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A Review on Potential and Status of Biofuel Production in Ethiopia

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Abstract: Fossil fuel is the back bone of the world energy demand. Since it is nonrenewable source, this energy is diminishing from time to time and it is more likely to be empty in near future. On the other hand, fossil fuel is the main contributor to air pollution and generally causes climate change. Furthermore, due to different factors such as political unrest in the fossil fuel producing countries, the price of the fuels is rising. All the aforementioned factors and other challenges lead to search alternatives which are renewable, environmentally friendly and cost effective fuels. Accordingly, biofuel is considered as the most promising source which can be used by blending or alone in the fossil fuel machine without more modification. Biofuels are produced from plant oils, animal fat and waste materials. The most common biofuel are ethanol and biodiesel. The biodiesel can be produced from different plants like Jatropha while the ethanol from molasses. USA is the leading country in biofuel production followed by Brazil and Europe. Developing countries including Ethiopia did not exploit their potential. Biofuel have also its own drawbacks like competition for food and climate change in the production of more biofuel.

Keywords: Biofuel, Ethiopia, Jatropha, *Recinus communis*, Transesterification

1. Background

The developments of societies have accompanied by an increase in growing energy needs and their energy requirements have achieved through the combustion of various materials (oil, coal and natural gas) which considered as fossil fuels [1]. However, fossil fuels are non renewable energy sources and within crease in consumption these sources are going to be empty in short period of time [2]. Due to the development of transportation vehicles and agricultural machinery, the production and consumption of petroleum oil increases persistently and it has been reported that about 75 million barrels of crude oil is consumed worldwide daily [3]. As a result world petroleum reserves diminish and many countries are becoming increasingly dependent upon imported sources of oil [4].The United States, for example, currently imports a full two-thirds of its petroleum from only a few countries around the world [4]. In many developing countries like Nigeria, there is a serious shortage of fuel and therefore energy crisis is a reality for most families [5].These facts show that fossil fuels are finite, non-renewable source of energy that will ultimately be exhausted [6].

On the other hand, the fossil fuel is a major contributor to air pollution especially within cities and along urban traffic routes [2]. The same document again reveals that, fossil fuel not only cause air pollution but it can also causes ground level ozone and smog in the atmosphere. According to [7], most of the observed warming in the past 50 years has been caused by human activities, particularly producing and consuming fossil fuels, increasing agriculture and changing land use. The combustion of fossil fuels such as coal, oil and natural gas has been identified as a major cause of the increase in the concentration of CO_2 in the earth's atmosphere [8]. When fuels are burnt, there are basic types of primary exhaust emissions like, oxides of nitrogen (NO_X), Carbon monoxide (CO), hydrocarbons (HC), Carbon dioxide (CO_2) and particulate matter [1]. Over the last 150 years, burning fossil fuels has resulted in more than a 25% increase in the amount of carbon dioxide in our atmosphere [9].

In addition to that, over the past century, increased CO_2 emissions have boosted its level in the atmosphere from 280 to 379 parts per million (ppm), while methane levels rose even faster, from 715 to 1774 parts per billion (ppb) [7]. Besides, due to political and social unrest in some oil producing countries, oil prices are escalated and destabilized worldwide [10].

These rising world fuels prices, the growing demand for energy, and concerns about global warming leads to search for an alternative and renewable energy sources [11]. Presently, biofuel (biodiesel, biogas and ethanol) are considered as the most promising alternatives in energy generation that can compete with the fossil fuel and to reduce the world‘s dependence on fossil fuels [4].The two most widely used types of biofuel are biodiesel and ethanol. These biodiesel products are potentially trusted substitutes of fossil fuels because they are clean and renewable fuels which can be used in any direct injection engine without the need to redesign the current technology [12]. Furthermore, biofuel offers full blending potential with conventional diesel, a high cetane number giving improved combustion in compression ignition engines, and low emissions of sulphur and particulates [13].

Biodiesel is derived from renewable and domestic feedstock and shows higher biodegradability than fossil fuels excellent lubricity and negligible sulfur content [12]. It is a liquid biofuel obtained by chemical processes from vegetable oils or animal fats and an alcohol that can be used in diesel engines, alone or blended with diesel oil [14]. According to [15], around 3 billion people in developing countries cook with solid fuels and suffer from severe health damages resulting from indoor air pollution.

Thus, biofuel could play a critical role in improving the health of billions of people. The production and use of biodiesel have increased significantly in many countries around the world. Despite their rich natural resource and high potential feedstock for biodiesel production, Sub-Saharan African country's region [5], is still in an embryonic status in many of them [1]. It is not less true in Ethiopia, which endowed with diverse ecological varieties that have an ample potential for biofuel-production. *Jatropha*, *Recinus communis*, and others are among the known non-edible naturally occurring biodiesel feedstocks in Ethiopia. Edible and non edible feedstocks in the country are not even identified yet. Therefore, identifying the most possible and trust worthy oil bearing plants for biodiesel from indigenous species is necessary for finding solution to all the problems discussed. This review was aimed to assess the potential and the current status of biofuel production in Ethiopia.

1.1. Biofuel

Biofuel is a fuel derived from biomass. It is an organic matter taken from plants and animals [16]. It comprises mainly wood, agricultural crops and products, aquatic plants, forestry products, wastes and residues, and animal wastes. In its most general meaning, biofuel is all type of solid, gaseous and liquid fuels that can be derived from biomass [8]. Biofuel include methanol, ethanol, plant oils and the methyl esters produced from these oils commonly referred to as biodiesel. The most common biofuel are ethanol and biodiesel, ethanol is made from fermented sugars while biodiesel is made from the oils of certain plants [17; 18].

Biodiesel is a liquid biofuel obtained by chemical processes from vegetable oils or animal fats and an alcohol that can be used in diesel engines, alone or blended with diesel oil [14]. It can be produced easily from common feedstocks (vegetable oils, animal fats and recyclable cooking oils) by transesterification in which oil or fat is reacted with a monohydric alcohol in the presence of acatalyst [2].There action of transesterification process is as follows:

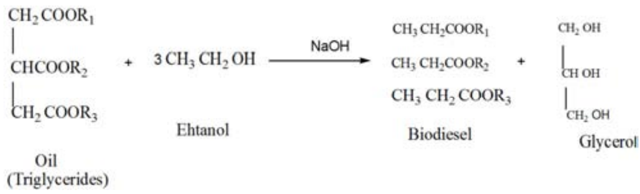


Figure 1. *Biodiesel Production by Transesterification.*

Where RI, RII, & RIII are long chain hydrocarbons.

Methanol is the most used alcohol in the transesterification process because it is the least expensive alcohol and it shows chemical advantages such as its shorter chain and its polar nature [12]. The same document also states that, the catalysts employed for transesterification reaction are homogeneous alkaline catalysts such as NaOH, KOH, CH_3ONa and CH_3OK. However, the most suitable ones are methoxides due to their ability to dissociate in to the methoxide and the metal ion without the production of water during transesterification reaction. More than 95% of global biodiesel production is made from edible vegetable oils and this fact has an influence on the global imbalance to the market demand and the food supply by their high prices and the reduction of food sources [12].

1.2. Raw Materials for Biofuel Production

A range of raw materials are available, some already in use and others which will supplement them in the near-term and longer-term future. There are several oil bearing crops identified whose cetane number and calorific value are comparable with those of diesel fuels and are compatible with material vehicle fuel system [2]. The major crops for biodiesel feedstock are *Jatropha curcas*, castor crop, palm tree, soybean, and sun flower [5].

1.3. Jatropha curcas as a Raw Material

Ever since the global momentum for biofuel began in 2007, the world has become increasingly familiar with the name of a little known plant called Jatropha [19]. Jatropha grows mainly in dry areas and also it grows in mid and high altitude. Its yield varies from one agro-ecology to agro-ecology with different climatic conditions. About 40% of the seed weight is oil and therefore about 800 litres of oil can be produces from one farmer's holdings [10]. In Ethiopia Jatropha and castor oil cost is estimated from 0.45 to 0.76 USD per liter but in Germany it is sold for 1.3 USD. If the oil is transported to Germany the cost of transportation is estimated 0.575 to 0.885 USD. Therefore, export of Jatropha or castor oil to Europe is competitive in terms of cost [10]. On the other hand, one key advantage of promoting Jatropha is the potential of the crop to restore the ecosystem and improves oil quality and to decreases oil erosion [20].

1.4. *Ricinus communis* as a Raw Material

Ricinus communis is a potential biodiesel source and comparing with potential sources, it has added advantages as rapid growth, higher speed production suitable for tropical and subtropical regions of the world [5]. It also has a higher resistance to drought, higher production of quality oil, can be used to combat desertification and poverty and its seed contains 30-35% oil that can be processed to produce a high quality biodiesel fuel usable in standard diesel engine. The oil produced from the seed of the castor plant (*Ricinus communis*) has stimulated some interest as a biofuel and the fatty acids in a castor oil contain a hydroxyl functional group, which cause castor oil to be more polar than other vegetable oils [1]. Furthermore, castor oil is best substance for producing biodiesel because it is the only one that is soluble in alcohol and does not require heat as well as consequent energy requirement of other vegetable oils in transforming them in to fuel [2].

1.5. Algae as a Source of Biofuel Production

Algae are another cutting-edge possibility for fuel derivation [17]. Algae may be even a greener alternative to some other cellulosic fuels because algae would not require the same amount of land for production. Many micro-algal species have the ability to accumulate large amounts of triglycerides, especially under stress-induced growth conditions [4]. Algae can produce 3,800-50,800litres/ha/year. However, there are drawbacks like the prohibitive expense of the technology needed to produce it on a large scale [17].

Table 1. *Comparison of oil yield from different biomass feedstocks Oil producing crop/plant.*

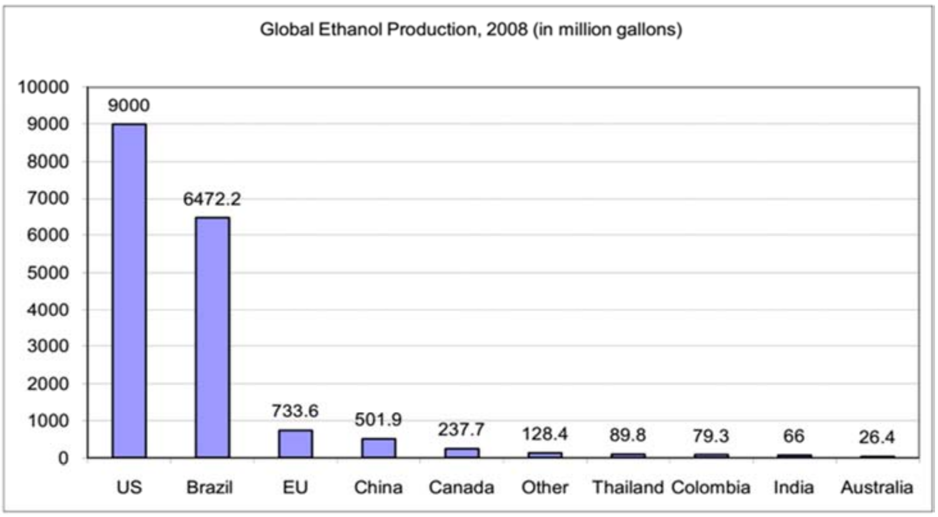
	Yield (LbOil/Acre)
Palm	4585
Coconut	2072
Sunflower	734
Soybean	344
Cottonseed	250
Jatropha	1458
Casterbeen	1089
Rubberseed	199

Source: [2]

1.6. The Status of Biofuel Production Worldwide

The annual world primary energy supply in 2009 has been estimated at 12,150 million tons of oil of which transport accounted 25% [16]. The demand for energy is growing worldwide especially in many of the rapidly developing countries such as in China and India [4]. As a result, international pressure comes from developed countries, hoping that biofuel will meet their vast energy needs, reduce the need for diminishing supplies of fossil fuels, solve the global climate crisis, and create new business opportunities and the world has witnessed a sharp increase in global production of biofuel, especially in the new millennium [19; 21].

However, globally, only few countries dominate the domestic use and export of biofuel [21]. The United States and Brazil are the largest producers of ethanol, accounting for over 80 percent of the world's total production [22]. As liquid biofuel, ethanol and biodiesel are currently blended with traditional fuels, gasoline and diesel, and serve as renewable fuel alternatives [22]. They have the potential to become complete substitutes for petroleum products.



Source: [22]

Figure 2. *Global Ethanol Production.*

1.7. The Potential and Status of Biofuel Production in Ethiopia.

About 95% of the total energy consumption in Ethiopia is composed of traditional biomass fuels with only 5% coming from modern energy sources [23; 24]. The biomass is mainly obtained from firewood, charcoal, dung and crop residues that mainly depend on the surrounding forest resources and agricultural residues [25]. As a result, the country's forest and land resources is being disappear and degrade with an alarming rate, resulting in desertification, reduction in agricultural production and recurrent drought [24].On the other hand, Ethiopia imports its entire petroleum fuel requirement by spending over 80% of the foreign earning annually [10].

The transport sector in general and road transport which accounts for about 52% of the country in particular is one of the most key sector which consume the majority of the imported petroleum and contributed more CO_2 to the environment [26]. Since the nation's economy is increasing, it is expected that the demand for petroleum fuel will increase. Hence, in order to ensure the country's sustainable development and fuel security, it is critical to look for locally available alternative fuels such as biofuel. Biofuel development is therefore believed by the government to have the potential to meet a substantial proportion of the national energy need, reduce dependency on imported fossil fuels, create new business opportunities and contribute towards reducing green house gas (GHG) emissions [27]. Taking the aforementioned challenges, Ethiopia is currently assessing its biofuel potential and is now in the process of implementing an ambitious biofuel strategy, which was approved in 2007 [27].

The overall objective of the strategy is to facilitate adequate production of biofuel from indigenous resources so as to substitute imported petroleum and export excess products [23]. The strategy is formulated based on principles that development of biofuel should not have unintended consequences on food security, land access, the environment, cultural values and the economy. The Government of Ethiopia considers biofuel as an opportunity for enhancing food security and meeting the growing energy demand in the country, thereby saving scarce foreign exchange [21]. Moreover, the government has already started blending gasoline and currently ethanol to gasoline ratio 10:90 and according to the strategy this ratio will increase to 25% by 2015.

Due to the favorable air condition and suitable soil type for bio-diesel development, different types of plant species which can be used for producing bio-diesel grow in the country. Jatropha, which is very important feed-stock for bio-diesel grows in many parts of the country and used as a hedge and medicinal plant [11].

The same document shows that, in Amahara region there are about 11million wild and planted Jatropha plants. It has various names depending on the locations it grows. In some areas it is called "Ayderkie", which means Draught Resistant, and in some places it is called "Yedinber Shimagilie", which means Border Mediator since it is widely used as hedge.

Another plant which grows in many parts of the country and important feed-stock for producing bio-diesel is castor oil. Imported Palm tree seedlings are planted in 100ha area in the Gambella Regional State for producing oil and soap around Tepi Area [10]. Ethiopia is endowed with natural resource suitable for bio-diesel development and at national level, an estimated area of 25 million hectare suitable land is available for development of biodiesel [21]. Of the total suitable land for biodiesel, the following land has been allocated for biodiesel investment.

1.8. Other Plant in Ethiopia for Potential Biofuel Production

It has been mentioned above as many plants are used for biofuel productions worldwide. These plants are also commonly found in Ethiopia. To mention some, castor plan, Jatropha and sunflower are common. Furthermore, these potential biofuel plants can grow in areas where agriculture is difficult. In addition to the above known biofuel plants, many other plants which are indigenous or exotic to Ethiopia are potentially the future sources of fuels. Some of these future potential biofuel plant species are *Euphorbia trucali* [28], *Cucurbita pepo* [29], *Argemon mexicana* [30], *Balanites aegyptiaca* [31; 32], *Carica papaya* [33], *Moringa* seed [34], Cotton seed [35], *Lagenaria siceraria* [36; 37], Coffee residue [38; 39], Avocado [40], *Azadirachta indica* [31] and water hyacinth [41; 42], an invasive plant in Ethiopian water bodies particularly in LakeTana [43].

Ethiopia has also been started 5% blending of Ethanol with gasoline implementing since 2009 and increased the ratio to 10% [24]. These blending started with one sugar factory and one blender company (Fincha and Nile petroleum). Beside to this, since 2011 the country has started 10% blending with two sugar factories and three blender campaniles (Fincha, Metehara and Nile petroleum, Oil Libya and NOC). Up to now Ethiopia blended more than 44 million liters of ethanol with gasoline and save more than 35millions USD [24].

If the ethanol production is considered, the feedstock comes primarily from large-scale sugar cane plantations and the sugar by product molasses is the most favorable feedstock for large-scale ethanol production [21]. The total identified suitable land for sugarcane plantation in Ethiopia is about 700,000 hectares [26]. Ethiopia has four sugar factories Wonji-Shoa, Metahara, Fincha, and Tendaho [26]. However, only two plants, Fincha and Metehara sugar factories, involved in fermentation and distillation of molasses for the production of bio-ethanol in Ethiopia. The other state owned factories are also actively involved to install ethanol production units from molasses following the government direction to introduce a binding rule to blend gasoline with bio-ethanol as vehicles fuel.

Generally, Ethiopia has set an impressive goal of becoming a middle income nation by 2025. The main driving vehicle for achieving this aim are the five year growth and transformation plan and the agricultural developmant led industralization strategy. By 2015, Ethiopia aims to reach a total capacity of 10,000 MW of electricity generated annually. Of this it is planned that 8000 MW will come from renewable source [24].

***Table 2.** Land allocated for biofuel investment in different regions of the country.*

S. No	Company Name	Region	Land acquired (ha)	out-growers land	Crop type
1.	Sun Biofuels Eth/NBC	Benshangul	80,000		Jatropha
2.	Amabasel Jatropha project	Benshangul	20,000		Jatropha
3.	Jatropha Biofuels Agro-Industry	Benshangul	100,000		Jatropha
4.	IDC Investment	Benshangul	15,000		Jatropha
5.	ORDA	Amahara	884		Jatropha
6.	Jemal Ibrahim	Amahara	7.8		Castor bean
7.	BDFC Ethiopia Industry	Amahara	18,000	30,000	Sugarcane/sugar beat
8.	A Belgium company	Amahara	2.5		Castorbean
9.	Flora Eco-power Ethiopia	Oromia	10,000	5,000	Castor bean
10.	Petro Palm corporation Ethiopia	Oromia	50,000		Castor/Jatropha
11.	VATIC International Business	Oromia	20,000		NA
12.	Global Energy Ethiopia	SNNPR	2,700	7,500	Castor bean
13.	Omo Sheleko Agro-Industry	SNNPR	5,500		Palm
14.	Sun Biofuel Eth/NBC	SNNPR	5000		Jatropha
TOTAL			327,094	42,500	

Source: [23]

***Table 3.** The potential and status of renewable energy in Ethiopia.*

Resource	Unit	Potential	Exploited%
Hydropower	MW	30,000	<3%
Solar/day	kWh/m^2	4-6	0%
Wind Speed	m/s	3.5-8	0%
Geothermal	MW	1070	0%
Wood	Milliontons	1120	50%
Agricultural waste	Milliontons	15-20	30%
Natural gas	$Billionm^3$	113	0
Coal	Milliontons	96.3	0

Source: [25]

1.9. The Advantages of Biodiesel Over Fossil Fuel

Biodiesel has lower carbon content than conventional diesel, due to its oxygen content. Consequently carbon dioxide emissions from biodiesel, measured as a ratio of fuel mass or volume, are lower than from diesel [44]. In addition to that, use of biodiesel, degrades more rapidly than diesel fuel, minimizing the environmental consequences, lower emissions of contaminants like carbon monoxide, particulate matter, polycyclic aromatic hydrocarbons, aldehydes and Lower health risk, due to reduced emissions of carcinogenic substances [14].

However, biodiesel is much more viscous (thicker) than fossil fuel [8]. It is 11to17 times thicker. Biodiesel also has very different chemical properties and combustion characteristics to those of fossil fuel. If the fuel is too thick it will not atomize properly when the fuel injectors spray it in to the combustion chamber and it will not combust properly.

1.10. The Challenges and Opportunities of Biofuel Production

Despite its huge advantages in economic, environmental and social issues, the biofuel production is a controversial issue, particularly in the developing countries [45]. Some believe that, biofuel is considered an important source of clean energy that provide employment opportunities, enhance agricultural productivities as well as it increases the prospects for the agricultural sector, which has suffered low prices for its prospects for several decades [18; 21]. Likewise, using biofuel may include reduction of reliance on foreign oil and reduction of pollution [17].

Others argue that, if the production and consumption of biofuel is continues with the same trend, the availability of sufficient food supply could be endangered, since the land for crop productivity, water, and other essential resources could be diverted away from food production [26]. Furthermore, land use changes and intensification of cultivation following the increased demand for biofuel may cause new green house gasses emission and affect the biodiversity, the soil quality, and the natural resources in general [46]. Ethiopia is an excellent example to see these effects. On the one hand, Ethiopia is a major energy importer and this shows the country is number one “energy poor country” in the world [45]. This indicates that, production of renewable energy is sounds appealing. On the other hand, Ethiopia’s agricultural sector is heavily dominated by subsistence small holder farmers whose food security is vulnerable and who are often food aid recipients. Therefore, it is clear that expansion of the biofuel may compete with the existing weak food supply system in Ethiopia.

There are also optimistic and pessimistic views surrounding the development of biofuel [21]. According to the optimistic view, allocation of land to biofuel crops will not affect food production because biofuel crops are grown in areas not occupied by small holders or on land not suitable force real production. According to this view, biofuel crops can be planted and grown on arable and marginal lands that are not under cultivation. In addition, biofuel production can enhance agricultural productivity through technology spillover effects and other inputs. Likewise, biofuel is expected to provide some new market and income opportunities for poor farmers in Africa, particularly for those whose livelihoods depend largely on agriculture [47]. However, the opponents of this view argue that there is no land which simply sits idle, since land is used for grazing, forests, or other purposes. When land is allocated to biofuel crops, both livelihood and environmental implications should be taken into account. The government of Ethiopia considers biofuel as an opportunity for enhancing food security and energy security and development of biofuel has been considered as a key in terms of meeting the growing energy demand in the country and reducing the dependence on imported fossil fuel, which consumes close to 80% of export earnings [10].

Table 4. *Some advantages and disadvantages of biofuel production and use.*

Aspects	Advantages	Disadvantages
Cost	It is made from renewable resource	Currently more expensive than fossil diesel fuel
Energy availability	Fossil diesel fuel is a limited resource, but biofuels can be manufactured from a wide range of materials	Mainly produced from edible oil, which could cause shortages of food supply and increased prices
GHG emission	Significantly less harmful carbon (CO_2,CO,TCH)emission	Reduction of fuel economy
Energy security	Viability of the first generation biofuel production	Conflicts with food supply
	relatively less flammable compared to fossil diesel	less suitable for use in low temperatures
Usage	significantly better lubricating properties	it can only be used in diesel powered engines
	significantly less harmful carbon emission compared to standard diesel	More likely than fossil diesel to attract moisture
Air pollution	significant reduction of PM emissions	Caused increases in NO_x

Source: [46]

2. Future Prospects

Currently with rapid expansion of developmental activities with stretched out human needs and recurrent shortage of fuels, looking for growing of high-yielding crops for the production of biofuel is mandatory. On the other hand, biofuel attracts an attention to address imminent energy shortages and reduce impacts of climate change and global warming. This usually needs to search for fast growing and enormous biofuel potential crops. Moreover, researching on biofuel plants will be indispensable because global warming and fossil fuel resource scarcity have been found to be the predominant problems to contemporary world. The burning of these fuels over the past century has dramatically increased the level of green house gases, which cause climate change. Furthermore, the price of petroleum has reached record levels in the world, and will continue to rise as domestic supplies of oil decline. Due to increased volumes of transport and traffic congestion, the public health risks associated with exposure gas emissions is increased. With this contemporary reality in this sector, having emphasis on biofuel offers the immediate potential to reduce the demand for fossil fuel based diesel in the transportation sector.

Biofuel, as alternate fuel has attracted considerable attention during the past decade as a renewable, biodegradable and non-toxic fuel. In addition to searching for biofuel crops to meet their energy demand, many countries have plans to built climate resilient green economy. However, promoting the cultivation of some popular species for biofuel production may increase two of the major causes of biodiversity loss on the planet: clearing and conversion of yet more natural areas for monocultures, and invasion by non-native species. Besides, the biofuel productions have to explore the feasibility of invasive and weed plants for biofuel. Utilization of this weed for energy production seems to be highly beneficial.

With these realities, plantation of these trees can potentially increase green coverage to sequester more CO_2. In spite of the environmental and economic benefits, the plantations of these potential biofuel crops involve detailed assessment on the environmental implications of different stages of biodiesel production to confirm these benefits. Moreover, along with a huge need on biofuel crops, their invasion history should be noted for careful management of their impacts on habitat conversion and biodiversity loss. This is important to limit enthusiastic cultivation of new crops because if productive areas areal ready invaded, conversion is not an easy task. Unless, the impact of newly planted potential biofuel plant is studied, their expansion prone to greater financial losses than gains to the long run. Because, many plants which are alien are found to be invasive species in many parts of the world.

Energy is an essential driving factor to socioeconomic development in our present society. Its impact touches all aspect of human endeavors such as agriculture, health, education, transportation among others. Petroleum based fuels are the major fuel sources used in transportation sector in most of the developing nations. The rising cost of petroleum products and climate change is a problem facing many developing countries and solution to this problem can be found in the explorations of biofuels. As a future prospective fuel, biodiesel has to compete economically with petroleum. Due to this, demand for biodiesel is expected to increase sharply in the near future. For this issue, developing countries like Ethiopia have a comparative advantage for biofuel production because of greater availability of land, favorable climatic conditions for agriculture and lower labor costs. The renewed interest to the quest for greener fuels sources is a topical issues that gain wide societal and political interest especially for its reduced green house emissions, biodegradability, sustainability as well its competitive nature to fossil fuels and food supply.

3. Conclusion

This paper has reviewed the evidences in support of exploring potential plants for biofuel production and a lesson to be taken for sustainable biofuel energy production in Ethiopia. In the near future, the world will face an energy crisis unless the renewable biofuel production rising more than ever. The fossil fuel combustion is the main reason for climate change and global warming happening now. With this fact, biofuel is the immediate and applicable option to solve the aforementioned problems. Biofuel is organic matter taken from plants and animals. However, if biofuel production from food crops is increasing and other non food crops are used for biofuel production, the price for food will increase. On the other hand, if non food crops are used for biofuel production, it will harm the grazing plants and it will harm the biodiversity. Ethiopia one of the developing countries is endowed with different potential for biofuel production. However, the country is not yet exploited its potential. To satisfy the goals of building of climate resilient green economy with minimal implication on biodiversity, the invasion potential of introduced species should be studied for their management. Generally, searching for biofuel plants and production of biofuels with their impact studied crops that are eco-friendly type can operate on the current civilized world.

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References

[1] Asmare M. and Gabbiye N. (2014). Synthesis and characterization of biodiesel from castor bean as alternative fuel for diesel engine *.American Journal of Energy Engineering*.2 *(1)*.

[2] Sreenivas P., Ramesh V. M., Chandra K.S. (2011). Development of Biodiesel from Castor Oil. *International Journal of Energy Science*, 1(3):192-197.

[3] Gerpen, V. J. (2005). Biodiesel processing and production. *Fuel Processing Technology. J.* 86 (10):1097–1107.

[4] Darzins A, Pienkos P. and Edye L. (2010). Current status and potential for algal biofuels production. A report to IEA bio-energy task 39. Commercializing 1st and 2nd generation liquid biofuels from biomass.

[5] Okechukwu R.I., I Wuchukwu A. C. and Anuforo H. U. (2015). Production and Characterization of Biodiesel from *Ricinus communis* seeds. *Research Journal of chemical sciences*, 5: 1-3.

[6] Abdulakreem, A. S & Odigure, J. O. (2002). Radiative heat evaluation from gas flaring by Computer simulation. *Association for the advancement of Modeling and simulation in enterprises, Lyon France. J.* 71: 219-35.

[7] OECD (2008). Organisation for economic cooperation and development. Policy brief.

[8] Uriarte F. (2010). Bio-fuels from plants. A book for practitioners and professionals' to improve biofuel.UCS (2015). Union of concerned scientists saves the planet for the future.

[9] Union of concerned scientists (UCS) (2007). Biofuels: An Important Part of a Low-Carbon Diet clean vehicles program.

[10] MME (2007). Ministry of Mines and Energy. The Biofuel Development and Utilization Strategy of Ethiopia. Addis Ababa, Ethiopia.

[11] Abdulkareem, A. S., Idibie, C. A., Afolabi, A. S., Pienaar, H. C. & Iyuke S. E. (2010): Kinetics of sulphonation of polystyrenebutadiene rubber in sulphuric acid medium. *International Review of Chemical Engineering. J.* 2: (7).

[12] Sánchez N., Encinar J., Martínez G., and González J. (2015). Biodiesel Production from Castor Oil under Subcritical Methanol Conditions. *International Journal of Environmental science and development: 6 (1):61-66.*

[13] International Energy Agency (IEA) (2007). Energy Technology Essentials. Biofuel Production.

[14] Romano S. and Sorichetti P. (2011). Dielectric Spectroscopy in Biodiesel Production and Characterization, Green Energy and Technology, DOI: 10. 1007/978-1-84996-519-4_2.

[15] United Nations Conference on Trade and Development (UNCTD) (2008). Biofuel production technologies: status, prospects and implications for trade and development. Geneva.

[16] European Academic science advisory council (EASAC) (2012).The current status of biofuels in the European Union, their environmental impacts and future prospects.

[17] Bryn M. (2009). Fuel, food, and the future of the planet. The biofuel debate. Prepared as an academic requirement for the agricultural law course at the Pennsylvania state University's Dickinson School of Law.

[18] Richard L.O.(2007). Biofuels-Potential, Problems & Solutions. Biofuels conference. The University of Tulsa College of law.

[19] African Biodiversity Network (ABN) (2010). Biofuels: A Failure for Africa. The Ethiopian Society for Consumer Protection, and the Gaia Foundation.

[20] Aziz E., Anna S. and Pascal L. (2013). A global assessment of sustainability issues, trends and policies for biofuels and related feedstocks. Food and agriculture organization of the United Nations.

[21] Tadele F., Zenebe G., Alem M. and Fantu G. (2013). Biofuels, Economic Growth, and the External Sector in Ethiopia. Environment for Development.

[22] Miguel Carriquiry, Fengxia Dong, Xiao dong Du, Amani Elobeid, Jacinto F. Fabiosa, EdChavez, and Suwen Pan (2010).World Market Impacts of High Biofuel Use in the European Union. Center for Agricultural and Rural Development. Iowa State University.

[23] Hilawe Lakew and Yohannes Shiferaw (2008). Rapid Assessment of Biofuels Development Status in Ethiopia. Proceedings of the National Workshop on Environmental Impact Assessment and Biofuels.

[24] Ministry of Water, Irrigation & Energy (MWIE) (2014). Bio-fuel development Experience of Ethiopia.

[25] Meskir Tesfaye (2007). Bio-fuels in Ethiopia. Eastern and Southern Africa Regional Workshop. Nairobi, Kenya.

[26] Yacob G. (2013). Long-term Bio-ethanol Shift and Transport Fuel Substitution in Ethiopia. Master of Science Thesis KTH School of Industrial Engineering and Management Energy Technology.

[27] EPA (2010). Towards sustainable biofuels in Ethiopia. A report produced by the Secretariat of the Roundtable on Sustainable Biofuels, Energy Center, Ecole Polytechnique Fédérale de Lausanne.

[28] Khaleghian, A., Nakaya, Y. and Nazari, H. (2011). Biodiesel production from *Euphorbia tirucalli*. *Journal of Medicinal Plants Research,* 5 (19): 4968-4973.

[29] Schina P., Karavalakis G., Davaris C., Anastopoulos G., Koranis D., Zannikos F., Stournas S., Lois E. (2009). Pumpkin (Cucurbita pepo L) seed oil as a nalternative feedstock for the production of biodiesel in Greece. Biomass and Bio energy 33:44-49.

[30] Rao, Y., Zubaidha, P., Kondhare, D., Reddy,N., and Deshmukh S. (2012). Biodiesel production from *Argemone Mexicana* seed oil using crystalline manganese carbonate. *Polish Journal of Chemical Technology, 14 (1):65-70.*

[31] Sylvester D., Chukwuneke C., Sali A., Yahaya M., Hayatu R., Agboola B., Uche O., Okoro L. and JinJahng W. (2014). Biofuel Production from *Balanite aegyptiaca* and *Azadirachta indica* Seeds. *International Journal of Scientific & Engineering Research*, 10(5):439-441.

[32] Lohlum S., Forcados E., Agida O., Ozele N., Gotep J. (2012). Enhancing the Chemical Composition of *Balanites aegyptiaca* Seeds through Ethanol Extraction for Use as a Protein Source in Feed Formulation. *Sustainable Agriculture Research*, 2 (1):251-256.

[33] Wong C. and Othma R. (2015). Biodiesel Production by Enzymatic Transesterification of Papaya Seed Oil and Rambutan Seed Oil. *International Journal of Engineering and Technology*, 6:2773-2777.

[34] Azad, A., R Asul, M., Khan, M., Sharma, S. and Islam, R. (2015). Prospect of Moringa seed oil as a sustainable biodiesel fuel in Australia: A review. Elsevier, Procedia Engineering, 105:601-606.

[35] Fan X., Wang X., and Chen F. (2011). Biodiesel Production from Crude Cotton seed Oil: An Optimization Process Using Response Surface Methodology. *The Open Fuels & Energy Science Journal: 4,* 1-8.

[36] Sokoto, M., Hassan, L., Salleh., Dangoggo, S., and Ahmad, H. (2013). Quality Assessment and Optimization of Biodiesel from *Lagenaria vulgaris* (Calabash) Seeds Oil. International Journal of Pure and Applied Sciences and Technology, 15(1):55-66.

[37] Mukhtar M., Muhammad C., Usman M., DabaiM., Mamuda M. (2014). Ethanolysis of Calabash (*Lageneria sinceraria*) Seed Oil for the Production of Biodiesel. *American Journal of Energy Engineering*, 2(6):141-145.

[38] Caetano N., Silva V., Mata T. (2012).Valorization of Coffee Grounds for Biodiesel Production. *Chemical engineering Transactions*, 26:267-272.

[39] Mebrhatu Hailu (2014). Integrated volarization of spent coffee grounds to biofuels. *Biofuel research Journal*, 2:65-69.

[40] Rachimoellah H, Dyah Ayu Resti, Ali Zibbeni, Wayan Susila (2009). Production of Biodiesel through Transesterification of Avocado (*Persea gratissima*) Seed Oil Using Base Catalyst. *Journal of technique machine*, 2 (11):85-90.

[41] Bergier, I., Salis, S., Miranda, C., Ortega E., Luengo, C. (2012). Biofuel production from water hyacinth in the Pantanal wetland. *Ecohydrology and ecobiology*, 12(1):77-84.

[42] Sagar V. and Kumari A. (2013). Sustainable Biofuel Production from Water Hyacinth (*Eicchornia crassipes*). *Journal of Engineering Trends and Technology: 10(4):4454-4458.*

[43] Dereje Tewabe (2015). Preliminary survey of water hayacinth in Lake Tana. Amhara Region Agricultural Research Institute report.

[44] Duncan J. (2003). Costs of biodiesel production. Energy efficiency and conservation authority.

[45] Martha N. and Jo S. (2012). Biofuels and Food Security: Micro-evidence from Ethiopia. LICOS Centre for Institutions and Economic Performance and Department of Economics and Katholieke Universiteit Leuven.

[46] Dainis V. and Ligita M. (2014). Advantages and disadvantages of biofuels: observations in Latvia. Jelgava, 2010-2015.

[47] Food and Agricultural Organization (FAO) (2008).The state of food and agriculture. Biofuels, prospects, risks and opportunities.