

# Contribution of Bioenergy Production to Household Income and Food Supply in Ethiopia

Hundessa Adugna Yadeta<sup>1,\*</sup>, Gemechu Kaba Sori<sup>2</sup>, Alemtsehay Eyasu Ferede<sup>1</sup>

<sup>1</sup>Central Ethiopia Environment and Forest Research Center, Ethiopian Environment and Forest Research Institute, Addis Ababa, Ethiopia

<sup>2</sup>Forest Products Innovation, Research and Training Center, Ethiopian Environment and Forest Research Institute, Addis Ababa, Ethiopia

## Email address:

hundessaa@gmail.com (H. A. Yadeta), gkabaa17@gmail.com (G. K. Sori), kalebe\_alem@yahoo.com (A. E. Ferede)

\*Corresponding author

## To cite this article:

Hundessa Adugna Yadeta, Gemechu Kaba Sori, Alemtsehay Eyasu Ferede. Contribution of Bioenergy Production to Household Income and Food Supply in Ethiopia. *American Journal of Modern Energy*. Vol. 7, No. 1, 2021, pp. 1-6. doi: 10.11648/j.ajme.20210701.11

**Received:** January 12, 2021; **Accepted:** January 26, 2021; **Published:** February 23, 2021

---

**Abstract:** Energy influences the livelihood of human beings in different aspects like food security, agricultural production, health care system, education, employment and sustainability of the environment. Ethiopia faces big challenge in both supply and access to energy in which majority of its rural population live without access to energy. Production of bioenergy is a good opportunity to get access to modern energy in developing countries like Ethiopia where traditional biomass energy is the dominant source of energy. In addition to creation of employment and being source of energy, bioenergy production has multiple advantages in agriculture and food security sector since the bio-slurry is used as organic fertilizer. The study shows that bioenergy production increased the income and thereby increased access to food for the rural households in Ethiopia. This resulted in food security as both quantity and quality of food increases along with the expansion of bioenergy production in the rural community. The result also shows that the increase in household income was from savings resulted in less purchase of other energy sources (kerosene, charcoal, firewood, etc.), increase in agricultural productivity using bio-slurry, and increase in employment in bioenergy sector. Having production potential, it needs to expand bioenergy production to ensure energy and food security in the rural population.

**Keywords:** Bioenergy, Food Security, Agricultural Productivity, Income, Biogas

---

## 1. Introduction

Energy is one of the important elements in economic development through its requirement to improve the livelihood [1]. It is linked with poverty reduction, education, food security, and public health, which is part of sustainable development [2, 3]. Energy has positive impact on livelihood by increasing provisions like water, agricultural productivity, health facility, education, employment and environmental protection [4]. As a result, access to sustainable, affordable, and dependable sources of energy is essential in alleviation of many global development challenges including poverty, inequality, climate change, food insecurity, and problems of access to health facility and school [5].

Introduction of bioenergy (biofuels in particular) enables access to modern energy sources, reducing the factors affecting climate change. However, the expansion of market for

bioenergy requires changes in food production, storage and distribution system [6]. Bioenergy production has positive impact on rural development and agricultural productivity. It can also increase employment and income for the rural communities, in addition to being source of energy [7]. Studies estimate that the job creation potential in bioenergy is higher than other energy sources, but it entails lower investment costs per unit of job generated [8].

Bioenergy has impact on food security through changes in incomes and food prices [7, 9]. Studies stated that the energy sector has impact on income, health, education, gender and the environment linkages and thereby poverty reduction [1]. Income influences both the quantity and quality of food purchased by households [7, 9, 10]. There are limited studies in Ethiopia on the contribution of bioenergy production on income changes and food supply. Therefore, the study was conducted to analyze the contribution of bioenergy production on income and food supply in rural communities of Ethiopia.

We used secondary data from different national data sets including data from National Biogas program of Ethiopia, Ministry of Environment, Forest and Climate Change and other relevant data. In addition, we reviewed all available support the data used in this study and identify the contribution bioenergy production in improving household income and its implication on food security.

## 2. Current Status of Ethiopian Energy Sector

Ethiopia is among the densely populated African countries with estimated population of about 108,000,000 based on the latest UN estimate [11]. The country is vulnerable to poverty

due to its dependence on rain-fed agriculture and livestock production. The country also faces different development challenges [12].

Ethiopia is endowed with good topography, suitable for the existence of abundant renewable and sustainable energy including high potential of geothermal energy, solar and wind power potential [13]. It is regarded as the water tower of Africa, with several large rivers draining its highlands. The approximated potential for hydropower is about 45 GW, wind is 10GW, geothermal is 5GW, and solar irradiation ranges from 4.5 kWh/m<sup>2</sup>/day to 7.5 kWh/m<sup>2</sup>/day. The final energy consumption of Ethiopia is estimated 40,000GWh; of which about 92% is consumed by domestic appliances, 4% is consumed by transport sector, 3% by industrial sectors and about 1% by others [14].

**Table 1.** Energy production capacities per different energy sources in 2014.

Sources	Energy production capacity [kWh]	Energy production capacity (%)	Energy production capacity per capita [kWh/capita]
Hydroelectric power	20.97 x 10 <sup>9</sup>	86%	199.83
Renewable energy (biomass, solar, wind)	2.7 x 10 <sup>9</sup>	11%	25.56
Fossil fuels	0.7 x 10 <sup>9</sup>	3%	6.97
Total	24.39 x 10 <sup>9</sup>	100%	232.36

Source: [11]

Having all these abundance of potential energy sources more than eighty percent of Ethiopian rural population has no access to modern energy. Like most sub-Saharan African countries, Ethiopia's energy sector is highly dependent on biomass energy (i.e., firewood, crop residues, and dung) for cooking and heating, which accounts for 91% of energy consumed [15-18]. This has resulted in the overexploitation and depletion of forest resources in the country [19]. This has resulted in shortage of fuel wood. Rural households meet their energy requirements by using cattle dung and/or crop residues. This in turn resulted in the reduction of soil fertility and thereby reduction in agricultural production [20], in addition to its contribution to climate change.

## 3. Bioenergy, Income and Food Security: Definitions and Linkages

FAO defines bioenergy as energy derived from biofuels (solid, liquid fuels and gaseous fuels) [21]. It is produced from sugar cane, beet, corn, energy grass or from fuel wood, agricultural residues and by-products, forestry residues, livestock manure and other sources. Bioenergy production enhances energy security and access by reducing the dependence on fossil fuels and providing a localized solution for the poor countries. In addition, bioenergy sector creates a new market for producers. Bioenergy production has advantage in reduction of greenhouse gas emissions and environmental sustainability.

Improvement in household income is directly related to positive changes in sources of revenues (e.g., through improvement in yield, quality and price) while minimizing all costs related to production and other payments [22]. About half of the Ethiopia population are below the poverty

line in 2015. The existence of wide spread poverty is one of the factors leading the rural population to depend on traditional and inefficient use of biomass energy sources [22]. Using bioenergy is one of the best solutions to the above problem as it increases access to better energy, improvement in household income, access to improved food, and all other human needs. This will be useful in changing the livelihood of people living in developing countries including Ethiopia [21]. Higher income leads to improved nutrition, clothing, better educational facilities, better health care system, low illiteracy rates, and viable social and political institutions [22]. Therefore, income level is regarded as better indicator of the status of people in their social, political, and cultural participation.

Food security exists when there is guaranteed and timely access to safe and nutritionally balanced, enough food through own production and/ or purchase from market [23]. In addition, when all people 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 in all the time, we can say that there is food security [21]. FAO outlined the four major dimensions of food security as availability, access, stability and utilization [21]. The development and expansion of bioenergy sector has positive or negative effects on the above four dimensions of food security in its environmental and socio-economic contributions [1]. For example, bioenergy production has positive impact on people's access to food through creation of new jobs and generation of income associated with its production. In other words, the bioenergy production may have negative impacts on the productive capacity of land or water availability and quality, if no properly practiced, creating negative repercussions on food security [9].

#### 4. Bioenergy Production and Agricultural Productivity

Accounting about 44% to GDP, agricultural sector is a major contributor to the Ethiopian economy. It is also having lion's share contribution in reducing poverty and creating food security [24, 25]. Even though, about most of rural population in Ethiopia are employed in Agricultural sector most of the people are poor because agriculture is not profitable due to lack means of production that enhance productivity [16, 24]. As a result, the government of Ethiopia has planned to improve the productivity and profitability in agricultural sector to meet the current needs created along with the increase in the country's population. Currently, all costs associated with food security are increasing at alarming rate, resulting in higher food price in Ethiopia than other African countries and the rest of the World [24]. There is government intervention to stabilize the existing market in terms of subsidies, but it brings inefficient and unsustainable result. This is because the market stability can be guaranteed when people have higher purchasing power that can resist the existing situation. Giving emphasis to bioenergy sector to the rural community will have positive contribution on agricultural productivity and household income, creating more jobs and rising their level of food security [4].

The importance of increasing production and productivity in agriculture sector in developing countries of Africa is very important since large part of their population resided in rural areas where poverty is very severe. It is also important to boost the agricultural productivity since it is the major contributor to GDP. To realize this, farmers, need to have access to finance, agricultural inputs (fertilizers, improved seeds, insecticide, herbicide, and different agricultural chemicals), stable market with minimal transaction costs, and efficient agricultural extension services. In addition, the continuous dependency on traditional biomass energy has negative effect in agricultural productivity. This is because in the absence of wood-fuel, there will be a use to crop residues and animal wastes as energy source instead of using it in farms, where they supplement soil nutrition, to provide energy needs [26]. Therefore, using sustainable access to energy sources like bioenergy will improve the agricultural productivity and livelihood of rural community [4].

#### 5. Benefits of Bioenergy Production in Ethiopia

Bioenergy has positive contribution to the rural community in getting access to energy and improving gender equity. It provides environmental and socioeconomic benefits for the society as a whole as well as for the involved farmers [27]. Introduction and expansion of Bioenergy technology to the rural community crates job opportunities for both skilled and unskilled rural labors. It opens employment opportunities for masons, plumbers, civil engineers, and agronomists in well-organized biogas development sector, in installations,

design and production of appliances, and construction equipment's areas [28, 29]. As compared to the use of imported fossil fuels, biogas production requires much more employment places to collect and transport raw materials, in equipment manufacturing, in construction, training, operation and maintenance [29]. Furthermore, organic fertilizer (bio slurry) is one of the outputs in biogas production used to enhance farm productivity and food security [30].

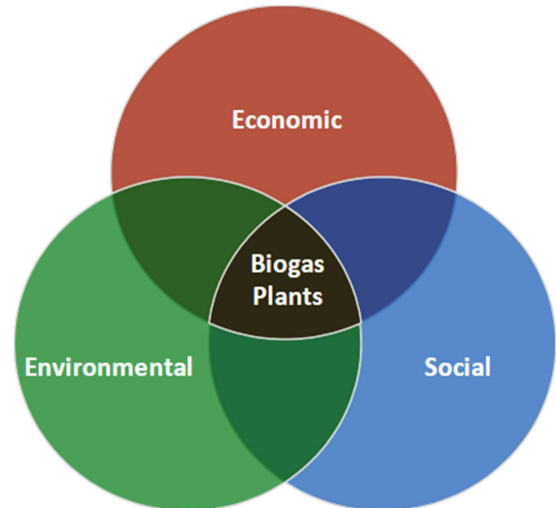


Figure 1. Benefit of household from installed biogas in Ethiopia.

##### 5.1. Masons' Income

Increase in the masons' income is one among the benefits of production and expansion of biogas [31, 4]. The table below shows that before starting biogas installation the monthly income of masons was 300-500 birr. However, their monthly income was increased to 1,300-6,000 birr after starting installation of biogas plant. This indicates that employment in bioenergy sector increases the income of those participating in this sector.

Table 2. Masons' income before and after starting installation of biogas plant (biogas digester).

Masons code	No. of digesters	Income (ETB)/month	
		Before biogas	After biogas
1	30	300.00	6000.00
2	20	300.00	4000.00
3	12	300.00	2400.00
4	7	300.00	1300.00
5	5	500.00	1335.00
6	7	400.00-500.00	2273.00
7	7	400.00-500.00	2273.00
8	15	2500.00	4376.00

Source: [4]

##### 5.2. Income Saving from Purchasing Expenditure

The economic roles of biogas production are savings from expenditures to be made for other fuel sources; time saved from participating other income generating activities; increase soil fertility from using bio-slurry, crop residues and cattle dung; and reduces the required quantity of chemical

fertilizer replaced by the use of bio-slurry [32]. Expenditure on firewood and charcoal for biogas users in Ethiopia reduced by 45% and 51%, respectively compared to the non-users [33].

**Table 3.** Income (Birr) saving due to installed biogas.

No	Types of resource/ source of savings	Amount in Birr
1	Saving from purchasing Firewood	1500
2	Saving from purchasing Charcoal	3600
3	Saving from purchasing Kerosene	4050
4	Saving from Electricity	2400
5	Saving from purchasing chemical fertilizer	718
6	Selling organic fertilizer	300
7	Saving from increased crop yield	2717
	Total	15285

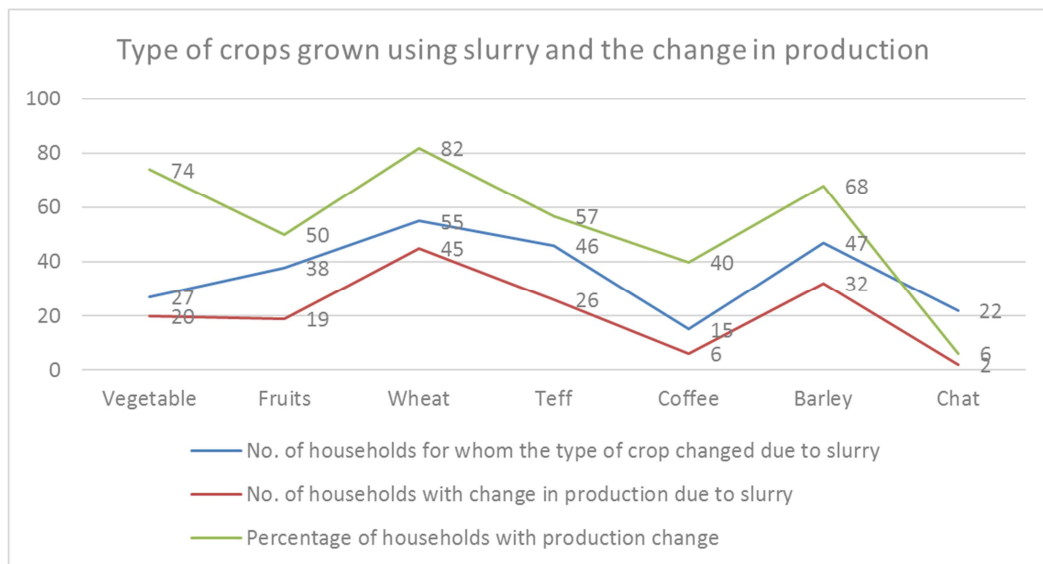
Source: Computation using data from [34, 28].

Different studies also stated that the biogas users save their expenditure about Birr 15285 annually from saving of purchasing firewood, charcoal, Kerosene, Electricity, chemical fertilizer, and selling of bio-slurry and increased crop yield.

In addition, findings indicated that biogas users have reduced their use of fertilizer by half (50%) [28]. At national level, the average savings from cost of chemical fertilizers was reduced by 35 percent. This figure is because of the increase in the price of fertilizers over the year and reduction in the use by owners of biogas plant [35].

### 5.3. Income from Increased Crop Yield

In addition to the use of biogas production for cooking and lightening the mechanization process produces the bio-slurry from the digestion of organic materials used in the production process. Bio-slurry consisted a mix of digested material and water. It has high concentration of minerals and soil nutrients like nitrogen, phosphorus, potassium and magnesium, having ability to improve crop yield by 10% to 50% or more, compared to compost. This directly affects food security status of beneficiaries and the community in general as it leads to increase in crop yield and higher incomes.



Source: computed based on the data [35]

**Figure 2.** Type of crops grown using slurry and the change in production.

Studies indicated that biogas production has a positive effect on crop productivity for households using the bio-slurry as fertilizer. Many households use the bio-slurry in production of maize and garden vegetables including onions, tomatoes, peppers and potatoes [36, 35]. After applying bio-slurry to their farms they observed the yield increase in different crops. These changes range from increase in wheat production by 64% to barley production by 72% [37]. Studies also indicated that application of bio-slurry in the crop production changes in their crop productivity by an average of 54% for all crops in general, 82% for wheat, 74% for vegetables; 68% for Barley, 57% for Teff, 40% for Coffee and lower results (6%) for growing chat [35].

## 6. Conclusions

The presence of large numbers of livestock resources indicates that there is high potential for biogas production in Ethiopia. Regardless of this high biogas potential, the actual production currently is minimal, limited to some pilot woredas in four regional states of the country. The production of biogas from organic waste has a direct contribution on agricultural productivity (mainly crops). This has significant contribution on food security since the bio-slurry is used to produce the crops used as staple food basket in Ethiopia. Biogas production also played major role in increasing household income in all processes of production, leading to security in

food production and energy use. Therefore, using the existing high bioenergy production potential as a good opportunity, there needs to increase the awareness of the rural community and expand the establishment of bioenergy sector. This has multiple effect on access to energy and thereby increase in household income and agricultural productivity in Ethiopia.

## Acknowledgements

Most of the information in this publication is based on the secondary data collected from different sources. The authors are very grateful to all the technical and supporting staff members of the Ethiopian Environment and Forest Research Institute and all other government and non-government institutions, which facilitated us with access to national data. We would like to gratefully acknowledge and express our warm appreciation to Mr. Berhane Kidane the former Forest Resource Utilization directorate director, Global Bio Energy Partnership (GBEP) coordinator and currently Senior Researcher at Central Ethiopia Forestry Research Center for his initiation and strong support to prepare this article.

## References

- [1] Sayin C., Mencet M. N., Ozkan B., 2005. Assessing of energy policies based on Turkish agriculture: current status and some implications. *Energy Policy* 33, 2361–73.
- [2] Thiam, R. (2011). Renewable energy, poverty alleviation and developing nations: Evidence from Senegal. *Journal of Energy in Southern Africa*, 22: 23-34.
- [3] Mainali, B., Pachauri, S., Rao, N., and Silveira, S. (2014). Assessing rural energy sustainability in developing countries. *Energy for Sustainable Development*, 19: 15-28.
- [4] Yitayal Addis. (2015). Status and benefits of renewable energy technologies in the rural areas of Ethiopia: A case study on improved cooking stoves and biogas technologies. *International Journal of Renewable Energy Development* 4 (2), 103- 111. <http://dx.doi.org/10.14710/ijred.4.2.103-111>.
- [5] Bazilian, M., Rogner, H., Howells, M., Hermann, S., Arent, D., Gielen, D., Steduto, P., Mueller, A., Komor, P., Tol, R., and Yumkella, K. (2011). Considering the energy, water and food nexus: Towards an integrated modelling approach. *Energy Policy*, 39: 7896-7906.
- [6] Achterbosch, T. J., G. W. Meijerink, M. A. Slingerland, and E. M. W. Smeets. 2013). Combining bioenergy production and food security. NL Agency.
- [7] Andre Faaij, (2008). Bioenergy and global food security. A paper prepared for the German Advisory Council on Global Change. Copernicus Institute Utrecht University, Berlin
- [8] Ackom, E. K., M. P. Brix, and J. Christensen. (2011). Bioenergy: The potential for rural development and poverty alleviation. Global Network on Energy for Sustainable Development (GNESD). Summary for policy-makers. GNESD-SPM-BET-11/2011.
- [9] FAO. (2012). Food and Agriculture Organization of the United Nations, Impacts of Bioenergy on Food Security. Guidance for Assessment and Response at National and Project Levels, Rome, Italy.
- [10] Matz, J. A., Kalkuhl, M. & Abegaz, G. A. (2015). The short-term impact of price shocks on food security-Evidence from urban and rural Ethiopia. *Food Sec.* 7, 657–679. <https://doi.org/10.1007/s12571-015-0467-4>.
- [11] United Nations Environment Programme. (2019). Global Bioenergy partnership indicators (GBEP) Sustainability of Biogas and Solid Biomass value Chains in Ethiopia. Technical report.
- [12] ECVP. (2020). Ethiopian Climate Vulnerability Profile. Accessed October, 2020. Available at: <https://www.climatelinks.org/resources/ethiopia-climate-vulnerability-profile>.
- [13] Guta, Dawit Diriba and Börner, Jan. (2015). Energy Security, Uncertainty, and Energy Resource Use Option in Ethiopia. A Sector Modelling Approach (July 2015). Available at SSRN: <https://ssrn.com/abstract=2637865> or <http://dx.doi.org/10.2139/ssrn.2637865>.
- [14] Mondal M. A. H., Bryan E., Ringler C., Rosegrant M. (2017). Ethiopian power sector development: renewable based universal electricity access and export strategies. *Renew Sustain Energy Rev* Nov., 75: pp. 11-20.
- [15] Guta F, Damte A, Rede TF, (2015). The residential demand for electricity in Ethiopia. *Environment for Development (EfD)*, 2015.
- [16] World Bank (2012). Gender equality and development. World development Report. Washington DC.
- [17] IEA. (2018). International Energy Agency. Accessed November 3, 2020. Available at: <https://www.iea.org/countries/ethiopia>.
- [18] Mekonnen D., Bryan E., Alemu T., Ringler C. (2015). Food versus fuel: examining tradeoffs in the allocation of biomass energy sources to domestic and productive uses in Ethiopia. *Agricultural and applied economics association*.
- [19] Jargstorf, B. (2004). Renewable Energy & Development. Deutsche Gesellschaft für Technische Zusammenarbeit and Ethiopian Rural Energy Development and Promotion Centre: Addis Ababa, Ethiopia.
- [20] Gebreegziabiher, Z. (2007). Household Fuel Consumption and Resource Use in Rural-Urban Ethiopia. PhD Dissertation, Department of Social Sciences, Wageningen University, Netherlands.
- [21] FAO. (2010). Bioenergy and Food Security, The BEFS Analytical Framework. Viale delle Terme di Caracalla - 00153 Rome, Italy. <http://www.fao.org>.
- [22] Abebe, D, Steven F. K, Alemu M. (2012). Coping with Fuel wood Scarcity: Household Responses in Rural Ethiopia. Discussion paper series on environment and development. EfD DP 12-01.
- [23] James C. Ogbonna, Nakao Nomura and Hideki Aoyagi. (2013). Bioenergy production and food security in Africa. *African Journal of Biotechnology*, Vol. 12 (52), pp. 7147-7157, 31, <http://dx.doi.org/10.5897/AJBX2013.13475>.
- [24] World Bank. (2009). Ethiopia diversifying the rural economy: An assessment of the investment climate for small and informal Enterprise. Report No. 49564-ET. Washington, D.C., USA.

- [25] Woldehanna, T. (2014). The Policy Environment for Linking Agriculture and Nutrition in Ethiopia. Agri Diet Working Paper 2, July, 2014.
- [26] ESD. (2000). Poverty reduction aspects of successful improved households' stoves programmes. Available online at <http://povertystoves.energyprojects.net>.
- [27] Erdogdu E., (2008). An expose of bioenergy and its potential and utilization in Turkey. Energy Policy 36, 2182-2190.
- [28] SNV. (2018). Report on National Biogas Users' Survey. National Biogas Programme of Ethiopia. Netherlands Development Organisation. Ministry of Water, Irrigation and Electricity. Addis Ababa.
- [29] Larisa Lovrencec, Sinergija. (2010). Highlights of socio-economic impacts from biogas in 28 target regions.
- [30] Loic Rakotojaona. (2013). Domestic Biogas Development in Developing Countries, A methodological guide for domestic biogas project holders in the early stages of setting up projects in developing countries. Belgium.
- [31] Gemechu Kaba, Hundessa Adugna and Alemtsehay Eyassu. (2019). Sustainability of Biogas and Solid Biomass value chains in Ethiopia, Results and recommendations from implementation of the Global Bioenergy Partnership Indicators, Change in income. Ethiopian Environment and Forest Research Institute, Addis Ababa, Ethiopia.
- [32] Mulu, G. (2016). Biogas Technology Adoption and Its Contributions to Rural Livelihood and Environment in Northern Ethiopia: The Case of Oflla and Mecha Woredas. A Thesis Submitted to Canter for Environment and Development Studies. Addis Ababa University. Addis Ababa.
- [33] Haftu, E. and Abel, O. (2016). Biogas as an alternative energy source and a waste management strategy in Northern Ethiopia. Biofuels 7 (5), 479-487, <http://dx.doi.org/10.1080/17597269.2016.11632>.
- [34] NBPE. (2018). Presentation of Report on National Biogas Program of Ethiopia. SNV Netherlands Development Organisation. Addis Ababa.
- [35] NBEP. (2015). Report on Biogas Users' Survey (BUS). National Biogas Programme of Ethiopia and Netherlands Development Organisation (SNV). Addis Ababa.
- [36] Hundessa Adugna, Gemechu Kaba and Alemtsehay Eyasu. (2019). Sustainability of Biogas and Solid Biomass Value Chains in Ethiopia, Results and recommendations from implementation of the Global Bioenergy Partnership Indicators, Price and supply of a national food basket. Ethiopian Environment and Forest Research Institute, Addis Ababa.
- [37] Fentaw Ejigu, Hailu Araya Sue Edwards. (2012). Bio-slurry as an organic input for improved agricultural production. Ecology & Farming, pp. 15-17, January 2012.