2006) have claimed that the potential for soybean biodiesel to reduce GHGs is much higher than maize grain ethanol, while Liska et al. (2009) suggested that a significant improvement in GHG reduction potential for maize can result in increased efficiency and crop management at GHG levels.

Searchinger et al. (2008) and some other noteworthy researches have argued that when carbon emissions from forested or grassland-stocked land conversion to crop production are considered, GHG's capacity for the saving of biofuels worsens vividly. Primarily, Searchinger et al. (2008) found that maize-based ethanol is almost double the emission of greenhouse gases over 30 years, instead of producing an economy of 20%, as far as land use changes are concerned. In view of Searchinger et al. (2008) consideration by Hertel et al. (2010), it has been concluded that there 28 years is required to compensate for GHG emissions from land conversion by reducing emissions by replacing fossil fuels with biofuels. One of the main contributors in terms of the current projected short period for GHG payments for biofuels according to Searchinger et al (2008) is a progressive improvement in ethanol production technological efficiency. The yield of ethanol per unit of input feedstock increases, the processing material and energy costs decrease and feedstock production yields increase. Hence the projected emissions of GHG are smaller. Dumortier et al. (2011), having followed the same model as Searchinger et al. (2008), but with some modifications found that biofuel-related GHG emissions are generally lower than those reported by Searchinger et al. (2008). Dumortier et al. (2011) stated that since the theories for GHG emission analysis are related to the forecasting of long-term human behavior, appropriate variations of the models dealing with GHG biofuel effects are possible.

Some environmental factors relating to biofuels include increasing soil erosion, deforestation, loss of biodiversity, higher air pollution risk as a feedstock growth and as a result of biofuel combustion, and impact on water supplies (Janda et al., 2012). Janda et al. (2012) noted that the possible detrimental effects of some above-reported factors depend heavily on the geography, climate and technology details of any identified biofuel project, as biofuels may actually improve, or be neutral in any environmental issue, in some cases.

A thorough assessment of social and economic impact of biofuels is particularly complicated, because biofuel development is an indirect way to meet the main targets of decreased fossil fuel dependence and climate change mitigation. The socio-economic implications of biofuels to energy and foodstuff markets complicates the social and economic implications of biofuels. Jaeger and Egelkraut (2011) noted that the sharp rise in biofuel production would lead to many social and economic externalities in the form of feedback effects and other unexpected social implications. The effect on food prices of development of biofuels from food crops is greater than energy prices according to Rajagopal and Zilberman (2007). Also, Janda et al. (2012) opined that diversion of use of land from production of food-crops and feedstock to that of biofuel is a major causative factor leading to rise in the prices of food. As stated by Abila (2014), the economic challenge involves ensuring that any economic growth envisaged via biofuel production activities remains steady and effective. According to Hochman et al. (2010), worldwide fossil fuel usage and prices of fuel globally reduced by approximately 1% and 2%, respectively.

Conclusively, the correlation between biofuels and agriculture is based on crops with dual usage as food and energy purposes for the most first generation of biofuels, which raises the risks of food security and affordability. The processes of the first-generation biofuels tend to employment opportunities in industrial fields, but workers may produce low and high incomes, depending on the levels of training and the nature of agribusiness. Furthermore, the socio-economic risks such as the inevitable struggle between the food and energy markets can be traced to the production process of first-generation biofuels. Few of the elements adduced as the factors liable for the variations in the prices of agricultural commodities include growing fossil oil prices, poor crop yields, increased food demand due to growing populace with an equally growing eating pattern, slow pace in the productivity developments arising from paltry investments in agriculture. Researches as regards the Biofuels-agriculture production relationship show that the link differs with cost of food and places; and that some biofuels as the second-generation biofuels are not compatible with food land output, despite lower price impact. Reports on the implications of biofuels in agriculture, specifically for biofuels of the first-generation, are interesting.

There is no question that biofuel has made a huge contribution and has been accepted as one source of energy. The advent of the life cycle assessment as a mechanism for determining the energy balance and the attendant environmental implications of biofuel offers a medium to assess energy efficiency and energy balance in production and consumption. It is interesting to find that the biggest energy and carbon dioxide advantages were provided by sugarcane ethanol. Cassava ethanol has also been found to be efficient in energy and carbon dioxide production, but not as effective as sugarcane production. Ethanol from maize also has a lower energy and environmental benefit compared with sugarcane and cassava. Significant elements in biofuels LCAs like environmental crop rotation values, cross-croping and use of co-products were emphasized. Increased production from GM crops has also been reported to enjoy substantially discounted price growth at the worldwide food crisis apex in 2008. In addition, Genetically engineered crops of the first generation also enable agriculture to intensify, potentially releasing land for biofuel production or, at least, the demand for new crops as a result of increasing food and fuel requirements.

The summary of findings that has emerged from the majority of researches into biofuels' effects was that, when GHG emissions from explicit or implicit land use changes caused by the production of biofuel feedstock are excluded, biofuel emissions from fossil fuels are reduced in part. Additional items to save GHG are palm oil, sugar beets, maize, sunflower, soybeans, and rapeseed, which save GHG in a medium range. It was also found that maize has a significantly higher GHG reduction potential as far as GHG emissions are concerned, compared to maize grain ethanol. However, through enhanced crop yield and crop management, bio-refinery operation and co-product uses the GHG potential reduction of maize could be enhanced considerably to sugar or soybeans.

4. POTENTIAL FEEDSTOCKS FOR BIOFUEL PRODUCTION IN NIGERIA

4.1. Sorghum

Sorghum, which represents 6.86 million hectares of cultivated land, is one the planted crops with high drought resistance in about 50% of the Nigerian farmlands, mainly the north of the country (8 0N-14 0N latitude). Sorghum is suited to Nigerian climate and can be cultivated on minimal soil. This will certainly be an outstanding illustration of food and biofuel co-production. Annual production was estimated to be 45% higher than in 1978 (Ogbonna, 2002) with a total production of 4.8 million tonnes. In 2010 sorghum production was 4.78 million tons (FAOSTAT, 2012) in Nigeria in particular. This figure gives Nigeria the potential to become Sub-Saharan Africa's highest sorghum producer, making up for approximately 70% of total sorghum production (Galadima et al, 2011). Sub-Saharan Africa's experience shows that 5 tons ha 1 year 1 of edible sorghum grain can be produced as well as 70 tons stalk (Reddy et al., 2005). (Reddy et al., 2005) 17 ha 1 tons of "green waste" are also produced, which can be used as a fertilizer or livestock feed, either for electricity generation (Reddy et al., 2005). However, eventual production in the specific case is determined by crop variety, soil quality, crop methods and varying other reasons (Ogbonna, 2008). Even if not a broad manufacturing phenomenon, Sorghum is mainly grown as grain and harvested twice a year, with a lower effect on storage requirements.

4.2. Cassava

Nigeria was the world's leading cassava producer by 2010, producing 37.5 million tons (FAOSTAT, 2012). Cassava is often referred to in the framework of biofuel programmes in Africa. This is another plant grown on local as well as on a market-based scale, due to its well-drained deep loamy soil, in some major regions of Nigeria, especially in the rainforest and the savannah areas of Northwest and Northern Central. A relatively tolerant crop, it is often grown on "marginal farm lands" where it doesn't have to contend with several other crops. Cassava ethanol is therefore regularly utilized as the benchmark technology for the assessment of biofuel capacity and limitations in Nigeria. There are currently more than 60 different varieties grown (Galadima et al., 2011) and like sorghum, cassava can be used locally as well as industrially. It is necessary to note however that cassava ethanol has not yet generated any compelling data on the cost of production and energy balance (Ishola et al., 2013). Furthermore, Nigeria employs tubers for food production rather than for industrial use, in stark comparison to other developed countries.

4.3. Sugarcane

As the aftermath of the European sailors' adventure into Nigeria's Western and Eastern regions in the 15th century, sugarcane is a major crop grown in so many parts of the country and is typically cultivated on small farm for juice and animal food preparation. However, as the country's demand for sugar rises, the crop is widely cultivated as a raw substance for the sugar sector. According to Agboire, Bacita, Lafiagi, Numan and Sunti who were the major sugar companies operating by 1997 used approximately 12,000 ha out of the total 30,000 ha available land for production of sugarcane (Agboire et al., 2002). As at 2008, it was estimated that about 100, 000 tonnes of sugar was produced in comparison with the 80, 000 tonnes produced in 2007. In line with its new initiative encouraging the production of ethanol biofuel, the Nigerian Government has designated sugarcane and cassava as the key basic materials for the NNPC's bioethanol program. Investments, both foreign and local have already started flowing in, some of which are the $3.86 billion for building about nineteen (19) ethanol bio-refineries, over 10,000 units of mini-refinery facilities, plantations of feedstock for over $2.6 billion litres of fuel-grade ethanol basically from sugarcane and cassava requiring about 859,561 ha of land (Ohimain, 2010).

4.4. Jatropha

Jatropha, according to the Biofuel policy of the Federal Government of Nigeria remains the basic raw material for its biofuel program. Jatropha is a non-edible, a factor that has made

Table 3: Nigeria's biofuel crops production

Crop	2007 average yield (MT)	biofuel Fuel type derivation	Derivable biofuel yield (L/Ha)	Nigeria's production rank (global)
Sesame	100,000	Biodiesels	696	7
Palm oil	1,300,000	Biodiesels	5950	3
Palm Kernel	1,275,000	Biodiesels	5950	3
Ground Nut	3,835,600	Biodiesels	1059	3
Soybean	604,000	Biodiesels	446	11
Coconut	225,500	Bio-ethanol	2689	17
Sugarcane	1, 506,000	Bio-ethanol	6000*	51
Cotton Seed	212,000	Biodiesels	325	16
Cassava	34,410,000	Bio-ethanol	4000*	1
Sweet Corn	6,724,000	Bio-ethanol	172	10

*Data from Liebig (2008); other fuel yield/ha from Mobius LLC (2007). Source: Abila (2010)

the plant not massively produced in Nigerian by farmers either subsistence or commercial. In recent years however, a few research farms have been developed to pilot the study on soil desertification. Some literature has shown Jatropha to be a very good source of biodiesel oil and yield roughly 100% of fuel in both homogeneous and heterogeneous conditions and in a short transesterification time (Lu et al., 2009; Sahoo and Das, 2009;). Looking at this from an economic angle, some researches showed successes in massive Jatropha plantations in several of the tropic's countries. In Thailand, Prueksakorn et al. (2010) revealed that up to 4720 and 9860 GJ net energy per ha could be generated via both a 20-year perennial system or an annual crop method involving the collection of tree forests and biodiesel seeds. In India, Jatropha biodiesel production and consumption have shown a decline in fossil fuel demand of 82% and in global warming potential to 52% (Achten et al., 2010). While the industralized production of Jatropha and its environmental impacts have not been thoroughly investigated, the selection in Nigeria of Jatropha would represent a multi-functional opportunity. Besides energy sources, problems of soil degradation, desertification and deforestation could be solved.

4.5. Palm Oil

Palm oil production grew to approximately 109 million tons by 2010 thereby making the country the fourth largest palm oil producer in the world (FAOSTAT, 2012). As at 2010 also, the global usage of Palm Oil was estimated to be 48.7 million tons (USDA, 2010) with the produce being the highest yielding viable crop, with an average harvest of 4 to 5 tons of oil $ha^{-1} yr^{-1}$ (Sumathi et al, 2008). It's also the most effective and efficient oil-bearing crop with an economic life of 20-25 years in terms of land use, productivity and efficiency (Singh et al., 2010). Two key palm fruit products are produced, and both are potential feedstock to produce biodiesel, mesocarp palm oil and endosperm palm kernel oil. Mesocarps and endosperms respectively contain approximately 49% palm oils and 50% palm kernel oil (Yusoff, 2006). Although Nigeria is likely to produce biodiesel on commercial scales in the future, Nigerians presently are heavily dependent on palm oil for human consumption.

4.6. Soybeans

Another veritable potential source for biodiesel production is soybeans, bearing in mind that Nigeria is presently projected to be the 15th country globally in terms of production of soybean with an estimated production of 3943,000 tons (FAOSTAT, 2012). The local and industrial demand of soybean in Nigeria far outweighs its supply making importation from Argentina and United States since 1999 inevitable (David, 2011). Given soybeans high protein content, they are considered essential for nutrition reasons. Due to the fact that because small scale farmers produce soya, local supply of this crop fall short of increasing demand with the average yield of 1.2 tons $ha^{-1} yr^{-1}$. Also, the non-mechanization of the production process of soybean in Nigeria contributes to the decrease in supply when compared to the demand (David, 2011) and substantial-scale production of biodiesel from soybeans would require better methods of production.

A critical evaluation of the production of biofuels feedstock capacity exposed the fact that Nigeria indeed has the potential for increased production of biofuels. This section ends by presenting Nigeria's biofuel capacity and 2007 global ranking in key feedstocks production for diesel and ethanol production (Table 3).

5. CONCLUSION AND RECOMMENDATIONS

Biofuels are becoming increasingly important in the agricultural and energy sectors. Countries across the globe are obviously pursuing policies on biofuel to sustainable growth, to achieve energy security and the transformation of rural economies by low carbon energy alternatives. In the light of the high potential of Nigeria in terms of biofuels production and due to the level of huge arable soil available for energy production, Nigeria is not arguably an unfair priority in this context.

Given that the Nigerian policy on biofuel policy was made to take care of issues such as feedstock, production framework, potential market and investment opportunities, further diligence and strategy is required if not, its execution and sustainability may become more problematic than its advantages. Therefore, the emphasis should be placed on previously exploited food and non-food crops in order to affect a balance between food, energy, domestic development and biofuel production. A safe and sustainable alternative should be crops with better options, such as jatropha. The research and development for the viability and feasibility of other feedstock potentials should however involve committing sufficient resources. Better yet because technologies from second generation can help solve certain problems with the first-generation biofuels, deliver green fuel affordably and offer greater environmental benefits, Nigeria needs to invest in first-generation biofuels.

Significantly, Nigeria needs to develop institutional structures to encourage and expand the sustainable development of biofuel as it was done in Brazil. Also, to guarantee the implementation of measures to make the sector's contribution to rural livelihood, Nigeria needs to develop a strong supporting policy and a strong legal, regulatory and institute framework. There should also be appropriate opportunities for involvement of the private sector in biofuel production and processing. Realistic steps that would allow the country to surmount its weak environmental regulations must be put in place. Solid environmental legislations should also be incorporated. In order to benefit from technology collaboration initiatives, Nigeria also needs to develop an international partnership with bilateral and multilateral partners. Finally, it is important to check the threat of systemic corruption and the drainage of investment funds meant for social development.

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