International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2022): 7.942

Socio-Economic and Environmental Impact of Biofuel Production in Western Kenya

Kiptoo, Daisy[1], Waswa, Sharon[2]

[1, 2]De Montfort University, Leicester United Kingdom

Abstract: ***Biofuel is a liquid or gaseous fuel sourced from biomass. They can be produced using the first generation which is from edible feedstock or the second generation from non-edible feedstock. Biofuels are a renewable source of energy, low-carbon promote rural development, and ensure energy security. They are essential in the transport sector (ethanol-gasoline blend) and substitute the use of fossil fuels. Biofuels can be used as cooking fuels, especially in developing countries, which reduces the reliance on firewood and charcoal. Climate change concerns and the availability of biofuel policies have been the key drivers of the deployment. Despite, its benefit, the increase in food prices in 2008 resulted in the debate on the food-biofuel nexus, questioning its sustainability. The study therefore sought to assess the socio-economic, as well as environmental impact of biofuel production in Western Kenya. The qualitative research design was adopted with both primary and secondary data collected. Data collection was through interviews, focus group discussions, case studies, and a review of secondary data. The results established that there was a link between food security and biofuel production. Other impacts coupled with bioethanol production were land use change, loss of biodiversity, loss of soil fertility, job creation, poverty, economic viability, and energy security. There is need for alternative sustainable farming methods that can incorporate cane farming and food crop farming to ensure food security, better farming practices to increase the cane yield, and research on consumer attitudes and behaviors towards biofuels to promote the adoption of the technology.***

Keywords: Renewable energy, Sugar cane production, food security, Land use change

1. Introduction

Biofuel production has gained significant attention as a potential solution to address energy security concerns and reduce greenhouse gas emissions.Renewable energy plays a key role in cutting down carbon emissions thus a mitigation measure to climate change. The government of Kenya considers the energy sector as a pillar to meet Vision 2030, which is a development blueprint that aims to improve the quality of life of its citizens in a clean and conducive environment, (Ministry of Energy and Petroleum, 2015). With this regard, the government is putting efforts to invest more in renewables to reduce carbon emissions by 30% by 2030 (Bounagui, 2015). The country is endowed with various renewable energy such as solar, wind, geothermal, hydro, and biofuels. There are two common types of biofuels in the country. These include bioethanol and biodiesel.

In Western Kenya, where agriculture is a key economic activity, the production of biofuels from agricultural feed-stocks presents an opportunity for rural development and energy diversification. Western Kenya is highly populated with an annual average growth ofabout 2.7% (Lindell and Kroon, 2010). This poses great pressure on natural resources. The increase in population also results in to increase in demand for food, energy, and water. Agriculture is the main economic activity in the region and since agriculture contributes to about 21% of the Gross Domestic Product, more emphasis has been on cash crop farming. The majority of residents cultivate sugarcane, which occupies 68% of the land. Only 32% is left for food crops (Masayi, 2012). Sugarcane is a feedstock for bioethanol and due to the government's urge to adopt biofuels in the country, there has been an emphasis to double the production of bioethanol to meet 10% ethanol-gasoline blend target (Afrinol, 2017).

The government through the Kenya Bureau of Standards (KEBS) authorized 10% ethanol-gasoline blend (Afrinol, 2015). To meet the target of 10% blend, there is need for national bioethanol production to double. The current gasoline consumption stands at 520.000 M^3 /year. With this regard, the government has emphasized the deployment of biofuel fuels and conducted more research on their feasibility and sustainability. Various sugar companies in the country are opting to adopt bioethanol production aside from only manufacturing sugar. Mumias Sugar Company, for instance, is leading across the country in sugar production and has established distillery ethanol plant that supports the production of about 22Million liters of ethanol yearly (Mumias Sugar Company, 2012).

Compared to bioethanol, the production of biodiesel is still in its early stages. Non-governmental organizations (NGOs) and private sectors are promoting the use of biodiesel in the country by cultivating Jatropha plants in arid and semi-arid regions (GTZ, 2008). The government has also shown interest in Jatropha farming by allocating 500,000 acres of land (Kiplagat, Wang, and Li, 2011). Jatropha curcas is suitable for biodiesel production and can be used as a substitute for crude oil-based diesel, especially in arid and semi-arid regions where about 80% of the land is suitable for its cultivation (Karekezi and Kimani, 2010). To reduce fossil fuel imports by 5%, the government has proposed a 3% blending of biodiesel (Kiplagat, Wang, and Li, 2011).

However, Jatropha farming has faced challenges due to a lack of sufficient market and low crop yields, which has slowed down the development process. Additionally, inadequate policy framework and limited technical capacity have hindered the adoption of biodiesel in this region (GTZ, 2008). To address these challenges, the government has established a national biofuel committee and formulated policies and strategies for bioethanol and biodiesel. The Energy Act of 2006 incorporates blending standards, and

KEBS plays a crucial role in determining fuel quality and standards (IEA, 2014). The National Energy Policy Seasonal Paper No.4 promotes the adoption of renewable energy technologies, including biofuels, and the Ministry of Energy and Petroleum has established the National Biofuels Committee (NBC) to coordinate activities and address issues in the biofuel sector (Diaby, 2011).

Despite the government's effort to adopt biofuels across the country, some challenges are impeding its full adoption. These include lack of a specific national biofuel policy framework that promotes sustainable development and use of biofuels, limited research, insufficient feedstock to increase production, over-reliance on rain-fed agriculture to grow energy crops, inadequate technology and technical expertise and some knowledge among stakeholders regarding the need and importance of biofuel deployment across the country. The other challenge is the threat of land use change because of competition between land for bioenergy crops and food crops, which could result in food insecurity (Ministry of Energy and Petroleum, 2015).

There are significant concerns worldwide regarding the sustainability of biofuels. These concerns encompass their economic, social, and environmental impacts, despite their crucial role in providing environmental resilience by reducing carbon emissions, promoting energy security, and fostering economic development. Biofuel production can negatively impact food security by increasing food prices and altering income distribution, posing a significant challenge for rural populations (FAO, 2010). This occurs due to competition for land between bioenergy crops and food crops, as well as competition for resources such as fertilizer, water, and labour to enhance yields. Moreover, since many biofuel feed-stocks are also food crops, the food supply chain is affected. Consequently, the rural poor are particularly vulnerable to these effects, as they are predominantly located in rural areas. Additionally, there is encroachment of forests to create more land for expanding bioenergy farming with the growing demand for biofuel. This leads to biodiversity loss, deforestation, and land degradation. For instance, large-scale sugarcane cultivation employs monocropping, resulting in soil fertility loss (Elbehri, Segerstedt, and Liu, 2013). Given the growing demand for biofuels amidst their associated side effects, this study aims to assess the socio-economic as well as environmental impacts of biofuel production in Western Kenya.

2. Materials and Methods

2.1 Study area

The study was conducted in Mumias district is found in Kakamega County in the western Kenya part of Kenya (Figure 1). The area is located at 0° 20' 11" North, 34° 29' 21" East of western Kenya (Figure 1), (Maplandia, 2016). The mean annual temperature in the region is about 21.6°C. The region has a single rainfall season with an average annual rainfall total of about 1743 mm per year (Climate Data, 2017). The Most suitable crops grown in the region include sugarcane, beans, and maize farming. The main economic activity in the region is agriculture. Sugar cane farming is the main cash crop and maize farming is the staple food done on small scale. Sugarcane farming occupies about 107,622ha of land which is 68%. The county has the largest sugar company that also produces biofuel (ethanol) namely Mumias Sugar Company. The company has 67,800 hectares of land with nucleus estates occupying 3,800 hectares and the farmers owning 64,000 hectares. The remaining 32% is for subsistence farming by small-scale farmers (Masayi, 2012).The area has a population of 116,358 according to the Kenya National Bureau of Standards (2009) census.

The choice of the area is because the region is known for sugarcane farming and is leading in bioethanol production. Due to concerns to opt for a low-carbon economy, the dynamics of sugar companies in the country have changed intensively to use sugar cane and molasses as a feedstock for bioethanol production. Mumias Sugar Company is situated in the region and has been a key leader in ethanol production (Mumias Sugar Company, 2012). As explained earlier in chapter one (1), as much as most people in the area engage in sugarcane farming, poverty is still a major issue. Based on the information gathered from the secondary sources, the region has had reported cases of food insecurity, land fragmentation, low crop yields, and land use change which provides a foundation for this research in terms of addressing the sustainability of biofuel production.

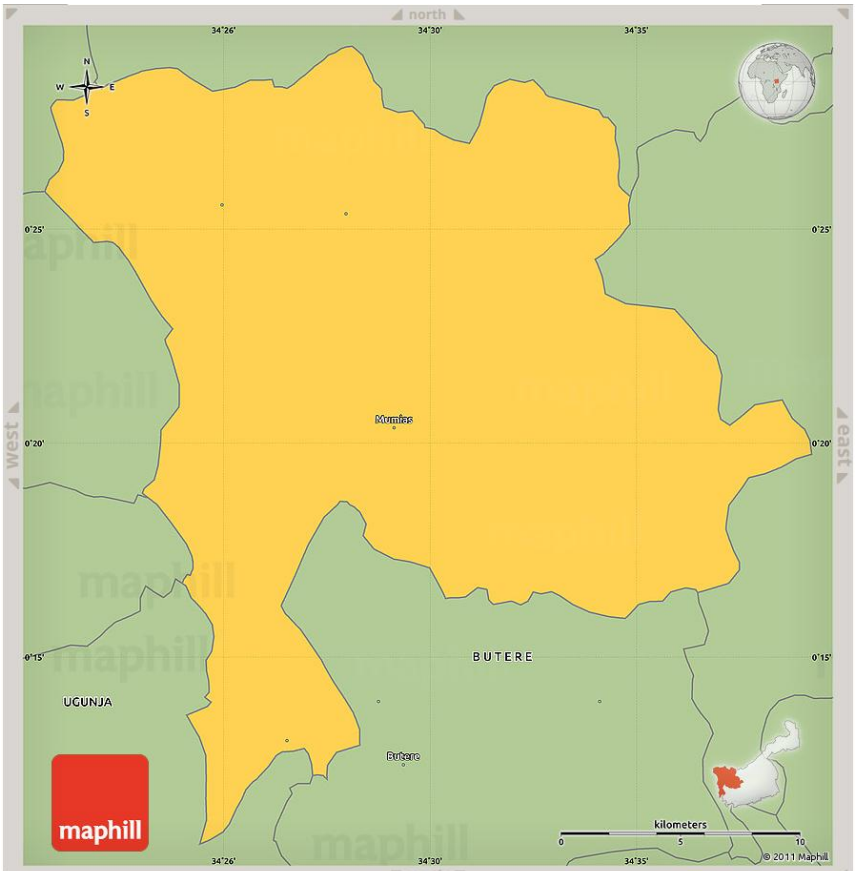

Figure 1: Map of the study area (Maphill, 2013)

2.2 Study design

A qualitative research design was used. Kothari (2004) defines research design as procedures or methods used to collect and analyze data to meet the research purpose. According to Creswell (2014), qualitative research involves the description of attributes or phenomena. This research, therefore, adopts a descriptive study by looking into the peoples' views on biofuels in terms of environmental and socioeconomic factors underlying biofuel production, the positive and negative impacts, and their opinion on mitigation measures to ensure espousal of the green energy. The explanatory study is also done by reviewing various case studies to explain the relationship between variables by studying the problem underpinning biofuel production (Saunders and Lewis, 2012). The key variables are the relationship between biofuel production, land use change, and food security.

The inductive research approach was used in this study. This entails the development of a thematic theory based on the results derived from the data collected. It adopts 'bottom up' to measure and observe different phenomena. This helps in the testing of hypotheses based on individual views (Saunders and Lewis, 2012). The approach in this research is incorporated during the interview to acquire information about people's understanding of biofuels, their essence, and impacts.

The research involves the use of case studies and interviews. A case study is a research strategy that investigates a particular topic of interest in the real-life context from various sources (Saunders and Lewis, 2012). The in-depth literature review is done on various research conducted on the impacts assessment of the sustainability of biofuel production from different parts of the world. Further, biofuel policies in Kenya are also reviewed. The information gathered provides the basis of the research. As a result, a tool for conducting the environmental, social, and economic impact assessment is developed after reviewing various impact assessment tools. The source of the information is derived from, books, reports, and academic papers.

The study adopts thematic theory. This is a research strategy where theory is developed from data generated from interviews or a series of observations (Saunders and Lewis, 2012). The thematic theory relies on the quality of data, which sometimes is subjected to biases from interviewees (Rowlands, 2005). Therefore, to address the challenge, the data collected from the interviewees are coded and categorized to point out important comments from participants.

2.3 Data collection

Primary and secondary data sources were used. The primary involves conducting interviews whereas secondary data is generated from various case studies, academic materials, and reports from relevant organizations that focus on biofuel production. The key part of this study is desk research-based.

2.3.1 Secondary data

Data about sugar cane crop type, land coverage, amount of bioethanol produced, the number of farmers growing sugar cane, and the number of jobs created are gathered from

Mumias Sugar Company. In addition, information about food security in the region is acquired from FAO reports and the organization database. The choice of relying on secondary sources to acquire data was because the method is flexible and reliable in giving tangible results.

2.3.2 Primary data

For secondary data, the interview schedule was administered to eight respondents (Table 1). The respondents includeda bioethanol practitioner from Mumias Sugar Company to get data regarding bioethanol, a local sugarcane farmer to provide a general understanding of the benefits and challenges they encounter, an ordinary Kenyan citizen to help provide general information about their understanding of biofuels to triangulate information gathered from interviews and secondary data. Additionally, three masters of Energy students from various universities in Kenya were interviewed to gain better understanding of biofuel from a developing country perspective. Further, a representative from the Ministry of Agriculture (MoA) and FAO to try to understand the agricultural status of the area and the aspect of food security.

Table 1: Interview Respondents List

Respondent	Position	Role
A	Bioethanol practitioner (Mumias Company)	Source data about the amount of bioethanol produced, demand for bioethanol, land utilized for sugarcane farming, number of jobs created, number of farmers growing sugarcane, and challenges faced in the deployment of ethanol
B	Representative Ministry of Agriculture (KakamegaCounty)	The situation of availability of Food in the region and agricultural status
C	Food Agriculture Organisation Staff	The situation of availability of Food in the region and agricultural status
D	Mumias sugarcane farmer	Sugarcane farming in the Mumias area
E	Environmental Studies (Community development) student	Perception of Biofuel in Kenya
F	MSc. Student (India)	Perception of Biofuel in India
G	MSc. Student(Ghana)	Perception of Biofuel in Ghana
H	MSc. Student(Nigeria)	Perception of Biofuel in Africa

2.3.3 Case study

A case study is done in western Kenya on the impact assessment of the sustainable production of biofuels. Based on the review of impact assessment tools in chapter three, the study adopts some of the Global Bioenergy Partnership sustainability indicators for the environmental, social, and economic impact to evaluate the themes of each dimension. Life cycle assessment could be appropriate to assess the sugarcane-ethanol production from cradle to grave, however, the tool was not selected since it is costly, and the period of the research would not allow the completion of LCA.

2.4 Data Management and Analysis

A systematic approach is used to increase the accuracy of the data collected. This involves data categorizing, immersion, processing, searching for patterns, and analysis. Inductive data analysis is done to group raw data into specific themes (Simon, 2011). Relevant information needed for the research is generated.Statistical analysis is also done to explore the contours of the data collected from the interviews and secondary sources. Data is then fed into Microsoft Excel to generate visual data displays that helped in the interpretation. This is in the form of graphs, tables, and charts presenting themes and their connectors.

2.5 Ethical consideration

Research ethics is vital to ensure the quality and integrity of the research. The interviewees were assured of their confidentiality including their personal information. The interviewer asked for consent from the interviewee before doing the interview. The responders were also informed about the purpose of the research which is for academic purposes. Their role in the research was also clarified. This enabled them to provide valid information and participate voluntarily without any suspicions. This also reduced instances of biases and ensured successful data collection.

3. Results and Discussion

3.1 Impacts of Biofuels

Interviewees were asked about the positive and negative impact of biofuel production and as a result, some themes aroused throughout the conversation.

3.2 Competition with food

A representative from FAO emphasized the fact that the food prices in the country are generally high and are caused by factors such as natural calamities such as drought, over-dependence on rain-fed agriculture, and poor farming practices. Additionally, a respondent from the Ministry of Agriculture highlighted the fact that the region is highly populated, and the land is limited since most farmers opt for sugarcane farming. Mumias company also stated that food insecurity has been a challenge in the region, and they have tried establishing a mechanism to educate farmers on better farming practices.

“The government of Kenya decided to shift from the first generation (edible feedstock) to the third generation (nonedible feedstock). This is because the country imports food and the use of edible feedstock did not meet the demand at the same time they competed with food. The government opted for the third generation to address this issue. The feedstock selected was algae” Respondent F.

In addition, “The use of edible feedstock such as sorghum, cassava has compromised the availability of food” Respondent E.

From the findings, bioenergy crops compete with food crops thereby raising concerns about food insecurity.

3.3 Biodiversity Loss

A respondent from the Ministry of Agriculture pointed out how most people encroach on forests to create more land for farming. With a particular focus on the region, there have been reported cases of deforestation. However, Mumias Company is participating in forest conservation in collaboration with other environmental organizations.

3.4 Loss of soil fertility

Ministry of Agriculture, FAO, Mumias Company highlighted the fact that sugarcane farming in the area is done through mono-cropping farming practice, which has led to low yields. This was supported by the sugarcane farmer who said, "The yield has been declining for the past years now and I think one of the reasons is growing the same crop instead of doing mixed farming to ensure nitrogen fixation"

3.5 Land use change

An interview with the Mumias company indicated that one of the major challenges that have led to a decline in the feedstock for bioethanol is the decline in the cane yield and land subdivision. In addition, most farmers diverted from food crops to sugarcane farming. A sugarcane farmer who explained supported this, "I decided to increase my portion of land under sugarcane to get more income so that I can pay my kids for their education and ensure there is food at my house"

3.6 Job creation

Responses from the Ministry of Agriculture and Mumias Company elaborated how sugarcane farming has created jobs and has been a source of livelihood for many. This was evident in the farmer who relies on that for income. The ethanol sector in the company led to recruiting more staff. However, the farmer complained about the payment saying sometimes the income delays affect their budgets. The company pointed out that there has been a decline in several farmers growing sugarcane.

3.7 Gender mainstreaming

The feedback from FAO pointed out the aspect of gender roles in the region and its contribution to food insecurity. "Sugarcane farming has resulted in less focus on food cropping and most women choose to work in sugarcane farms as labours, rather than focus on their gender roles of ensuring there is enough supply of food in the household."

3.8 Energy security

The feedback from Mumias Company indicated that the market for ethanol production is vibrant and the ethanol blend mandate whose implementation is still at the infant stage is the driving force. In addition, respondent C added, "Biofuels can substitute the use fossil fuels, firewood, and improves air quality through reducing effects of greenhouse gas emissions. There is a clean ethanol stove project in Nyanza Kenya, though this is still in the piloting stage."

3.9 Impact Assessment of Bioethanol Production in Mumias

The assessment of bioethanol in western Kenya adopted the Global Bioenergy Partnership sustainability indicators. Integration of secondary sources, case studies, and interviews resulted in the selection of themes, which were measured using the indicators.

Table 2: Summary of Themes and Indicators for Impact Assessment of Bioethanol Production in Western Kenya

Sustainability pillars	Themes	Indicators
Environmental	Land use/land use change	Amount of land used for sugarcane farming
	Water availability	Type of sugarcane farming (rain-fed/ irrigation)
	Biodiversity loss	Amount of area covered by forest
	Soil quality	Type of soil in the area and type of farming practiced (mono-cropping/intercropping?)
Social	Food security	Amount of land for food crop Income generated to offset the debate of food and biofuel nexus
	Employment	Access to labour Number of people employed by Mumias sugar company Number of farmers growing sugarcane
	Poverty	Income generated from sugarcane farming Ranking of the county in terms of poverty at the national level
	Energy security	Primary energy by type Rate of consumption of petroleum in the transport sector
	Access to technology/ infrastructure	Availability of technology/infrastructure for effective production of bioethanol
	Economic viability	Demand for bioethanol in the market Amount of bioethanol produced in Mumias
Institutional	Biofuel policies	Availability of biofuel policies

3.10 Environmental Impacts of Bioethanol Production

3.10.1 Land Use and Land use change

According to Mayasi and Netondo (2014), 68% of the land is under commercial sugarcane farming while 32% is for subsistence farming and other land uses. However, there has been a gradual change of land under sugarcane for the last 34 years and some driving factors have been population growth, settlement, and expansion of towns (Mbayakiet al, 2016). The cultivation of sugarcane on a large scale is diminishing. This is evident by the study which indicated that 76.7% have sugarcane farms of less than three (3) acres and 65% are subdivided into small portions (Were, 2013). Land fragmentation is attributed to cultural factors such as inheritance where land is subdivided between sons; land leasing and population pressure (Waswa et al., 2010). Additionally, an interview with Mumias Company showed that land subdivision has been a major challenge facing cane development, which in turn affects bioethanol production whereby most farmers currently, have a mean of 0.7 acres of land.

According to research done by Were Kweyu (2013), on factors influencing the withdrawal of farmers from sugarcane farming in Mumias western Kenya, it was established that most farmers grow sugarcane on small scale and they need strict supervision from the company staff in order to deliver quality cane to the factory. It has not only, affected the overall yield of the sugarcane, but also contributed to less production of ethanol due to insufficient feedstock.

This is among the reasons why the company has opted to import molasses from neighboring countries to meet the needed demand. According to Business Daily, (2016),Mumias Sugar Company has been importing molasses from Uganda and Tanzania for the past 8 months due to sugarcane shortage. This continues to slow down ethanol production making the ethanol plant produce a capacity of 120,000 liters a day. The ethanol plant requires 300 metric tonnes of molasses daily to operate optimally.

Discussions with Mumias Company revealed that there is lack of implementation of land development policies to determine the extent to which land is converted for other purposes(Mbayaki et al., 2016). Therefore, land use change has led to slow growth of the bioethanol sector due to inadequate feedstock.

3.10.2 Water Availability

Sugarcane is a water-intensive and thirstiest crop thereby having, significant impact on the environment (WWF, 2017). In the western part of Kenya; sugarcane farming depends on the rainfall. Due to fluctuations in weather patterns because of climate change, the country experiences natural calamities such as drought and floods, which affect the overall yield thus affecting the amount of bioethanol produced. The reliance on rain-fed agriculture has been a challenge facing the sector hence not sustainable. For instance, according to Mumias Sugar Company, (2012), the dry spells experienced in 2009 and excessive rainfall in 2011 led to the decline in the overall yields and poor cane quality hence, a decline in production.

3.10.3 Biodiversity loss

Looking into the ecological trend of the region, there has been a tremendous decline in agro-biodiversity (Waswa et al., 2010). According to Waswa and Netondo, (2014), the allocation of land for commercial farming such as sugarcane and other cash crops poses a threat to the country's forest cover, which stands at 2.2% against the required coverage of 10%. Encroachment of Kakamega forest, which is one of the natural forests in the study area to create more land for expansion of sugarcane and settlement, has been a major concern. The amount and quality of biodiversity is a key determinant of ecosystem service, therefore, integration and increase of agrobiodiversity and forest cover within monoculture production of sugarcane are vital to conserve and restore the biodiversity.

3.10.4 Soil Fertility

According to Waswa et al. (2010), before the introduction of commercial sugarcane farming, the farming practice for indigenous food crops employed traditional practices such as intercropping, fallow cropping, and relay cropping. These are environmentally friendly and helps improves soil quality. However, sugarcane farming in the region employs monoculture practice, which has not only resulted in the loss of soil fertility but also contributed to agrobiodiversity erosion.

3.11 Social Impacts of Bioethanol Production

3.11.1 Food security

“Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life”. (FAO, 1996). Food security is characterized by food availability, access, utilization, and stability.

As elaborated by Were Kweyu (2013), food insecurity is caused by climate change, population growth, oil price shift, and urbanization. A case study of one of the most populated countries in Africa, Nigeria was provided where corruption and oil exploration resulted in the weakening of the agricultural sector, thus, reported cases of hunger in the region. Further, Mohajan, (2014) expounds on other causes of food insecurity as, ‘unavailability of food, insufficient purchasing power, inappropriate distribution, or inadequate use of food at the household level.’ In Kenya for instance, food insecurity is caused by drought, low income, and purchasing power due to poverty, inadequate market and technology, and dependence on rain-fed agriculture. There has been a tremendous increase in food prices across the country, Mumias not being an exception (Daily Nation, 2017).

The aspect of food insecurity in the Mumias district has been a major concern because of the expansion of land to cultivate sugarcane. As indicated by Dindi (2013), about 24.5% of the farmers in Mumias have between 1 and 2 acres of land under food crops. The rest have less than an acre for food crops. More farmers have dedicated their land to sugarcane farming. The aspect of contracted sugarcane farming encouraged by the sugar company has made it

difficult for farmers to prioritize food crop farming at a wider range. The research findings depicted that the food produced was not enough to cater to most families hence they had to work as farm labourers, lease sugarcane, and sell fertilizer to get some income for purchasing food.

In addition, under the gender roles in the area, women are responsible to ensure there is an availability of food in their household whereas men are to engage in sugarcane cane farming for economic purposes. However, the scenario is different whereby most women in the region instead are involved in the cultivation of sugarcane on small scale as labourers with little attention on food crop farming (Were Kweyu, 2013).

Further, Waswa et al. (2010) did a study on how Agrobiodiversity is endangered by sugarcane farming in the Mumias district of Western Kenya. It was established that food crops such as cassava, sweet potatoes, sorghum, and finger millet were abundant in the area before the introduction of sugarcane. This has declined over time when farmers abandoned indigenous food crops and vegetables to opt for sugarcane farming. This has led to low food yields that do not cater to the growing population in the region.

Despite the direct and indirect employment created during sugarcane and bioethanol production, the income generated is not able to meet the basic need and this affects the social well-being of the community. Therefore, the cultivation of sugarcane in the region is unsustainable affecting the overall product. These factors have been attributed to the slow deployment of biofuel technology in the region.

3.11.2 Employment

The production of sugarcane and ethanol is an important source of employment for the locals. Two forms of employment include direct employment generated by the company for sugarcane and ethanol production, and indirect employment that provides deliveries to the company (Smeets et al., 2008). Contract sugarcane farming has boosted job creation in the region especially unskilled wage labour, however, due to low and unreliable wages, the labourers are unable to cater to their families. This has contributed to some farmers withdrawing from sugarcane farming (Were Kweyu, 2013). This is illustrated in Tables3 and 4.

Table 3: Direct Employment

Year	Number of employees
2010	1,523
2011	1,804
2012	1,896
2013	1,932
2014	1,689

Source: Mumias Company

Table 4: Number of Sugarcane (Farmers' Indirect employment)

Year	Number of employees
2012	147,000
2013	103,950
2014	101,688
2015	96,234

Source: Mumias Company

3.11.3 Poverty

Mumias district has a higher poverty class and higher risk regarding food availability and malnutrition (Mbayaki, Mubea, and Mundia, 2016). Sugarcane takes between 12 to 24 months to mature making farmers not enjoy the benefits. According to (Were, 2013), the situation is even worsened by delayed cane payment, which has resulted in continuous poverty rates in the region. Most of the farmers wait for more than a month to receive their payment. Additionally, about 90.2% of the farmers complain about the low price per tonne.

Further, as indicated by Waswa and Netondo, (2014), Mumias sugar company is among the most successful milling company across the country yet it is ranked second poorest when it comes to payment of farmers. This has resulted in continued financial poverty of farmers depriving them of meeting their basic needs. The little income generated is directed into repayment of debts hence most smallholder farmers continue being trapped in a vicious cycle of poverty. This has discouraged farmers to opt for sugarcane farming, therefore, leading to the supply of inadequate feedstock for ethanol production.

3.12 Economic Impacts of Bioethanol Production

3.12.1 Economic viability

The indicator used to measure economic viability was the demand for bioethanol in the market through the review of the various literature. It was established that the rising cost of fossil fuel in the international market has driven policymakers to implement the bioethanol blend program. Sugar millers across the country have supported the move since this could help reduce the country's cost of imports of petroleum products. This has made bioethanol fetch demand in the market. With the particular focus on Mumias Sugar Company, the limited supply of crude oil and concerns about environmental degradation were the drivers behind the initiation of the ethanol distillery plant (Mumias, 2012).

The company started with the production of 100,000 liters of ethanol during the commencement of the project in 2012 and there has been an increment in that, by 2016 it produced 12.4million liters. This is shown in Figure 2.

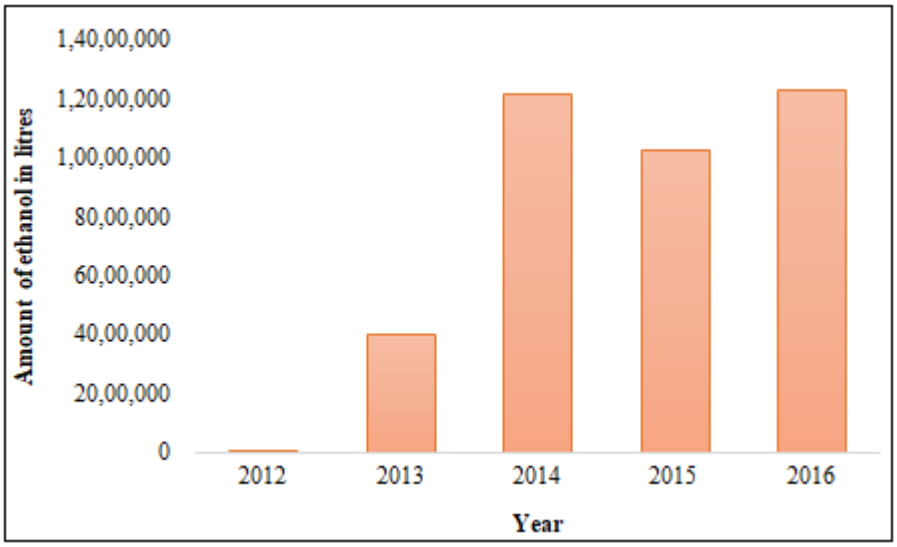

Figure 2: Annual Ethanol Production (Litres) by Mumias Company (Data sourced from Mumias Company)

From the interview with Mumias Company, the decline in ethanol produced in 2015 as shown in Figure 5.2 was attributed to inadequate feedstock thus forcing the company to import molasses from the neighbouring country. This is the main challenge preventing the company from meeting the target capacity of 22million liters annually. However, the market opportunity for bioethanol is large in terms of demand and profitability. This is due to the availability of ethanol blend (E10) authorized by the Kenya Bureau of Standards. The current gasoline consumption is about 520.000 M3 /year which does not meet the demand. To comply with the E10 mandate, ethanol production is required to double.

Bioethanol provides a viable option in the market to substitute the use of firewood and charcoal. According to Afrinol (2015), the use of firewood accounts for about 80%, kerosene 15%, and Liquefied Petroleum Gas (LPG) 5%. Additionally, 18 million M3 of wood is needed annually to provide 2.8 million tons of charcoal, and this results in the deforestation of 550.000 ha each year in Kenya. Therefore, because of the wood fuel shortage, the situation worsens. This has driven the country to opt for clean burning ethanol stoves to replace charcoal use. Therefore, looking into the market demand for ethanol, it is clear that ethanol plays a key role in the transport sector (ethanol-gasoline blend) and is economically viable as a clean cooking fuel.

3.12.2 Energy security

With a particular focus on the essence of bioethanol in the transport sector through the ethanol-gasoline blend program, the indicator used to access the current energy situation in the country was; primary energy by type and rate of consumption of petroleum in the transport sector. The choice was to highlight the economic viability of bioethanol in the market and its essence in ensuring energy access.

The primary source of energy in Kenya is biomass, which is about 68 percent, petroleum 22 percent, and electricity 9 percent, solar, wind, biofuels, and other renewable energy sources account for the remaining 1% (KIPPRA, 2010). From Figure 3, it is clear that biofuel contribution to the energy mix is still insignificant.

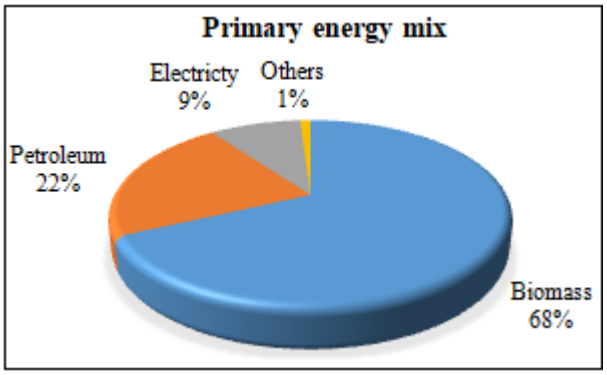

Figure 3: Primary Energy Mix (Adopted from (KIPPRA, 2010))

The transport sector, which comprises land, water, and air transport, is the largest consumer of petroleum products and accounts for about 70 percent of the total net domestic sales of petroleum (KIPPRA, 2010). The petroleum products are motor spirit premium, automotive gas oil, kerosene, LPG, diesel oil, and motor spirit regular (Figure 4). There has been an increase in demand over the years, for instance, the total demand for petroleum products in 2014 was 3,939.5 thousand tonnes which increased compared to 3,745.4 thousand tonnes in 2013.In the same year, LPG 61.1. % and motor gasoline increased by 11.6%.Additionally, diesel oil accounted for about 43.7% of total domestic demand (ERC, 2015).

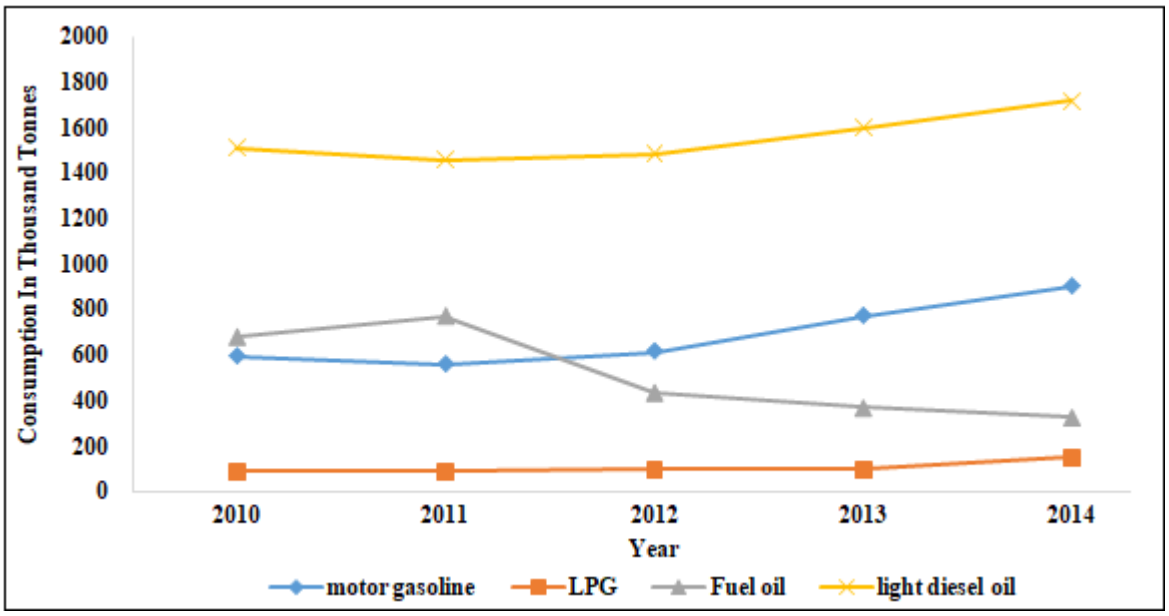

Figure 4: Annual Petroleum Products' Consumption (Data adapted from Energy Regulatory Commission, 2015)

From the figure above, there has been an increase in demand for petroleum products. This provides an opportunity for the implementation of a gasoline-ethanol blend program to address the environmental concerns associated with carbon emissions from fossil fuels.

3.12.3 Access to Infrastructure/Technology

In terms of infrastructure development in the region, most of the roads are inaccessible, and unreliable, especially in the rural areas resulting to delay in cane delivery to the factory (Kakamega County Government, 2015). According to Mumias Sugar Company, poor transport infrastructure has been a challenge that has affected the cane production in the area.

Advanced technology plays a key role in improving agricultural yield and ensuring efficient production of bioethanol. The company has an ethanol distillery plant, however, inadequate technology in the agricultural sector to boost yields has resulted in insufficient feedstock thus forcing Mumias Company to import molasses leading to declining in the net income and rate of profitability from ethanol production, (Business Daily, 2016)

4. Conclusion

An assessment of the sustainable production of biofuels was done in Mumias, Western Kenya to understand the environmental, social, and economic impact of bioethanol production. The findings demonstrated that biofuel plays a key role in reducing carbon emissions, ensuring energy security, and promoting rural development. Climate change concerns and the establishment of biofuel policies have been the driving force for its deployment. There has been a tremendous increase, in biofuel growth over the yearsin 2015. In addition, aside from the benefits generated by biofuel production, such as employment creation, and generation of revenue just to name a few, the development of biofuel is coupled with sustainability concerns. From this research, the increase in food prices in 2008, triggered the debate on the nexus between food and biofuel production raising concerns about its sustainability. Focusing on the environmental impact, land use, and land use change was the major impact. Conversion of land from food crop to cash crop in this case sugarcane resulted in the loss of agrobiodiversity and food insecurity. In addition, the increase in population in the region led to land fragmentation, which caused a decline in cane production thus resulting in inadequate feedstock for bioethanol production.The debate between biofuel fuel and food production is supported by the fact that food insecurity is a major issue in the area. Despite the job created by the industry, it was identified that the income generated is not enough to offset food insecurity in the region. Therefore, there is a need for a more focused and joint effort that will encourage investment, and promote bioethanol sustainability and economic development.Furthermore, there is need for alternative sustainable farming methods that can incorporate cane farming and food crop farming to ensure food security, better farming practices to increase the cane yield, and research on consumer attitudes and behaviours towards biofuels to promote the adoption of the technology.

References

[1] AETS, (2013). Assessing the impact of biofuel production on developing countries from the point of view of Policy Coherence for Development. [Online] Available at https://ec.europa.eu/europeaid/sites/devco/files/study-impact-assesment-biofuels-production-on-development-pcd-201302_en_2.pdf.

[2] Afrinol. (2015). The Kenyan Market. [Online] Available at http://afrinol.com/ethanol-market-in-kenya/ [Accessed 7 Jun. 2017].

[3] Alshuwaikhat, H. (2005). Strategic environmental assessment can help solve environmental impact assessment failures in developing countries. *Environmental Impact Assessment Review*, 25(4), pp.307-317.

[4] Amigun, B., Musango, J. and Stafford, W. (2011). Biofuels and sustainability in Africa. Renewable and Sustainable Energy Reviews, 15(2), pp.1360-1372.
[5] Araújo, K., Mahajan, D., Kerr, R. and Silva, M. (2017). Global Biofuels at the Crossroads: An Overview of Technical, Policy, and Investment Complexities in the Sustainability of Biofuel Development. *Agriculture*, 7(4), p.32.
[6] Biodiesel Magazine. (2016). Biodiesel Magazine - The Latest News and Data About Biodiesel Production. [Online] Available at http://biodieselmagazine.com/articles/731989/us-biodiesel-consumption-hits-nearly-2-1-billion-gallons-in-2015 [Accessed 30 Jun. 2017].
[7] Bounagui, R. (2015). Kenya pledges to cut carbon emissions 30% by 2030. [Online] The Guardian. Available at: https://www.theguardian.com/environment/2015/jul/24/kenya-pledges-to-cut-carbon-emissions-30-by-2030.
[8] Business Daily. (2016). Mumias Sugar steps up regional molasses imports. [Online] Available at: http://www.businessdailyafrica.com/corporate/Mumias-Sugar-steps-up-regional-molasses-imports-/539550-3466834-x24jsi/index.html [Accessed 4 Aug. 2017].
[9] C2ES. (2017). Biofuels Overview | Center for Climate and Energy Solutions (C2ES). [Online] Available at https://www.c2es.org/technology/overview/biofuels [Accessed Jun. 2017].
[10] Climate Data. (2017). Climate Mumias: Temperature, Climate graph, Climate table for Mumias - Climate-Data.org. [Online] Available at: https://en.climate-data.org/location/11130/ [Accessed 12 Jun. 2017].
[11] Cotula, L., Dyer, N. and Vermeulen, S. (2008). *Fuelling Exclusion? The Biofuels Boom and Poor People's Access to Land*. London: International Institute for Environment and Development.
[12] Creswell, J. (2014) Research design: qualitative, quantitative, and mixed methods approach.4th ed. London: SAGE.
[13] Daily Nation. (2014). Kakamega is the poorest county. [Online] Available at http://www.nation.co.ke/counties/Kakamega-Poverty-Devolution-Ministry-Report/1107872-2517956-30hd8t/index.html [Accessed 7 Jun. 2017].
[14] Daily Nation. (2017). Food prices rise across Kenya - VIDEO. [Online] Available at: http://www.nation.co.ke/news/food-prices-rise-across-kenya/1056-3920610-1067j0tz/index.html [Accessed 8 Aug. 2017].
[15] Deenanath, E., Iyuke, S. and Rumbold, K. (2012). The Bioethanol Industry in Sub-Saharan Africa: History, Challenges, and Prospects. Journal of Biomedicine and Biotechnology, 2012, pp.1-11.
[16] Delucchi, M. (2006). *Lifecycle Analyses of Biofuels*. Califonia: Institute of Transportation Studies the University of California.
[17] Diaby, S. (2011). *Kenya's Draft National Biofuel Policy*. [Online] Available at: https://gain.fas.usda.gov/Recent%20GAIN%20Publications/Kenya%E2%80%99s%20Draft%20National%20Biofuel%20Policy_Nairobi_Kenya_3-30-2011.pdf [Accessed 13 Jun. 2017].
[18] Dindi, E. (2013). The Managerial Factors Influencing Sugarcane Production by Farmers of Mayoni Division, Mumias Sugar Company in Kenya. Masters. Kenyatta University, Kenya.
[19] Eepafrica. (2015). Kenya – EEP Africa. [Online] Available at: http://eepafrica.org/projects/kenya/[Accessed 15 Aug. 2017].
[20] Efroymson, R., Dale, V., Kline, K., McBride, A., Bielicki, J., Smith, R., Parish, E., Schweizer, P. and Shaw, D. (2012). Environmental Indicators of Biofuel Sustainability: What about Context? *Environmental Management*, 51(2), pp.291-306
[21] Elbehri, A., Segerstedt, A. and Liu, P. (2013). *Biofuel and the Sustainability Challenge*. A global assessment of sustainability issues, trends, and policies for biofuels and related feedstock. Rome: Food and Agriculture Organization of the United Nations (FAO).
[22] Elghali, L., Clift, R., Sinclair, P., Panoutsou, C. and Bauen, A. (2007). Developing a sustainability framework for the assessment of bioenergy systems. *Energy Policy*, 35(12), pp.6075-6083.
[23] ERC (2015). Energy Regulatory Commission 2014-2015 Annual Report.
[24] European Commission. (2015). *TOOL #58: Life Cycle Analysis - European Commission*. [Online] Available at: http://ec.europa.eu/smart-regulation/guidelines/tool_58_en.htm [Accessed 8 Jul. 2017].
[25] European Commission. (2017). Biofuels - Energy - European Commission. [Online] Available at: https://ec.europa.eu/energy/en/topics/renewable-energy/biofuels [Accessed 9 Jun. 2017].
[26] FAO (1996). Rome Declaration on Food Security and World Food Summit Plan of Action. Rome.
[27] FAO (2008). The State of Food and Agriculture. Biofuels: prospects, risks, and opportunities. Rome: Food and Agriculture Organization of the United Nations (FAO).
[28] FAO (2010). *Bioenergy Environmental Impact Analysis (BIAS): Analytical Framework*. Rome: Food and Agriculture Organization of the United Nations.
[29] FAO, (2010). The Bioenergy and Food Security Project: The BEFS Analysis for Tanzania. [Online] Rome, Italy: FAO. Available at: http://www.fao.org/docrep/012/i1544e/i1544e.pdf.
[30] Flach, B., Bendz, K., Krautgartner, R. and Lieberz, S. (2013). EU Biofuels Annual 2013.
[31] Flach, B., Lieberz, S., Rondon, M., Williams, B. and Wilson, C. (2016). EU Biofuels 2016 Annual Report.
[32] GBEP (2011). *The Global Bioenergy Partnership Sustainability Indicators for Bioenergy*. [Online] Rome: FAO. Available at: http://www.globalbioenergy.org/fileadmin/user_upload/gbep/docs/Indicators/The_GBEP_Sustainability_Indicators_for_Bioenergy_FINAL.pdf [Accessed 9 Jul. 2017]
[33] GTZ (2008). A Roadmap for Biofuels in Kenya Opportunities and Obstacles. Commissioned by Germany Technical Corporation and Kenya Ministry of Agriculture. Eschborn, German: GTZ.
[34] HLPE (2013). *Biofuel and Food Security*. A report by the High-Level Panel of Experts on Food Security and

Nutrition of the Committee on World Food Security. Rome.
[35] IEA (2010). Sustainable Production of Second-Generation Biofuels Potential and Perspectives in major economies and developing countries. [Online] Paris, France: International Energy Agency. Available at:https://www.iea.org/publications/freepublications/publication/second_generation_biofuels.pdf [Accessed 9 Jun. 2017].
[36] IEA (2012). Biofuels Issues and Trends. [Online] U.S. Department of Energy, Washington, DC. Available at: https://www.eia.gov/biofuels/issuestrends/pdf/bit.pdf [Accessed Jun. 2017].
[37] IEA. (2014). IEA - Kenya. [Online] Available at: https://www.iea.org/policiesandmeasures/pams/kenya/name-24780-en.php [Accessed 7 Jun. 2017].
[38] Kakamega County Government. (2015). Infrastructure and Access. [Online] Available at: https://kakamega.go.ke/infrastructure/ [Accessed 22 Aug. 2017].
[39] Karekezi, S. and Kimani, J. (2010). Status of Bioenergy Development in Kenya: The Case of Bagasse-based Cogeneration.
[40] Kenya Institute for Public Policy Research and Analysis.(2010). A Comprehensive Study and Analysis on Energy Consumption in Kenya. A Synopsis of the Draft Final Report.
[41] Kiplagat, J., Wang, R. and Li, T. (2011). Renewable energy in Kenya: Resource potential and status of exploitation. Renewable and Sustainable Energy Reviews, 15(6), pp.2960-2973.
[42] KNBS (2009). *KENYA 2009 Population and Housing Census*.
[43] Kothari, C.R., (2004). Research Methodology: Methods and techniques. 2nd ed. New Delhi: New Age International Publishers.
[44] Kumar, S., Salam, P., Shrestha, P. and Ackom, E. (2013). An Assessment of Thailand's Biofuel Development. Sustainability, 5(4), pp.1577-1597.
[45] Kwaho. (2012). ButereMumias District. [Online] Available at http://www.kwaho.org/new/butere-mumias.html [Accessed 8 Jun. 2017].
[46] Lindell, I. and Kroon, G. (2010). Sugarcane and agroforestry farming in western Kenya a comparative study of different farming systems in the Nyando district. Bachelors. Swedish University of Agricultural Sciences.
[47] Mandil, C. and Shihab-Eldin, A. (2010). Assessment of Biofuels Potentials and Limitations. A Report commissioned by the International Agency Forum.
[48] Maphill. (2013). Savanna Style Simple Map of MUMIAS. [Online] Available at http://www.maphill.com/kenya/western/kakamega/mumias/simple-maps/savanna-style-map/ [Accessed 12 Jun. 2017].
[49] Maplandia. (2016). Mumias Map | Kenya Google Satellite Maps. [Online] Available at: http://www.maplandia.com/kenya/western/mumias/ [Accessed 8 Jun. 2017].
[50] Masayi, N. (2012). Effects of sugarcane farming on the diversity of vegetable crops in Mumias Division, Western Kenya. International Journal of Biodiversity and Conservation, 4(13).
[51] Masayi, N. and Netondo, G. (2014). Effects of sugarcane farming on the diversity of vegetable crops in Mumias Division, Western Kenya. International Journal of Biodiversity and Ecosystems, 2(1), pp.001-010.
[52] Mbayaki, H., Mubea, K., and Mundia, C. (2016). Assessment of Land Uses Land Cover Change and Decline in Sugarcane Farming Using GIS and Remote Sensing in Mumias District, Kenya. International Journal of Science and Research (IJSR), 5(2), pp.1655-1666.
[53] Ministry of Energy and Petroleum (2015). DRAFT NATIONAL ENERGY AND PETROLEUM POLICY. [Online] Available at http://www.erc.go.ke/images/docs/National_Energy_Petroleum_Policy_August_2015.pdf [Accessed 8 Jun. 2017].
[54] Mitchell, D. (2011). Biofuels in Africa Opportunities, Prospects, and Challenges. Washington DC: The World Bank.
[55] Mohajan, H. (2014). Food and Nutrition Scenario of Kenya. American Journal of Food and Nutrition, [online] 2(2), pp. 28-38.
[56] Mumias Sugar Company. (2012). 2012 Annual Report. [Online] Available at: http://www.mumias-sugar.com/index.php?page=annual-reports [Accessed 10 Aug. 2017].
[57] Mumias Sugar Company. (2012). Mumias Sugar Company Limited: Our Products. [Online] Available at: http://mumias-sugar.com/ [Accessed 9 Jun .2017].
[58] Ndegwa, G., Moraa, V. and Liyama, M. (2011). Potential for Biofuel Feedstock In Kenya.
[59] Ness, B., Urbel-Piirsalu, E., Anderberg, S. and Olsson, L. (2007). Categorizing tools for sustainability assessment. *Ecological Economics*, 60(3), pp.498-508.
[60] OECD (2006). *Applying Strategic Environmental Assessment*. Good Practice Guidance for Development Co-Operation. [Online] Paris: Organisation for Economic Co-Operation and Development (OECD). Available at: https://www.oecd.org/environment/environment-development/37353858.pdf [Accessed 8 Jul. 2017].
[61] Ogola, P. (2007). *Environmental Impact Assessment General Procedures*. [Online] Available at: http://www.os.is/gogn/unu-gtp-sc/UNU-GTP-SC-05-28.pdf [Accessed 9 Jul. 2017].
[62] Ontomwa, F. (2013). Mumias embraces new technology that cuts pollution by 50pc. [Online] The Standard. Available at: https://www.standardmedia.co.ke/business/article/2000090238/mumias-embraces-new-technology-that-cuts-pollution-by-50pc [Accessed 8 Aug. 2017].
[63] Preechajarn, S. and Prasertsri, P. (2016). Thailand Biofuel 2016 Annual Report.
[64] Renewable Fuels Association. (2017). Industry Statistics. [Online] Available at http://www.ethanolrfa.org/resources/industry/statistics/#1454099788442-e48b2782-ea53 [Accessed 29 Jun. 2017].
[65] Rowlands, B.H., 2005. Grounded in practice: using interpretive research to build theory. The electronic journal of business research methodology, 3(1), PP.81-92.

[66] Saunders, M. and Lewis, P. (2012) Doing research in business and management: an essential guide to planning your project. Harlow: Pearson Education.
[67] Saunders, M. and Osey, P. (2012). The Layers of Research Design. [Online] Academia.edu. Available at: http://www.academia.edu/4107831/The_Layers_of_Research_Design [Accessed 19 Jul. 2017].
[68] Sekoai, P. and Yoro, K. (2016). Biofuel Development Initiatives in Sub-Saharan Africa: Opportunities and Challenges. Climate, 4(2), p.33.
[69] Simon, M. (2011). Analysis of Qualitative Data. [Online] Available at http://dissertationrecipes.com/wp-content/uploads/2011/04/Analysis-of-Qualitative-DataXY.pdf. [Accessed 19 Jul. 2017].
[70] Sims, R., Mabee, W., Saddler, J. and Taylor, M. (2010). An overview of second-generation biofuel technologies. Bioresource Technology, 101(6), pp.1570-1580.
[71] Smeets, E., Junginger, M., Faaij, A., Walter, A., Dolzan, P. and Turkenburg, W. (2008). The sustainability of Brazilian ethanol—an assessment of the possibilities of certified production. Biomass and Bioenergy, 32(8), pp.781-813.
[72] UN. (2016). Goal 7: Sustainable Development Knowledge Platform. [Online] Available at: https://sustainabledevelopment.un.org/sdg7 [Accessed 9 Jun. 2017].
[73] UNEP (2004). *Environmental Impact Assessment and Strategic Environmental Assessment: Towards an Integrated Approach*. [Online] Available at: http://unep.ch/etu/publications/textonubr.pdf [Accessed 8 Jul. 2017].
[74] UNIDO (2013). *Biofuels Screening Toolkit: Guidelines for Decision Makers*. [Online] Available at: https://www.unido.org/fileadmin/user_media_upgrade/What_we_do/Topics/Energy_access/Guidelines_for_Decision_Makers__FINAL_WEB_20022014.pdf [Accessed 10 Jul. 2017]
[75] Walter, A., Dolzan, P., Quilodrán, O., Garcia, J., Silva, C., Piacente, F. and Segerstedt, A. (2008). A Sustainability Analysis of the Brazilian Ethanol. [Online] Available at http://www.globalbioenergy.org/uploads/media/0811_Unicamp_-_A_sustainability_analysis_of_the_Brazilian_ethanol.pdf [Accessed 24 Jun. 2017].
[76] Wang, M., Huo, H. and Arora, S. (2011). Methods of dealing with co-products of biofuels in life-cycle analysis and consequent results within the U.S. context. *Energy Policy*, 39(10), pp.5726-5736.
[77] Waswa, F., Mayasi, N., Godfrey, W., Maina, L., Nasioko, T. and Ngaira, J. (2010). Agrobiodiversity endangered by sugarcane farming in Mumias and Nzoia Sugar Belts of Western Kenya. African Journal of Environmental Science and Technology, 4(7), pp.437-445.
[78] Were Kweyu, W. (2013). Factors Influencing Withdrawal of Farmers From Sugarcane Farming; A Case Of Mumias District, Kakamega County, Kenya. Masters. University of Nairobi, Kenya.
[79] World Wildlife Fund. (2017). SugarcaneIndustries WWF. [Online] Available at: https://www.worldwildlife.org/industries/sugarcane [Accessed 7 Aug. 2017].