Determinants of Rural Household Source of Energy Consumption in Enderta District, Tigray Region, Ethiopia

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Abstract
The study was developed with the aim of to understand the rural household energy consumption patterns. To achieve the objectives of the research survey was a method of data collection using appropriate instruments such as structured questionnaire based interview technique. The survey was covered a random sample of 120 household heads selected from three rural villages based on a Probability Proportional to Size (PPS). For quantitative data Probit model and t-test was used to analyze determinants of adoption of improved energy technology using STATA software. Interview results were presented by aggregating the responses. The major finding shows that biomass source of energy are found the main source of energy consumption in the study area used for cooking food and baking injera (Ethiopian bread) while kerosene and dry cells are the main source of energy used for the purpose of lighting by households with no access to modern fuel while electricity is found using for purpose of lighting by households with access to modern fuel. Based on the finding concluded that the consequences of uses of biomass energy sources leads forest degradation, deforestation, and lands degradation all severe environmental problems. To improved the existing energy consumption patterns; rural development planners should encouraging the rural households to plant trees on their own farm land for fuel wood purpose and adoption of improved stove could contribute to reducing burden on biomass moreover different strategies should plan to introduce and disseminate alternative technologies via demonstrations, posters, and radio or TV advertisements is vital.
Keywords: Household, energy, adoption, biomass, cooking

Introduction

Energy is very crucial for daily life to meet human beings basic need such as cooking, boiling water, lighting and heating (WHO, 2006; Kankara, 2013). In Ethiopia, household energy is mainly used for cooking, lighting and space conditioning. However, energy use patterns largely depend on the place of residence of a household present that implies the distribution of household by type of fuel used for cooking and place of residence. Moreover, firewood is widely used for cooking in both rural and urban households; the only slight difference is that urban households purchase their firewood while their rural counterparts collect it. Relatively, kerosene is the main energy source for lighting in the rural areas of Ethiopia, while in the urban areas; electricity is the main source (UN, 2004; Guta, 2014; Gebreegziabher *et al.*, 2012).

In Ethiopia, more than 90% of the total energy supply of the country is derived from biomass fuels including woody biomass (77%), crop residues (8.7%) and dung (7.7%). However, national figures considerable regional and local variations in both supply and consumption patterns, as well as temporal changes in these patterns in face of declining stocks and yields of wood fuels. The energy requirements of a large and fast growing population and the fact that the major proportion is supplied by traditional energy sources have serious implications on the natural resource base. Looking at biomass supply and demand balances, there is a huge and constantly widening gap between demand and sustainable fuel wood supply (GTZ, 2000; Gebreegziabher *et al.*, 2012; Tekle, 2014).

Research by FAO (2006), illustrated that in people's daily lives, energy provides essential services for food production and storage, education and health services. However, there is a real energy gap between industrialized and developing countries, mainly rural and urban, communities where obtaining energy for basic human needs is a daily challenge. In those areas, solid fuels (wood and agricultural wastes) provide most of the energy that is available. Especially in developing countries there is wider gap in energy consumption patterns between rural and urban area (Madubansi & Shackleton, 2007).

Efficient energy consumption is a basic input for socio-economic growth and development at district, regional, national and local as well as global levels. There is a strong linkage between energy and the millennium development goals because the existence of extensive poverty in developing countries particularly sub-Saharan Africa without appropriate energy service provision could not address the challenges in the region. In short the provision of efficient energy services is a compulsory but not sufficient condition for sub Saharan Africa to pull itself out of poverty. Energy services are seen as one of the means rather than the end itself (Hammond, 2007; Balachandra, 2012).

Statement of the Problem

Biomass is very common in Ethiopia; fuels are mainly burned in inefficient open fires and traditional stoves. In many cases the demand for biomass fuels far exceeds sustainable supply. This leads to massive deforestation, land degradation and desertification (Heimann, 2007; Gebreegziabher *et al.*, 2012). Studies by WHO (2006) have shown that indoor air pollution is a major attributable factor for health problems in developing countries. Especially women, children and older generation are victim indoor pollution since mostly spend their time indoor cooking activities. Moreover, the major reasons for indoor air pollution are inefficient burning of inferior fuels like solid fuels (dung, agricultural residues and fuel wood) as well as poor ventilation system inside the house that exposures to these pollutants, in many ways, have to be linked to several adverse health effects including acute respiratory infection, chronic obstructive lung disease, adverse pregnancy outcomes, and eye diseases (Tekle, 2014).

Girma (2000) and Ibitoye (2013) research has shown that cooking energy has the major share in total household energy consumption in Ethiopia. Accessibility and ease of use of cooking fuels at affordable prices is becoming more difficult day by day especially for poor people, hence many of whom are outside from modern energy system. And also according to Girma (2000), Ethiopia one of the developing nations in the world has proved the close relation that exists between low level of energy consumption and underdevelopment by registering low per capita energy consumption. Moreover, the main household's sources of energy derived from wood and biomass which account about 93% of the total energy consumption of the country. Despite massive efforts and expenditure for electrification in Ethiopia the absolute number of people relying on biomass energy is still increasing; hence research conducted by Embassy of Japan in Ethiopia (2008) have shown that even the access to energy is gradually improving to reach 20% in 2007 by the efforts of the Ethiopian Electric Power Corporation (EEPCo) and the government of Ethiopia through constructing new power plants and expanding the national grid, but lower than the Sub-Sahara African average. This is a major limitation on the country's growth and development.

When a nation intends to measure the level of its development, energy is one that comes to the top priority. Development attained through efficient household energy consumption is last-longing and serves the best of sustained development. However, this ideal issue is not the case for many of the rural population due to a number of factors such as lack of access to modern energy sources, lack of awareness and weaker propensity to adopting improved technologies and so on. Efficient energy supply coverage in the rural areas of Ethiopia is very marginal. The coverage still remains low because of limited progress in energy supply activities in these areas. This major problem is that biomass, which covers 70-80% of Ethiopia's primary energy demand, is used in a very inefficient way (Heimann, 2007). This leads to deforestation and with it to further environmental problems like soil erosion.

This requires a systematic investigation as to how the energy players: users, environment, alternative energy technologies, and the overall provision interact with in the domains of efficient energy supply. For achieving sustainability in rural development with emphasis on livelihood and the means of enhancing the economic well being of the poor households, it is necessary that affordable access to energy is provided to the households. As well as gender issues need to be addressed with adequate focus in the context of energy use. Moreover, little research had been done on the subject and in the study area hence by addressing the issue, the results of the study will serve as baseline information (will fill the knowledge gap) for other researchers who want to conduct further research on sustainable energy options in rural Ethiopia.

The general objective of the study was to assess the determinants of rural household energy consumption patterns in Ethiopia. The specific objectives of the study were: 1) to identify the major source of energy consumption in the study area, and 2) to assess the availability of alternative energy sources to improve the existing energy consumption patterns. In light of the aforementioned research objectives this study strives to answer the following key research questions: 1) what are the major sources of energy consumption patterns in the study area? And 2) what are the availability of alternative energy sources to improve the existing energy consumption patterns?

Literature Review

The sources of energy consumption patterns at household level in the world could be broadly classified as renewable energy sources such as solar, wind, firewood, charcoal, crop residues, biogas and hydropower and non-renewable energy sources such as fossil fuel, coal, petroleum, natural gas and so on. However, the type of energy consumption might be determined by different factors such as income level, educational status, cultural preference and households' use of energy purposes such as cooking, lighting, boiling water and space conditioning and so on. In short, household's sources of energy consumption patterns in the world are diverse in nature.

Mfune and Boon (2008), illustrates that a great disparity in energy consumption exists between the developed and developing countries. Hence, the latter have 80 percent of the world's population but consume only 30 percent of the world's commercial energy like electricity. However, many of developing countries are richly endowed with energy resources.

Moreover, research by WHO (2006) and Guta (2014) found that cooking is as a task and threat to the lives of the great majority on an open fire in rural area of developing countries such as Africa, south Asia and Latin America especially women, children and older generation who mostly spent their time indoor air pollution. Moreover, worldwide more than three billion people depend on inefficient traditional source of energy such as solid fuels to meet their most fundamental energy needs. Additionally, the inefficient burning of solid fuels on traditional stove indoors creates a dangerous health of hundreds of people due to pollutants.

The term traditional and modern energy consumption has relative meaning. In the other words, some improve stoves in developing countries might be consider as traditional in developed countries. Moreover, the term traditional energy as used in this research refers to the direct very inefficient device such as wood, charcoal, leaves, agricultural residue and animal waste, for cooking, drying and charcoal production (Karekezi, 2004; Ogola *et al.,* 2011) while modern energy consumption refers to the conversion of energy to advanced fuels namely liquid fuels, gas and electricity etc.

Traditional household energy consumption patterns are mainly use of inefficient fuels biomass (wood and dung) source of energy directly or indirectly has environmental problems such as soil erosion and declining agricultural productivity, and also economic and health impacts. Hence, increased use of firewood and charcoal leads to deforestation, and that leading to ecological imbalance, and increased use of agricultural residues and animal dung deprives the land of essential nutrients that are necessary for soil fertility. Moreover, smoke from the use of fuel wood and dung for cooking has health impact such as acute respiratory infections. The other problem indoor air pollution is worse in poor countries where households' houses are not equipped with separate living and cooking places relatively to developed countries since majority of them do not have access to modern energy services (www.homepages.wmich.edu).

Moreover, in 1984 a joint World Bank and UNDP energy sector study in Ethiopia identified the unsound consumption of fuel wood, leading environmental problems such as deforestation and soil erosion. On the other hand, in national terms fuel wood consumption was estimated at 20 million tons and annual yield only 8.1 million tons, the consumption being some 2.5 times the annual yield. After ten years the Ethiopian Forestry Action Plan (EFAP) predictable that nationally annual fuel wood consumption was 35 million tons and the annual yield was only 8.6 million tons, the consumption being over 4 times the annual yield this implies "fuel wood gap" will be continue if not take measure to solve the problem of energy poverty (Sutcliffe, 2006; Sesan, 2014).

While, according to Karekezi (2004) and Hanna *et al.* (2012) modern biomass energy technologies can contribute to better bio-waste management relatively to traditional energy devices by reducing the problem of waste disposal of biogases. Moreover, relatively advantage of modern biomass energy is its job generation potential a very important attraction for many developing countries particularly for Africa and Latin America faced with chronic levels of unemployment and underemployment. Moreover, research by Modi *et al.* (2006) point out that modern energy services help drive economic growth by improving productivity and enabling local income generation through improved agricultural development and non-farm employment. Modern fuels and electricity, for example, help boost household income by providing lighting that extends livelihood activities beyond daylight hours.

In Ethiopian, rural households have been dependent for centuries on two main solid fuels woody biomass and dung with kerosene used for lighting however diesel, electricity, and liquefied petroleum gas are possible alternative energy sources, they are hardly used at all in these rural areas for various reasons, but primarily prohibitively high prices and lack of access or availability (Beyene and Koch, 2013). In addition, according to Mekonnen *et al.* (2009), have shown that biomass fuel is the most important household fuel types in Ethiopia particularly in rural areas, some argue that they are to a significant extent complements particularly for the baking of *injera*[1], which consumes about half of cooking fuels, using the traditional three stone fire.

Therefore, research by Gebreegziabher (2007) and Gebreegziabher *et al*. (2012) indicated that in developing country's household energy consumption is dependent on biomass (wood and animal wastes) particularly in rural areas this implies that such kind of sources of energy leads to environmental problem and poverty that imply the final consequence of this problem leads to reducing agricultural productivity hence failure recycle soil nutrients. In short, these nutrient losses depletion through using dung for cooking activities, leads to reduces a source of soil humus and fertility (See Figure 1).

[1] Injera, made from teff, is the staple bread in Ethiopia

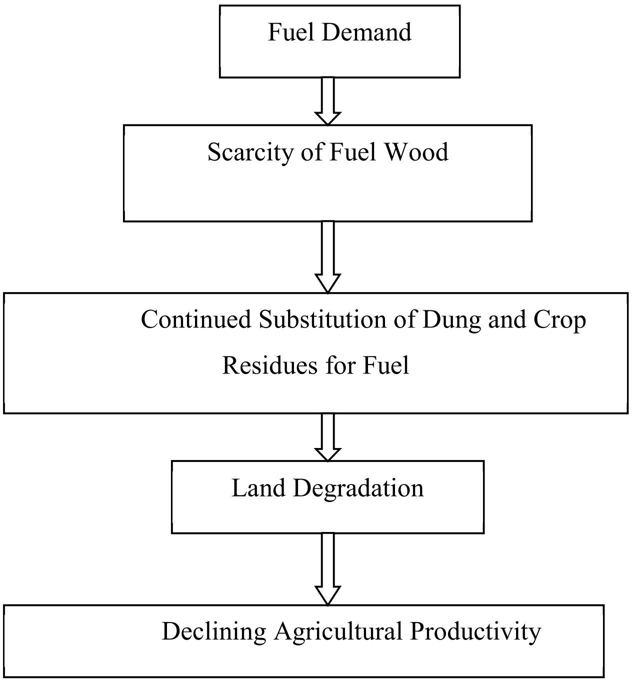


Figure 1: Biomass fuel consumption and its impact

Research Methodology

Study Area

Enderta district is located in South East zone of Tigray, the district one of the few highly populated areas in Ethiopia and its total population estimated 129,876 from which 49.3% male and the remaining 50.7% female (CSA, 2011). Number of family heads are 28,432 which male 18,879 and female 9,553 (CSA, 2011). Enderta district bounded in the north by Kelteie Awelaielo district, in the east by the Afar district Abeala, in the south district Sehartie Samere and Hentalo Wajerat and in the west side by Degua Tenben. The total area of the district is 93,048 km^2 and Altitude in the area ranges from 1400m to 1800m (Almaz, 2008).

Enderta district has been selected in that it is highly populated implying the unbalanced carrying capacity of the natural resource base and hence the main source of energy, is drought prone and low energy per capita consumption. Moreover, majority of their energy consumption depends on traditional energy sources such as wood, charcoal, dung and crop residues leading to the increasing deforestation and reducing agricultural productivity in the study area.

Research Design

In this study exploratory type of study was employed to investigate and examine the current state of problems that affecting energy consumption of households. Survey was a method of data collection using appropriate instruments such as structured questionnaire based on interview technique. Both qualitative and quantitative data were collected to examine the situation of household energy consumption patterns in rural Enderta district. Moreover, both primary and secondary data were collected while the primary data were cross-sectional data. The survey was covered a random sample of 120 household heads selected from three rural villages based on a Probability Proportional to Size (PPS).

Sources of Data and Collection Methods

In assessing the household energy consumption patterns, the secondary data was collected from different sources such as census, regional documents, district manuscripts, records and official documents of energy office. Documents from the ministry of Energy and Water, Annual Statistical Abstract were consulted. Relevant literatures concerning household energy consumption patterns were also reviewed. However, the primary data were gathered from the household heads of the study area.

In the study area the following respondents were selected as primary data source.

a) Household head
b) Rural village leaders and Development agents
c) Key informants: - they were taken to identify household energy consumption patterns

Each sample rural village was randomly selected from 17 rural villages through Simple Random Sampling method.

Key informants from each community were selected on the basis of purposive sample technique.

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, Enderta disrict was purposively selected since the district is populous and cutting trees for charcoal purposes is a common practice. In the second stage, three rural villages were selected from 17 rural villages through Simple randomly method such as Debri, Mayambesa, Felegeselam in order to accommodate household heads. Finally, the researcher selected 120 household heads through simple random sampling method, 53 households who has access to modern source of energy (electricity) and the remaining 67 household heads from their source of energy were traditional inefficient biomass based on Probability Proportional to Size (PPS). In short, the required information regarding rural villages and the sampling frame were collected from both Enderta district and rural village administration.

Table 1: The distribution of sample sizes of household heads in selected rural villages

Name of rural villages	Total household heads				Proportionality of the sample to actual population
	Actual		Sample proportion		
	Number	Percentage	Number	Percentage	
Myambesa	6665	31.1	31	25.8	10%
Debri	7913	37.0	53	44.2	10%
Felegeselam	6820	31.9	36	30	10%
Total	21398	100	120	100	10%

Source: Enderta district administration, 2011

Model Specification

This study used probit model. The rural household owner would decide to consume modern source of energy, that is either transitional or advanced modern fuels, or decide to consume traditional sources of energy. Therefore, an energy consumption utility function was a function *U(x)* that assigns a number to every energy consumption bundle *x* where the energy consumption preference bundle is an element of the set of all possible energy consumption preferences *X.* The utility function *U(x)* represents preference relation between bundle *x* and bundle *y* where both bundles *x* and *y* are elements of the set of all alternative bundles space *X.* Therefore, *U(x)* is at least as large as *U(y)* if and only if bundle *x* is at least as good as *y.*

Therefore, in this thesis the choice of source of energy consumption was modeled as a latent or unobservable variable Y_i^* :

$$Y_i^* = \alpha + \beta' X_i + \varepsilon \quad (1)$$

Where α is the intercept, β is the coefficient estimated and *X is* matrix of the independent variables determining energy consumption source preference and $\beta' X$ is the index function and the error term has a logistic distribution with mean 0 and variance 1. We do not directly observe the energy consumption preferences, what we do observe was only whether a given rural household prefers to use modern or traditional source of energy consumption. Hence, our observation goes like:

$$y_i = \begin{cases} 1 & if \ y_i^* > 0 \\ 0 & if \ y_i^* <= 0 \end{cases} \quad (2)$$

Where:

Y_i is a dummy variable indicating that Y_i takes 1 if the household participates in modern energy consumption patterns and 0 other wise (Maddala, 1983).

Source of energy: it is a dummy dependent variable with value of 1 if the household participates in modern source of energy (electricity, kerosene, liquefied petroleum gas/LPG and biogases) for cooking, lighting ,baking *injera* and heating, 0 otherwise that their source of energy could be inefficient traditional type of source of energy (firewood, dung, crop residue and the likes).

Independent variables:

Household income/Per capita expenditure: it is a continuous variable measured in Ethiopian birr. It is expected who have higher income of household could participate in modern source of energy and using improved technologies than have lower income of household in the study area.

Household size: it is a continuous variable; the number of family size live in the same household affects household energy consumption patterns due to the availability of active labour force in the household. It is expected that the larger family size could participating in modern source of energy and using improved technologies than smaller family size in the study area.

Educational level of household head: it is a dummy variable with value of 1 for those who were literate (who were attend formal school), 0 otherwise for those respondent illiterate (who were not attend formal school). It is expected that educated household head have better chance to participating in modern source of energy and using improved technologies than illiterate headed of household in the study area.

Occupation of household head: it is a dummy variable with value of 1 if the household headed employed out of farming activities, other wise 0. It is expected the household who employed out of farming activities could participating in modern source of energy and using improved technologies than who employed in farming activities.

Sex of household head: it is dummy variable with a value of 0 for male, other wise 1. It is expected that relatively male head of household could participating modern source of energy and using improved technologies than female headed of household.

Access to credit services: is a dummy variable with values of 0 for that had access to credit services, 1 otherwise. It is expected that relatively who had access to credit service households could participating in modern source of energy and using improved technologies than who had not access to credit households.

Age of household head: it is a continuous variable measured in years. It is expected that the younger families could participating in modern source of energy and using improved technologies than older generation due to emotional resistant.

Number of livestock owned: it is a continuous variable measured in TLU. It is expected who had lager number of cattle; they could used dung for source of energy than who had no/ had smaller number of cattle.

Use wood from own tree: it is a dummy variable with value of 0 for those households use wood from own tree in their land, 1 otherwise. It is expected who had used firewood from own farm land tree, they could used firewood for cooking purposes than who had no used wood from own farm land tree.

Distance wood collected: it is a continuous variable measured in kilometers. It is expected that if the collecting fire wood far from the household resident, they could spent more time for collection fire wood and dung. It is hypothesized that distance traveled to collect fuel wood will have positive effect on the time spent for collecting fuel wood.

Distance dung collected: it is a continuous variable measured in kilometers. It is expected that if the collecting dung far from the household resident, they could spent more time for collection fire wood and dung than participation other productive activities. It is hypothesized that distance traveled to collect fuel wood will have positive effect on the time spent for collecting dung.

Smoke from stove: it is a dummy variable with value of 0 if household respond high emissions of smoke from stove, 1 otherwise. It is expected that the smoke emission from stove is affect the cooking time of households. It is expected that the smoke from stove will have a direct effect on the time spent for cooking.

Kitchen service: it is a dummy variable with value of 0 household cook in side kitchen, 1 otherwise. It is expected that households who cook in kitchen have better chance reducing both time of cooking and consumption of energy. It is expected that the kitchen service will have an inverse effect on the time spent for cooking.

Methods of Data Analysis

In this study, both 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. Specifically: percentage, mean, standard deviation, maximum and minimum values of the required variables were computed. The statements from scheduled interview were used to substantiate the responses of quantitative findings. For quantitative Probit model and t-test was used to analyze determinants of adoption of improved using STATA software.

RESULTS AND DISCUSSION

Discussion on Descriptive Statistics of the Survey Result

Education and Occupation of Household Heads

As in Figure 2 illustrates that more than three-fourth of the household heads found illiterate (60.83%) with only 15.83 percent could simply read and write. While about 23.33 percent of the households attained formal education from grade one up to college diploma. In fact, only 39.17% of household heads have got chance to attain formal education. Education is expected to affect the adoption decision of household energy consumption. In this study, educated head of households are assumed to be more aware of the environmental and health effects of using biomass fuels (firewood, dung, crop residues) and, as a result, the researcher expect that education plays a great role of increasing consumption of modern sources of energy as well as adoption of improved stoves in the area of energy consumption. Supported by similar study Gebreegziabher (2007) had shown that the education of household head significantly and negatively influenced the decision to consume wood implies the less likely would the household consume wood the higher level of education. And also supported by other research (Barnes *et al.*, 2010) had shown that education is negatively related to energy use and this would probably mean that they are more aware of the benefits of switching to modern cooking fuels or conserving biomass energy.

Figure 2 Overall educational statuses of the heads of household

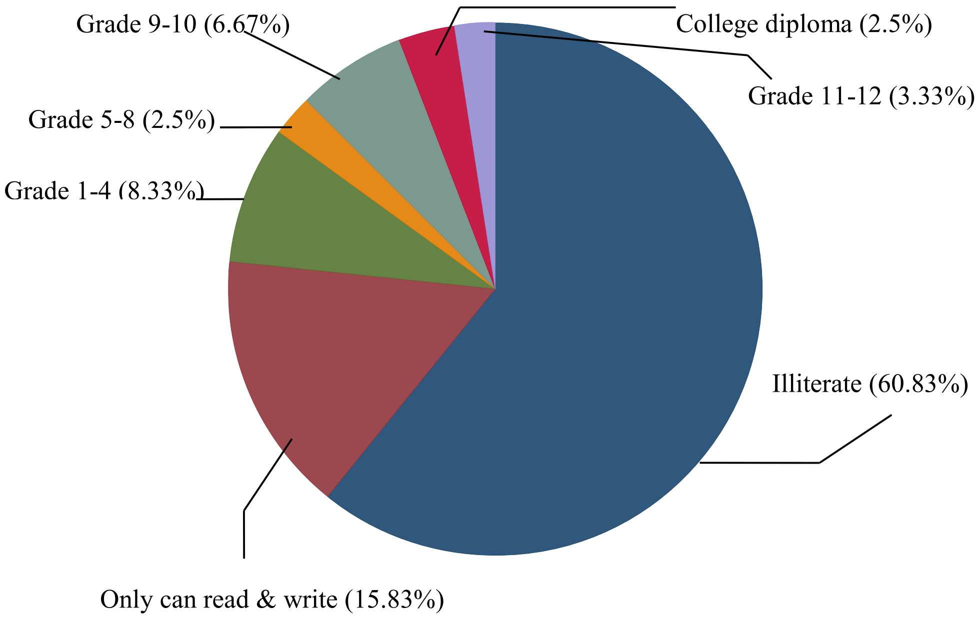
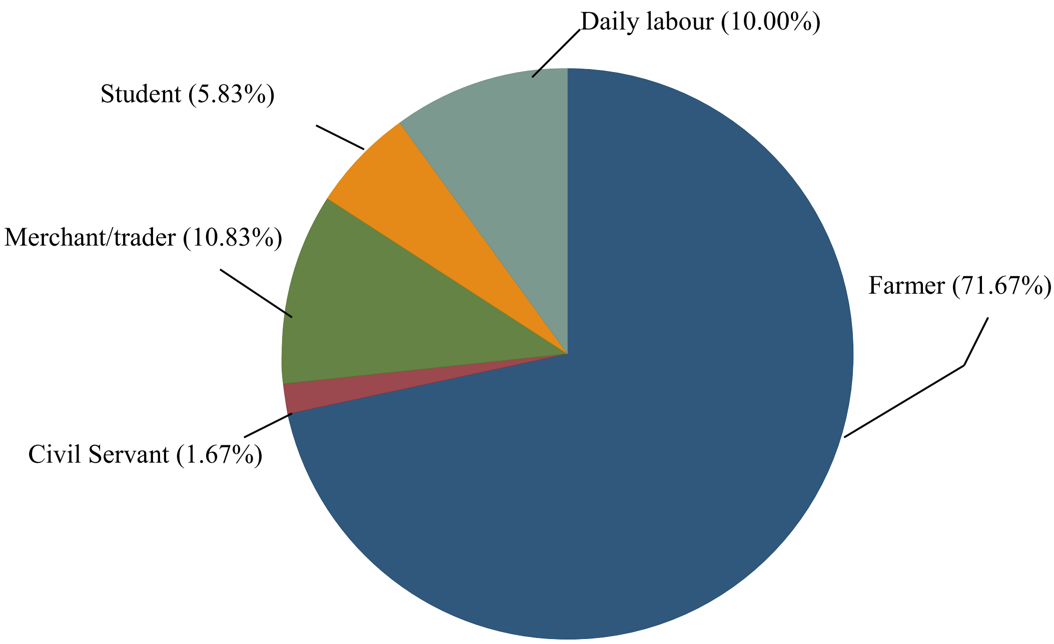


Figure 3 the primary occupation of household heads in the study area is farming in more than four-fifth of the households. The result also shows that of the total household heads; about 5.83 percent are found student, 10% are daily laborer, 10.83% undertaking their business and the remaining only 1.67% are found employed (see Figure 3). As such as have indicated that the educational status has a direct implication to the primary occupation of the sample household heads with greatest number of households are being employed on farming activities. It is expected that the household heads who are employed out of farming activities could use more modern source of energy and adoption improved technologies than who are employed in farming activities. Supported by similar research by (Maser *et al.,* 2000) indicated that households that remained as fuel wood-only users showed no or a small positive change in a stable main occupational structure; all households also remained in the same income group.

Figure 3 Overall primary occupations of heads of household

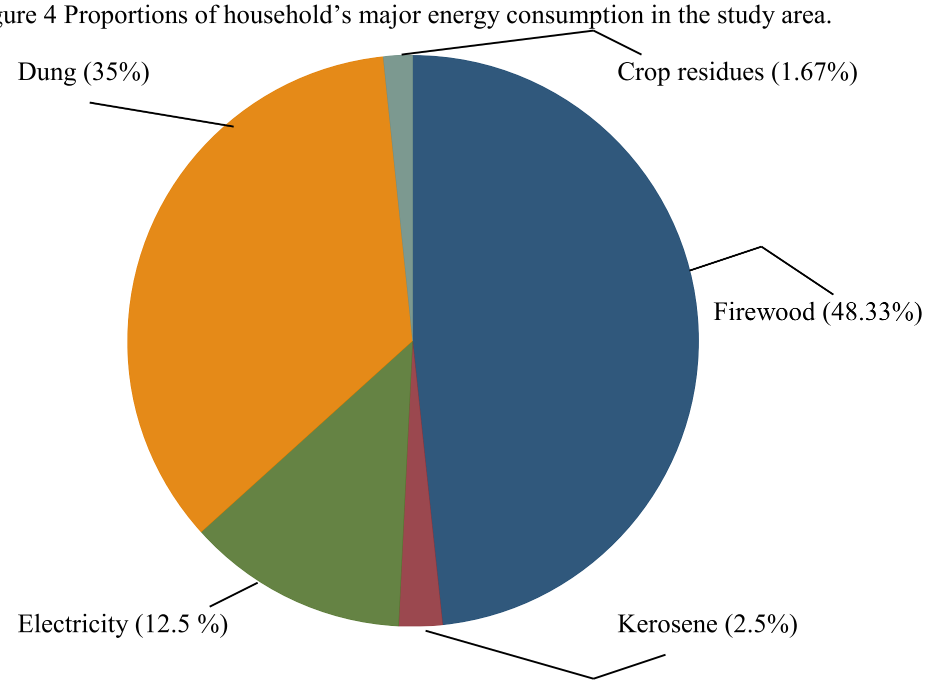


Rural Household Energy Consumption

In this section, key variables of interest that characterize households' energy consumption patterns are presented.

Larger proportion of rural households are dependent on traditional fuels (biomass) while some used modern source of energy such as electricity and kerosene for cooking, lighting, baking *injera* (Ethiopian bread) and heating. As clearly shown in Figure 4 that larger proportion of households are dependent on firewood and dung source of energy consumption while kerosene and crop residues are found lowest energy consumption in rural Enderta district. The main reasons for preference of household energy consumption in the study area is ease of access (59.70%) and convenience (31.34%) source of energy furthermore the least reasons for choice of rural household's energy consumption is cultural preference and cheap prices, 1.49% and 7.46% respectively. This is supported by research (Mekonnen and Kohlin, 2008), in Ethiopian, rural households have been dependent for centuries on two main solid fuels woody biomass and dung with kerosene used for lighting however electricity, and liquefied petroleum gas are possible alternative energy sources, they are hardly used at all in these rural areas due to high prices and lack of access. The researcher argue in favor of this pervious work hence rural households dependent on biomass source of energy consumption for various reasons but mainly due to lack of availability of modern energy sources. In fact, the results show that the existing in rural household energy consumption patterns in progress hence there is improvement such as access to electricity and distribution of improved stove for rural communities.

Figure 4 Proportions of household's major energy consumption in the study area.



The characteristic of household fuel utilization is shown (See Table 2) the majority of households use firewood followed by dung for the purpose of baking '*injera'* while crop residues and electricity are found in the third and fourth level respectively. As we can seen from the Table 2, charcoal is the first widely used fuel type, dung is the second, firewood and kerosene is the third and fourth respectively widely used fuel by households for the purposes of cooking (stew (wet), soup, making tea and coffee and likes) with respect to other fuel types. Furthermore, as the third column of Table 2 shows that electricity followed by dry cells, kerosene is found in the third with respect to other fuel types used for household's source of lighting purposes. Study by Gebreegziabher *et al.* (2012) had shown that *injera* baking and general cooking are the two most common end uses of urban domestic energy consumption in Ethiopia. Fuel wood, electricity, and dung are mainly used to bake *injera*, while charcoal and kerosene are used for other cooking. The researcher argue in favor of Gebreegziabher *et al.* (2012) work but this finding conducted in rural area even if some rural households with access to electric service, they did not use for the purposes of baking *injera* as well as cooking mainly only use it for the purposes of lighting.

The finding shown that in the study area larger proportion of households with no access to modern fuel are found using a combination of firewood and dung (83.58%) for domestic source of energy consumption and some of them also use a combination of firewood and crop residue (10.45%) for domestic end sources of energy consumption whereas majority households with access to modern fuel have used a combination of firewood and electricity (90.57%), followed by firewood and dung (5.66%) the next most important source of fuel for a combination of household's source of energy consumption in the study area (see Table 2). The major reasons for a combination of source of energy were availability and convenience of source of energy. For households with no access to modern fuel the most reasons a combination of source of energy are found availability (62.69%) and convenience (37.31%) source of fuel while majority of households with access to modern fuel in the study area the main motive for mixture of source of fuel were convenience (50.94%) and availability (49.06).

Table 2: Proportion of Household Fuel Utilization

Kind of fuel	Proportion of total energy consumption in %		
	Baking *injera*	Cooking	Lighting
Firewood	50.00	16.67	0.00
Charcoal	0.00	38.33	0.00
Crop residue	7.50	0.00	1.67
Dung	40.00	32.50	0.00
Kerosene	0.00	12.50	18.33
Electricity	2.50	0.00	44.17
Candle	0.00	0.00	4.17
Dry cells	0.00	0.00	31.67

Among the various fuels considered wood and dung turned out to be the prominent fuel sources of households in the study area. A descriptive summary of households' energy sources is presented in Table 3 showing that all households in sample use firewood as energy source with small portion of it coming from the market (purchasing).

Dung is the next important for household's sources of energy consumption with largest proportion being collected by the households themselves but almost few of them have not used dung for household source of energy. According to Gebreegziabher (2007), none of the sample households were found using crop residues. However, this finding shows that some households are found using crop residues hence highly depletion of firewood leads to substitution of crop residues for source of energy consumption.

Table 3: Fuel sources, households involved and mode of acquisition of biomass energy sources

Fuel sources	Households involved (%)	No use (%)	Way of acquired (%)	
			Buying (%)	Self collecting (%)
Firewood	100.00	0.00	10.92	89.07
Dung	71.67	28.33	0.83	70.83
Crop residue	20.83	79.17	0.83	20.00
Charcoal	40.83	59.17	10.00	30.81

Rhett (2006) and INBAR (2008) had shown that Ethiopia had an initial forest cover of about 13,000,000 hectares, but between 1990 and 2000, it lost an average of 140,900 hectares of forest per year which amounts to an average annual deforestation rate of 0.93% (Rhett, 2006). 90% of the forest is removal associated with firewood and the production of charcoal, which increasingly contributes to the country's overall deforestation rates of 141,000 hectares per year (INBAR, 2008). In this study, also found out that survey of availability of biomass (firewood, crop residue, dung, charcoal) in the last five years is (See Table 4) reveals that majority of households indicated that the available biomass is highly depleted as compared to the availability in the last five years. Particularly the availability of crop residue and charcoal is less available. In addition, the third and fourth less available biomass is dung and firewood respectively. However, some households have been agreed that the availability of firewood and dung is more as compared to in the previous years hence these households have planted trees on their farm land for fuel wood purpose and they are collected dung from their own livestock.

Table 4: Availability of biomass in the last five years

Variable	Fire wood	Crop residue	Dung	Charcoal
	%	%	%	%
More available	14.17	0.00	10.00	5.00
Same as before	8.33	5.83	4.17	5.00
Less available	77.50	94.17	85.83	90.00

Damm and Triebe (2008) found out that rural households spend the majority of their time (up to 30 hours per month) on survival activities such as cooking, fuel wood collection and so on include an increased risk of injury due to the heavy loads carried (typical head loads have been measured at 20 – 50 kg). In this study, also finding shown that (See Table 5) on average households traveled 12.94 km, 2.72 km, 32.61 km and 11.45 km for collection of firewood, crop residues, dung and charcoal per week respectively. In the other words, on average 8.48 and 7.98 hours are spent for collecting firewood and dung per week respectively. And also on average 0.70 and 3.95 hours are spent for collecting crop residues and charcoal per week respectively. From this could concluded that households in the study area spent significant amount of time for collecting fuel that could be used for other productive purposes such as carried out agriculture activities and likes.

Table 5: Distance traveled, frequency and time spent for biomass collection

Variable	Mean	Std. Dev.	Min	Max
Distance traveled to collect firewood (km/ week)	12.94	12.67	0	50
Time spent to collect firewood (hour/week)	8.48	7.58	0	36
Frequency of firewood collection per week	1.91	0.93	0	3
Distance traveled to collect crop residues (km/ week)	2.72	10.54	0	60
Time spent to collect crop residues (hour/ week)	0.70	2.21	0	12
Frequency of crop residues collection per week	0.33	0.88	0	3
Distance traveled to collect dung (km/week)	32.61	40.78	0	150
Time spent to collect dung (hour/week)	7.98	9.01	0	36
Frequency of dung collection per week	2.09	1.10	0	3
Distance traveled to collect charcoal per week (km/week)	11.45	19.17	0	80
Time spent to collect charcoal (hour/week)	3.95	6.46	0	27
Frequency of charcoal collection per week	0.82	1.09	0	3

The rank of households' use of energy sources for purposes of *mitad/mogogo*[1], general cooking and lighting are present in Table 6, Table 7 and Table 8 respectively.

As indicated in Table 6 shows that households with no access to modern fuel, dung is very important a sources of fuel for '*mitad/mogogo'* followed by firewood while households with access to modern fuel is true regarding, firewood is first and dung the next very important source of energy for purposes of '*mitad/mogogo'* and only in rare cases electricity *mitad* is used for baking *injera.*

As shown in Table 6 that all of households with no access to modern fuel have not chance to used electricity *mitad* for baking *injera* additionally the finding reveals that majority of households with access to modern fuel have not used crop residues for '*mitad/mogogo'* purposes. Furthermore, the data shows that in both households with no and with accesses modern fuel, crop residues is found less important for baking *injera* purposes.

Table 6: Ranking households use of energy sources for *'mitad/Mogogo'*

Variables	Wood		Dung		Crop residue		Electricity	
	Households with no access to modern fuel	Households with access to modern fuel	Households with no access to modern fuel	Households with access to modern fuel	Households with no access to modern fuel	Households with access to modern fuel	Households with no access to modern fuel	Households with access to modern fuel
	%	%	%	%	%	%	%	%
Very important	46.27	79.25	59.70	16.67	1.49	0.00	0.00	14.00
Important	32.84	9.43	31.34	18.75	7.46	2.08	0.00	0.00
Less important	16.42	7.55	4.48	8.33	17.91	2.08	0.00	2.00
No use	4.48	3.77	4.48	56.25	73.13	95.83	100.00	84.00

In similar way, below Table 7 concerning the ranking households using source of energy for cooking (preparing stew (wet), soup, making tea and coffee and so on), like in Table 6, dung is found the first very important source of energy, followed by charcoal by households with no access to modern fuel. While households with access to modern fuel, charcoal is found the first very important source of energy consumption for cooking purposes while kerosene is second. Wood and dung are also very important sources of energy for some households with access to modern fuel.

Table 7 indicates that both households with no and with accesses to modern fuel do not use electricity for cooking purposes. Crop residues is not used for cooking purposes by households with access to modern fuel but only in rare cases that it is used for cooking purposes by households with no access to modern fuel.

[1] Mitad/Moggo is an instrument used to make injera (Ethiopian bread)

Table 7: Ranking households using sources of energy for cooking (preparing stew (wet), soup, making tea and coffee) purposes

Variables	Wood		Dung		Crop residue		Charcoal		Kerosene		Electricity	
	Households with no access to modern fuel	Households with access to modern fuel	Households with no access to modern fuel	Households with access to modern fuel	Households with no access to modern fuel	Households with access to modern fuel	Households with no access to modern fuel	Households with access to modern fuel	Households with no access to modern fuel	Households with access to modern fuel	Households with no access to modern fuel	Households with access to modern fuel
	%	%	%	%	%	%	%	%	%	%	%	%
Very important	23.88	14.58	64.18	16.67	0.00	0.00	28.36	53.85	1.49	21.15	0.00	0.00
Important	43.28	10.42	20.90	2.08	7.46	0.00	5.97	13.46	1.49	13.46	0.00	0.00
Less important	5.97	6.25	8.96	10.42	14.93	0.00	4.48	5.77	0.00	0.00	0.00	0.00
No use	26.87	68.75	5.97	70.83	77.61	100.00	61.19	26.92	97.01	65.38	100.00	100.00

Table 8 presents dry cells and kerosene are the first and second important source of energy for purposes of lighting by households with no access to modern fuel while electricity is very important by all households with access to modern fuel.

Table 8 also shows that firewood is not found using for lighting purposes in both households with no and with accesses to modern fuel. In similar way, in table 8, crop residues is also not used by households with access to modern fuel but only in rare cases used for lighting purposes in households with no access to modern fuel.

Table 8: Ranking households using source of energy for lighting

Variables	Wood		Crop residue		Kerosene		Electricity		Dry cells		Candle	
	Households with no access to modern fuel	Households with access to modern fuel	Households with no access to modern fuel	Households with access to modern fuel	Households with no access to modern fuel	Households with access to modern fuel	Households with no access to modern fuel	Households with access to modern fuel	Households with no access to modern fuel	Households with access to modern fuel	Households with no access to modern fuel	Households with access to modern fuel
	%	%	%	%	%	%	%	%	%	%	%	%
Very important	1.49	0.00	1.49	0.00	34.33	4.17	0.00	100.00	58.21	0.00	4.48	0.00
Important	1.49	0.00	5.97	0.00	16.42	0.00	0.00	0.00	14.93	14.58	17.91	0.00
Less important	4.48	0.00	7.46	0.00	10.45	4.17	0.00	0.00	1.49	22.92	16.42	8.51
No use	92.54	100.00	85.07	100.00	38.81	91.67	100.00	0.00	25.37	62.50	61.19	91.49

Alternative Energy Sources

Gebreegziabher (2010) found out that improvement in resource-use efficiency through technological alternatives like biogas is vital. Still application of technological alternative energy sources production and use in Ethiopia is in an infant stage. In this study, also finding shown that (Table 9), all a households in the study do not have access to information/ training on biogas technologies, solar heating and wind power. Only, 39.39 percent and 43.40 percent of households with no and with access to modern fuel respectively have access information on energy saving devices but majority of both households with no and with access to modern fuel do not have information/ training on energy saving devices. In addition, larger proportion of households do not have information on improved stoves, in fact some households have better access to information on improved stove than other alternative technologies (biogas, solar heating and wind power) in the area of energy consumption. From this could conclude that biomass energy sources is the dominant fuel sources by both households with no and with access to modern fuel in the study area implying that burden on biomass (wood, dung and crop residue) energy sources which leads to environmental problem and subsequent reduction in agricultural productivity.

Table 9: Sample households towards access to information/training on alternative technologies in the area of energy consumption

Variables	Energy saving devices		Biogas		Solar heating		Wind power		Improved stove	
	Households with no access to modern fuel	Households with access to modern fuel	Households with no access to modern fuel	Households with access to modern fuel	Households with no access to modern fuel	Households with access to modern fuel	Households with no access to modern fuel	Households with access to modern fuel	Households with no access to modern fuel	Households with access to modern fuel
	%	%	%	%	%	%	%	%	%	%
Yes	39.39	43.40	0.00	0.00	0.00	0.00	0.00	0.00	39.39	43.40
No	60.61	56.60	100.00	100.00	100.00	100.00	100.00	100.00	60.61	56.60

Comparison of Households with no and with Access to Modern Fuel

In order to identify and analyze the factors which influence the adoption of modern source of energy are presented in Table 10. It is essential to classify variables into three sub-categories such as demographic, economic and access to facilities.

The demographic characteristics of households defined in terms of sex, religion, marital status, education level, age and family size. The Distributions of household's demographic characteristics have indicated (Table 10). The result of this study reveals that mean age of the household is 39 and 34 years of old for households with no and with access to modern fuel respectively, this difference is statistically highly significant at 1%. This implies that younger families' relatively beneficial using modern source of energy than older families.

The result in Table 10 shows that average of family size in the study area is 5.9 and 6.2 for households with no and with access to modern fuel households respectively, the difference is statistically not significant too. In similar way, the sex of the household head, about 59.70 percent of households with no access to modern fuel is male headed household while households with access to modern fuel are account 54.72 percent. This difference is also statistically not significant.

Table 10 indicates the educational level of head of the households; about 20.90 percent of households with no access to modern fuel are literate household head while households with access to modern fuel account 62.26 percent household heads are literate. This difference is statically highly significant at 1%. This implies that literate headed households are consumed more modern sources of energy than illiterate headed households.

Economic variables are very important variables that determine the status and life style of households including their patterns and levels of consumption of goods and services (Gebremeskel, 2010). The distribution of the sample household heads by economic variables is given (see Table 10).

Table 10, the occupational status of household heads, only 11% of households with no access to modern fuel are found to be engage on out of farming activities, while 43.40% of households with access to modern fuel are found to be employed out of farming activities with the remaining majority of being employed in farming activities. This difference between in primary occupation of households with no and with access to modern fuel is found to be highly statistically significant at 1%. We can conclude from this households employed out of farming activities is higher in access to modern sources of energy than households employed in farming activities.

Furthermore, the survey result indicates that average per capital expenditure is 391.50 and 347.42 for households with no and with access to modern fuel respectively, this difference is statistically not significant. In similar way, average size of farm size is 1.6 and 1 '*timad*[1]' for households with no and with access to modern fuel respectively; this difference is also statistically not significant too. Similar fashion, the livestock holding that is measured in tropical livestock unit (TLU) indicated a mean is 2.01 and 1.69 for households with no and with access to modern fuel respectively; this difference also is statistically not significant (See Table 10).

Adoption of a particular technology in particular places at different times is conditioned by many facilities and institutional factors. The access to extension service with regard to information and technology, access to market and input and access to credit will determine for new technology adoption (Gebremeskel, 2010). Gebremeskel further added that access to credit for households in general and for poor rural households in particular is an economic incentive to participate in some programs.

[1] Timad is a farm size measurement an equivalent with 0.25 hectare

Below Table 10 indicates that the institutional and facility variables the survey result illustrates about 80.60% of households with no access to modern fuel have access to credit service, while 67.92% of households with access to modern fuel have access credit; access to credit service statistically is not significant too adopt modern energy sources. In similar way, 47.76 percent and 49.06 percent of households with no and with access to modern fuel respectively have access to information on improved stove. This implies that access to information on improved stove is also statistically not significant to adopt modern source of energy.

As shown (Table 10) that households with no access to modern fuel about kitchen service is 50.75%, 20.90% and 28.36% prepared food in separate kitchen, outdoor and in living room respectively while households with access to modern fuel prepared the food is 35.85% and 20.75% in separate kitchen and outdoor respectively while the remaining 43.40% households with access to modern fuel prepared the food in their living room. This difference is statistically significant at 10%. This implies that households with no access to modern have more separate kitchen service than households with access to modern fuel.

Furthermore, the average distant from the household's home to the agriculture extension center for households with no and with access to modern fuel is 2.4 km and 1.7 km respectively; this mean difference is statistically highly significant at 1%. In similar way, the mean distant from the households' home to health extension center for households with no access to modern fuel is about 2.3 km; the mean distance traveled by households with access to modern fuel is 0.9 km. This difference is also statistically significant at 5%. In addition, the average distance from the household's home to the road is 2.6 km for households with no access to modern fuel; whereas the mean distance traveled by households with access to modern fuel is 1.8 km. This is also statistically highly significant at 1%. In similar way, the average distant from household's home to market services for households with no access to modern fuel is 12.6 km; while the mean distance traveled by households with access to modern fuel is 10.7 km. Similarly way, this is also statistically significant at 5% (See Table 10).

Therefore households with access to modern fuel are close to agriculture extension center, health extension center, road and market as result, have better opportunity to acquire the services than households with no access to modern fuel.

Table 10: Overview of demographic, economic and access to facilities characteristics of sample household decision on energy consumption

Variable Name	Households with no access to modern fuel		Households with access to modern fuel		t-test
	Mean	Std. Dev.	Mean	Std. Dev.	
Age of household head	39.18	10.64	33.77	11.34	2.69***
Family size of household	5.93	2.00	6.17	2.05	-0.66
Sex of household	0.40	0.49	0.45	0.50	-0.55
Education of household head	0.21	0.41	0.62	0.49	-5.04***
Occupation of household head	0.164	0.37	0.433	0.50	-3.38***
Per capital expenditure	391.50	238.64	347.42	257.36	0.97
Farm size measured in '*timad'*	1.60	1.70	1.26	0.92	1.29
Total livestock measured in TLU	2.01	3.17	1.69	3.54	0.52
Access to credit service	0.19	0.40	0.32	0.47	-1.60
Access to improved stove information	0.52	0.50	0.51	0.51	0.14
Access to kitchen service	0.78	0.87	1.08	0.90	-1.85*
Distance from agriculture extension center	2.40	1.77	1.66	0.87	2.80***
Distance from health extension center	2.29	1.78	1.65	0.92	2.40**
Distance from road	2.61	1.95	1.78	1.47	2.59***
Distance from market	12.57	5.37	10.73	4.56	1.99**

*, **and *** indicate significant at 10%, 5% and 1% level respectively.

Results of econometric analysis on determinants of use of modern energy sources

The rural household owner would decide to consume modern source of energy, that is either transitional or advanced modern fuels, or decide to consume traditional sources of energy. And the result of probit model helps to identify the determinants of household decision whether to adopt or not adopt improved stove. The estimation result of the probit model that indicates of household decision to consume modern source of energy in Table 11.

Table 11, the educational level of the household head has highly significant impact on the decision of consumption of modern source of energy positively at 1% level of significance. When household head's educational level increased by one, the probability of consume modern source of energy will increase by 58.2%. This implies that educational level of household head play useful role for consumption of modern source of energy.

Table 11 indicates that sex of female headed of household has a negative influence on consumption of modern energy sources decision at 10% level of significance. When female household head's in increased one female headed household, source of modern energy consumption will decreased by 25.6%. This implies that male headed of household would use more modern source of energy than female headed households.

It is also evident (from Table 11) that access to credit service has positively significant effect for the household to consumed modern energy sources at 10% level of significance. A 1% increase in access to credit service will have a positive effect on the probability use of modern energy sources by 32.2%. This implies that access to credit service of household head motivates to consume modern source of energy.

In similar way, livestock ownership has a positive effect on consumption of modern source of energy decision 10% level of significance. As livestock ownership increased by one TLU, the probability use of modern energy sources will increase by 6.1% in household heads. Hence livestock is asset of household; this implies that livestock ownership of household head plays useful role for consumption of modern source of energy (see Table 11).

As clearly shown in Table 11, the distance from the head of the household home to both wood and dung collection have negative influence on the consumption of modern source of energy decision of households at statistically significance level of 1% and 5% respectively. As distance from the head of the household home to firewood collection increase by one kilometer, the likelihood of consumption modern source of energy will decrease by 2.0%. In similar way, as distance from the head of the household home to dung collection increased by one kilometer, the probability of consumption of modern source of energy decision will decrease by 1.0%. This implies that the distance from the head of the household home to both firewood and dung collections have an adverse effect on consumption of modern source of energy decision of household head. Hence, relatively households with access to modern fuel live in small towns so their way of acquiring source of fuel (wood and dung) are found involved in fuel buying than self collecting by households with no access to modern fuel.

Furthermore, the distance from the head of the household home to charcoal collection has a positive impact on the consumption of modern energy sources decision of households at statistically significance level of 1%. As distance from the head of the household home to charcoal collection increase by one kilometer, the probability of consumption of modern energy sources will increase by 2.0% (see Table 11).

The Kitchen service of household heads has significant positive effect on decisions to consumed modern source of energy at 10% level of significance. A 1% increase in use of kitchen service will have a positive effect on the probability of use of modern energy sources by 15.4% (see Table 11). In addition to this the model fitness, the variability of the error term variances and the multicollinearity is tested and the result shows that the model has 79.59% predicting power and it is free from hetreoscadesticity and multicollinearity. Hence these assure that the model specification is feasible and accurate.

Table 11: Probit model estimates of use of modern energy sources

Explanatory Variable	*Coefficient*	*Std. Err.*	*Z*	**Marginal effect (dy/dx)**
Per capital expenditure	-0.001	0.000	-1.25	-0.001
Family size	0.034	0.040	0.34	0.014
Educational level of hhh	1.640	0.148	3.93***	0.582
Occupation of hhh	0.646	0.192	1.32	0.251
Sex of hhh	-0.656	0.152	-1.69*	-0.256
Access to credit service	0.840	0.182	1.76*	0.322
Age of hhh	-.011	0.008	-0.56	-0.004
Livestock ownership	0.154	0.002	1.71*	0.061
Distance wood collection from home	-0.050	0.006	-2.66***	-0.020
Distant dung collection from home	-0.013	0.002	-2.37**	-0.005
Distant charcoal collection from home	0.037	0.006	2.66***	0.015
Kitchen service	0.386	0.080	1.93*	0.154
Improved stove Adopter	0.690	0.314	0.85	0.268
Way of acquiring improved stove	-0.047	0.107	-0.18	-0.019
Constant	-0.406			

*, **and *** indicate significant at 10%, 5% and 1% level respectively.

Conclusion and Recommendation

The finding reveals that major of households dependent on firewood and dung for purposes of baking *injera* and general cooking while kerosene, crop residue and electricity are lowest energy consumption in rural Enderta district. This implies the consequences of uses of biomass energy sources leads forest degradation, deforestation, and lands degradation all severe environmental problems. Moreover, the result shows that availability biomass in the last five years is highly depleted as compared to the availability of in the last five years. Improvement in resource-use efficiency through technological alternatives like biogas, wind power, solar heating and improved stove is vital however still application of technological alternative energy sources production and use in Ethiopia, particularly in Enderta district is in an infant stage. To overcome these, rural development planners should be encouraged the rural households to plant trees on their own farm land for fuel wood purpose and also adoption of improved stove could contribute to reducing burden on biomass.

In addition, to fill these knowledge gap different strategies should be planned to introduce and disseminate the alternative technologies, or at least create awareness to the population about the benefits of energy saving device and technologies via demonstrations, posters, and radio or TV advertisements is vital.

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