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EXAMINING BIOFUEL SUSTAINABILITY AS AN ALTERNATIVE ENERGY SOURCE AND IMPLICATION FOR FOOD SECURITY IN SUB-SAHARAN AFRICA

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ABSTRACT

This study reviewed a body of literature to provide an overview of biofuel production as an alternative energy source and its implication for food security; highlighted the benefits and impact of biofuel on food security and food prices; the challenges and gaps inherent in the development of biofuel and policy framework that steered the biofuel industry in Sub-Saharan Africa (SSA). Seventy-seven (77) scientific papers and grey literatures published between 2007 and 2017 were selected and used; with 52 scientific papers published in 26 peer-reviewed journals and 32 published literatures which includes documents from Food and Agriculture Organization/UN Environment Programme (FAO/UNEP), The World Bank, ACTIONAID, Council for Scientific and Industrial Research (CSIR), and South Africa's Department of Minerals and Energy. The review revealed that sustaining biofuel production is a convoluted process that requires dealing with many facets within and around its production and use. Expansion of biofuel production may therefore be executed at the expense of local, national, and global food security. Furthermore, it is also important for SSA policy makers to identify the local and national context within which the biofuel production revolve. The paper recommended a strict biofuel sustainability scheme that sets proper regulations and control on bioenergy production, which guarantees food security. The debate and hysterics on the potential risk of increased biofuel production impacting on food security must be examined. The conflicting interest and the trade-offs that characterized biofuel development must be settled with effective and planned policies to unlock the desired potential for biofuel sector in SSA.

Keywords: Bioenergy, benefits, challenges, sustainability, policy frameworks, food security, energy

1. INTRODUCTION

Energy is one of the most essential human needs, and its sourcing constitutes one of the main problems confronting many nations of the world. Technological advancement towards providing solution to energychallenge have made commendable progress.These measures have achieved some success at providing energy sources, and the most common being the fossil fuel which shares more than 80% (Pfenninger & Keirstead, 2015:19) of the global energy requirement. Fossil fuel, however, has proven to constitute detrimental effects to the environment, as burning of conventional fuels have resulted in the release of greenhouse gas to the environment,thereby contributing to the global climate challenges. This situation, therefore, has forced the attention of relevant stakeholders in thedirection of alternative energy sources that are more environmentally friendly, and cost effective. Biofuel has been found to represent an alternative idea. It is an energy source of crop and wood-based raw materials origin such asmolasses, rice husks, corn, and wood waste. Biofuel are produced from bio-origin resources by thermochemical processes (Ertas & Alma, 2011) and biochemical process (Shukla, Thanikal, Haouech, Patil, and Kumar, 2017; Uddin, Rashed,Nithe and 2016).Khan (2007) asserted that biofuel present a means to both reduce energy import bills as well as earn precious foreign exchange, among many sub-SaharaAfrican countries.

In Sub-Saharan Africa (SSA), biofuels were recognised in the early 2000s as an essential approach for reducing the dependence on fossil fuels and extenuating the related greenhouse gas emissions within the environment. Many SSA countries perceived biofuels not only as a panacea for delivering sustainable fuel but also with numerous additional benefits of reducing carbon emissions, economic growth, energy security and poverty alleviation (Gasparatos, 2013). Biofuels have accordingly received support and attention from government and private domain in Sub-Saharan Africa (SSA). As an indicator to these developmental benefits, the surge to acquire large expanse of land and direct foreign investment became imminent as investors considered biofuel as lucrative commodities that could be connected to international markets, and more importantly the European Union (EU) biofuel market. The urge and enthusiasm were further heightened by the ratification of the EU

Renewable Directives 2009/28/EC (EU-RED), which sent a very strong signal that biofuel/feedstock imports could be possible from SSA if the production in EU is insufficient (Carmody, 2013). The total reliance by most SSA countries on traditional biomass and imported fossil fuel remain the second driver of the expansion of biofuel industry. The biofuel is supposedly attractive to most SSA landlocked countries like Malawi, where fossil fuel import takes a large toll on her international balance of trade (International Energy Agency (IEA), 2014). However, before 2000, most biofuel initiatives in SSA especially in Kenya, Malawi, South Africa and Zimbabwe were aimed at reducing oil imports, saving on foreign exchange and conserving energy (Gasparatos, 2013).

The use of biofuel for transport in Southern and Eastern Africa is pronounced while in West Africa, it is mainly used for the generation of local energy such as rural electrification. However, SSA countries' viewpoint is that biofuel production could have positive impact on rural development with its attendant ripple effects on national initiatives to mitigate poverty (Mitchell, 2011). On the contrary, issues of ecological factors such as lessening of greenhouse gas emission (GHG) and the improvement of air quality have not been viewed as important reasons for biofuel expansion in SSA. However, the EU directives on the promotion and use of biofuel as renewable energy sources led to further expansion with the understanding in part, that it has climate mitigation properties. The aforementioned factors triggered very high expectation in SSA over biofuel expansion witnessed in the second half of the 2000s.

The need to amalgamate biofuels into transport fuels became pronounced as a legislative law for increasing biofuel uptake in the transport sector in SSA. Thus, many countries like Angola, Ethiopia, Malawi, Mozambique, Sudan, Zambia, and Zimbabwe passed laws on the merger of biofuel into the transport sector. Such laws were surrounded with numerous policies to protect biofuel production (REN21). Similarly, countries in Western Africa like Mali, made joint biofuel production a priority model and used biofuel for local electrification, replacing the conventional fuel. Most farmers as part of the benefits received monetary compensation for growing feedstock, which is the money that would have been allocated for importing diesel fuel (Favretto, Stringer,& Dougill, 2014).Varying studies have, in the past few years, reported biofuel related findings, with specific reference to the Sub-Saharan Africa (Borras, Fig, & Suárez, 2011; Gasparatos, Lee, Von Maltitz, Mathai, De Oliveira, & Willis, 2012)**.** Other studieshave also been reported in the more recent time. For example, Samuel Dahunsi, Shoyombo, and Fagbiele (2019)had also outlined the potential for production and associated gains from biofuel production and relatedenterprises. Dahunsi, Shoyombo and Fagbiele (2019)argued thatin view of over-dependence on fossil fuel, as the main energy source among many nations in the Sub-Saharan Africa and associated environmental challenges, policy actions should be supportive of production of biofuel. However, Dahunsi, Shoyombo and Fagbiele (2019)failed to pay due consideration to potential negative implications for food security. Also, the Renewable Energy Agency (2017) made a pro-biofuel analysis with specific emphasis on reducing food waste and utilization of residues to promote production.The analysis was however,also without due consideration to the potential effects of a rapidly developed biofuel sub-sector on an already worse food security situation in the Sub-Saharan Africa.In this perspective, the review papertherefore, reviewed a body of literature to provide in-depthsynopsis of biofuel production as an alternative energy source and its implication for food security in Sub-Saharan Africa. The paperconcludes with a comprehensive summary of key findings in context.

2. METHODOLOGY

Comprehensive literature search was carried out independently by all four authors using academic data bases and search engines amongst which are Web of Science (WoS), Science Direct, Scopus, SciELO, and Google Scholar (GS). Institutional repositories were also used to access academic journals, with relevant scientific materials accessed from the online library of the University of Fort Hare, South Africa, using its Online Public Access CatLog (OPAC), Cat Plus and Digital Collections. All authors adhered to the following search criteria: (1) Language format of selected scientific papers was only English; (2) Scientific materials used, largely focus on biofuel as an alternative energy source with contents related to the core objectives of this review paper; (3) Selection of articles was from recognised, highly rated, and peer-reviewed journals which are known to publish high quality and original research; (4) literature search was diverse and not limited to journal articles; and extremely valuable information from grey literature such as book chapters, conference proceedings, technical reports, working papers, white papers and other government documents were also incorporated.

A string of keywords/phrases were used to search for related articles in the academic databases and search engines, some of which includes biofuel, bioenergy, production, benefits/ opportunities, challenges, sustainability/conservation, policy framework, development, impact on food security and food prices, Sub-Saharan Africa (SSA) and European Union (EU) amongst many other ranges of terms. Authors separately

explored paper titles/themes, abstract, keywords and engaged in a full or sectional perusal of articles to exclude materials with contents unrelated to the focus of this review paper. Seventy-seven (77) scientific papers and grey literatures published between 2007 and 2017 were eventually selected for use; with 52 scientific papers published in 26 peer-reviewed journals and 32 published literatures which includes documents from Food and Agriculture Organization/UN Environment Programme (FAO/UNEP), The World Bank, ACTIONAID, Council for Scientific and Industrial Research (CSIR), and South Africa's Department of Minerals and Energy.

Specifically, the study addresses the following questions: (a) What are the impact of biofuel on food security and food prices? (b) What are the benefits of biofuel? (c) What are the diverse sustainability concepts and how sustainable is biofuel production? (d) What are the challenges and gaps inherent in the development of biofuel? In addressing these questions, it became imperative to explore the policy framework that steered the biofuel industry in SSA.

3. RESULTS AND DISCUSSION

Biofuel has been strongly reinforced as a better replacement for fossil fuel in the fight for the reduction of greenhouse gas (GHG) emissions, healthier and sustainable environment, improved energy supply, access, diversification, and security. It offers increased job prospects in agriculture as primary biofuel feed stocks are acquired from agricultural produce like maize, wheat, and sugar cane, which presents local farmers with increased production opportunities.In contrast, the impact of biofuel could be felt directly when food crops otherwise meant for human consumption are utilized as energy sources or indirectly when lands set aside for food production are cultivated for energy production purposes. The supposed link between biofuel production and rise in food prices and food security, presents an ethical and policy challenge to bioenergy producing countries.

There are contending views that biofuel production affects food prices and food security, with several recommendations adduced by various studies to help mitigate its production impacts. Additionally, some critics of biofuel proposed the abstinence of national governments from further supporting the production of conventional biofuels and the removal of national policies in support of biofuel production. However, proponents of biofuel production highlightedseveral measures some of which include using feedstock that does not necessarily compete with food intended for human consumption and allowing strict biofuel sustainability arrangements that set proper regulations and control on production. Therefore,the challenge is the trade-off in biofuel intensification, with its attendant environmental problems, and sustainable livelihood of the rural farming populace. Furthermore, biofuel policies in SSA remain declaratory rather than being precise and proactive

3.1Impact of biofuel on food security and food prices in Sub-Saharan Africa

The demand for bioenergy continues to rise (Demirbas, 2017) as awareness of its potential socio-economic and environmental associated values (Renzaho , Kamara & Toole, 2017) spreads universally. The production of conventional biofuels termed as 'first generation biofuels' is primarily reliant on the use of food crops such as sugar cane, corn, wheat, cassava, soybeans and palm oil (Acheampong, Ertem, Kappler & Neubauer, 2017; Ellas, 2014; Gerasimchuk, Bridle, Moerenhout, Laan, Charles & Asmelash,2013; Hodbod & Tomei, 2013). The implication is that, more staple crops are being converted for use in biofuel production (Vignesh, Selvakumar, Santosh & Prabhakar,2013) bringing about a surge in the global demand of agricultural produce(Mohr, Beuchelt, Schneider, & Virchow,2016). However, some schools of thought have argued that increased biofuel production may lead to an increased demand for feedstock (Olah, Lengyel, Balogh, Harangi-Rákos, & Popp, 2017); and diverting food to biofuel feed stock production, and may trigger severe impact on food prices and food security (Carmenza Castiblanco & Andrés Etter, 2013; Hodbod & Tomei, 2013; Stattman & Mol, 2014). A major concern of critics is the negative impact of biofuel production expansion and limited access to staple food (Stattman & Mol, 2014). Selfa, Kulcsar, Bain, Goe, & Middendorf (2011) posited that the rise in food prices is a consequence of a shift from food to biofuel feed stock productionposing potential threats to food security. This impact could be felt directly when food crops otherwise meant for human consumption are utilized as energy sources or indirectly when lands set aside for food production are cultivated for energy production purposes (German, Schoneveld, & Pacheco, 2011; Hodbod & Tomei, 2013; Oladosu& Msangi, 2013). The resulting effect is the competition for food, which affects food prices and food security (German *et al*., 2011; Koizumi, 2015; Oladosu& Msangi, 2013)

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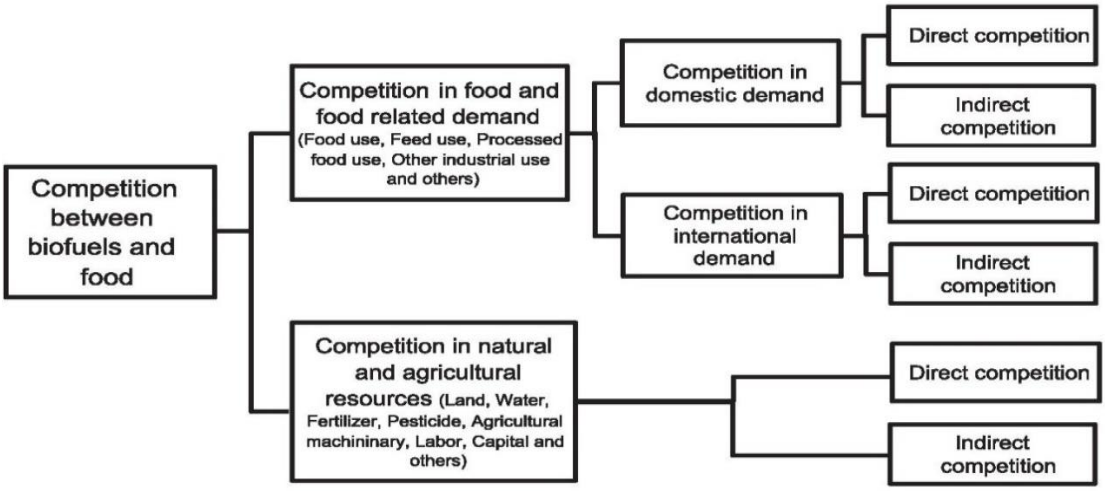

Fig. 1 Model showing the competition between biofuels and food.

Adapted fromKoizumi (2015)

The role of biofuel production in Sub-Sahara Africa could be considered more crucial than in industrialized economies as a larger percentage of its population completely depend on access to land and its yields for survival ((Lynd, Sow, Chimphango, Cortez, Brito Cruz, Elmissiry, Laser, Mayaki, Moraes, Nogueira, Wolfaardt, Woods, & Van Zyl, 2015) this raises some form of concern in relation to bioenergy production because, as the demand for biofuel increases, existing lands typically used for food production could be diverted for biofuel feed stock production creating competition for land, water, inputs and labour (Norgrove, 2010). Regardless of its associated benefits, there are apprehensions to the supposed re-direction of land used for food purposes to biofuel production (Oladosu&Msangi, 2013). Popp, Lakner, Harangi-Rákos, & Fári, (2014) described how land resources are further stretched considering that their availability and productivity are already threatened by climate change conditions. According to Bracco (2015), increased pressure on land-use due to demand for biofuel staple crops could result in a displacement effect of food and feed, and worsen food security.Evidence from Bracco (2015)'s study shows the extensive rate at which land is acquired in Africa by European Union investors mainly for biofuel feedstock cultivation purposes. At the time of the study, EU investors had acquired nearly 4 million hectares of land in Africa to grow staple crops for bioenergy production. A major downside to this development is the manner in which investors seemingly disregard regulations in the sustainability criteria created by the EU to abate the effects of land-use change. Lynd and Woods (2011)also noted the increased outsourcing of biofuel feedstock production by numerous developed countries to developing nations.

Koizumi (2015) identified five stages of relationship between biofuel production and food security (figure 2):

Stage 1: Competition is initiated amongst biofuels and agricultural commodities in regions.
Stage 2: A 'price reaction' is triggered because of increasing competition between food and biofuel.
Stage 3: Food-fuel competition triggered price reaction, which transmits to food prices.
Stage 4: The reaction-transmission process of food prices is manifested.
Stage 5: Impacts of rising food prices on food security becomes established. This is mostly felt by resource-poor households who expend a larger proportion of their earnings on staple food for consumption. As such, regions with a higher resource-deprived population are more prone to biofuel production induced food insecurity.

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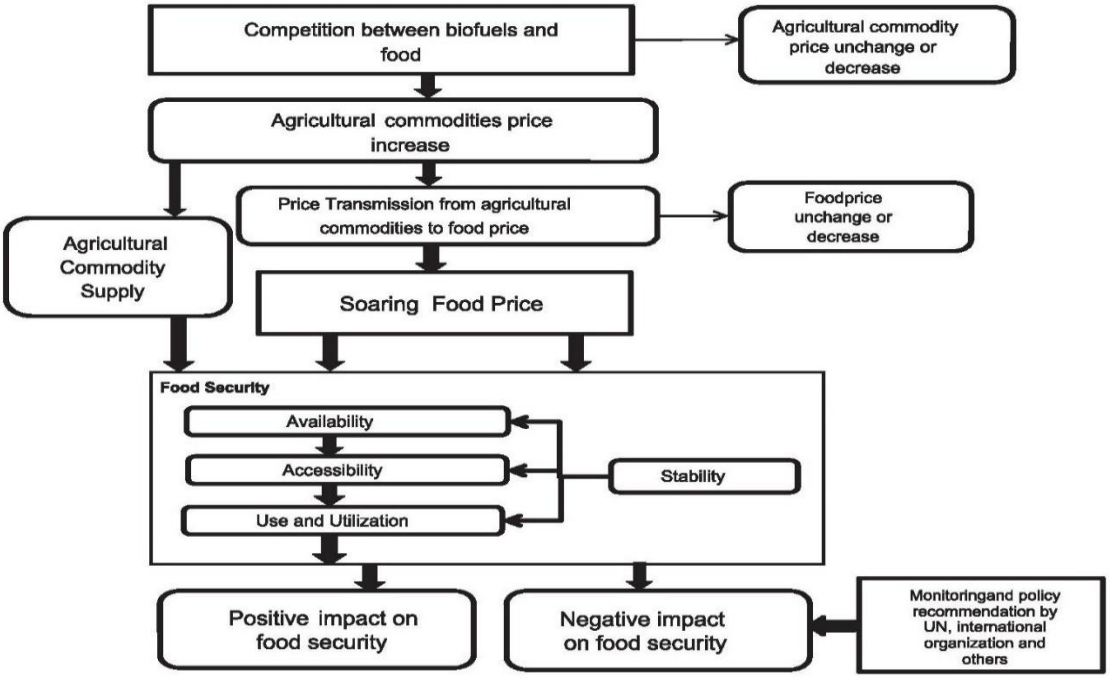

Fig. 2. Relationship between biofuels and food security (Koizumi 2015)

Ellas(2014) evaluated some arguments for and against the 'food versus fuel' debate and clearly emphasized that the cost of first-generation biofuels on food security is too high to continue producing renewable energy. The continual reliance on first generation fuel production technologies may negatively impact food security. The process is considered quite inefficient and detrimental to the poor; many of whom live in developing countries. Expansion of biofuel production may therefore be executed at the expense of local, national and global food security (Dale, Efroymson, Kline, Langholtz, Leiby, Oladosu, Davis, Downing, & Hilliard, 2013; Hunsberger,Bolwig, Corbera & Creutzig, 2014). It becomes even more of a concern looking at the statistics for the estimated increase in the use of staple foods for biofuel production. Renzaho, Kamara, and Toole (2017) alluded to Food and Agriculture Organization (FAO) report in 2012 which projected an increase in the use of cereals and vegetable oil from 65 to 185 and 7 to 29 million tons respectively from 2005 to 2030. The use of sugarcane and fresh cassava for biofuel production is also being predicted to rise from 28 to 81 and 1 to 8 million tons respectively.Lynd and Woods (2011) also noted from the British Petroleum 2011 report that biofuel daily production was likely to increase from 1.8 to about 6.7 million barrels. This could induce inflation of food prices.

Food-biofuel competition continues to be a major driver for higher food prices; and higher food prices may threaten food security (Koizumi, 2015; Silalertruksa, Gheewala, Hunecke & Fritsche,2012). Many studies for instance, cited accounts from preceding literatures on global food crisis from 2007 – 2008 where the sudden increase in food prices was linked to the upsurge in demand for agricultural commodities(Dale 2013; Oladosu and Msangi 2013; Maroun and La Rovere 2014; Kline, Msangi, Dale, Woods, Souza, Osseweijer, Clancy, Hilbert, Johnson& Mugera1, 2016). Acheampong *et al*. (2017) found from studies that rise in agricultural commodity prices was usually supply-driven where market demands were unable to meet supply. Also noted that the sharp rise in food prices in the said period was demand driven. Demanddriven in the sense that more staple crops were diverted from consumption to biofuel feed stocks. This led to increased cognizance of the potential risks of increased biofuel production and food security debates on biofuel production (Olah*et al*., 2017). Contrary to the viewpoints of many critics who held that increased biofuel production is liable to food crisis, (Smyth, Kline, Msangi, Dale, Woods, Souza, Osseweijer, Clancy, Hilbert, Johnson& Mugera1, 2016) could have been exaggerated. Dale *et al.* (2013) found that the effect of biofuel production on the hike in food prices was indeed overemphasized. While (Oladosu and Msangi 2013) also reiterated the standpoint of other scholars that many factors aside biofuels jointly triggered the sharp rise of food prices.For instance, Olah *et al.* (2017)in their study, provided evidence to show that the primary driver of variations in food prices was oil price shocks. While Iheke and Osondu (2012) considered the fusion of competition food and biofuel feedstock production to limited stocks of grains, high oil prices, severe weather conditions, and speculations in food markets.

Kline *et al*. (2016) review of many studies pooled number of critical statements to support this differing opinion:

i. Numerous studies have credited the rise of food prices in the said period mainly to other factors like 'as oil prices, economic growth, currency exchange rates, and trade policies.
ii. The assumed relationship between hike in food prices and biofuel production failed to stand because prices of grains fell or exhibited varied patterns in subsequent years even as biofuel consumption steadily increased. Food prices was rather driven more by factors such as 'oil price, national agricultural policies, and exchange rates.
iii. Many literatures, which infer that biofuel is detrimental to food security primarily, base their argument on the supposed relationship between biofuel, rise in global food prices and food security over a relatively short period.

Insights from (Oladosu and Msangi 2013) review of related studies further established that:

i. For most part, there has been a change in the inference that hike in food prices experienced especially between 2005 and 2008 was solely caused by biofuel factors.
ii. There is a need to separate the impact of other non-biofuel factors on food prices to adequately assess the impacts of bio-fuel factors on food prices and food security.
iii. Local, national, and global impacts of bio-fuel factors on food prices is far reaching.
iv. Changes in food prices at country-level is linked to the hike in international food prices; as such, the impacts of such rise in food prices on household wellbeing varies across regions.

With the above conflicting views by several researchers on the impacts of biofuel production on agricultural commodity prices and food security, Silalertruksa, Gheewala, Hünecke, & Fritsche, (2012) suggested that the level of influence requires an extended analysis which could help provide the much needed balance between opposing perspectives.

In the light of the notion that biofuel production indeed affects food prices and food security, several recommendations have been put forward by various studies to help mitigate its production impacts. Gerasimchuk (2013) proposed the abstinence of national governments from further supporting the production of conventional (first generation) biofuels and to make it more flexible. The study further alluded to the removal of national policies in support of biofuel production and consumption that competes with food production for human consumption. (Maroun & La Rovere, 2014) highlighted several measures some of which includes using non-food products that may compete with second and third generation biofuels and, the increased use of feedstock that does not necessarily compete with food intended for human consumption. Strict biofuel sustainability schemes that set proper regulations and control on bioenergy production, which guarantees food security, must be put into law and stringently implemented (Bracco, 2015; German & Schoneveld, 2012; Mohr *et al.*, 2016; Ribeiro, 2013). Continuously supporting agricultural production, setting up proper infrastructure, improving management practices and using advanced technologies for food and feed stock production could also minimize the risk of food insecurity (Popp *et al.* 2014; Ellas 2014; Lynd *et al*. 2015; Souza, Henrique, and Cruz 2017; Kline *et al.* 2016)**.**Projected land demands for bioenergy fell well within conservative estimates of current and future land availability(Souza et al., 2017). Other proposed approaches for promoting an efficient biofuel production and food security sustainability includes promoting food price stability to encourage indigenous production(Souza *et al.*, 2017). The supposed link between biofuel production and rise in food prices and food security thus, presents an ethical and policy challenge to bioenergy producing countries (Renzaho, Kamara, & Toole, 2017).

3.2 Benefits and opportunities of biofuel

Multiple benefits have been credited to the use of biofuel as an alternative energy source. High on the list is the values its presents as a potential solution to the rising global environmental problems. Biofuel has been strongly advocated for, as a better replacement for fossil fuel in the fight for the reduction of greenhouse gas (GHG) emissions, healthier and sustainable environment, improved energy supply, access, diversification and security (Koizumi, 2015; Meyer *et al.*, 2014; Scarlat & Dallemand, 2011; Solomon, 2010)**.** Various socio-economic opportunities have been reported to be linked to biofuel production. National governments tend to derive economic benefits from large-scale production as tax payments increases with the growth and development of the biofuel industry boosting local, regional and national economies(Gerasimchuk *et al*., 2013; Demırbas, 2017). Operational expansion of biofuel plants and their increased expenditures could also, have positive impacts on other sectors of a national economy by stimulating more economic activities (Silalertruksa et al., 2012) and facilitating technology transfer (Gerasimchuk et al., 2013; Renzaho et al., 2017).

Employment opportunities multiply with a developing biofuel industry as its industrial activities employs labour from agricultural and processing sectors (Silalertruksa et al., 2012); increasing earnings (Hunsberger *et al.*, 2014). Opportunities in terms of employment are linked to cultivation and harvesting biofuel crops, handling, transportation, operations, manufacturing and maintaining plant equipment (Demırbas 2017). Biofuel also offers increased job prospects in agriculture as primary biofuel feed stocks are obtained from agricultural produce like maize, wheat and sugar cane which presents local farmers with increased production opportunities (Gerasimchuk *et al*., 2013; Selfa *et al*., 2011; Silalertruksa *et al*., 2012). According to Silalertruksa *et al.* (2012), about 350, 000 direct employments could be generated in South Africa if 15% of petrol usage could be replaced with ethanol from biodiesel. Solomon (2010) opined that biofuel could at least in theory, play a significant role in offering solutions to many national challenges if its production and use remains sustainable.
There is more to sustainability than simply substituting non-renewable with renewable energy sources (Schaffel & La Rovere, 2010). Considering that biofuel has been given credence to especially addressing critical issues effecting global climate change (Demırbas, 2017; Meyer *et al*., 2014; Scarlat & Dallemand, 2011; Solomon, 2010), its sustainability therefore, remains key to attaining the vision of ultimately phasing out use of fossil fuels for global energy supply. Sustaining biofuel production is an intricate process that requires dealing with many facets within and around its production and use as an alternative energy source. Recent research (Meyer, Meyerm & Priess, 2014; Ribeiro, 2013; Shane, Gheewala, Fungtammasan, Silalertruksa, Bonnet & Phiri, 2016) have established that economic, environmental and social components are crucial to the sustenance of biofuel production system. Souza, Henrique, & Cruz, (2017) expressed that sustainable biofuel production could be attained if issues pertaining industrial rivalries and overhead costs of bioenergy production could be dealt with in ways that not only considers absolute economic gains, but also environmental and social benefits.

Though the replacement of fossil fuel with biofuel has been essentially acclaimed particularly for its potential in abating rising environmental related problems, sustaining its production at a large scale however has raised a lot of environmental concerns. Many studies have pointed to the negative impacts of increased biofuel production on the ecosystem. For instance, there are notable fears regarding intensified deforestation, land amalgamation and concentration, use of agricultural and reserved lands and oddly, GHG emissions due to indirect land use change (Goetz *et al*., 2017; Hunsberger *et al*., 2014; Stattman & Mol, 2014). The most critical bioenergy sustainability issues are linked to some of its major production impacts (Scarlat & Dallemand, 2011). Some of these allude to loss of biodiversity, effects on water availability, soil and water quality, land tenure and rights, air pollutions, food availability, prices and security, and market opportunities (Acheampong *et al.*, 2017; Koizumi, 2015; Meyer *et al*., 2014; Mohr *et al*., 2016; Renzaho *et al*., 2017; Scarlat & Dallemand, 2011). According to (Renzaho *et al.*, 2017), extensive deforestation for biofuel production could lead to soil erosions, protracted drought, land use change and other deleterious conditions which in the long run affects food security. Goetz, German, Hunsberger & Schmidt, 2017speculates the possibility of producing bioenergy without having to compromise existing land uses and values, which is still essential to providing food, housing, fibre and infrastructure.

Solomon (2010) from review of relevant literature identified three key socio-economic components that affect the growth and sustainability of biofuel production as: small-scale financing, economic development and employment generation, and health and gender implications. This suggests that bioenergy production systems should create and maintain a positive influence on these socio-economic elements in order to remain sustainable. Ribeiro (2013) opinion is that the social aspect of biofuel sustainability assessment has long been relegated and that biofuel production cannot be achieved at the cost of rural welfare as they are more socially vulnerable to bioenergy production activities. Land grabbing by aggressive investors for instance, result in the displacement of resource poor land owners (Hunsberger *et al.*, 2014; Stattman & Mol, 2014). Other social elements considered in biofuel sustainability include equitable land ownership, existing competition between bioenergy crops and food crops, access to quality food and water, existence of good work conditions, capacity building, food prices and, smallholder farmer marginalization amongst others (Ribeiro, 2013; Selfa *et al.*, 2011; Stattman & Mol, 2014). According to Souza, Henrique, and Cruz (2017), a comprehensive understanding of social implications could indeed, aid biofuel production risk assessment.

Heated debates and criticisms over the resultant economic, environmental and social concerns of biofuel production and sustainability led to the conception, development and enactment of biofuels sustainability initiatives and certification systems as a response approach (Scarlat & Dallemand, 2011; Schaffel & La Rovere, 2010). The implementation of the set systems is aimed at curbing budding adverse impacts linked to biofuel production (Popp *et al.*, 2014) to allow for continuous development and expansion of bioenergy production and use. A number of organizations both private and public have discussed the criteria required for inclusion in the biofuel sustainability certification scheme and its compliance measures (Selfa *et al*., 2011). Attempts to produce and implement the biofuel sustainability criteria and certification systems began to yield results in 2008

(Solomon, 2010) and has continued to be implemented over the past years (De Man and German 2017). Certification systems oversee the application of standard sustainability practices (Mohr et al., 2016). It outlines specific environmental and social criteria governed by sustainability principles with the central objective of sustaining the ecosystem while using its resources to meet the demands of the current generation without having to short change the resource utilization capacity of future generations (Lynd & Woods, 2011).

Existing certification systems for biofuel sustainability have been drafted using economic, environmental and social sustainability criteria that must be satisfied to ensure biofuel development (Scarlat & Dallemand, 2011). The 'European Union Biofuels Sustainability Criteria' for instance, has directed that all biofuel markets in the EU must meet environmental and social standards and adhere to the set sustainability criteria in order access government aid (Bracco, 2015). The implementation of the EU biofuel sustainability criteria is therefore, critical to ensure that biofuel producers take into cognizance environmentally responsible production practices(German & Schoneveld, 2012). Other sustainability certification initiatives as identified in literatures (Hunsberger et al., 2014; Scarlat & Dallemand, 2011; Schaffel & La Rovere, 2010; Solomon, 2010) include: Roundtable on Sustainable Biofuels (RSB, renamed as Roundtable on Sustainable Biomaterials), Roundtable on Sustainable Palm Oil (RSPO), Better Sugarcane Initiative (BSI), Roundtable for Responsible Soy Production (RTRS), Sustainable Production of Biomass, International Sustainability and Carbon Certification (ISCC). The Food and Agriculture Organization (FAO) also came up with a 'Bioenergy and Food Security' initiative aimed at providing assistance to countries in creating and implementing sustainable bioenergy regulations that particularly, protect food security and rural development (Mohr *et al*., 2016).

The various sustainability initiatives address a wide range of economic, environmental, and social elements considered to be crucial in the sustainable production of biofuels. Examples are the economic benefits and social impacts of production to communities (Scarlat & Dallemand, 2011). Schaffel and La Rovere (2010) compiled a list of major environmental and social elements considered in the RSB and RSPO biofuel sustainability initiatives (Table 1).

Table 1: Major environmental and social components in the biofuel sustainability initiatives

Nature	Major Issues
Environmental	- Soil and Land Use: fertility, control of erosion and degradation, burning, monoculture. - Water Resources: availability and quality of surface and ground waters, water management. - Air: air quality, atmospheric pollution, atmospheric emissions. - Control of pests, diseases, invasive species, minimization of the use of chemical pesticides, use of fertilizers. - Biodiversity. - Pollution Control: waste management, use of co-products. - Energy Efficiency (Energy Balance). - Global Climate Change (GHG emissions).
Social	- Employment and income generation. - Keeping people on the rural areas. - Landowning structure. - Food security and competition for food. - Human Rights. - Labor Rights and working conditions. - Land Use Rights. - Child Labour. - Technical Assistance and Rural Extension, Training and Capacity Development. - Transparency. - Stakeholders Engagement.

Source: Adapted from Schaffel and La Rovere (2010)

The sustainable development of Biofuel production could indeed be achieved if the underlying economic, environmental, and social challenges of production can be effectively addressed across all sectors. For this to be occur, stakeholders must be resolute in practicing standard biofuel sustainability regulations as established by the various sustainability certification schemes.

3.3. Challenges of biofuel in Sub-Saharan Africa.

Despite the many benefits and prospects of the biofuel, several challenges have been identified as possible limiting factors to its use in SSA.

3.3.1. Land and food security

Available statistics across most SSA countries indicate that majority of the people are residents in the rural area where land is primarily used for agricultural purposes(Goh & Lee, 2010). The rural areas therefore are the main sources of food that is consumed in both rural and urban areas of the region, and hence they are very central to food security in most Sub-Saharan Africa countries. Therefore, the large expanse of land required to establish a biofuel plantation is being considered as a threat, not only to ownership and control of land resource, but also access to food by its citizens. The region has over 800 million people and about 233 million of these are currently undernourished(Alliance for Green Revolution in Africa (AGRA), 2014), while majority of the countries are net importers of food. The fact that bioethanol can be produced directly from edible feedstock, such as barley, sugarcane, sorghum, and cassava further establish the inverse relationship between biofuel production intensification and food security.

Although it can be argued that one of the reasons for food insecurity situation in SSA countries is the over-reliance on ruralsmall-scale farmers, as sources of food crops. The reality of the situation, however, suggests that majority of the countries in SSA do not have the resources to shift to commercial farming. Therefore, until there is a change in the current narratives of food-supply chain in the region, biofuel and land access and/or food security will be seen as two mutually exclusive variables. (Sekoai & Yoro, 2016) corroborate this by arguing that achieving poverty reduction and food security in sub-Sahara Africa requires that access to land on which the livelihood of most rural dwellers depend be given priority.

3.3.2. Technical and quality challenges

Another key challenge peculiar to the SSA countries is the lack of/or inadequate technical expertise. Large-scale batch processing biodiesel plants are technically complex systems although they are well established and turnkey installations are readily available. This could pose a challenge to deeply rural areas without the technical capacity to ensure the plant is run efficiently.

3.3.3. Poor economies of scale

Since majority of farmers in SSA countries operate on a subsistence scale, establishment of biofuel in the region is expected to be dominated by small scale farmers. The prevalent land tenure system in operation in many of these countries does not also favour ownership of large expanse of land. This therefore means that the capital and operational costs are greater for smaller plants, which can reduce total profits. A comparative study of 23 jatropha projects in Mali, Mozambique and Tanzania, showed that plantation and smallholder-based projects show limited economic viability (Romijn, Heijnen, Colthoff, De Jong & Van Eijck, 2014).

3.3.4. Fear of increase in unemployment rate

Presently, unemployment rate is highest in SSA, compared to other regions of the world. Available information indicates that majority of the job holders are either engaged directly or indirectly in farming. However, establishment of biofuel project is being seen as having the potential of reducing government and other stakeholders' attention on agriculture due to competition for resources such as land and machineries. Therefore, concerns are growing that the biofuel farms, if established has a lower potential for job creation (Bickel and Drosin in Von Maltitz and Stafford (2011) especially if mechanization is used. So even though jobs may bring greater benefits to the individual, a net consequence is that several households become poorer. This problem may be compounded, as poverty remains a consequence and expected to deepen due to a loss of livelihoods amongst communitiesdispossessed of their land used for farming prior biofuel farm project(ActionAid International, 2010). Von Maltitz and Setzkorn (2012) also argued that foreign labour is often preferred to local labour especially in areas with low number of human resources like SSA for both management positions. An example is the Sun Biofuel project in Tanzania, which promised to generate thousands of jobs and minimum wage for local villages. However, the project according to (Bergius, n.d.) eventually lacked financial viability and closed down in 2011 leaving hundreds of people unemployed. Other large-scale jatropha projects in Tanzania, Mozambique and Madagascar also either fully closed, have encountered financial difficulties or have been sold to new investors resulting in the eventual loss of jobs (Von Maltitz & Setzkorn, 2012). This can exacerbate the inequitable sharing of benefits and reduce livelihoods.

3.4Policy framework for biofuel industry development in Sub-Saharan Africa

In SSA, efforts to mitigate the effects of energy predicament have led to the proposition of biofuel as crucial component of energy supply. However, policy framework and guidelines to drive the biofuel project to success become paramount. In Sub Saharan Africa, the determination to mitigate the effects of the ongoing energy predicament, spurred countries to suggest that biofuels should form an integral part of the region's energy supply (Blanchard, Richardson, Farrell & Von Maltitz2011). For instance, the contribution of liquid biofuels to the national fuel supply is predicted to be at least 5% by 2021. During the hysteria period of biofuel in SSA, the country Malawi had the only effective biofuel market in SSA. Thereafter, some countries in SSA recognised the need to promote biofuel through many states supported programmes. Nevertheless, despite the abrupt interest in biofuel production in SSA, most countries in the region failed to put regulatory policies in place for biofuel development (Johnson and Silveira 2013). South Africa became the first country in SSA to reassess biofuel plan in 2007, and followed by Mozambique in 2009 (International Energy Agency (IEA) 2014), while countries such as Ethiopia, Tanzania and Zambia prepared incoherent biofuel policies (Locke & Henley, 2013). Later, the UN-Energy and FAO-UNEP took up the initiatives to prepare guidelines and decision indicators for planning biofuel policy but it was not explicit how much the various government in SSA imbibed the purported policy (FAO/UNEP)., 2011)

However, despite these initiatives, the socioeconomic and environmental impacts of biofuel production were rarely justified in the purported policy guidelines. Except for Mozambique, it was obvious that biofuel policies put in place in SSA lack sufficient provision for socio-economic and environmental impact assessment of biofuel growth and development. This phenomenon thereof, became evident during the drop in the production of jatropha as a biofuel crop in the SSA. It is on record that dozens of jatropha projects cultivated on thousands of hectares of land collapsed because of the lack of understanding of the environmental conditions and socioeconomic effects associated with the production of jatropha, leaving the local people involved in the production activities worse-off (Von Maltitz, Gasparatos, and Fabricius 2014). This suggest that there is inadequate consideration of both environmental and socio-economic issues that are associated with biofuel venture,couple with lack of policy instrument regulating biofuel sector.

Countries in SSA recently expanded the cultivation of biofuel crops such as the jatropha and sugar cane. SSA countries adopted and cultivated diverse biofuel crops to promote domestic use in the transport industry, with main policy goal geared towards the boosting of energy security and the support of rural development. It is imperative for African countries who have developed biofuels programme to strike a balance between crop investments and sustainable goals.However, political will and support for the preparation of regulatory policy tools for advancement of biofuel is paramount. The involvement of all stakeholders like the private sectors, civil societies may enhance the development for an ideal policy instrument which will foster growth in biofuel development in SSA.

Within the macroeconomic level, countries that are forward-thinking has revealed that decent policies exhibits common characteristics which include amongst others: policies that are consistent over time, civil society participation, defined niche for big and small investors and transparent governance (Von Maltitz, Gasparatos, and Fabricius 2014).Government in most SSA countries as part of their policy initiatives, developed incentivising strategies such as subsidized funds, tax credits and rebates to encourage biofuel development. Policies and framework on biofuels in SSA before now, centred on first group of marketable biofuels. This is so because of advancement of research, while the second-generation biofuel is on-going with barriers to overcome. From the rural domain, and at the micro-economic standpoint, biofuel policy must aim at contributing to the larger developmental goal without neglect to issues of social and food security.

3.4.1 The recent biofuel policy position in Sub-Saharan Africa.

The main policy movers for biofuel production in SSA are security of energy supply and reduced oil importation and mitigation of greenhouse gas. Besides, the biofuel sector offers glaring opportunities for investment and employment (Janssen & Rutz, 2012). Most SSA countries do not have policies in place to sell biofuel and this not only limited the use of biofuel but also discouraged production. The associated fall in oil prices in 1980s and 1990s further reduced the production of biofuels (Mitchell, 2011). However, several SSA countries are now developing regulatory framework with the intention of promoting sustainable biofuel sector (Janssen & Rutz, 2012). For instance, Benin republic promulgated decree 360/2008 and 361/2008 on biofuel production and conditions for siting biofuel companies in the region in 2008 (Cocchi, Grassi, Onobon & Grassi, 2009). In 2009, the government of Ghana issued a draft paper aimed to offer institutional and regulatory framework for

the promotion and development of renewable energy while in Kenyan, the ministry of energy drafted biofuel policy in 2008, and in 2009 the policy on bioethanol was ratified detailing Kenya's ability to produce enough ethanol fuel from molasses to complement or blend 10% ethanol in conventional gasoline. This policy supported the need and apparition to increase access to energy via sustainable production levels and to decrease importation of fossils by 25% in 2030 (Janssen & Rutz, 2012).

In similar vein, Mozambique embraced national biofuel policy strategy to increase biofuel production for local consumption and export in 2009. The policy aimed amongst other things to institute energy security and socio-economic development (Government of Mozambique 2009). In South Africa the regulatory framework that targeted 4% of renewable energy was launched in 2000. In a bid to encourage the growth of renewable energy sector, the National Energy Regulatory of South Africa (NERSA), instituted a tariff programme. However, in 2013 South Africa revised down the projected level of biofuel infiltration to 2% primarily due to food security concern (Republic of South Africa, 2007). The national biofuel task force whose mandate were to develop national biofuel policy was inaugurated by Tanzanian government in 2005. The task force put in place a suitable guidelines for the biofuel policy and was approved by the parliament (Maltsoglou and Khwaja 2010).

Angola government has ratified the proposed biofuel policy and biofuel strategy in 2010 while Malawi has adopted a comprehensive energy act from 2004 to date and have been blending ethanol with fossil fuel. Similarly, biofuel policy in Nigeria encompasses the renewable energy policy of 2003, master renewable energy plan of 2007 as well as the fuel-ethanol programme of Nigerian National Petroleum Corporation (Amigun *et al*., 2011). In SSA, there has been an increasing need for using biofuel for vehicles through blending with petroleum. Countries like Nigeria, Angola, Ethiopia, Kenya, South Africa and Sudan has been adopting the blending procedures with a ratio of 5:10% while Malawi has been blending ethanol with fossil fuel for more than a decade (Lane, 2012).

In SSA, biofuels are being established in a complex, dynamic, and varied context. Most biofuel policies in SSA remain declaratory rather than been precise and proactive and besides, most of the policies are waiting final ratification.Therefore, in assessing performance of biofuel policies, there is need for a single framework to allow for sustainable development based on the potential social, economic, and environmental controls. However, many of the policies in SSA are being suggested and developed by international commercial interest rather than national or regional need. This has led to many multiple and conflicting frameworks and policies. To date, only a few SSA countries have adopted and implemented effective policies for biofuels (Complete, 2009). Although, reminiscent from literature reviewed, it is apparent that some priority areas of interest which include: supporting biofuel policies with national imperatives and broader planned objectives; improving viable markets for biofuels; enhancing the knowledge of agronomic practices in biofuel feed stocks; allowing innovation and research in biofuel area; protecting land rights; and controlling of harmful environmental practices, need to be targeted to enhanced sustained production and use of biofuels in SSA.

3.5 Implication of biofuel for food security

Themultifaceted impacts and interconnected effects of biofuel include pollution, deforestation, habitat degradation, and loss of biodiversity potentials of the biofuel plant,(Dobaa *et al.,* 2015). The pollution potential of biofuel has to do with the danger the use of chemicals like fertilizer, pesticides and other synthetic crop improvement and protection measures often associated with biofuel plant, pose to the environment. Burley & Bebb, (2010) reported an example of such environmental problem in Gombe, Nigeria, in the production of sugar cane for ethanol. A relationship has also been established between energy crops and deforestation in tropical forests of the SSA. For example, there are processes for the removal of Congo Basin forests in Cameroon for the purpose of planting oil palm. These have been proven to have significant impacts on the environment, food security, biodiversity and human (Von Maltitz and Setzkorn 2012) in an interconnected pattern. Reports have also indicated that African wetlands are the most wetlands at risk of degradation, caused by many factors such as cultivation of both biofuel crops and food crops, thus affecting the productivity, functions and the amount of water and water quality. Many reports showed that many of the large tracts of wetlands in Tanzania, Uganda and Kenya are cultivated with sugarcane on a large scale to obtain biofuel. Specifically, up to 20,000 hectares of the territory of the Tana River Delta in Kenya was reported as being processed for the purpose of cultivation of sugar cane for ethanol production. Loss of ecosystem services and reduced resiliency as a result of biodiversity degradation (Von Maltitz 2010) have also been reported. In another reported, South Africa faces severe negative effects on biodiversity in the Cape region after millions of hectares have been allocated for the cultivation of corn for ethanol production(Sielhorst, Molenaar & Offermans, 2008). It can also be argued further that since the entire livelihood of the people depend primarily on the environment (for which biodiversity is key), intensification of biofuel projects poses a direct threat to the well-being of the people. The challenge

therefore becomes that of a trade-off between biofuel intensification, with its attendant environmental problems, and sustainable livelihood of the rural farming populace.

There have been several socioeconomic challenges for the adoption of biofuel in SSA. One of such relates to gender and ownership and control of land as a resource. In many SSA countries, men own land and are recognized as better farmers than female. The persistent gender differences associated with farming activities create a major challenge to agricultural growth and food security. The activities of women in farming are seldom documented and are merely reduced to unpaid family assistance (Agholor, 2019). Gasparatos *et al.* (2012) however observes that in cases of rented land, often, women do not get enough gains from cultivation of crops, while men folks account for most of the gains, because of gender inequality. This therefore has the tendency to further widen gender gaps which is already in most SSA countries. Other socioeconomic challenges range from displacement of local farmers to make way for cultivation of large tracts of lands with biofuel crops as experienced in Mozambique (Gasparatos *et al*., 2012;Odeny, Leonhard, Borras, & Rocha, 2010), land seizure, among others.

4. CONCLUSION

Sustaining biofuel production is aconvoluted process that requires dealing with many facets within and around its production and use. Considering that biofuel has been given credence to addressing critical issues affecting global climate change, its sustainability therefore, remains key to attaining the vision of ultimately phasing out the use of fossil fuels. The evaluation of arguments for and against the food versus fuel debate clearly emphasized that the cost of first-generation biofuels on food security is high and may impact food security. Expansion of biofuel production may, therefore, be executed at the expense of local, national, and global food security. However, it is also important for SSA policy makers to identify the local and national context within which the biofuel production revolve. In recognition of this circumstance, the paper concludes that the conflicting interest and balance therein will be settled with effective and planned biofuel policies to unlock the desired potential of biofuel sector in SSA.

5. RECOMMENDATION

The paper recommended a strict biofuel sustainability scheme that sets proper regulations and control on bioenergy production, which guarantees food security. The debate and hysterics on the potential risk of increased biofuel production affecting food security must be examined with caution as many factors interact to limit food shortages in SSA. The conflicting interest and the trade-offs that characterized biofuel development must be settled with effective and planned policies to unlock the desired potential for biofuel sector in SSA. Furthermore, in assessing performance of biofuel policies, there is a need for a single framework to allow for sustainable development based on the social, economic, and environmental controls for biofuel in SSA.

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