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Impact of Petroleum on Developing Economies and Prospect of Liquid Biofuel Substitute: Scenario in Ethiopia

[1]Berhanu Andualem and [2]Amare Gessesse

[1]Department of Biotechnology, Faculty of Natural and Computational Sciences, University of Gondar, Gondar, Ethiopia
[2]Biotechnology Institute, Addis Ababa University, Addis Ababa, Ethiopia

Abstract: Petroleum is highly affecting the economic development of developing countries. This study was undertaken because of the economic impact of petroleum in Ethiopia and is a model for developing countries. The objective of this study was to analyze the impact of petroleum on the economy of the country and the prospect of biofuel to solve this adverse problem. National expense of petroleum was analyzed by using data collected from Ethiopian National Bank and Petroleum Enterprise. In 2007/08 fiscal year, the amount of petroleum imported showed 16% increase from the previous year while in the same period expenditure on petroleum was increased by 71%. This was due to the sharp increase in the price of petroleum in the international market. Thus in the last seven years, the cost of petroleum import was increased almost exponentially. From 2000/01 to 2009/10, the volume and value of diesel imported was grown exponentially. To lower the economic impact of petroleum, it is important to invest an alternative energy sources as substitutes and it can also address environmental problems on the other hand. The biofuels have economic significant to generate income for farmers and also creates job opportunity for the society thereby contributes a lot for economic development of the developing countries. This finding may provide basic knowledge of the role biofuel for petroleum substitute and thereby provides inputs to policy-makers, entrepreneurs, researchers, industrial actors and the society as a whole, thereby to facilitate biofuel production from the available resources.

Key words: Alternative energy · Biodiesel · Bioethanol · Biofuel · Energy · Petroleum

INTRODUCTION

Energy is vital for human survival and plays a significant role in human civilization. Before industrialization the main requirement for energy by all of mankind was for cooking and lighting the home. All or most of this energy requirement was obtained from biomass. However, with the advent of industrialization the level of consumption and the demand for energy greatly increased. Thus, today to run modern economies modern sources of energy like coal, petroleum and electricity are increasingly used. But, depending on their level of development, countries greatly differ in the amount of energy consumption and the sources of the energy. Thus, compared to developed countries, the energy requirement of most developing countries is very low and a large part of it is still derived from biomass.

Modern energy sources are largely from petroleum, coal and natural gas. Global energy consumption has about doubled in the last three decades of the past century. In 2004, about 77.8% of the primary energy consumption was estimated to be derived from fossil fuel (32.8% oil, 21% natural gas and 24% coal), 5.4% from nuclear fuels and 16.5% from renewable resources. Of the renewable energy sources 5.5% is hydroelectric, 11% from non commercial biomasses, such as wood, hay and other types of fodder [1].

With industrialization and improvement in people's life style in many parts of the world, demand for energy is always on the increase. For example, in the industrialized countries there is a high energy demand for use in the transport and industry sectors [2, 3]. As more and more countries industrialize the demand for fossil fuels is expected to grow significantly.

Corresponding Author: Berhanu Andualem, University of Gondar, P.O. Box: 196, Gondar, Ethiopia.
Cell: +251918-70-00-27, Fax: +25158-14-19-31.

Large scale uses of fossil fuel have a number of problems [4]. First fossil fuel reserve of the world is finite and its excessive use could lead to rapid depletion. At the present pace of consumption it is estimated that the world could run out of petroleum within 50 years, natural gas within 65 years and coal in about 200 years [5]. According to Campbell and Laherrere [6], the world may reach its maximum petroleum production at around 2010 and after that petroleum production will start to decline. Secondly, excessive use of fossil fuel exert a number of negative impacts on the environment, such as greenhouse gas emissions (which aggravate global warming), air pollution and acid rain, [3,7]. Thirdly, as the demand for petroleum increases, petroleum prices are expected to increase further sharply. This fundamental long-term upward trend may of course be temporarily broken by the effects of market disturbances, politically unstable situations or crises on a world scale [8].

To overcome the risk of fossil fuel depletion and minimize the impact of excessive burning of fossil fuel on the environment, it is important for mankind to look for alternative energy sources. Renewable energy sources derived from biomass, hydropower, wind power, etc has enormous potential to replace at least part of the fossil fuel currently in use. Liquid biofuels derived from biomass have a good potential to substitute part or all petroleum derived liquid fuels used in the transport and other economic sectors [7].

Replacement of petroleum derived fuels with biofuels is considered to offer several advantages [9]. First, burning of such fuels is carbon neutral thus avoiding release of excess green house gasses. Secondly, unlike fossil fuels, biofuels are derived from biomass and thus no risk of depletion. Third, biofuels are biodegradable which, in the case of accidental spill, results little or no environmental disaster.

Currently, petroleum is highly affecting the economy of developing countries than that of developed countries. Study on economical impact of petroleum in developing countries and the prospect of biofuel as partial substitute for petroleum is significant to brining about solution for the encountered problem. To address the problem, this study was considered the economical impact of petroleum on Ethiopia as model since it is one of the member of developing countries.

Currently, Ethiopia faces two serious problems in connection with energy consumption. There are high rate of environmental degradation and high price of petroleum that consumes large portion of the national income. Of the total energy consumption, 82.7% is derived from biomass while imported petroleum and electricity supply are account for only 4.3% and 13% of the requirement, respectively [10]. In rural areas where 85% of Ethiopian's population lives, 99.8% of the energy for cooking is obtained from biomass with kerosene accounting only 0.2% of the demand. Of the total biomass used for cooking, 75.5% is obtained from fuel wood, while 24.3% is from other biomass (such as agricultural residues, animal dung, etc) [11]. Over dependence, in such a way, on biomass as energy source has a negative consequence, which resulted in the massive deforestation in the country that is already aggravated by the rapid increase in population in one hand and has health and other socio-economic problem on the other hand.

Generally, rural communities have for centuries relied solely on traditional biomass energy sources. The basic stock of traditional biomass energy sources dwindling fast for two reasons; first, due to rapid population growth and second, due to the absence of energy substitutes for traditional energy sources. Renewable energy technologies and other modern energy technologies are almost non-existent [11]. Thus, the application of new and renewable sources of energy through biotechnological techniques is now a major issue in the country.

The main objective of this study is to identify and evaluate the degree of the economic impact of the petroleum price on the national income and to recommend problem solving methods for the production of an alternative energy source. Currently, biomass derived energy covers about 13% of the world's energy demand [12]. Of the different forms of biomass derived energy sources, bioethanol and biodiesel are the two liquid biofuels commonly used as energy sources partially replacing petroleum derived liquid fuels [8]. Biodiesel from non-edible vegetable oils through the application of modern technology is highly recommended and such oil source plants can serve for rehabilitation of degraded land. The outcome of this research may provide basic information for policy-makers, entrepreneurs, industrial sectors, researchers and the society as a whole and thereby help to facilitate biofuel production from the available resources. With regard to policy-makers, this finding provides a range of available policy options that could be considered to adopt in Ethiopia context to support the bio-ethanol development. The information contained in the study provides important data to industrial sectors and create opportunities for production in the future. So, this study tries to indicate implications associated with biofuel expanded production. The study can also serve as a platform to provide basic information on the biofuel development to make further research on areas of data insufficiency. In summary, this is significantly important to reduce the impact of petroleum on the country economy.

MATERIALS AND METHODS

National expenses of petroleum (diesel oil, kerosene and gasoline) was analyzed by using data collected from the concerned institutions (Ethiopian National Bank and Ethiopian Petroleum Enterprise) in order to evaluate the economic impact of petroleum on national economy. The volume and value of imported petroleum from 1998/99 to 2009/10 fiscal year was collected and analyzed to determine the economic impact on the country. To address the influence of imported petroleum on the economy, the value of petroleum of each year was compared with the total value (money in Birr) obtained from exported goods in the country. Based on the experiences of some countries that are used biodiesel as an alternative energy source, efficiency of the diesel/ biodiesel and kerosene/biodiesel mixing for driving cars and cooking was analyzed and compared with that of using petroleum alone. Moreover, review of studies from Ethiopian National Bank and Ethiopian Petroleum Enterprise and other literatures found in different journal, reviews and other necessary materials were investigated. In brief, a literature review was conducted to investigate background information on the main issues surrounding biofuel in an international context and implications on production. During the formulation of the problem, secondary data was mainly collected from research papers, review papers, workshop papers, strategic documents, reports, proceedings, various web pages and books. The available or potential land resource for production of biofuel in the country under investigation was reviewed from Ministry of Agriculture and Ministry of Water and Energy reports. The data were entered and analyzed using Microsoft Office Excel 2007.

RESULT AND DISCUSSION

Ethiopia's Economic Structure and Indicators: Ethiopian's economic structure consists of *agriculture*, service and industry which accounts for 42.9, 45.2 and 12.4%, respectively (Table 1) [13]. The transport and communication economic activity accounts for 17.4% of the GDP in 2012/2013. In 2011/12, nearly 2.14 million metric tons of petroleum products worth Birr 36.7 million were imported into the country.Total value of petroleum product imports surged by 37.3% was mainly due to an increase in import bill of gass oil (59.8%), regular gasoline (49.4%) and fuel oil (54.2%). The total volume of petroleum imports increased by 12.6% solely due to higher volume of gas oil (24.3%) and regular gasoline (4.7%) despite marginal reduction in volume of fuel oil (4.3%) and jet fuel (2.7%) [14]. The value of petroleum imports account for 15.54% of the total import of the year in 2012 (where 36.7 billion Ethiopian Birr) (Table 2).

Trends in Petroleum Demand in Ethiopia: In the last eight years the amount of petroleum imported in Ethiopia was rapidly increasing (Fig. 1). Compared to the previous years the rate of increase was much higher in the last six years. One reason for the increase in demand is increased economic activity. In the last six years Ethiopia had double digit economic growth. However, the rate of increment of petroleum price in the last five years was much higher than the rate of volume of petroleum imported in the country. For example in the fiscal year 2007/08 the amount of petroleum the country imported was showed 16% increase from the previous year while in the same period expenditure on petroleum was increased by 71%. One of the major reasons for this disparity is the sharp increase in the price of petroleum in the international market in the last few years. Thus in the last seven years, the cost of petroleum import increased almost exponentially. Such high cost of petroleum import pose serious challenges to the country's developmental activities.

Main Forms of Petroleum Products in the Country: Ethiopia does not have a refinery of its own, it directly import refined petroleum products. The main petroleum products imported to the country are diesel, gasoline and kerosene which are used in the transport sector. In the 2007/08 budget year out of the total petroleum products the country imported three fuels (diesel, gasoline and kerosene) accounted for 1911385.7 metric ton (90%) of the volume and 15011117200.0 Birr (89.2%) of the cost. This was due high economic activity in construction of buildings, roads and high activity of industrial sectors. To transport materials necessary for such type of economical activities demand high amount of petroleum. Other petroleum products account 122376.3 (10%) in volume and 1817489526.46 Birr (10.80%) in value of total petroleum imported (Fig. 2).

Diesel: As shown in Fig. 3 between the budget years of 2000/01 to 2009/10 the amount of diesel cost was grown exponentially. The rate of increase was very high in the three years between 2005/06 to 2009/10 (Fig. 1). This period corresponded with the rapid increase in the price of petroleum products in the international market. But, the demand for petroleum has also sharply increased due to high economic activity in the country.

Table 1: Percentage distribution of GDP by major economical structure sectors

Sector	2003 (2010/11)	2004 (2011/12)	2005 (2012/13)
Agriculture	45.6	43.9	42.9
Industry	10.0	11.0	12.0
Service	44.4	45.1	45.0
Total	100	100	100

Source: MoFED, 2013; National Bank of Ethiopia Annual Bulletin, 2013

Table 2: Volume and value of petroleum imports in 2010/11 and 2011/12 (volume in MT and volume in '000 Birr)

	2010/11		2011/12		Percentage Change	
Products	Volume (A)	Value (B)	Volume (C)	Value (D)	C/A	D/B
Regular gasoline (MGR)	143878.8	1,743,315.0	150,619.1	2,604,584.2	4.7	49.4
Jet fuel	558,522.5	9,738,630.0	544,519.6	9,795,246.5	-2.7	0.6
Fuel oil	150,968.0	1,171,276.2	144.501.3	1,805,728.2	-4.3	54.2
Gas oil (ADO)	1,047,862.0	14,096,853.0	1,302,451.2	22,531,329.0	24.3	59.8
Total	1,902,232.0	26,750,074.0	2,142,091.2	36.736,887.0	12.6	37.3

Source: Ethiopian Petroleum Enterprise, 2013

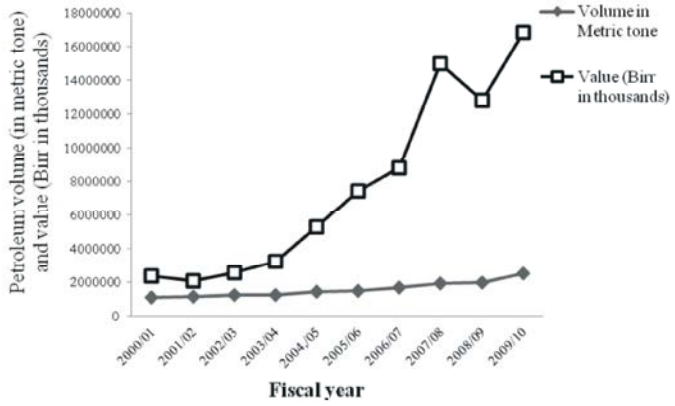

Fig. 1: Volume and value of imported petroleum from 200/01 to 2009/10 fiscal years (MT = metric ton): Calculated based on data obtained from Ethiopian Petroleum Enterprise and Ethiopian National Bank, 2012. One dollar is nearly exchanged by 16. 60 Birr in 2009/2010 fiscal year

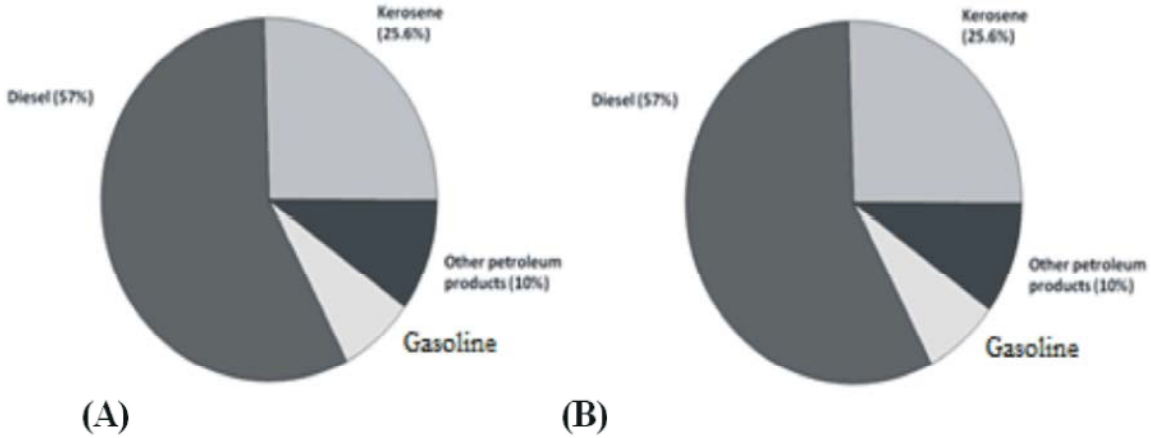

Fig. 2: Percentage share of different petroleum products imported based on the quantity (A) and price (B) of all petroleum products the country imported in 2007/2008 fiscal year: Calculated based on data obtained from Ethiopian Petroleum Enterprise, 2008

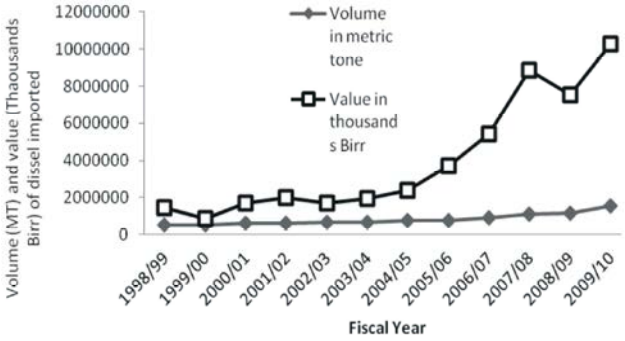

Fig. 3: Volume and value of imported diesel from 2000/01 to 2009/10 fiscal years (MT = metric ton): Calculated based on data obtained from Ethiopian Petroleum Enterprise and Ethiopian National Bank, 2012. One dollar is nearly exchanged by 16. 60 Birr in 2009/2010 fiscal year

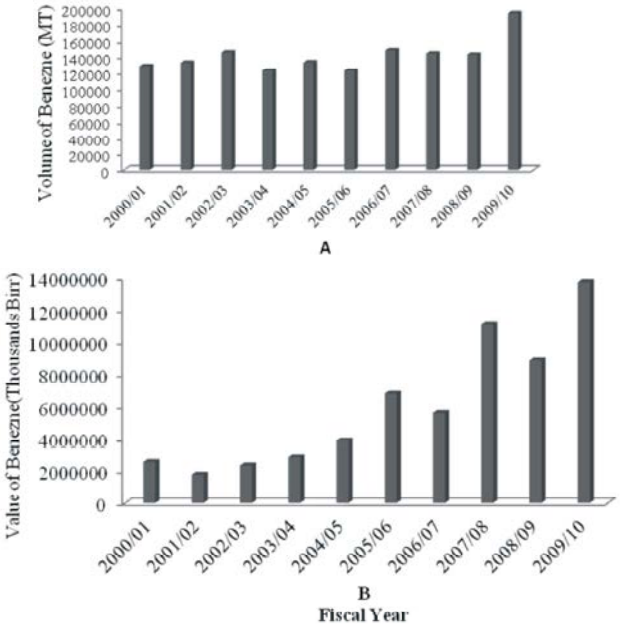

Fig. 4: Volume (A) and value (B) of imported gasoline from 2000/01 to 2009/10 fiscal years (MT = metric ton): Calculated based on data obtained from Ethiopian National Bank. One dollar is nearly exchanged by 16. 60 Birr in 2009/2010 fiscal year

Gasoline: It is the second fuel imported in Ethiopia is gasoline. Between 2000/01 to 2007/08 the amount of gasoline imported did not show any significant change (Fig. 4). Import of gasoline in 2007/08 was only 8% higher than the import of gasoline in 2000/01. When compared the percentage share of gasoline from the total petroleum import, it was decreased from 11.7% in 2000/01 to 7.4% in 2007/08. Similarly, in the same period, the percentage share of gasoline from the total import bill of petroleum was decreased from 14% in the 2000/01 budget year to 7.2% in the 2007/08 budget year. However, the cost of gasoline was increased by 245% between 2000/01 and 2006/07 budget years. The volume of gasoline import was increased by 34.3% in 2009/10 fiscal year than 2007/08 fiscal year and the value also increased by 23% in the same fiscal years.

The volume of gasoline was increased by 34.3% in 2009/10 fiscal year when compared with 2007/08 fiscal year. However, the price of gasoline was reduced by 25.6% in 2008/09 fiscal year compared with 2007/08 fiscal year. But the price of gasoline was increased by 22.9% in 2009/10 fiscal year in comparison with 2007/08 fiscal year. In 2008/09 fiscal year, the country was started to use 10% bioethanol mixed with gasoline. In summary, together with population increment, the number of small vehicles may also significantly increase and thereby the demand for gasoline could be expected to increase in the near future.

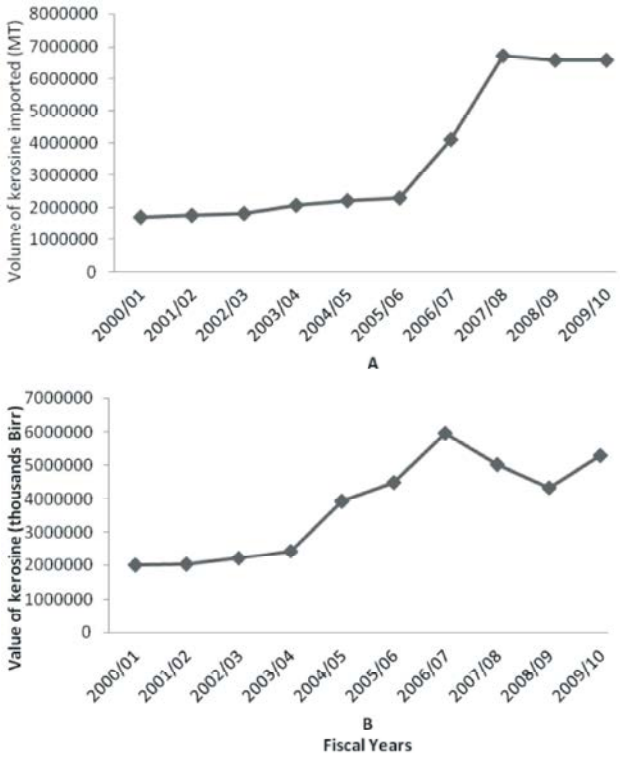

Fig. 5: Volume and value of imported kerosene from 2000/01 to 2007/08 fiscal years (MT = metric ton): Calculated based on data obtained from Ethiopian Petroleum Enterprise. One dollar is nearly exchanged by 16. 60 Birr in 2009/2010 fiscal year

Kerosene: Kerosene is the third fuel type the country imports in large quantities. For five consecutive budget years between 2000/01 and 2005/06 the import of kerosene was showed moderate increase both in total volume imported and total cost (Fig. 5). Thus, compared with 2000/01 the total volume of kerosene imported in 2005/06 was increased by 33.9% and also its cost increased by 21.6%. Between 2005/06 and 2007/08 the total volume of kerosene imported to the country increased exponentially. For example, the total kerosene imported to the country has increased by 180.9% compared to 2000/01 budget year and 109.8% compared to the 2005/06 import. Similarly, the total cost of kerosene import in 2007/08 has increased by 15 fold when compared with the 2000/01 budget year or 5 fold when compared with the 2005/06 budget year. The same trend of total volume of kerosene was imported from 2007/08 to 2009/10 fiscal years but the value of kerosene imported was reduced by 13.8% in 2008/9 fiscal year in comparison with that of 2007/08 fiscal year. However, the value of total kerosene was increased by 5.1% in 2009/10 fiscal year than 2007/08 fiscal year.

Between the 2000/01 and 2006/07 budget-years, 58 - 69% of the total kerosene was used for household cooking. In 2007/08 up to 83.3% of the total kerosene imported was used for household cooking. Thus in 2007/08 kerosene used for household cooking accounted for 83% of the total kerosene cost. Since import of kerosene accounted for 23.4% of the total petroleum import in 2007/08, kerosene used for household cooking accounted for 19.5% of the total cost of petroleum imported in 2007/08 (the data were not shown in the Fig. 5).

Continuous Increase in Demand: The quantity of petroleum consumption highly increased from year to year. For instance, the total quantity imported in 2007/08 fiscal year shows 111.2% increase as compared to the 1998/99 fiscal year (Fig. 1). The demand for modern energy sources such as petroleum fuels is increasing with increase in population (Fig. 6) and economic growth [15].

Share of Petroleum Import out of the Total National Export: In the 20 years period from 1984/85 to 2003/04 (with the exception of 1992/93) between 21.5 - 59.50% of Ethiopia's export earnings was used for the import of petroleum (Fig. 7). In 1992/93 import of petroleum consumed up to 83% of the country export earnings.

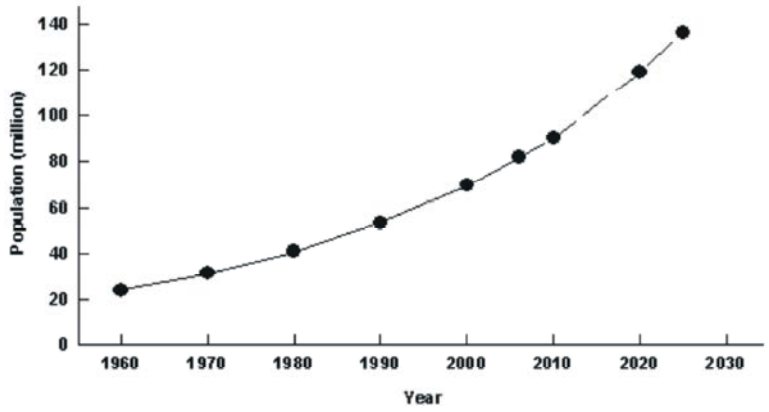

Fig. 6: The population growth (rate 2.7%) of Ethiopia (source; CSA Ethiopia, ORC Macro, [14]

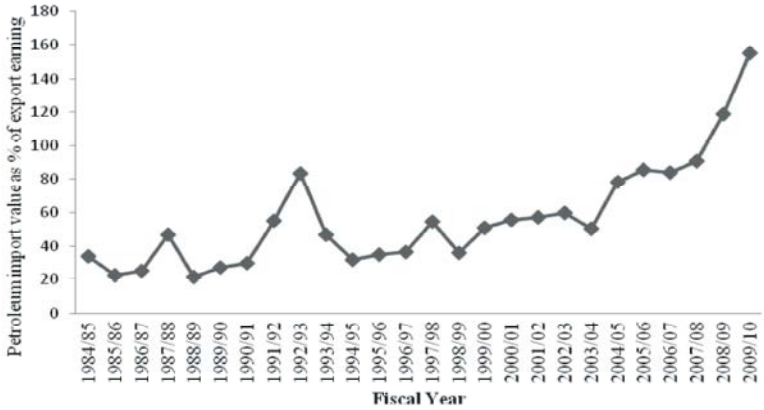

Fig. 7: Share of petroleum import out of the total national export, 1984/85 to 2009/10 fiscal years. Calculated based on data obtained from Ethiopian Petroleum Enterprise and Ethiopian National Bank

Starting from 2004/2005, however, the amount of money used to import petroleum was increased sharply in comparison with the amount of money obtained from country's export goods. Thus in the fiscal years 2004/05-2006/07, petroleum import accounted for 78, 86 and 84% of the country's export earnings, respectively. But in 2007/08, all the export earnings of the country was not sufficient to pay for the import of petroleum where petroleum import was 116% of the country's export earnings. This was the period where petroleum price reached its highest peak in the international market. Thus to import other vital commodities, such as machineries, spare parts, medicines, etc the country must obtain the required foreign currency through other means (such as loan, foreign aid, etc). This clearly showed the burden of petroleum import on the economic development of poor countries like Ethiopia. To lower the impact of petroleum import on economic development, it is important to invest on alternative energy sources as partial substitutes for imported petroleum. This could help to save substantial amount of money in foreign currency.

Economic Impact of Partial Replacement with Biofuels: As shown in Fig. 2, in 2007/08 import value of diesel and gasoline which are almost exclusively used in the transport sector accounted for 65.8%. In addition, in the same year, 16.7% of the kerosene imported was used for the transport sector. Thus, out of the total petroleum imported in 2007/08, 82.5% was used in the transport sector while about 6.7% was used for household cooking. The remaining 10.8% is accounted for light and heavy fuel oils used in furnaces and boilers.

Study has shown that up to 20% of the diesel and gasoline used in the transport sector can be replaced with biodiesel and bioethanol without major engine modification [17]. With engine modification, much more of the gasoline or diesel can be replaced by biofuels. Thus, for developing countries replacement of imported petroleum products by biofuels is expected to have significant economic benefits. Ethiopian imported volume and value of petroleum (2009/10 fiscal year) was taken to evaluate and investigate the effect of the impact of petroleum on the country's economy.

Table 3: Replacement of diesel and kerosene by biodiesel and gasoline by ethanol their comparison with that of percentage of total export value (in Birr) in 2005/06 fiscal year; Ethiopian National Bank, 2007

Total volume (*MT)	Total value (Birr in 1000)	Replacement (%)	Volume of replacement (MT)	Replacement Value (Birr in 1000)	Value * (Dollar in 1000)
Diesel		Replacement of diesel by biodiesel			
1568443.25	10254924	10	156844.325	1025492.9	61776.70
1568443.25	10254924	15	235266.49	1538238.6	92664.97
1568443.25	10254924	20	313688.65	2050986.8	123553.30
1568443.25	10254924	25	392110.81	2563731	154441.63
Kerosene		Replacement of kerosene by biodiesel			
734467.4	5296032	10	73446.74	529603.20	31903.81
734467.4	5296032	15	110170.11	794404.80	47855.71
734467.4	5296032	20	146893.48	1059206.40	63807.61
734467.4	5296032	25	183616.85	1324008.00	79759.52
Gasoline		Replacement of benzene by ethanol			
194066	1375397	10	19406.6	137539.70	8285.52
194066	1375397	15	29109.9	206309.55	12428.29
194066	1375397	20	38813.20	275079.4	16571.05
194066	1375397	25	48516.5	343849.25	20713.81

*One dollar is nearly exchanged by 16. 60 Birr in 2005/06 fiscal year. * MT = metric ton

Partial replacement of diesel and kerosene by biodiesel and gasoline by bioethanol is shown on Table 3. If the country is able to produce biodiesel and substituted for petroleum (diesel and kerosene) and gasoline by bioethanol, it can save some part of the expense used for importation of petroleum. For instance, let's take 2009/10 fiscal year petroleum expense as reference to show the role of biodiesel in the country's economy. If the total expense of imported diesel and kerosene are substituted by 10%, 15%, 20% and 25% biodiesel, the country can save 1.5×10^9, 2.3×10^9, 3.1×10^9 and 3.8×10^9 birr, respectively. On the same fiscal year, if the total expense for gasoline is substituted by 10%, 15%, 20% and 25% bioethanol, Ethiopia can save 1.3×10^7, 2.0×10^8, 2.7×10^8 and 3.4×10^9 birr, respectively. If Ethiopia substitutes 20% of diesel and kerosene by biodiesel and 20% of gasoline by bioethanol, it can save a total of 3.3 10^9 birr or 2.0×10^7 US dollar. If the country produces biodiesel and bioethanol especially from marginal lands, it can use these parts of the expense for different infrastructures, such as hospitals, schools, universities, road construction and so forth.

Ethiopian Land Source for Biofuel Production: According to Forum for Environment report [18] report, Ethiopia has a total land area of 1.12 million square kilometers with varied agro-climatic zones such as hot semi-arid lowlands, semitropical valleys and semi-arid highlands. Of the total available land area, 66% is potentially arable for crop production, only 14% of which is currently under cultivation [18]. According to Biofuels Development in Ethiopia [19] report, more than 23 million hectares of land are available for biofuel development. If Ethiopia has such huge land source for biofuel production, there would be good opportunity to produce large amount of biofuel to tackle problems encountered with high price of fossil oil in one hand and global warming on the other hand.

Apart from the land available for biofuel production, Ethiopia has enormous potential to produce biofuel from different biomass such as biodiesel from non-edible plant oil produced from *Jatropha curcas*, *Millettia ferruginea,* castor beans and other oil sources [20]. According to the document of Biofuel Development and Use Strategy (BDUS) drafted by Ministry of Energy three potential plants such as *Jatropha curcas,* castor bean and palm oil were given priority for biodiesel production with a lion's share of the focus on *Jatropha curcas* [21]. To make biodiesel production competitive and commercially attractive a sustainable supply of less expensive oil source is crucial. As a result, in many countries the use of non-edible vegetable oil for biodiesel production is becoming very popular. The use of non-edible oils avoids direct competition with food. In addition, plants bearing non-edible oil are considered capable of growing on marginal soil, land not suitable for food production [22]. As a result, there is no competition between the growth of non-edible oil producing plants and crops used for food production. Currently, the technology of biodiesel production from vegetable oil feedstock is clearly defined. A sustainable supply of less expensive oil will be a crucial factor for biodiesel to be competitive commercially [23].

Plantation of oil bearing plants on marginal land is not only important for production of biodiesel but also significant for reduction of environmental degradation.

To avoid the conflict of biodiesel production with food production, China banned the use of grain-based feedstocks for biofuel production and focus only on perennial crops grown on marginal land. To alleviate such problem, the country chose *Jatropha curcas* potential biodiesel feedstock because of its adaptability to the diverse growing conditions [24]. Apart from other advantages, after harvesting, oil extraction and separation is a less capital-intensive process. The maintenance and operational costs for extraction of oil are minimal and approximately account for 10 - 15% of the capital cost. This implies that *Jatropha* oil could be the best candidate for biodiesel as alternative energy source for cooking and transport sector [25]. Pure filtered *Jatropha* oil can be used directly in modified diesel engines. Therefore, *Jatropha curcas* could be one of the best biodiesel sources for Ethiopia.

After three years of cultivation, *Jatropha* seeds have an oil yield between 1 to 4 tons per hectare [25]. A hectare of *Jatropha* plantation is reported to produce 2.5-3.5 tons of seeds in the third year and increases sharply up to 5.0 to 12.0 tons per hectare from sixth year onwards [26] with oil content of 35.15 % [27]. After six years of plantation, one hectare of land can produce between 1.76 to 4.22 tons of oil. Out of 23.3 million hectares of land available in Ethiopia [28], if 10 million hectares of land is used for biodiesel production, there would be 17600000 (1.76 x 10,000,000) to 42200000 (4.22 x 10.000, 000) tons of oil after six years of plantation. The maximum biodiesel yield obtained from the pre-treated *Jatropha curcas* oil (non edible oil) was 87 % [29]. Based on the above data, it is possible to produce from 15312000 to 36714000 ton of oil per hectare. One litter or kg biodiesel of *Jatropha* price was 1.21 USA Dollar [25] which was nearly competitor with the price of one litter of diesel.

Ethiopia has also another potential area for production of bioethanol. Currently, it has 960,000 hectares of irrigable land. Out of this area, 700,000 hectares is identified as suitable for sugarcane plantation which can potentially able to produce more than 1 billion liters of bioethanol per year [30]. Nowadays, there are three large-scale sugar establishments; two of them in the Awash Basin (Wonji/shewa and Metehara) and one (Fincha) in the Blue Nile Basin. The total sugar and molasses productions from three-sugar estates are about 261,041 and 87,257 tons per annum, respectively [30]. If 23,769 hectares of land produce 87,257 tons of molasses, it is possible to produce 2.5 x 10^6 tons molasses from 7 x 10^5 ha of land. From this data, one can conclude that there is huge potential to produce bioethanol from molasses produced during sugar production process. However, the total area developed for the production of sugar cane in the country is only about 8% of the total identified suitable areas.

Potential agro-ecological characteristics of Ethiopia can support most biofuel crops. Particularly lowlands consist of many of the river basins which are suitable for various large scale agricultural commercial productions, irrigation schemes and hydropower dams. Future large scale bioethanol and biodiesel producing commercial farms could be located. To implement such commercial activities, investment incentives, appropriate energy policy, basic information and promotion activities are significant [31]. Diversification of energy in such a way helps to avoid oil price shocks, inflation, exchange rate problems and debt levels [32]. Bioethanol from sugarcane is the best choice for countries having huge capacity sugarcane production at reasonable cost without adverse environmental and social impacts [33]. The biofuels cost in comparison with the actual blends at global level is reasonable and fair. So, the overall outcome of this study will have huge economic benefits, in terms of external balance, environmental benefits, income for farmers and employment. Moreover, biodiesel production from *Jatropha curcas*, *Millettia ferruginea* and castor beans using marginal land and bioethanol from molasses have no impact on food prices and no competition between the land used to food production. Generally, the climate and soil types in the country are favorable for the growth and productivity of biofuels [34].

Cost of Bioethanol Production and Retail Price: As an attempt to secure increasing energy demands and reduce the foreign currency burden, the government has been undertaking measures to use biofuels; namely using *Jatropha* as a main feedstock for biodiesel and sugarcane for bio-ethanol. *Jatropha* plantation is started in different part of the country but the production and use of biodiesel as a blend with diesel and kerosene has not materialized.

The feedstock for production of bio-ethanol is molasses from sugarcane. Sugarcane grows in Ethiopia for production of sugar and molasses as by-product, the latter is used for bio-ethanol production (Table 4) [35]. According to the Ministry of Water and Energy report [36], out of the total (14,519,000 liter) bioethanol, which has been produced from molasses, 7.900,000 liter has been

Table 4: Ethiopian Sugar Corporation product type, annual production and product price

Product Types	Unit of measurement	Average annual production
Sugar	Quintal	3,000,000
Molasses	Quintal	739,750
Bioethanol	liter	14,519,000
Bioethanol blended with gasoline	liter	7,900,000
Cost analysis	Unit of measurement	Price
Bioethanol production cost	Birr	12.13
Bioethanol retail price per liter	Birr	16.78
Gasoline retail price per liter	Birr	19.80
Savings potential of Bioethanol (19.8-16.78)	Birr	3.02
Total saving potential of ethanol (7.9 million)	Birr (3.02 x 7.9 million)	23,858,000

Source: MoWE, 2013; Ethiopian Sugar Corporation (http://www.etsugar.gov.et/en/, July 2013

blended with benzene and supplied to local markets during the past 11 months. Metehara and Fincha sugar factories are the two plants engaged in ethanol production, while Nile, Oil Libya and National Oil Company Plc (NOC) are the companies engaged in the blending business. Nearly 38.54 million liters of ethanol has been blended with benzene since the beginning of the blending four years ago, thereby enabling the country to save 30.2 million US dollars [36]. According to Takle [37], bioethanol production and use in Ethiopia creates a market for excess molasses generated as a by product from sugar factories. It also improves trade balances by providing foreign currency savings. Since the retail cost of bioethanol is much less than the gasoline price, the savings potential by using bioethanol is rather high. Bioethanol production cost was 12.13 birr per litter, while its retail price was 16.79 birr per litter (Table 4). Therefore, the savings potential of bioethanol was 3.03 birr per litter. Apart from its saving capacity of dollars used to import gasoline, it provides energy diversification and supports the effort to improve the energy security of the country and creates job opportunities for the society. Job creation is one of an external social benefit that provides direct advantage during domestic bioethanol development [37]. It is possible to take Brazil as best example for production of bioethanol from sugarcane. In Brazil, bioethanol production was able to employee more than 1 million unskilled workers. Large category of the workers are also women and from rural areas [38]. In addition to income generation by creating job, bioethanol domestic production offers opportunities for better livelihoods [37].

CONCLUSION

The adverse economic impact of higher oil prices on oil-importing developing countries, like Ethiopia, is generally more than developed countries. This is because their economies are more dependent on imported oil and more energy-intensive. As the result, inflation would rise unexpectedly and unemployment would also increase. To solve this problem, use of alternative energy sources is highly recommended to reduce the amount of imported petroleum. In this case, bioethanol and biodiesel together can provide the quality of multiple energy services: cooking fuel, heat, electricity and transportation fuels. Thus, they may help to reduce the amount of currency expenditure for the imported petroleum and address environmental problems on the other hand. The biofuels, in general, have economic significant in order to generate income for farmers and also create job opportunity for the society thereby contributes a lot for economic development of the developing countries. We have to pay attention that plants used for biofuel production should not be compete with crops used for food production.

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