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Review

Role of biogas technology adoption in forest conservations: evidence from Ethiopia

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Abstract: Almost all developing countries satisfy their energy requirements from firewood. In Ethiopia majority of the rural population relies on biomass energy sources for every energy necessities. Fuelwood accounts for about 78 % of the total energy needs, whereas animal dung and crop residue share 12 % and nine percent, respectively. Almost all of the firewoods are collected from natural forests and few of them from homestead trees. Chronic drought, land degradation, and loss of soil fertility that are positively correlated with low livestock and crop productivity are extensions of deforestation for firewood. Heavy dependency on biomass fuel in Ethiopia has resulted in fast deforestation, desertification, climate change, global warming and finally decrease in agricultural productivity. Therefore the adoption of biogas technologies has great potentials to supply low-cost energy and results in less dependency on firewood. To improve such adverse socio-economic and ecological costs, interventions like improved biogas technologies, raising community awareness on deforestation, and utilization of alternative energy technologies are recommended to conserve natural forests.

Keywords: *biogas technology, conservation, Ethiopia, forest*

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Introduction

Fuelwood production was estimated to be 3.9 billion m^3 globally from which reached 2.3 billion m^3 was used as fuel wood (FAO, 2008). More than 43% of the world's population depends on firewood for cooking (Bonjour et al., 2013). Accordingly, about 60% of the world's forest removal is used for sources of energy, especially in developing countries. More than 64 % of the world's deforestation is happening in developing countries for their daily consumptions (Damte et al., 2012).

Nearly all African countries satisfy their energy requirements from firewood (Zenebe et al., 2010). Over 90% of the energy consumption in most Sub-Saharan Africa is generated from firewood (Idiata et al., 2013). In Ethiopia majority of the rural population relies on biomass energy sources for every energy necessities. Fuelwood accounts for about 78 % of the total energy needs, whereas animal dung and crop residue share 12 % and nine percent, respectively. Almost all of the firewoods are collected from natural forests and few of them from homestead trees.

In Ethiopia, fuelwood is mainly used for cooking, heating, and lighting in both rural and urban areas. Different studies confirm that utilization of firewood has negative environmental implications (Damte et al., 2012). Fuelwood is used as a supply of energy for more than 70% of the population in Africa (Matsika et al., 2013). According to Amankwah (2011), about 90 percent of fuelwood is collected from natural forests. This

high dependency on energy from fuelwood resulted in depletion of natural forest which compounds with the tricky impacts of climate change (Riti and Shu, 2016). On top of this, chronic drought, land degradation, and loss of soil fertility that are positively correlated with low livestock and crop productivity are extensions of deforestation for firewood (Bisu et al., 2016). Therefore, access to modern energy sources got due attention in Africa within a context of sustainable forest conservation and less dependency on natural resources for energy generation (Amare, 2014; Kamp and Bermúdez Forn, 2016).

In some African countries, fuelwood and charcoal are considered as a centre of business besides to power sources. About 76 to 80 percent of the total energy comes from conventional biomass fuels (Kebede et al., 2010). This percentage might be very high in east African countries where almost all households depend on biomass fuel (Gebreegziabher, 2007). According to the International Energy Agency (2014), solid biomass fuels goes for all rural households and 80 percent of urban households in Ethiopia.

Fuelwood has negative effects like forest depletion, carbon emissions, and hence air pollution contributing to climate change (Bluffstone et al., 2013). Theoretically, depending less on fuelwood utilization leads to forest conservations. Studies confirmed the impact of substitutes for fuelwood by the local community (Timko and Kozak, 2016), and the role of forestation on degraded lands to satisfy fuelwood demand (Gruenewald et al., 2007; Khamzina et al., 2012). Other researches assessed the impact of biogas technologies and reported the reduction of fuelwood demand and forest regeneration (Baylis et al., 2016).

Discussion

Biogas technologies have potentials to supply low-cost energy and results in less dependency on firewood (Arthur et al., 2011). Production of biogas from waste materials can lessen the use of fuelwoods from natural forests (Kumar et al., 2015), and hence encourages forest conservations. These technologies highly contribute to global carbon emission reductions and balance the natural climate. Biogas technologies can advance rural livelihoods by minimizing costs for energy and saving time from firewood collection (Agoramoorthy and Hsu, 2008).

According to Bisu et al. (2016), the dissemination of biogas technologies has been considered as one of the significant strategies for safe and sustainable energy supply in many African countries. Subsidizing biogas technology is also considered in Ethiopia (Kamp and Bermúdez Forn, 2016) to reduce deforestation which is tied with land degradation and loss of soil fertility (Mengistu et al., 2015). Consequently, the National Biogas Program (NBP) was practiced to assess the viability of biogas technologies in rural and urban settings. About fourteen thousand biogas technologies were disseminated in four regional states of the country. Ethiopia has a high potential for biogas production. Waste of livestock can be used for biogas production. In Ethiopia, the attempt of making biogas from cattle dung was started before 50 years ago. However, the development of biogas technology has remained very minimal.

Determinants of biogas technology adoption in Ethiopia

Biogas technologies have been installed in Burundi, Ethiopia, Ghana, Namibia, Nigeria, Rwanda, Zimbabwe and Uganda in recent years (Renwick et al., 2007) aiming to install more than two million biogas technologies by 2020 (Rupt et al., 2015).

Adoption of any technology in general and biogas technology, in particular, depends on various factors and varies from place to place. Adoption and dissemination of technologies can be determined by demographic, environmental, institutional setup, and related socioeconomic factors. Technology that is perceived to be more important than the other one is usually adopted earlier (Mengistu et al., 2015)

According to Mwirigi et al. (2014), technology users in rural areas where access to credit and income is low, users go for technologies with minimum cost and continue for a long period of time. The other studies also confirmed that subsidizing biogas technology encourages its adoption and facilitates forest conservation (Rajendran et al., 2012).

Costs of technology, income, land holding, livestock holding, water availability, access to credit facilities are directly determining the adoption rate of biogas technology (Smith, 2005). Availability of manure is also among the major determinants of biogas adoption in developing countries (Winrock International, 2007).

Additionally, education, perception, age and sex of household head were identified to be the determinants of adoption since they can affect once able to get information and assess the advantage of the technology in their livelihood. Education improves information possession talent leading to usage of new technologies (Vien, 2011). Consciousness about technology also plays a major role in technology adoption. Mwirigi et

al. (2014) reported that income is the other factor determining technology adoption to cover costs. Gender role can either directly or indirectly determine the adoption of technology. In Ethiopia, women have a vital role in energy utilization for cooking.

Firewood consumption and deforestation in Ethiopia

Approximately about 50% of the world's population used biomass fuels for cooking and heating. In sub-Saharan Africa, biomass is the central energy source implemented through three stone fire. About five percent of greenhouse gas emissions come from biomass burning in the world.

More than 85% of Ethiopian population lives in rural areas where agriculture remains the backbone of the economy (World Bank, 2010). Currently, over 93 million people in Ethiopia are using firewood as the main source of energy. Such intensive utilization of firewood from forests resulted in environmental disasters including deforestation over the past three decades. On the other hand, farmers spent more time and money on firewood collection and hence which reduces their productivity in agriculture putting them in vicious circle of poverty.

According to FAO (2010), about 11.2 percent of land was covered by forests in Ethiopia. But the country had lost over 2,818,000 hectares of its forest cover within 1990 and 2010. The population pressure in Ethiopia had exacerbated deforestation through fuelwood consumption and traditional agricultural expansion (Mekonnen and Kohlin, 2009). Rough estimations revealed that an additional 250 to 300 million hectares of new land is required in the next 25 years for commercial farming (Dessie and Kleman, 2007).

Firewood consumption has negative environmental, economic and health impacts. They primarily lead to deforestation. Ecological disturbances may happen due to charcoal production and consumption. It is a cause for air pollution due to indoor smokes in rural households (Geissler et al., 2013). Livestock dung, firewood and charcoal generate more than 90 percent of basic energy consumption in Ethiopia (Mekonnen and Kohlin, 2009). Gurmessa (2010) also reported that about 84 percent of urban dwellers and about 99 percent of rural households depend on biomass for cooking fuel. Surprisingly, both urban and rural households shifted from biomass utilization to wood and charcoal (Damte et al., 2012). According to Geissler et al. (2013), Ethiopia uses about 105,172,465 tons of biomass which directly comes from charcoal, tree branches and leaves. Consequently, charcoal consumption in the country jumped annually from 48,581 tons to 4,132,873 tons in 2000 to 2013 years.

Such heavy dependency on fuelwood, leads to carbon dioxide emission, environmental degradation, and deforestation and due attention must be given by the government.

From the following table, the household fuelwood consumption in Ethiopia is increasing at an increasing rate which can be used as an alarm for an environmental crisis like climate change. Ethiopia lost about 796,678,000 m^3 of wood from 2008 to 2017. This further implies that the country is missing on average about 79,667,800 m^3 per year.

Table 1. Household fuelwood consumption in Ethiopia.

Year	Thousand of m^3
2017	82,097
2016	82,190
2015	81,760
2014	80,962
2013	80,183
2012	79,429
2011	78,682
2010	77,944
2009	77,122
2008	76,309

Source: UN data, http://www.factfish.com/statistic.

Ethiopia has about 4.7% of the world share in fuelwood consumption. The following table compares Ethiopia's fuel consumption by households with different countries.

Table 2. Comparison of countries by fuelwood consumption.

Countries	Household fuelwood consumption (thousands of m^3) in 2016
Burma	43,629
Indonesia	175,129
Nepal	38,773
Nigeria	177,996
India	198,277
Ethiopia	**82,190**
Tanzania	47,025
Vetnam	52,823
United states	56,119

Source: UN data, UN data, http://www.factfish.com/statistic.

Ethiopia is one of the most biomass energy-dependent countries in the world sharing about

92% of total national energy consumption in 2010. Children and women are very vulnerable to firewood gathering, especially where biomass is scarce.

According to FAO (2000), about 1.86 billion m^3 of firewood in the world comes from forests converted to charcoal where about 28 percent of it is happening in Africa. Therefore, significant emission of greenhouse gases and forest degradation in developing countries is correlated with dependency on fuelwood as a major source of energy. On the other hand, rapid population growth and inflation were reported as the main drivers of deforestation (Arnold et al., 2003). Environmental harm from fuelwood collection is much worsened when many people rely on the few forested areas (Specht et al., 2015).

The monopolistic dependency on fuelwood in developing countries has led to loss of biodiversity, loss of soil fertility, desertification, and high Co_2 emission which is a direct cause for global warming and climate change (Ojonigu et al., 2010). In Ethiopia, more than 140,000 hectares of forests are lost per year mainly for firewood (FAO, 2010). This has a direct implication on climate change which further exacerbates food insecurity and poverty. Adoption of biogas technologies has the potential to reduce forest degradation and saves biodiversity. Other alternative sources of energy should be innovated and adopted. Thus it is very important to maintain and promote usage of renewable energy technologies like biogas to conserve natural forests in developing countries.

Conclusions and Recommendations

Fuelwood is being consumed in Ethiopia without tree planting. Deforestation due to firewood collection and agricultural expansion is the main headache for the government and related policy makers. Over utilization of firewood in the country is leading to a shortage in rural communities. This heavy dependency on biomass fuel has resulted in fast deforestation, desertification, climate change, global warming and finally decrease in agricultural productivity. To improve such adverse socio-economic and ecological costs, interventions like improved biogas technologies; community awareness on deforestation, and the utilization of alternative energy technologies are recommended to conserve natural forests.

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