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Determinants of Adoption of Renewable Energy Sources towards Reducing Deforestation in Ambo district, West Shoa, Oromia Regional State, Ethiopia

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Abstract
In rural Ethiopia, firewood and animal dung is the main source of energy which is factors to forest deforestation and degradation of land all severe environmental problems. However, Ethiopia has a vast potential of alternative renewable energy resources (like solar and biogas) that are still unutilized. The aim of study was to assess the determinants of adopting renewable energy sources for minimizing burden on biomass energy source at rural household level in the study area. In order to achieve objectives of the study; data were collected from 452 household heads randomly sampled using survey questionnaire (scheduled interview). In addition to this sample, key informants such as rural village leaders, development agents (government and non-governmental organizations), renewable energy source users and elder people were also sources of primary data using interview checklist and field observation were also done for triangulation of quantitative data. Collected survey data were analyzed by descriptive statistics and econometric model (probit model) using Stata and SPSS software. The statements from key informant interview were often used to substantiate the responses of questionnaire. The findings of the study confirmed that the probability of a household adopting renewable energy sources (biogas and solar) technology increases with decreasing age of head of household, increasing household income, increasing number of cattle owned, increasing size of farm land, increasing location of traditional fuels and while adoption decreases with increasing remoteness of household location from agricultural extension center, health extension center & market service. With respect to renewable energy source adopter households confirmed that more advantages in terms of contribution to reducing environmental pollution and minimize burden on biomass fuels, economical energy source, saves time of women & children and reduce smoke/ashes as compared to non-adopters. Based on the findings, it is recommended that development planers should be work at grass root level for scale up expansion of renewable energy sources. Since, the most bottle neck in expansion of renewable energy sources in the study area were fail to adopt because they fail to understand their immediate use and inadequate information. Finally, both governmental and non-governmental organizations must be encouraged, promoted, implemented, and demonstrated by full-scale plan especially for use in remote rural areas.
Keywords: Adoption, deforestation, determinants, households, renewable energy source

Introduction and Justification

Energy is one of the basic things needed to satisfy basic human needs. Thus, energy plays a pivotal role in socio-economic development by raising standard of living (Andadari *et al*., 2014; Mirza *et al.,* 2008; Reddy & Balachandra, 2006). Correspondingly, sustainable development recognizes the significance of key resources such as energy, water, forests and soils in helping to create the bases for human development needs in terms of human welfare and biophysical environmental supports (Guta, 2014; Osei, 1996). It is fact that energy plays an important role for development in terms of poverty reduction (Zulu and Richardson, 2013; Kanagawa & Nakata, 2007).

Similarly, household access to clean and affordable energy is critical for the realization of the Millennium Development Goals (MDGs) (Ibitoye, 2013; Ogola *et al.,* 2011) as well as vital to achieve sustainable development goals. However, in many developing countries, a large proportion of household energy requirements are met by use of non-commercial fuels includes wood, animal dung, crop residues, etc. so this traditional household energy sources associated health and environmental hazards. As a result use of modern fuels (like electricity, biogas, solar) for cooking in a reduction of in the overall fuel wood consumption is essential (Ibitoye, 2013). Similarly in rural Ethiopia in order to combat poverty and support the MDGs providing access to renewable energy sources is a crucial. Hence, household with access to clean energy sources expected benefits in health, work and education; enhances in the autonomy of children, flexibility, security, family life and the reduction of stress (Müggenburg, *et al*., 2012).

Firewood remains a key source of energy for households in developing countries, it results forest degradation and deforestation (Bhattarai, 2014; Edwards & Langpap, 2005) including Ethiopia. Moreover, wood fuels includes charcoal, animal dung, and crop residues are the most heavily used household source of energy in Sub-Saharan Africa like Ethiopia (Bhattarai, 2014; Beyene & Koch, 2013; Zulu & Richardson, 2013; Hanna *et*

al., 2012; Bailis *et al*., 2005). Consequently, heavy reliance on firewood consequences in a range of negative environmental impacts both at local and global level such as greenhouse emissions, deforestation, reduction of agricultural production (Gebreegziabher *et al.,* 2012; Gebreegziabher, 2007).

Similarly, in Ethiopia, 94% of households predominately dependent on traditional energy sources (firewood, crop residue, animal dung, charcoal and like) while only 6% of households with access to modern energy source use for the purpose of cooking food, boiling water and heating activities (JICA, 2010). Moreover, according to Breyer *et al.* (2009), nearly all of 80% of Ethiopians living in rural areas have no access to electricity. Implies that will continue destruction of forestry resources for firewood has resulted in environmental problems, loss of productivity and ecological imbalance (JICA, 2010). In similar fashion, recent study by Guta (2014) reveals that in Ethiopia biomass is predominantly utilized for household energy needs often using inefficient rudimentary stoves which cause adverse environmental and welfare effects.

Accordingly, deforestation and land degradation in Ethiopia is a critical problem. Resulting in massive environmental degradation and constituting a serious threat to sustainable forestry (Gwavuya *et al.,* 2012; Bishaw, 2001). Therefore to minimize these problems, adoption of clean fuels such utilization renewable energy sources could benefits contributing conservation of forests. As well as it could be a solutions for environmental problems since renewable energy resources appear to be the one of the most efficient and effective solutions (Gwavuya *et al.,* 2012; Dincer, 2000). Therefore, in order to mitigate the adverse impact of traditional energy sources (firewood, animal dung, crop residues) and minimize pressure on forests; a cost effective and environmentally friendly manner alternative renewable energy sources such as biogas, solar home system and others is vital (Coelho & Goldemberg, 2013).

Hence, alternative renewable energy sources are the new, renewable and non-conventional forms of energy technologies, which use local energy resources other than commercial fuels (petroleum products, gas, coal and so on) and biomass fuels in traditional forms primarily includes micro-hydropower (MHP), plants, biogas plants, solar energy system (Mahat, 2004; Gwavuya *et al.,* 2012). Moreover, renewable technologies are considered as clean sources of energy and optimal use of these resources minimize environmental impacts, produce minimum wastes and are sustainable based on current and future economic and social needs (Beyene and Koch, 2013; Javadi *et al*., 2013).

Problem Statement of the Study

Provision of renewable energy services is recognized as a critical foundation of sustainable development, and is central to the everyday lives of people in rural area (Nussbaumer *et al.*, 2012; Mulugetta, 2008). Hence, in the world 1.3 billion people do not have access to electricity and 2.7 billion people use primitive fuels mainly fuel wood for cooking and heating (Coelho & Goldemberg, 2013; Bhanot & Jha, 2012). Particularly, approximately 3 billion people do not have access to modern cooking fuels and technologies, the majority of them living in Sub-Saharan Africa (Kaygusuz, 2012; Bazilian, *et al.,* 2011; Zerriffi, 2011). Moreover, the number of people relying on the traditional use of biomass is projected to rise from 2.7 billion today to 2.8 billion in 2030 (Kaygusuz, 2012). As a result, this has clear impacts on social and economic development, adverse health consequences, and gender impacts (Bazilian *et al.,* 2011).

Deichmann *et al.* (2011) recommended that renewable energy source will likely play an important role in expanding rural energy access. Accelerating development in general in Sub-Saharan Africa, particularly in Ethiopia requires massive expansion of access to clean energy sources thus currently reaching only about one third of households. Thus, renewable energy is competitive mostly in remote and rural areas. Similarly, a recent study shows that in rural Ethiopia a cost-benefit analysis of clean fuel source on biogas plants yields positive net present values for households collecting their own energy sources (Beyene and Koch, 2013; Gwavuya *et al.*, 2012).

Similarly, Wolde-Ghiorgis (2002) and Gwavuya *et al.,* (2012) illustrates that renewable energy sources for rural development in Ethiopia will ensure energy initiatives for rural development meet the desired expectations. Moreover, Reddy *et al.* (2009) attest that provision of renewable energy services for cooking and lighting is an essential component of any policy aiming to address health, education or welfare issues. Since facilitate large-scale dissemination of renewable technologies like small scale biogas plants is clean, safe, reliable and sustainable energy to rural households. Because of firewood using is continuing declining access to supplies/ markets raise significant problems for user. As a result an appropriate form of intervention like renewable energy sources is fundamental to reduce reliance on biomass energy sources.

There are gaps that need to be filled in order to enrich the literature for example some studies on household energy consumption in Ethiopia were carried out by Bishaw (2001), Gebreegziabher *et al*. (2012), Beyene and Koch (2013) and Guta (2014). Four of them empirical findings conducted in Ethiopia. The first Bishaw (2001) carried out on deforestation and land degradation in the Ethiopian highlands a strategy for physical recovery. Although the study shown that a strategy for physical recovery of deforestation and land degradation, there are gaps that need to be filled in order to enrich the literature hence adoption of renewable

energy sources at household level is also a solution to address a problem. Similarly the second and third carried out in Ethiopia on energy transition and technology adoption and clean fuel-saving technology adoption in urban Ethiopia respectively. The two research evidence from households in major cities in Ethiopia implies that the results cannot be used as direct policy in rural development. The fourth study by Guta (2014) is relatively a recent and better study covers a variety of issues on effect of fuel wood scarcity and socio-economic factors on household bio-based energy use and energy substitution in rural Ethiopia but the results are not in harmony with the existing use in rural household energy consumption progress hence there is improvement in energy consumption such as access to electricity and renewable energy sources (biogas and solar technologies) for rural communities. Moreover, Ethiopia has rich in renewable energy resources that can play a significant role in meeting the energy needs of the country as well as in the development of rural areas but the exploitation of alternative renewable energy sources is still in its infancy stage because alternative renewable energy technologies are poorly integrated in development planning in energy issues.

In order to mitigate the adverse impact of pressure on forests, the Ethiopian government has devised a number of strategies. Of particular relevance to this research is the promotion of alternative modern fuels (Cooke *et al*., 2008). Although it is not clear that renewable energy sources will alleviate forest dependence but there is a strong evidence of significant potential health benefits for households that adopt renewable energy sources (Tekle, 2014; WHO, 2006).

In Ethiopia a number of development projects going on to reduce deforestation and forest degradation due to biomass energy consumption. However, there are challenges in how to address drivers of deforestation bearing rural communities depend on the natural resources base for their livelihoods. Provision of alternative renewable sources of energy could the way to reduce dependence on fuel wood based energy sources. Thus, most rural communities do not have access to modern energy sources like electricity, liquid petroleum gas and coal options. Therefore need to be conduct research on alternative renewable energy sources (biogas and solar technologies) in the context of adoption options in those biomass dependent communities in rural areas. As a result, a key information gap on this topic is how alternative renewable energy sources use was contribute to future reducing biomass energy sources in the study area.

Therefore, this research makes contributions to the literature. Thus, the available limited studies focus on rural areas. Since, the high dependence of rural household on biomass resources causes to environmental problems. For example, charcoal production is one of the main causes of deforestation in rural Ethiopia. Additionally, many of rural households with no adequate access to modern energy sources (kerosene, liquefied petroleum gas (LPG) and electricity), a substantial portion of the rural household will continue to rely on fuel wood and charcoal. Therefore, focusing on rural households is useful, from the viewpoint of protecting forest cover.

The main objective of the study was to assess the determinants of adopting renewable energy sources to reduce burden on biomass energy source at rural household level and to propose possible solution in the study district. The specific objectives of the study were: 1) to examine household's perception towards adoption of renewable energy sources at household level and 2) to analyze factors affecting adoption of renewable energy sources at rural household level in the study area. In light of the aforementioned research objectives this study strives to answer the following key research questions: 1) how are households perceived towards adoption of renewable energy sources at household level in the study area? 2) And what are the determinants of adoption of renewable energy sources at household level?

Research Methodology

Description of the Study Area

Ambo is located 114 km south of Addis Ababa capital city of Ethiopia. The altitude of the area ranges from 1380-3030 meters above sea level (m.a.s.l), characterized by warm temperate weather which is locally called *woina dega* (mid altitude). The temperature ranges from 15°C-29°C with average temperature of 22°C. It receives a mean annual rain fall ranging from 800-1000mm with an average of 900 mm. The highest rainfall concentration occurs from June to September and the mean monthly relative humidity varies from 64.6% in August to 35.8% in December, which is comfortable for human life. The total human population of Ambo is estimated to be 112,129 with a total of 55,491 (50.08 %) and 769 (57.69%) female and 55, 305 (49.92 %) and 564 (42.31%) male in rural and urban respectively (Beyene *et al.*, 2013; Ambo District Agricultural Office, 2014). In short it is one of the most densely populated areas in the country with an average of 290 people per km^2. The area is divided into three ecological zones: *Kola* (lowland <1500m), *Woina Dega* (mid-altitude 1500-2300m) and *Dega* (highland > 2300m). Most of the area lies within the mid altitude zone (Ambo District Agricultural Office, 2014).

Sampling Design

In this study, multistage sampling procedures were used to select the survey areas and the sampling unit frame of

household heads. At the first stage, Ambo district was purposively selected for the following reasons: no research conducted with the issue in the study area and its access to renewable energy sources (biogas and solar) (West-Shoa zone water mines and energy office, 2015). In the second stage, five rural villages (Amaro, Gosu Qora, Metti, Boji Bilo and Dase Aklilu) were selected through simple random sampling method in order to accommodate household heads. Hence, West-Shoa zone water mines and energy office (2015) noted that all rural villages in Ambo district the weather condition is suitable to adopt renewable energy sources particularly biogas and solar technologies. Finally, sample household heads were selected from five rural villages based on Probability Proportional to Size (PPS).

The sample size for household survey was determined on the total number of rural households in the selected rural villages (Amaro, Gosu Qora, Metti, Boji Bilo and Dase Aklilu). Accordingly, the sample size for collecting primary data from households for the purpose of this study was determined by using the following formula (Yamane, 1967):

$$n=\frac{N}{1+N(e)^2}$$

The following steps were used to determine sample size derived from the above formula.

Where;
n= designates the sample size the study uses;
N= designates total number of households
e= designates maximum variability or margin of error 5%
1= designates the probability of the event occurring.
Therefore;

$$n=\frac{N}{1+N(e)^2}$$

$$n=\frac{2646}{1+2646(0.05)^2}=348$$

30% of sample households were included to compensate for non-response (Israel, 1992). Accordingly, the total sample size for this study was 452 households. From a total of 452 sample households, 106 households were from Amaro, 150 households were from Gosu Qora, 43 households were from Metti, 93 households were from Boji Bilo and 60 households were from Dase Aklilu.

Therefore, each sample rural villages and household heads were randomly selected from through Simple Random Sampling method. Key informants from each community were selected on the basis of purposive sample technique.

Sources of Data and Collection Methods

In assessing the determinants of adopting renewable energy sources; secondary and primary data were collected. The secondary data were collected from different sources such as census, regional documents, records and official documents of energy office. Relevant literatures concerning rural household renewable energy sources were also reviewed. However, the primary data was gathered from the household heads and key informants (rural village leaders, development agents, renewable energy sources users and elder people) in the study area. Survey questionnaire and interview checklist were instruments of methods of data collection for household head and key informants respectively.

Methods of Data Analysis

In this study, descriptive statistics and econometric model were used for analysis of data collected. Descriptive statistics was used to describe relevant aspects of observable facts about the variables thereby providing detailed information about each relevant variable. The statements from scheduled interview were used to substantiate the responses of quantitative findings. For quantitative Probit model and t-test were used to analyze determinants of adoption of renewable energy sources using STATA and SPSS software.

Model specification

The probit model was be used to identify and quantify factors that affect adoption of renewable energy sources at household level. This model is appropriate because the dependent variable is discrete (that is, binary yes=1, otherwise=0) as it measures whether one had adopted use of renewable energy source or not. It is preferred to other model because authors anticipate to drawing their sample from normal distributed population (such that the error term is normally distributed) (Maddala, 1983).
Following was the probit model used:

$$Y_i = \beta_0 + \sum_{j=8}^{k} \beta_j X_{ij} + e_i$$

Where: Y = Adoption of renewable energy source (1= yes, 0= otherwise); X1 = Sex of household head (male-headed and female-headed); X2 = Age of household head (age in years continuous); X3 = Marital status of household head (Married and never married); X4 = Household size (size in numbers continuous); X5 = Household head's education level (education years); X6 = Occupation of household head (Farming/non-farming); X7=Household's farm size of land (*timad*), X8 = Household annual income (Birr); X9 =Distance from agricultural extension center (kilometers); X10 = Distance from health extension center (kilometers); X11 = Distance from main road (kilometers); X12 = Distance from market service (kilometers); X13 = Access to credit service (yes or no); X14 = Owner of livestock (TLU continuous); X15 = Wood availability in the last five years (more/the same/less); X16 = Distance traveled to collect firewood (kilometers); X17 =Time taken to collect firewood (hour); X20 = Animal dung availability in the last five years (more/the same/less); X21=Charcoal availability in the last five years (more/the same/less) X22 = Distance traveled to collect charcoal (kilometers); X23 = Time taken to collect charcoal (hour); X24 = Household cook meals (per day); X25 =Household active participation in social organizations; X26 = Household awareness on any project focused on firewood usage.

Result and Discussion

Overview of socio-economic profile of respondents

A total of 452 households were covered in this study. The sex, age, marital status, family size, level of education and primary occupation of sampled household heads were assessed as demographic characteristics. With regard to the sex composition of household heads, 87.6 % of household heads were male-head while the remaining 12.4% of them were female-headed households. With regards to age composition of household heads, survey result illustrates that 35.4%, 29.9%, 18.6%, 11.3% and 4.9% of household heads were between 39-48 years of age, between 29-38 years of age, between 49-58 years of age, greater than 59 years of age and between 18-28 years of age respectively (Table 1). In short, the mean age of sampled household heads was 44 years of age with the range of 19 to 85 years of age.

With regard to marital status composition of household head, majority (89.8%) of the household heads were married while 6.9%, 2.2% and 1.1% of them were winnowed, divorced and unmarried respectively. With regard to family size of households, 66.6%, 17.3%, 12.6% and 3.5% of households were with 4-7, 8-10, 1-3 and above 10 family sizes respectively. The mean family size of sampled households was 6 with the range of 1 to 13. With regard to the education level of household heads, 32.5%, 23.2%, 15.5%, 10.8%, 6.2%, 5.3%, 3.8% and 2.7% of household heads were with no education level, grade 5-8 education level, grade 1-4 education level, grade 9-10 education level, only could read & write (non-formal education) level, grade 11-12 education level, bachelor degree & above education level and college diploma education level respectively (Table 1).

Agriculture is the predominant occupation for the majority of people in rural Ambo district. Among the sampled household heads, majority (87.6%) of household heads were primarily engaged in farming activities while the remaining 5.8%, 4.9%, 1.1% and 0.6% of household heads were engaged with merchant/trader, civil servant, non-governmental (NGOs) worker, student and other respectively (Table 1).

Rural household perception towards coping strategy of cooking energy shortage

Rural households in rural areas primarily depend on biomass mainly firewood for fulfilling household energy requirements leads to cooking energy shortage in developing countries (Ayenagbo *et al.,* 2011; Legros *et al.*, 2011) including Ethiopia. Furthermore, increasing fuelwood consumption contributes to deforestation, desertification and soil erosion (Kankara, 2013; Gebreegziabher *et al.*, 2012). In line with the aforementioned assertion, this study confirmed that among the various fuels firewood followed animal dung is being used the prominent fuel sources of households in Ambo district. Moreover, all households confirmed that they are being used firewood as household energy source as a result cooking energy shortage there is in the study area.

In this study with regards to household's awareness about any government/non-government project or program focused on fuel wood or charcoal usage like fuel subsidy, 39.6% of respondents confirmed that they have information about government/non-government projects/program which focused on firewood or charcoal usage like fuel subsidy while more than of the respondents (60.4%) said that they have no information (Table 2).

With regards to household's coping strategy for cooking energy shortage, 17.3% and 25.2% of respondents reported that their coping strategy for cooking energy shortage is being increased fuel wood gathering time and substituted inferior fuels (like dung & crop residues) respectively while 15.5% and 42% of them reported that their coping strategy for cooking energy shortage is being substituted commercial fuels and conserved energy consumption respectively (Table 2). Similarly, a previous research by Gebreegziabher *et al.* (2012) affirms that scarcity of firewood is factors to increasing firewood gathering time and continued substitution of inferior fuels (animal dung and crop residues). On the other hand, as indicates a study by Koroma and Rongcheng (2009) contends that coping strategy for cooking energy shortage for developing countries like Ethiopia must be designed to sustain efficient production and use of traditional energy for addressing socioeconomic and environmental problems as well as transition to the efficient use of clean modern energy is

crucial.

Additionally, in this study with regards to household's mechanism of conserving shortage of energy consumption, 76.5%, 12.2%, 8% and 3.3% of respondents reported that their mechanism of conserving shortage of energy consumption is being used modified energy saving stoves, cooking less, preparing less food and using solar/biogas energy sources respectively (Table 2). In the same way, a study by Cooke *et al.* (2008) attest that fuelwood scarcity has the potential consequences of households using less fuel wood and of using more time to collect it. Moreover, welfare might be reduced if women have to spend more time cooking when they switch to crop residues because the residues require more attention.

An overview of household awareness on alternative renewable energy sources

A previous research by Lithole (1997) assert that the role of alternative energy systems, including biomass, solar systems, wind and hydro potential are expected an important role in the overall development of rural energy. It is also imperative to make rural people conscious of the crucial role that can be played by these energy resources to their benefit. Since, alternative energy options are refers to the new, renewable and non-conventional forms of energy technologies, which use local energy resources other than commercial fuels (petroleum products, gas, coal and so on) and biomass fuels in traditional forms primarily includes micro-hydropower (MHP), plants, biogas plants, wind, solar energy system (Mahat, 2004). Similarly, Omer (2009) strongly agrees that renewable energy sources are environmentally friendly must be encouraged, promoted, implemented, and demonstrated by full-scale plan especially for use in remote rural areas. Since according to Ailawadi & Bhattacharyya (2006), rural electrification is unlikely to resolve the energy problems of scarcity of firewood in developing countries like Ethiopia so alternative strategies are crucial.

In line with the aforementioned assertion, respondents were asked whether household with or with no information about socio-economic benefits of alternative renewable energy sources (like biogas and solar), more than three fourth of respondents (84.3%) reported that they have information about the benefits of alternative renewable energy sources like biogas and solar power while only 15.7% of them said that they have no information so far (Table 3).

Particularly, respondents were also asked whether household with or with no information/training about socio-economic benefits of solar energy at household level, more than half of respondents (69.5%) confirmed that they have information so far the benefits of solar energy while 30.5% of them opined that they have no information so far. Similarly, respondents were also asked whether household with or with no information/training about socio-economic benefits of biogas technologies at household level, the survey results reveal that more than half (55.5%) of respondents confirmed that households with awareness so far the socio-economic benefits of using biogas technologies while 44.5% of them said that they have no information so far. However, respondents were also asked whether household with or with no information/training about wind power, almost all of respondents (98.2%) said that households with no information so far about benefits of wind power at household level source of energy while only 1.8% of respondents reported that they have information so far (Table 3).

As Table 3 shows, respondents were also asked whether household with or with no information/training about how to save energy, three fourth of respondents (74.1%) confirmed that they have awareness so far how to save energy through modified stoves while 25.9% of them said that they have no information so far.

Furthermore, to assess rural household status of renewable energy sources adoption, respondents were asked whether they purchased/adopted renewable energy sources (like solar and biogas) or not in the form of 'Yes' or 'no' response question. Though the study results reveal that more than three fourth respondents (84.3%) confirmed that they have information about benefits of alternative renewable energy sources however, less than one fourth of respondents (21.7%) reported that they have adopted implies that more than three fourth of respondents (78.3%) said that they have not adopted alternative renewable energy sources at household level in the study area (Table 3). Though majority of respondents reported that they have information about the benefits of alternative renewable energy sources like biogas and solar power so far in Ambo district, at grass level the cause of low expansion of renewable energy sources in the area were identified through key informant interview and field observation. The identified the most bottle neck problem in expansion of renewable energy source in the study area; households were fail to adopt because they fail to understand their immediate use and inadequate information.

Household fuel switching history and options to stop using firewood

As indicates in the above use of traditional energy sources (like firewood and charcoal) contributed to scarcity of fuel and deforestation (de-vegetation) (Gebreegziabher *et al.*, 2012). Therefore, according to Takama *et al.* (2012), switching from traditional biomass energy sources to alternative renewable energy sources (like biogas and solar) could be improve health and social welfare of people that lack reliable access to modern energy

services. However, switching from traditional household energy sources to modern energy sources (electricity and LPG, biogas, solar) price of fuel and type and access conditions to fuels, technical characteristics and cooking practices; cultural preferences; and health impacts are determinant factors (Sesan, 2014).

In line with the aforementioned assertion, this study confirmed that fuel switching history at household level, more than three fourth of respondents (81.6%) confirmed that they have noticed fuel switching at household level for instance switching from firewood to conventional fuel sources like kerosene, liquid petroleum gas, electricity, biogas, solar, etc while 18.4% of them opined that they have not noticed. Besides, respondents were also asked the main reasons for fuel switching, more than half of respondents (68.4) reported that the main reasons for fuel switching is shortages of biomass energy sources while the remaining 36.1% and 5.5% of respondents reported that to minimize smoke/ashes and access to electricity respectively (Table 4).

As clearly shows Table 4, respondents were also asked whether households with or with no plan to continue using wood fuels in the next two/three/four/five years, the survey result reveals that half of the respondents (50.2%) reported that they have plan to continue using firewood in the next two/three/four/five years while 49.8% of them said that they have no plan. Respondents were also asked whether household would like stop using wood fuels or not, almost all of respondents (90%) confirmed that they would stop using firewood while only 10% of them opined that they would not stop using firewood. According to respondents' household options to stop using wood fuels, 42.5%, 28.5%, 25.7%, 2.6% and 0.7% of respondents confirmed that access to biogas, access to electricity, access to solar power, access to kerosene and access to liquid petroleum gas (LPG) respectively vital to stop rely on using firewood in the study area.

Household head's attitude towards adoption of alternative renewable energy sources

This section presents the results on household head's attitude towards adoption of alternative renewable energy sources like biogas and solar as measured based on a criterion scale designed specifically to answer research question. Measuring attitude implies quantifying a qualitative variable. For in depth understanding about the attitude of household heads towards an alternative renewable energy sources; it was grouped attitudinal criterion scales into ranges of three scale values such as unfavorable with mean score value of 1 to 1.66, neutral from 1.67 to 2.33 and favorable from 2.34 to 3.00 (see Table 5).

A study by Yadav et al. (2009) attests that 31%, 56% and 13% of respondents with unfavorable, neutral and favorable attitude respectively towards renewable energy sources (solar). However, in this study more than half of respondents (69%) confirmed that in the range of 2.34 to 3.00, implies that there is enhancement of the positive/favorable attitudes of household heads towards adoption of renewable energy sources (like solar and biogas) while 31% of them scored in range of 1.67 to 2.33 that implies neutral attitude. On the other hand, there was no any score within the range of 1-1.66 for unfavorable attitude towards use of renewable energy sources (biogas and solar) (Table 5). This implies that the method of introducing renewable energy sources (solar and biogas) in the study area, that includes intensive promotional and awareness campaigns has given the beneficiaries an opportunity to see, feel and experience the benefits of alternative renewable energy sources (solar and biogas) and have belief and trust on the existing and future development of the technology. However, neutral attitude household heads needed to be motivated to change their attitude towards favorable side then it can be scale up expansion of renewable energy sources for rural households in minimizing rely on biomass energy sources ultimately can be reduce deforestation in the study area.

It can be observed from Table 6, with regards to environmental pollution through smoke can easily be safe guarded by the use of alternative energy sources, almost all of respondents (96.9%) agreed that environmental pollution through smoke can easily be safe guarded by the use of alternative renewable energy sources while only 3.1% of them were neutral. With this specific item, the mean value of all responses was 2.97, indicates that its advantages in adoption of alternative renewable energy sources and that there is a need to utilize existing alternative renewable energy sources (solar and biogas technology) at household level.

Similarly, with regards to alternative renewable energy sources can easily use because no complicated technical knowhow is needed for its use, more than three fourth of respondents (87.8%) agreed that alternative renewable energy sources can easily use because no complicated technical knowhow is needed for its use while only 3.3% of them disagreed and also the remaining 8.8% of them were neutral. With this specific item, the mean value of all responses was 2.85, indicates that its advantages in adoption of alternative renewable energy sources (Table 6).

Moreover, with regards to alternative renewable energy sources is an economical energy source, 90.2% of respondents agreed while only 3.3% and 8.8% of them were disagreed and neutral respectively alternative renewable energy sources is economical energy sources at household level. With this specific item, the mean value of all responses was 2.83, indicates that its advantages in adoption of alternative renewable energy sources and that there is a need to utilize existing alternative renewable energy sources (solar and biogas technology) at household level (Table 6).

Furthermore, with regards to alternative renewable energy sources can saves time of women and

children, the survey results reveal that largest proportion of respondents (95.8%) agreed that alternative renewable energy sources can saves time of women and children while only 0.2% and 4% of them disagreed and neutral correspondingly. With this specific item, the mean value of all responses was 2.96, reveals that its advantages in adoption of alternative renewable energy sources. Additionally, alternative renewable energy sources would assist women a great deal when they are away in the farm or any other job, in similar fashion, majority of respondents (90.7%) agreed while 1.3% and 8% of them disagreed and neutral respectively. With this specific item, the mean value of all responses was 2.89, shows that its advantages in adoption of alternative renewable energy sources and that there is a need to utilize existing alternative renewable energy sources (solar and biogas technology) at household level (Table 6).

With regards to alternative renewable energy source is a natural source of energy so one should make best use of it to cook food, more than three fourth of respondents (86.3%) agreed while only 7.7% and 6% of them disagreed and neutral respectively. With this specific item, the mean value of all responses was 2.79, shows that its advantages in adoption of alternative renewable energy sources and that there is a need to utilize existing alternative renewable energy sources (solar and biogas technology) at household level (Table 6).

With regards to alternative renewable energy source option is a time saving source of energy, the survey results reveal that almost all of respondents (97.3%) agreed while 0.4% and 2.2% of them disagreed and neutral respectively. With this specific item, the mean value of all responses was 2.97, reveals that its advantages in adoption of alternative renewable energy sources. In the same way, with regards to if one adopts alternative renewable energy sources; money can be saved which can be used for other consumption expenditures, majority of respondents (93.4%) agreed while only 3.1% and 3.5% of them disagreed and neutral respectively. With this specific item, the mean value of all responses was 2.90, reveals that its advantages in adoption of alternative renewable energy sources and that there is a need to utilize existing alternative renewable energy sources (solar and biogas technology) at household level (Table 6).

With regards to alternative renewable energy sources requires technical skill to use and operate it which is very difficult in the case of Ethiopia conditions, the survey results show that 44% respondents disagreed while 17.5% and 38.5% of them neutral and agreed respectively. This implies that operation of alterative renewable energy sources at household level is not difficult. With this specific item, the mean value of all responses was 1.94, indicates that its advantages in adoption of alternative renewable energy sources (Table 6).

However, with regards to alternative renewable energy sources can be hazardous for children, more than half of respondents (54.5%) agreed while 33.6% and 11.9% of them disagreed and neutral respectively. With this specific item, the mean value of all responses was 2.21; this implies that using alternative renewable energy sources particularly biogas at household is required careful utilization for avoiding hazardous for children. Similarly, with regards to alternative renewable energy sources device is a costly device, therefore, everyone can not afford to buy it, half of respondents (51.8%) agreed while 39.8% and 8.4% of them disagreed and neutral respectively. With this specific item, the mean value of all responses was 2.12; so to adopt alternative renewable energy sources (like biogas technology and solar power) at household level financial incentives is crucial (Table 6).

However, with regards to using alternative renewable energy sources while there is plenty of biomass fuel is wastage of time, more than three fourth of respondents (84.7%) disagreed while only 7.3% and 8% of them neutral and agreed respectively. This implies that there is no plenty of biomass fuel. With this specific item, the mean value of all responses was 1.23, indicates that of its advantages in adoption of alternative renewable energy sources and that there is a need to utilize existing alternative renewable energy sources (solar and biogas technology) at household level to solve shortage of biomass energy sources (Table 6).

Household head's attitude towards usefulness and process of adoption alternative renewable energy sources

Table 7 presents survey results on household head's attitude towards extent of concerning perceived usefulness and adoption process of alternative renewable energy sources as measured by the Likert Scale designed specifically to answer research question. Measuring attitude implies quantifying a qualitative variable.

With regards to the customers fail to adopt new products at household level because they fail to understand their immediate use, the survey results indicate that only 8% and 11.5% of respondents disagreed and neutral respectively while larger proportion 46.5% and 34.1% of them agreed and strongly agreed respectively. With this specific item, the mean value of all responses was 4.07, indicates that of its advantages in adoption of alternative renewable energy sources. Similarly, with regards inadequate information on new products, survey results show that only 7.5% and 7.1% of respondents strongly disagreed and disagreed respectively while larger proportion 52.9% and 27% of them agreed and strongly agreed respectively inadequate information on new products (biogas technology, solar power etc) fail in adoption decision, the remaining 5.5% of them neutral. With this specific item, the mean value of all responses was 3.85, shows that its advantages in adoption of alternative renewable energy sources and that there is a need to utilize existing alternative renewable energy

sources (solar and biogas technology) at household level (Table 7).

However, with regards to lack of differentiation between existing and new products, the result reveals that larger proportion 33.4% and 41.4% of respondents strongly disagreed and disagreed correspondingly while only 8.2%, 14.8% and 2.2% of them were neutral, agreed and strongly agreed respectively. This implies that there is clear variation between existing and new products for example according to respondents there is difference between firewood and alternative renewable energy source like biogas and solar. With this specific item, the mean value of all responses was 2.11, indicates that its advantages in adoption of alternative renewable energy sources and (Table 7).

With regards to difficulty in operation, the survey result indicates that 12.7% and 42% of respondents strongly disagreed and disagreed respectively while 17.5%, 15% and 12.8% of them were neutral, agreed and strongly agreed respectively. This implies that operation of alternative renewable energy source like biogas technology, solar is not difficult. With this specific item, the mean value of all responses was 2.73, indicates that its advantages in adoption of alternative renewable energy sources and that there is a need to utilize existing alternative renewable energy sources (solar and biogas technology) at household level (Table 7).

Moreover, the sampled respondents were also asked whether their believes affect adoption of alternative renewable energy sources to a great extent or not, the study results reveal that 35.6% and 23.5% of respondents strongly disagreed and disagreed respectively while 6.2%, 32.7% and 2% of them were neutral, agreed and strongly agreed respectively their believes affect adoption of alternative renewable energy sources to a great extent. This implies that household believes have influence in adoption of alternative renewable energy sources to a great extent. With this specific item, the mean value of all responses was 2.73, indicates that its advantages in adoption of alternative renewable energy sources (solar and biogas) at household level (Table 7).

Alternative renewable energy source adopters and non-adopter households

As shows in Table 8, with regards to concerning the demographic characteristics of households, average age was 43.44 and 44.83 years old for adopter and non-adopter alternative renewable energy source household heads respectively. It is statistically significant at 10%. A similar study by Walekhwa *et al.* (2009), illustrates that the probability of a household adopting renewable energy source (biogas technology) increases with decreasing age of head of household. As a result, it can be concluded that younger age household head is better than older age household head in adopting alternative renewable energy source for rural household's energy consumption in the study district. With regards to the mean family size of alternative renewable energy source adopter household was 7; the mean family size of non-adopter alternative renewable energy source household was 6. This difference is statistically not significant. However, Walekhwa *et al.* (2009) found out that the probability of a household adopting renewable energy source (biogas technology) increases with increasing household size.

Households' average farm size was 11.78 *timad* and 7.22 *timad* for alternative renewable energy source adopter and non-adopter households respectively. This difference is statistically significant at 5%. This implies that who have larger farm size households is better in adopting alternative renewable energy source for rural household's energy consumption. With regard to the annual income of households, average annual income was 29,676.04 Ethiopian Birr (ETB) and 14,143.97 Ethiopian Birr (ETB) for adopter and non-adopter alternative renewable energy source households respectively; this mean difference is statistically significant at 5% (Table 8). This finding supported by Walekhwa *et al.* (2009) attest that the probability of a household adopting renewable energy source (biogas technology) increases with increasing household income. Therefore, household have adequate annual income is better in adopting alternative renewable energy source for rural household's energy consumption. In the same way, on average total livestock hold own was 12.99 and 7.55 TLU for renewable energy source (biogas & solar power) adopter and non-adopter households respectively. This difference is statistically significant at 10% (Table 8). Additionally the study result supported by Walekhwa *et al.* (2009) the probability of a household adopting renewable energy source (biogas technology) increases with increasing number of cattle owned. This implies that who have larger number of cattle owned households is better in adoption of renewable energy sources.

With regards to public services like agricultural extension center, health extension center, market, access to main road and so on services directly and indirectly has contribution for adoption of alternative renewable energy sources such as biogas technology and solar power. Hence, the average distant from the household's home to the agriculture extension center for alternative renewable energy source adopter and non-adopter households were 1.52 kilometers and 2.34 kilometers respectively; this mean difference is highly statistically significant at 1%. In line with the attestation study by Legesse *et al*., (2015) attest that location of households are close to agricultural extension center better in adoption of technologies. It can be concluded that location of renewable energy adopter households are close to agricultural extension center. As a result, they have better opportunity to acquire the services than non-adopter households. Similarly, the mean distant from the households' home to the health extension center for renewable energy source (biogas & solar) adopter households was about 1.70 kilometers while the mean distance traveled by non-adopter of renewable energy

source households was about 2.63 kilometers. Similarly, this difference is highly statistically significant at 1% (Table 8). In the same way, in line with the attestation supported by Abate (2016) attest that location of households are close to health extension better in adoption of technology. This implies that location of renewable energy source (biogas and solar) adopter households are close to health extension center and, have better opportunity to acquire the services than non-adopter households.

Likewise, the average distance from the household's home to the main road was 1.04 kilometers for alternative renewable energy source adopter households while the mean distance traveled by non-adopter of renewable energy source households was 1.94 kilometers. This difference is highly statistically significant at 1%. In line with the attestation studies by Legesse *et al.* (2015) reveals that location of households is close to road have opportunities in adoption technology decision. This implies that renewable energy source adopter households were being close to main road and have better opportunity to acquire transportation facilities than non-adopter households. In similarly way, the average distant from household's home to market services for renewable energy source adopter household was 3.55 kilometers while the mean distance traveled by access to renewable energy source non-adopter households was 6.83 kilometers. This difference is also highly statistically significant at 1% (Table 8). The study result supported by Abate (2016) indicates that location of households is close to market better in adoption technology decision. So it can be concluded that renewable energy source adopter households have access to market opportunity and have better opportunity to acquire market opportunity than non-adopter households. Therefore, location of renewable energy sources (biogas and solar power) adopter households are close to agriculture extension center, health extension center, main road and market and as a result, have better opportunity to acquire the services than and non-adopter households in the study area.

In similar fashion, the mean daily household use of firewood was 6.70 kilogram and 9.84 kilogram for alternative renewable energy source adopter households and non-adopter households respectively. Similarly, this is also highly statistically significant at 1% (Table 8). Therefore, renewable energy source adopter households are consume daily less amount of firewood consumed compared to non-adopter households.

The average distant from the household's home to firewood collection for renewable energy source adopter and non-adopter households was 1.69 kilometers and 1.64 kilometers respectively; this mean difference is statistically significant at 5% (Table 8). In line with the attestation study by Walekhwa *et al.* (2009) attest that the probability of a household adoption renewable energy source (biogas technology) decreases with increasing location of traditional fuels. It can be concluded that renewable energy source adopter households were being far to location of firewood collection place. However, the mean time taken to firewood collection for renewable energy source adopter and non-adopter households was 2.63 hours and 2.96 hours respectively; this mean difference is not statistically significant. In similar fashion, the average distant from the household's home to crop residue collection for renewable energy source adopter and non-adopter households was 0.81 kilometers and 0.73 kilometers respectively; this mean difference is not also statistically significant. In similar way, the mean time taken to crop residue collection for alternative renewable energy source adopter and non-adopter households was 1.09 hours and 1.03 hours respectively; this mean difference is not also statistically significant.

Moreover, the average distant from the household's home to animal dung collection place renewable energy source (biogas/solar) adopter and non-adopter households was 0.62 kilometers and 0.66 kilometers respectively; this mean difference is not statistically significant. And also, the mean time taken to dung collection for renewable energy source adopter and non-adopter households was 1.00 hours and 1.04 hours respectively; this mean difference is not also statistically significant (Table 8).

Furthermore, the mean distant from the households' home to charcoal collection place for renewable energy source (biogas/solar) adopter households was about 4.44 kilometers while the mean distance traveled by non-adopter of renewable energy source (biogas/solar) households was about 3.87 kilometers. Similarly, this difference is not statistically significant. And also, the mean time taken to charcoal collection for renewable energy source (biogas/solar) adopter and non-adopter households was 11.48 hours and 11.11 hours respectively; this mean difference is not also statistically significant. Similarly, the mean distant from the households' home to tree residue (leaves) collection place for renewable energy source (biogas/solar) adopter households was about 1.12 kilometers while the mean distance traveled by non-adopter of renewable energy source (biogas/solar) households was about 1.28 kilometers; this difference is not also statistically significant. And also the mean time taken to tree residues (leaves) collection for renewable energy source (biogas/solar) adopter and non-adopter households was 1.75 hours and 1.14 hours respectively; this mean difference is not also statistically significant (Table 8).

Therefore; the probability of a household adopting renewable energy sources (biogas and solar) technology increases with decreasing age of head of household, increasing household size of farm land, increasing household income, increasing number of cattle owned and increasing location of traditional fuels while adoption decreases with increasing remoteness of household location from agricultural extension center, health extension center & market service and increasing household fuel consumption.

Results of econometric model analysis on determinants of alternative renewable energy sources

As indicates in Table 9, the age of household head has negatively significant effect on the decision of adoption of alternative renewable energy source at 10% level of significance. When household head age is increased by one; the probability of adoption of renewable energy source (biogas/solar power) will be decreased by 2%. Supported by a similar research by Walekhwa *et al.* (2009) attest that the probability of a household adopting renewable energy source (biogas technology) increases with decreasing age of head of household. Similarly, primary occupation of household head has negatively highly significant effect for the household to adopt renewable energy source at 1% level of significance. This implies that if household head primary occupation farming increase by one, the probability of adoption of renewable energy source will be decreased by 53%.

However, household farm size of land has positively significant effect on the decision of adoption of renewable energy source positively at 1% level of significance. This implies that household's farm size of land is increased by one; the probability of adoption of renewable energy source will be increased by 13%. Similarly, household annual income has positively significant effect on the decision of adoption of renewable energy source positively at 5% level of significance. This implies that household's annual income is increased by one; the probability of adoption of renewable energy source will be increased by 56% (Table 9).

Distant from the household's home to the agricultural extension center had significant but negative effect on household adoption of renewable energy source at 10% level of significance. This implies that the distant from the household's home to the agricultural extension center is increased by one; the probability of adoption of the renewable energy source will be decreased by 23%. In similar way, the distant from household's home to market services had significant effect on the decision of adoption of renewable energy source negatively at 5% level of significance. When household head's market distance is increased by one; the probability of adoption of renewable energy source will be decreased by 11%. With regards to livestock ownership, households' livestock ownership has positively significant effect on the decision of adoption of renewable energy source positively at 1% level of significance. This implies that household's number of livestock own is increased by one; the probability of adoption of renewable energy source will be increased by 14% (Table 9). Hence, livestock is an asset of household.

With regards to availability of firewood, the study results indicate that availability of firewood for household energy consumption negatively significant effect for household to adopt renewable energy source at 1% level of statistical significant. This implies that household availability of firewood is increased by one; the probability of adoption of the renewable energy source will be decreased by 53%. Similarly, time taken to firewood collection has negative effect on the adoption of renewable energy source decision of households at statistically significance level of 10%. As a time taken to firewood collection is increased by one; the probability of adoption of renewable energy source will be decreased by 12%. However, availability of dung has positive effect on the adoption of renewable energy source particularly biogas technology decision of households at highly statistically significant level of 1%. As availability of dung is increased by one; the probability of adoption of renewable energy source (biogas technology) will be increased by 44% (Table 9).

With regards to availability of utilization of charcoal has positive effect on the adoption of renewable energy source decision statistically significant level of 10%. As availability of charcoal utilization is increased by one; the probability of adoption of renewable energy source will be increased by 57% hence mainly in Ethiopia, charcoal used in town/urban or semi-town communities compared to rural and remote rural villages. And also, location of charcoal collection place has positive effect on the adoption of renewable energy source decision of households at statistically significance level of 5%. As distant from the households' home to charcoal collection place is increased by one; the probability of adoption of renewable energy source will be increased by 11%. However, time taken for charcoal collection has negative effect on the adoption of renewable energy source decision of households at statistically significance level of 5%. As a time taken charcoal collection is increased by one; the probability of adoption of renewable energy source will be decreased by 6% (Table 9).

With regards to household cook meals, the study results reveal that household daily cooks meals has negative effect on the adoption of renewable energy source decision of households at highly statistically significance level of 1%. As household daily cooks meals is increase by one; the probability of adoption of renewable energy source will be decreased by 39%. However, household's awareness on any project focused on firewood/charcoal usage has positive effect on the adoption of renewable energy source decision of households at highly statistically significance level of 1%. As household's awareness on any project focused on firewood/charcoal usage is increased by one; the probability of adoption of renewable energy source will be increased by 80% (Table 9).

Therefore; the probability of a household adopting renewable energy sources (biogas and solar) technology increases with decreasing age of head of household, increasing household income, increasing number of cattle owned, increasing availability of animal dung and increasing awareness of households towards to alternative energy options while adoption decreases with increasing household farming occupation, increasing remoteness of household location from agricultural extension center & market service, increasing firewood

availability, increasing time taken collection of firewood and increasing frequency of cooking meals.

The model fitness, the variability of the variances of error term and the multicollinearity is tested and the result shows that the model has 89.16% predicting power and it is free from hetreoscadesticity and multicollinearity (See annex 1).

Annex 1- Link Test for Model Specification

```
. lstat

Probit model for Hrenewable

                    True
Classified |         D              ~D |          Total
-----------+--------------------------+-----------------
     +     |        67              20 |             87
     -     |        29             336 |            365
-----------+--------------------------+-----------------
   Total   |        96             356 |            452

Classified + if predicted Pr(D) >= .5
True D defined as Hrenewable != 0
--------------------------------------------------------------
Sensitivity                     Pr( +| D)    69.79%
Specificity                     Pr( -|~D)    94.38%
Positive predictive value       Pr( D| +)    77.01%
Negative predictive value       Pr(~D| -)    92.05%
--------------------------------------------------------------
False + rate for true ~D        Pr( +|~D)     5.62%
False - rate for true D         Pr( -| D)    30.21%
False + rate for classified +   Pr(~D| +)    22.99%
False - rate for classified -   Pr( D| -)     7.95%
--------------------------------------------------------------
Correctly classified                         89.16%
--------------------------------------------------------------
```

Table 1: Demographic characteristics of household heads, rural household (n=452)

Variable Name		Percentage
Sex of household heads	Male	87.6
	Female	12.4
Age composition of household heads	18-28	4.9
	29-38	29.9
	39-48	35.4
	49-58	18.6
	Above 59	11.3
Marital status composition of household heads	Married	89.8
	Unmarried	1.1
	Divorced	2.2
	Widowed	6.9
Composition of household family size	1-3	12.6
	4-7	66.6
	8-10	17.3
	Above 10	3.5
Educational level of household heads	Only can read and write education level	6.2
	No education level	32.5
	Grade 1-4 education level	15.5
	Grade 5-8 education level	23.2
	Grade 9-10 education level	10.8
	Grade 11-12 education	5.3
	College diploma education	2.7
	Bachelor degree and above education	3.8
Primary occupation of household heads	Farmer	87.6
	Civil servant	4.9
	NGO worker	1.1
	Merchant/trader	5.8
	Student	0.6

Source: Field survey, 2016.

Table 5: Distribution of household heads as per their attitude towards adoption of renewable energy sources, rural household (n=452)

Attitude criterion scale	Mean ranges of criterion scores	Frequency	Percentage
Unfavorable/negative	1-1.66	0	0
Undecided/neutral	1.67-2.33	140	31
Favorable/positive	2.34-3.00	312	69

Source: Field survey, 2016.

Table 2: Household awareness of governmental/non-governmental organization projects focused on fuel wood, coping strategy for cooking energy shortage and mechanism of conserving shortage of energy consumption, rural household (n=452).

Variables		Percentage
Household's awareness about any GOs/NGO project/program focused on firewood usage	Yes	39.6
	No	60.4
Household's coping strategy for cooking energy shortage	Increasing fuel wood gathering time	17.3
	Substituting inferior fuels	25.2
	Substituting commercial fuels	15.5
	Conserving energy consumption	42.0
Household's mechanism of conserving shortage of energy consumption	Using modified energy saving stoves	76.5
	Cooking less	12.2
	Preparing less food	8.0
	Using solar cookers/biogas	3.3

Source: Field survey, 2016.

Table 3: Household awareness of alternative renewable energy source, rural household (n=452)

Variables		Percentage
Awareness of about the benefit of alternative renewable energy source/s	Yes	84.3
	No	15.7
Awareness of about the benefit of solar	Yes	69.5
	No	30.5
Awareness of about the benefit of biogas technologies	Yes	55.5
	No	44.5
Awareness of about the benefit of wind power	Yes	1.8
	No	98.2
Awareness of about the benefit of how to save energy	Yes	74.1
	No	25.9
Status of alternative renewable energy source/s adoption	Adopters	21.7
	Non-adopters	78.3

Source: Field survey, 2016.

Table 4: Household fuel-switching history & the reasons for fuel switching and options to stop using wood fuels, rural household (n=452)

Variables		Percentage
Fuel-switching history in household (eg. from firewood to conventional fuel sources)	Yes	81.6
	No	18.4
The reasons for fuel switching	Shortages of biomass energy sources	68.4
	To avoid/minimize smoke/ashes	36.1
	Access to electricity	5.5
Household plan to continue using wood fuels in the next two/three/four/five years	Yes	50.2
	No	49.8
Household would like stop using wood fuels	Yes	90.0
	No	10.0
Household options to stop using wood fuels	Access to electricity	28.5
	Access to solar	25.7
	Access to biogas	42.5
	LPG	0.7
	Kerosene	2.6

Source: Field survey, 2016.

Table 7: Household extent of concerning perceived usefulness and in adoption of alternative renewable energy source using Likert scale, rural household (n=452).

Attitude Statement	SD	D	N	A	SA	Mean	Std. Dev.
The customers fail to adopt new products at household level because they fail to understand their immediate use	0	8.0	11.5	46.5	34.1	4.07	0.88
Inadequate information on new products	7.5	7.1	5.5	52.9	27.0	3.85	1.13
Lack of differentiation between existing and new products	33.4	41.4	8.2	14.8	2.2	2.11	1.10
Difficulty in operation	12.7	42.0	17.5	15.0	12.8	2.73	1.23
Household believes affect the adoption of alternative energy sources to a great extent	35.6	23.5	6.2	32.7	2.0	2.42	1.32

Source: Field survey, 2016.
NB: SD=strongly disagree, D= Disagree, N=Neutral, A=Agree, SA=strongly agree

Table 6: Attitude of household heads towards alternative renewable energy sources, rural household (n=452)

Attitude Statement	Disagree	Undecided	Agree	Mean	SD
Environmental pollution through smoke can easily be safe guarded by the use of alternative renewable energy sources	0	3.1	96.9	2.97	0.17
Alternative renewable energy sources can easily use because no complicated technical knowhow is needed for its use	3.3	8.8	87.8	2.85	0.45
Alternative renewable energy sources is economical energy sources	7.1	2.7	90.2	2.83	0.53
Alternative renewable energy sources can saves time of women and children	0.2	4.0	95.8	2.96	0.22
Alternative renewable energy sources would assist women a great deal when they are away in the farm or any other job	1.3	8.0	90.7	2.89	0.35
Alternative renewable energy source is a natural source of energy so one should make best use of it to cook food	7.7	6.0	86.3	2.79	0.57
Alternative renewable energy source option is a time saving source of energy	0.4	2.2	97.3	2.97	0.20
If one adopts alternative renewable energy sources, money can be saved which can be used for other consumption expenditures	3.1	3.5	93.4	2.90	0.39
Alternative renewable energy sources requires technical skill to use and operate it which is very difficult in the case of Ethiopia conditions	44.0	17.5	38.5	1.94	0.91
Alternative renewable energy sources can be hazardous for children	33.6	11.9	54.5	2.21	0.92
Alternative renewable energy sources device is a costly device, therefore, everyone can not afford to buy it	39.8	8.4	51.8	2.12	0.95
using alternative renewable energy sources while there is plenty of biomass fuel is wastage of time	84.7	7.3	8.0	1.23	0.58

Source: Field survey, 2016. NB: SD=Standard deviation

Table 8: Demographic, economic and access to facilities characteristics of sample households decision on alternative renewable energy source adoption, rural household (n=452)

Variable Name	*Adopter*		*Non-adopter*		*t-test*	P-value
	Mean	Std. Dev.	Mean	Std. Dev.		
Age of household head (years)	43.44	10.24	44.83	11.53	1.07*	0.072
Household's family size	7.01	2.12	5.64	2.08	5.70	0.998
Household's size of farm land (*timad*)	11.78	3.58	7.22	3.37	11.61**	0.039
Annual income of household (Ethiopian Birr)	29676.04	14143.97	16601.69	12677.38	8.75**	0.041
Number of livestock owned (TLU)	12.99	5.25	7.55	3.77	11.45*	0.065
Distance of the agricultural extension center from home (Km)	1.52	0.91	2.34	1.53	-5.01***	0.000
Distance of the health extension center from home (km)	1.70	0.97	2.63	1.55	-5.60***	0.000
Distance of the main road from home (km)	1.04	0.98	1.94	1.60	-5.29***	0.000
Distance from Market (km)	3.55	1.94	6.83	3.69	-8.40***	0.000
Household use of firewood (kg/day)	6.70	2.21	9.84	3.74	-7.86***	0.000
Fuel wood collection distance (km)	1.69	1.49	1.64	1.12	0.29**	0.019
Time spent for fuel wood collection (hour)	2.63	2.20	2.96	1.78	-1.51	0.141
Crop residue collection distance (km)	0.81	0.42	0.73	0.43	1.65	0.304
Time spent for crop residue collection (hour)	1.09	0.52	1.03	0.63	0.85	0.359
Cow dung collection distance (km)	0.62	0.51	0.66	0.54	-0.72	0.961
Time spent for dung collection (hour)	1.00	0.90	1.04	0.84	-0.41	0.701
Charcoal collection distance (km)	4.44	2.20	3.87	2.18	2.27	0.973
Time spent for charcoal collection (hour)	11.48	3.67	11.11	4.09	0.80	0.146
Tree residue (leaves) collection distance (km)	1.12	0.89	1.28	1.29	-1.16	0.656
Time spent for tree residue (leaves) collection (hour)	1.75	1.14	2.01	1.27	-1.82	0.496

***, **and * indicate significant at 1%, 5% and 10% level respectively.
Source: Field survey, 2016.

Table 9: Determinants of adoption alternative renewable energy source using propit model, rural household (n=452)

Explanatory Variable	Coefficient	Std. Err.	Z	Marginal effect (dy/dx)
Sex of household head	0.468	0.550	0.85	0.26
Age of household head	-0.020	0.012	-1.63*	-0.02
Marital status of household head	-0.394	0.579	-0.68	-0.40
Household family size	0.076	0.056	1.37	0.06
Educational level of household head	0.022	0.088	0.26	0.02
Primary occupation of household head	-1.637	0.414	-3.96***	-0.53
Household's farm size of land (*timad*)	0.165	0.044	3.72***	0.13
Households' annual income (ETB)	0.000	0.000	2.29**	0.560
Distance agricultural extension from home (km)	-0.299	0.186	1.61*	-0.23
Distance health extension from home (km)	0.135	0.176	0.77	0.10
Distance main road from home (km)	-0.136	0.134	-1.01	-0.11
Distance market from home (km)	-0.140	0.065	-2.14**	-0.11
Household access to credit service	0.123	0.255	0.49	0.09
Number livestock ownership (TLU)	0.187	0.037	5.03***	0.14
Wood availability in the last five years	-0.699	0.266	-2.63***	-0.53
Distance wood collection from home (km)	0.136	0.139	0.98	0.10
Time taken firewood collection (hour)	-0.158	0.088	-1.79*	-0.12
Dung availability in the last five year	0.579	0.171	3.38***	0.44
Charcoal availability in the last five year	0.743	0.436	1.70*	0.57
Distant charcoal collection from home (km)	0.146	0.061	2.41**	0.11
Tike taken charcoal collection (hour)	-0.084	0.035	-2.42**	-0.06
Household frequency of cook meals (per day)	-0.514	0.181	-2.85***	-0.39
Household active participation in social organizations	0.174	0.240	0.72	0.14
Household awareness on any project focused on firewood/charcoal usage	0.844	0.265	3.19***	0.80
Constant	0.003			

***, **and * indicate significant at 1%, 5% and 10% level respectively.
Source: Field survey, 2016.

Conclusion and Recommendation

Based on the findings all rural village communities are rely on biomass fuels (firewood, charcoal, animal dung and crop residues) for lighting and cooking contributed to scarcity of fuel, deforestation (de-vegetation), desertification and soil erosion. Moreover, scarcity of firewood was factors to increasing firewood gathering time and continued substitution of inferior fuels (animal dung and crop residues) in the study area. Therefore, switching from traditional biomass energy sources to alternative energy sources (like biogas and solar) is indispensable to improve health and social welfare of people that lack reliable access to modern energy services. As a result, development planers (both governmental and non-governmental) organizations must be designed sustain efficient production and use of traditional energy as well as transition to the efficient use of clean modern energy is crucial for addressing socio-economic and environmental problems. Additionally, both governmental and non-governmental organizations must be encouraged, promoted, implemented, and demonstrated by full-scale plan especially for use in remote rural areas. Since rural electrification is unlikely to resolve the energy problems of scarcity of firewood in rural village of the study area.

In Ambo district, with respect to renewable energy source adopter households were more advantages in terms of contribution to reducing environmental pollution and minimize burden on biomass fuels, economical energy source, saves time of women and children and reduce smoke/ashes as compared to non-adopters. Implies that renewable energy source could contribute minimizing deforestation, land degradation and increasing agricultural productivity. Furthermore, adoption of renewable energy source is benefit women and children by reducing fuel collection workloads and limiting exposure to flame hazards and the emission of harmful pollutants. However, renewable energy sources adopters were noticed particularly biogas could be hazardous for children and costly device; therefore, everyone can not afford to buy it. So it can be recommended that development planers should be work at grass root level for scale up renewable energy sources. Since, the most bottle neck in expansion of renewable energy sources in the study area were fail to adopt because they fail to understand their immediate use and inadequate information.

Declaration of conflict of interest

The authors fully declare that they have no any conflict of interest in publishing the manuscript.

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