MEKELLE UNIVERSITY

MANAGEMENT DEPARTMENT

COLLEGE OF BUSINESS AND ECONOMICS

Survey on Household Energy Consumption Patterns: the Case of Enderta Woreda, Tigray Regional State

By:

Warkaw Legesse

A Thesis Submitted in Partial Fulfillment of the Requirements for Degree of Master of Development Studies

Major advisor: Hosaena Ghebru (PhD)

Co -Advisor: Solomon Petros (M.sc)

June, 2011

MEKELLE, ETHIOPIA

Declaration

I declare that this thesis work entitled **"Survey on household energy consumption patterns: the case of Enderta Woreda, Tigray Regional State"** submitted in partial fulfillment of the requirements for the award of the degree of MA in Development Studies to the College of Business and Economics, Mekelle University, through the Department of Management, is original work carried out by **Warkaw Legesse, Id.No. CBE/PR 116/02** is an authentic work has not been submitted earlier to any university or institution for award of any degree, diploma or prize to the best of my knowledge and belief.

Name of student: Warkaw Legesse Signature & date ____________________________

Certification

This is to certify that this thesis entitled "**Survey on Household Energy Consumption Patterns: the case of Enderta Woreda, Tigray Regional State**" submitted in partial fulfillment of the requirements for the award of the degree of MA in Development Studies to the College of Business and Economics, Mekelle University, through the Department of Management, done by **Mr. Warkaw Legesse, Id.No. CBE/PR 116/02** is an authentic work carried out by him under my guidance. The matter embodied in this project work has not been submitted earlier to any university or institution for an award of any degree, diploma or price to the best of my knowledge and belief.

Name of the student: Warkaw Legesse Signature & date______________________

Name Of the supervisor: Hosaena Ghebru (PhD) Signature & date____________________

Name of the co-supervisor: Solomon Petros (Msc) Signature & date_____________________

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Acronyms

EEPCO- Ethiopian Electric Power Corporation

EFAP- Ethiopian Forestry Action Plan

ESMAP- Energy Sector Management Assistant Program

FOA- Food and Agricultural Organization

GoE- Government of Ethiopia

GTZ- Gesellschaft Für Technische Zusammenarbeit

ICS- Improve Cooking Stove

INBAR- International Network for Bamboo and Rattan

LPG - Liquefied Petroleum Gas

MDGS- Millennium Development Goals

ProBEC- Program for Basic Energy and Conservation

TLU- Tropical livestock unit

UN- United Nation

UNDP- United Nation Development Program

WB- World Bank

WHO- World Health Organization

ACKNOWLEDGEMENTS

In the course of this thesis, I have received valuable assistance from various professionals and friends. These give me a great pleasure to express my heart-felt gratitude to those people who deserve my acknowledgment.

I appreciate the cooperation and unreserved contribution of various individuals, group and organizations for the successful accomplishment of the study. Above all I express my heartfelt gratitude to my principal advisor, Dr.Hosaena Ghebru not only for devoting much of his time to give my paper shape; critical comments and constructive suggestions but also for encouraging me to complete the task on time. I believe that this study would have been impossible without his unreserved dedication and encouragement.

My deepest gratitude goes to my co-advisor Ato Solomon Petros whose invaluable advice; critical comments and constructive suggestions were the major factors for the completion of this study. In addition to his unfailing and unreserved commitment and meticulous comments, Solomon has generously shared his precious materials throughout my writing of the thesis.

Most deeply, I wish to express my strong indebtedness to my advisor late G/Egziabher H/Selasie (Asst. Professor) for his strong motivate and helping me so greatly to carry on my thesis up to his accidental death.

I am particularly, grateful to my research grants award sponsor, the Ethiopia Strategy Support Program II (ESSP II) is a collaborative program between the Ethiopian Development Research Institute (EDRI) and the International Food Policy Research Institute (IFPRI) project for awarded for this research. Without this financial support, it would not have been possible to carry out the research works in its magnitude.

My special thanks go to Ato Gemechu Shale for his precious materials and his loving suggestions and comments have greatly helped me on draft of the thesis, which are dully considered in preparing the final draft. And also I am indebted to many of my friends Shishay Bitew, Dereje Yohanes and Amir Mohamed who deserves special thanks.

I wish to express my gratefulness to the Ministry of Education and Ambo University for scholarship I had been awarded or pursuing the Master's Degree program in Mekelle University.

I would like to acknowledge the strong collaboration of Tigray Region Water, Mines and Energy Bureau particularly Yared Mulu Abay (Alternative energy expert), Enderta woreda Water, Mines and Energy Bureau specifically Ato Mehari and Enderta woreda administration who helped me to get factual information during the data collection process.

My special thanks and limitless appreciation go to my mother Atalay Mengaw for persistent financial, technical and moral support and encouragement will remain engraved in my heart. My brothers, particularly, G/mariam Legesse and Eshetea Legesse deserve special thanks.

In addition, my deepest gratitude goes to all respondents for their willingness to contribute to the study by being the source of necessary data and information. I also thank the enumerators for their participation in the collection of much of the field data and information.

ABSTRACT

This study entitled "SURVEY ON HOUSEHOLD ENERGY CONSUMPTION PATTERNS: The case of Enderta woreda, Tigray." was developed with the aim of to understand the rural household energy consumption patterns with specific objective to identify the major source of energy consumption, to assess the determinants of adoption of improved stove and to assess the availability of alternative energy sources in the study area. To achieve the objectives of the research survey was a method of data collection using appropriate instruments such as structured questionnaire based on interview technique. The survey was covered a random sample of 120 household heads selected from three tabias based on a Probability Proportional to Size (PPS). To analysis the collected data both descriptive statistics and econometric model were adopted. For quantitative data STATA software is used to estimate probit model for analysis the determinants of adoption of improved energy technology. 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 baking injera and cooking 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. Improvement in resource-use efficiency through technological alternatives is vital however still application of technological alternative energy sources production and use in Ethiopia, particularly in the study area is in an infant stage. 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. Challenges and opportunities of renewable sources of energy and Obstacles of use of electric oven in rural households need to be addressed for future work in the study area.

Chapter I: Introduction

1.1 Background of the Study

Energy is very crucial for daily life to meet human beings basic need such as cooking, boiling water, lighting and heating (WHO, 2006). 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-DESA REPORT, 2004, p.12).

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).

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.

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).

Moreover, according to World Bank (2009), energy service delivery, especially to the poor, contributes to achieving the millennium development goals. Hence, without efficient and accessible modern energy economies cannot grow and develop and also poverty could not be eradicated. Since energy is vital input to all sectors of the economy, mainly such as industry, commerce, agriculture, and social services. However, the majority of the developing countries face a lack of sufficient power supply that is obstacle for their economy growth as well as reducing poverty. Moreover, most of the household in developing countries continue to be dependent on traditional use of solid fuels (biomass) for cooking and heating, due to lack of access to electricity and modern energy sources.

Studies on household energy consumption in Ethiopia was carried out by Mekonnen *et al*, (2009); Mekonnen and Kohlin, (2008) and Zenebe (2007), however Mfune and Boon (2008), You and Sulpya, (n.d) conducted in Zambia and Cambodia respectively. The first three of them empirical findings conducted in Ethiopia particularly the first and third carried out in Tigray regional state while the second carried out in Amhara regional state. But there are gaps that need to be filled in order to enrich the literature. For instance, Mekonnen *et al*, (2009) find out that income alone doesn't determine adoption and choice of fuel types, evidence from households in Tigrai and major cities in Ethiopia implies that the results cannot be used as direct policy in rural development. Mekonnen and Kohlin (2008) found out on biomass fuel consumption and dung use as manure; evidence from rural households in the Amhara region of Ethiopia indicate that use of dung as manure, particularly in the northern half of the Ethiopian highlands is limited partly because of a significant level of dung consumption as household fuel but household energy consumption patterns a continues studies important to see the progress. Zenbe, (2007) is relatively a better study covers a variety of issues on household fuel consumption and resource use in rural-urban Ethiopia but the results are not in harmony with the existing use pattern in rural household energy consumption patterns progress hence there is improvement in energy consumption such as access to electricity and distribution of improved stove for rural communities.

Data in Zambia by Mfune and Boon (2008) found on promoting renewable energy technologies for rural development in Africa: experiences Zambia shown that Zambia is dependent on primary source of energy such as wood fuel (79%), electricity (10%), coal (2%) and petroleum (9%). However, Zambia 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 energy sources is still in its infancy because alternative renewable energy technologies are poorly integrated in development plans. The same applies for Ethiopia hence the country is rich in alternative renewable energy sources but still not exploited as well due to lack of integrated rural development planning in energy issues. You, and Sulpya, (nd) gender's role in household energy and indoor air pollution in Cambodia found out that women are recognized as the primary source of biomass energy users as well as the emission receiver. Cooking food is considered as women's task and is generally conducted by women though the male helps her but staying near the fire is always women and the children. The same applies in Ethiopia in household energy consumption hence women are responsible for collection of fuel sources (wood and dung) as well as preparation of food as compared to men (www.sea-uema.ait.ac.th).

Zenebe (2007, p.29) has shown that in Ethiopia rural household energy consumption pattern is characterized by inefficient use of traditional biomass and limited access to modern energy sources. According to Zenebe in Tigray regional state source of energy is broadly categorized into two, such as modern fuels and inefficient traditional bio fuels. Both rural and urban households often consume a mix of both traditional and modern energy type. However, the traditional bio fuels are relatively dominated in their presence than modern fuels. The major source of "modern fuels such as petroleum and electricity are also used. Beside to the petroleum products, naphtha and kerosene are consumed in both rural and urban areas of the region. Moreover, in rural areas, both kerosene and diesel are mostly used for lighting but only in rare cases used for cooking purposes." Moreover, bio fuels are the dominant sources of energy in the household sector in urban and rural areas of the region. The traditional bio fuels used in the region include firewood, tree residues, animal dung, crop residues and charcoal. Besides, free collection accounts for the majority of the traditional fuels consumed by rural households.

1.2 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). Recent 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.

Girma (2000) 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, 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.

1.3 Objective of the Study

1.3.1 General objective of the Study

The general objective of the study was to assess the household energy consumption patterns in the case of rural area of Enderta woreda, Tigray Regional State.

1.3.2 Specific Objective of the Study

The specific objectives of the study were:

1. To identify the major source of energy consumption in the study area,
2. To assess the determinants of adoption of improved stove in household energy consumption in the study area,
3. To assess the availability of alternative energy sources in the study area.

1.4 Research Questions

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?
2. What are determinants of adoption of improved stove in household energy consumption in the study area?
3. What is the availability of alternative energy sources in the study area?

1.5 Significance of the Study

The survey covers a variety of issues, which in most cases was account for the bulk of energy consumption in the residence. In short, the result obtained from this study could be utilized in many ways. In the first place to aware the policy maker of ministry of energy, obstacles of households' adoption of improves energy technologies, community, governmental and non-governmental institutions. Moreover, it will help the rural development planners in the woreda and in the region to design integrated and gender-responsive rural development programs and projects which had significant contribution for promoting sustainable rural development. 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 Enderta woreda.

1.6 Scope of the study

This research study was delimited to: household energy consumption patterns have multidimensional impacts with regard to ecological, environmental, economical, social, political, health and cultural concerns at national, regional, zone and district levels. However, the study was focused on household energy consumption patterns at rural area of Enderta woreda. In short, the geographical scope of this study was delimited in to the boundary of rural Enderta woreda, Tigray, Ethiopia and also the sampling units of this study were delimited to 120 household heads in rural Enderta woreda. Moreover, three Tabias randomly in the district were selected to assess household energy consumption patterns for the purpose of the study. Content wise household energy consumption patterns were covered.

1.7 Limitation of the study

The researcher was facing the following constraints when conducted the research: there was lack of available of secondary data to see the trend of household energy consumption and there was language barrier between the researcher and the respondents. The sample size for this study was not large enough to study the issue and to represent the study population due to there was limited time for data collection. These were limiting the findings of the research.

1.8 Organization of the Paper

This thesis has five chapters. Chapter one provides the introduction part of the thesis, which includes statement of the problem, objective, research questions, significance and scope of the study. Chapter two deals with the literature review part, which consists of results of similar previous studies. Chapter three describes the study area, research design, sampling design, instruments and procedures for data collection, sources of data and collection and methods of data analysis. Chapter four deals with result and discussion part of the thesis and the final chapter five describes conclusion and recommendations of the thesis.

Chapter II: Literature Review

2.1 Concepts and Definitions

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, p.2), illustrate that:

> "*The long term global impact of current fossil fuel use is a major worrisome factor for industrialized countries; most developing countries are pre occupied with meeting the barest energy needs of their developing economies and populations. A great disparity in energy consumption exists between the developed and developing countries. The latter have 80 percent of the world's population but consume only 30 percent of the world's commercial energy. Ironically, many of these countries are richly endowed with energy resources.*"

Moreover, research by WHO (2006), 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 (biomass and coal) to meet their most fundamental energy needs. Hence, opening the door to their homes makes for a hazy welcome: thick grey smoke fills the air, making breathing unbearable and bringing tears to the eyes. Additionally, the inefficient burning of solid fuels on traditional stove indoors creates a dangerous health of hundreds of people due to pollutants. "Day in day out, and for hours at a time, women and their small children breathe in amounts of smoke equivalent to consuming two packs of cigarettes per day."

In addition Dzioubinski, O. and Chipman, R. (1999), have shown that in many developing countries particularly in their rural areas, inefficient traditional fuels constitute a major portion of total household energy consumption. Relatively the efficiency of a traditional fuel wood cooking stove is as low as 10-12% as with compared a liquefied petroleum gas (LPG) stove since efficiency of more than 40%. Despite the potential energy savings from the use of available efficient improved technologies for cooking, heating, lighting, electrical appliances and building insulation could reach as high as 75%. Unluckily, diffusion of these improved technologies especially in developing countries is slow as compare to developed countries. Hence, the main reasons for that is their high initial cost to the consumer; particularly relative to the low cash incomes in many rural areas. The second reasons that include shortages of particular fuels, lack of a distribution network, and failures of the distribution system as well as developing country's people emotionally resistant adoption of technologies. Form this paragraph we could understand that household energy consumption patterns in developing countries mainly dependent on traditional energy sources such as wood, charcoal, dung and crop residues this implies directly or indirectly reduces soil fertility and increasing land degradation leads to decline agricultural productivity.

2.2 Improved Cooking Stoves

Zenebe (2007, p.32), illustrated that except for Tigrai, the traditional *'tripod'* constitutes the dominant stoves for millions of rural and urban households in Ethiopia both for cooking and baking. The open fire stoves have very low energy efficiency, about 10 to 15% for cooking and 7% for baking. This shows that most of the potential energy (85%) or more is wasted in traditional cooking stoves comparing to improved cooking stoves. Hence, the low utilization efficiency of the open fire stoves have resulted in a higher demand for biomass, particularly for households that primarily or entirely rely on bio fuels. The traditional "*Tigrai*" *injera* stove was an indigenous innovation in response to the growing problem of fuel scarcity in the region. These traditional stoves are enclosed with a clay wall, and had a relatively better performance in fuel saving compared to the more common open fire stove. Moreover, according to Zenebe later, an improved stove was introduced, but it had only limited modifications to the pervious "*Tigrai*" type stove. However, except for these attempts, it is not yet clear whether the stoves being disseminated actually have the desired level of efficiency in terms of fuel saving and whether there is a scope for further improvements in fuel efficiency.

Moreover, research by Kathmandu (2005), illustrate that improved cooking stoves have the potential to save the fuel wood used for household cooking as compare to traditional stoves/open fire energy consumption. Hence, about 11 million tonnes of fuel wood are burnt annually for cooking alone. In theory, it is possible to reduce fuel wood consumption for cooking by half. Because improve cooking stoves have an efficiency factor in the range of 15-30%, while the efficiency of traditional mud stoves varies from 3-15%. However, the amount of fuel wood saved depends among other things such as the type of stoves, the condition of the fuel wood, the type and amount of food prepared, and the type of pots used for cooking. In addition according to Kathmandu even if with a low performance of 11% fuel wood savings, estimates indicate that one ICS can save an average of 1 tonne of fuel wood annually as compare to inefficient traditional stoves.

In addition according to Slaski and Thurber (2009. p.8), research indicated that:

> "*Despite the potentially huge health benefits of programs to disseminate improved cook stoves in the developing world, such programs have struggled to make an impact over several decades of effort. The entrance of commercial players into the cook stove space in recent years has the potential to bring innovative and hard-headed thinking to the question of how to scale cook stove adoption. Entrepreneurship in supplying cook stoves meshes nicely with the idea that serving the urgent needs of the millions at the bottom of the pyramid can be profitable (and thus sustainable and scalable) as well.*"

2.2.1 Determinants of Adoption of Improved Stoves

The adoption of improve stoves in a given society might be affected by variety factors such as income, education, stove price, smoke level, taste preference, cultural preferences and so on.

Research by Slaski and Thurber (2009), have shown that "the determinant of adoption of a new technology is inherent incentive or motivation, hence human beings by nature resistant which is connected with the perceived value of the new product or service. Since cook stove programs are most successful when seen by prospective customers to provide concrete and observable benefits." Currently, in rural areas where fuel is scarce, people similarly see the value of fuel-saving stoves, which help reduce long or dangerous trips to collect wood especially women and children spend majority of their time for collection fire wood rather than participating in productivity activities. Moreover, the other contribution of improved technologies the value that outside observers usually see as paramount the improvement of health through elimination of indoor air pollution. “Education about this benefit has for the most part been ineffective; even when informed about health benefits, users do not seem to value them highly enough to overcome preferences for traditional cooking methods”. In addition, what have worked better are efforts that actually create and market new perceived value associated with the stove.

Moreover, Tsephel *et al.* (2009, p.2) had shown that determinates of adoption improved cooking stove:

> “*In theory, all determinant factors of cooking stove choice fall into either the socio-economic or the product-specific category. Some factors reported in the literature such as level of deforestation, government policy and level of urbanization do not immediately seem specific to a product or individual. However, when the impact of such factors on stove choice is deconstructed, they essentially fall into either of the above two categories. For example, deforestation's effect on fuel choice is influenced by changing price or cost of fuel wood collection, which is a product-specific factor.”*

2.3 Energy and Gender

Gender refers to social creation of men and women to play different roles, have different needs, and face different constraints on a number of different levels. Hence, energy and gender has direct relation in terms of collection of fuel wood, dung, and crop residues for cooking purpose and activities. Moreover, this implies in developing countries including Ethiopia majority of the household energy consumption activities carried out by women as compared to men.

There is a strong gender dimension to the fuel wood issue. By tradition, it is the responsibility of women and children to collect fuel wood, while the marketing of fuel wood, where relevant, is dominated by men. Moreover, women also do the bulk of the household chores such as cleaning, cooking, washing and the like. Hence, women bear the brunt of all the negative aspects associated with the use of fuel wood. These imply that the opportunity cost of the time spent in collecting fuel wood, which can range from several hours up to 30 hours per month. Additionally hazards include an increased risk of injury due to the heavy loads carried (typical head loads have been measured at 20 – 50 kg), and other health hazards related to the regular exposure to wood smoke. In short, rural women spend the majority of their time on survival activities such as cooking, fuel wood collection, water carrying and food preparation, represents a high social and economic cost to the households (Damm, O. and Triebel, R., 2008).

UN-DESA REPORT (2004, p. 15) have shown that:

> "*The link between rural household energy use and women is an area that is often ignored; yet its importance cannot be overstated. The relationship between energy and women's work and well-being is evident in women's role as users of energy sources, producers of traditional biomass fuels and educators concerning the collection, management and use of fuels. In addition, women and children are the most vulnerable group in terms of energy scarcity and adverse environmental impacts associated with energy production and use. Women are the major users of traditional energy sources for household activities. For example, the preparation of food in most rural areas is the responsibility of women. Women have practical interest and applied expertise in the burning properties of different fuels, fire and heat management, fuel-saving techniques, and the advantages and disadvantages of different fuels and stoves. Women also purchase (or influence the purchasing patterns of) fuels, stoves and other household energy appliances. More importantly, women influence the direct and indirect energy consumption patterns of their households. Since women are at the centre of household energy use in rural areas, they should be the target of sustainable energy projects. In addition, the women should be involved in actual implementation of the projects.*"

2.4 Traditional Versus Modern Source of Energy Consumption

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) while modern energy consumption refers to the conversion of energy to advanced fuels namely liquid fuels, gas and electricity etc.

2.4.1 Traditional Energy Consumption

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).

Research by Karekezi *et al* (2002), Goldemberg (2003) and Reddy *et al* (1997) point out that traditional biomass energy sources refers to the direct combustion and in very inefficient devices use of solid fuels for baking, cooking, boiling water, drying and charcoal production. However, biomass energy plays a vital role in meeting local energy demand in many regions of developing countries. Furthermore, according some scholars had shown that biomass is a primary source of energy for close to 2.4 billion people in developing countries. Hence, it is easily available to many of the world's poor and provides vital and affordable energy for cooking and space heating (as cited in Karekezi, 2004).

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).

2.4.2 Modern Energy Consumption

According to Karekezi (2004), indicate that 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.

Research by Modi, V., S. *et al* (2006, p.17), 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. When they are available to all income groups, modern energy services are also an invaluable means of improving social equality. Productive uses of energy are particularly important to economic*

growth. Modern fuels and electricity, for example, help boost household income by providing lighting that extends livelihood activities beyond daylight hours. They power machines that save time and increase output and value added. By providing additional opportunities for employment, energy services also enable farmers to diversify their income sources, and thus mitigate the inherent risks associated with agriculture-dependent livelihoods. Energy is important in supporting productive activities in both formal and informal sectors."

2.5 Major Energy Consumption Patterns in Ethiopia

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 (Mekonnen and Kohlin, 2008).

In addition, according to Alemu *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*, which consumes about half of cooking fuels, using the traditional three stone fire.

Zenebe *et al.* (2010, p.8) found out that:

"*The various end uses, baking injera and normal cooking are the two most important uses in domestic fuel consumption in Ethiopia. In addition, in normal cooking is preparing or cooking sauce, soup, or stew (wet) from meat, vegetables, or other comestibles to eat with injera. Moreover, boiling water, making coffee, and the like, which involve lighting a fire several times a day, are also considered normal cooking. In all settlement typologies, injera baking is the major consumer of fuel wood and accounts for over 50 percent of the total household fuel consumption.*"

Mekonen (1998) illustrated that Ethiopia has a huge potential of alternative energy resources but are still unutilized. Hence, the country is one of the least energy intensive countries in the world that implies low energy per consumption. In addition, in the year 1998/99 traditional bio fuels (fuel wood, animal dung, crop residues and charcoal) constituted over 94% of the country's energy consumption. Even if the data in 2001 have shown that solid biomass accounted for about 93% of the country's energy consumption. Generally most of these bio fuels are also consumed at the household level and mainly in rural areas relatively to urban areas (as cited in Zenebe, 2007, p.3).

Research conducted by Embassy of Japan in Ethiopia (2008, p. 1), have shown that:

> *"The access to energy in Ethiopia is relatively low, as little as 16 % (2005), while the average access rate of Sub-Sahara Africa is 26%. The access to energy is gradually improving to reach 20% in 2007 by the efforts of the EEPCo (Ethiopian Electric Power Corporation) and the GoE (Government of Ethiopia) constructing new power plants and expanding the national grid, although it is still lower than the Sub-Sahara African average. In addition, some say that this figure is not reflecting the number of the population who are actually using electricity. The official number, 16%, is calculated by the population living in the electrified area (which means the area the national grid reaches) but many of the poor do not have money to pay the cost for distribution lines from the national grid to their houses and they are left without electricity. The real access rate of the population that is actually using electricity is said to be much lower, about 6 %."*

In addition, research by Heimann (2009), illustrated that the present situation of energy use in Ethiopia differs fundamentally from the situation in an industrialized country like Germany. Hence, in Ethiopia still majority household energy consumption derived from biomass since around 70-80% of the primary energy shares are taken from biomass. However, the energy consumption patterns in Ethiopia basically wood which is processed to charcoal is neither cultivated in a sustainable way nor is it used efficiently. On the other hand, deforestation and soil erosion, loose of farm yield potential and desertification are the consequences. And up till now the gap between biomass demand and supply is increasing constantly. In rural Ethiopia the people very often do not have any access to electricity and rely to kerosene fuel-based lighting relatively to urban and towns. It is true that kerosene's emissions are extremely hazardous for health. Even in 2006 the household energy consumption per capita was assessed on about 32.94 kWh, which is extremely low compared to most other countries in the world.

2.6 Empirical Evidences on Household Energy Consumption

Micro survey data using in India Pachauri (2004) found out shown that the pattern and quantum of total household energy requirements differ significantly across different households hence results from the estimation of a double logarithmic linear model indicate that differences relating to economic, geographic and household dwelling and family characteristics, explain a significant part of the variation in per capita total household energy requirements. Moreover, the results of the estimation show that all the independent variables, both individually and together, are significant at the 99% confidence level in explaining the variation in the dependent variable. Total household expenditure per capita has the largest positive effect on per capita total energy requirements according to the model estimated. Other independent variables include in geographic variables relating to the location of the household were seen to have an important bearing on variation in per capita energy requirements, and on average, other factors remaining unchanged, per capita energy requirements of rural households were found to be marginally higher than that of urban households.

Rajmohan, K. and Weerahewa, J. (2010) study examines the pattern of household energy consumption among urban, rural and estate sectors, over time and across income groups in Sri Lanka using consumer finances and socio economic survey data from 1978/79-2003/2004 the energy ladder hypothesis was tested and Engle functions were estimated. Results reveal that for Sri Lanka and the country as a whole is moving towards modern fuels such as liquefied petroleum gas (LPG) and electricity and the estimated for individual fuels and for different sectors reveal that the budget elasticity values were negative for firewood and kerosene respectively. According to Rajmohan and Weerahewa concluded that the income is the main factor that determines the fuel shifting pattern of the households except for the lower income classes. Also considering the rural sector, income level of households has turned to be the most important determining factor of fuel switching with time. Moreover, existence of differences in the fuel consumption pattern of households in different sectors shows that region of residence is another factor that affects the fuel choice of households. Availability of alternative fuels, prices of fuels and their substitutes and household characteristics could be other factors that determine the fuel choice of households. Kerosene consumption patterns of households particularly among the rural and estate sectors explicates that government pricing policies could also influence the fuel choice of households.

Samuel (2003) found out on household’s consumption pattern and demand for energy in urban Ethiopia the analysis indicates that the use of traditional fuels dominates households' consumption pattern. However, according Samuel a multivariate analysis of the consumption pattern reveals that the probability of consuming traditional fuels in general declines with increase in income and prices of the traditional fuels where as it increases with the increase in the prices of the modern fuels. Moreover, the most immediate policy concern in Ethiopia is to insure sustained supply of biomass fuel, which requires agro forestry, and maintenance of large land size under forest cover. Furthermore, the "energy ladder" hypothesis maintains that energy transition is a positive function of household income.

Maser, R. O., Saatkamp, D. B. & Kammen, M. D. (2000) had shown that on promoting sustainable development requires evaluating the technical and policy options that will facilitate the adoption and use of energy efficient and less polluting cooking stoves and practices. According to researchers the transition from traditional to modern fuels and devices has been explained by the energy ladder model that suggests that with increasing affluence, a progression is expected from traditional biomass fuels to more advanced and less polluting fuels based on evaluate the energy ladder model utilizing data from a four-year (1992-96) case study of a village in Mexico and from a large-scale survey from four states of Mexico that show that an alternate multiple fuel model of stove and fuel management based on the observed pattern of household accumulation of energy options, rather than the simple progression depicted in the traditional energy ladder scenario, more accurately depicts cooking fuel use patterns in rural households. The fuel wood savings depend on demographic conditions, on the energy requirements of local cooking practices, and on broader cultural issues related to preferences and traditions. Improved stoves, present an important and interesting alternative to the options modeled in the energy ladder. It helps to save 30 to 40% fuel wood when compared with traditional stoves, and also show pollution reductions of 30% or more.

2.7 Conceptual Framework and Energy Ladder Model

Research by Zenebe (2007, p.3), 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.

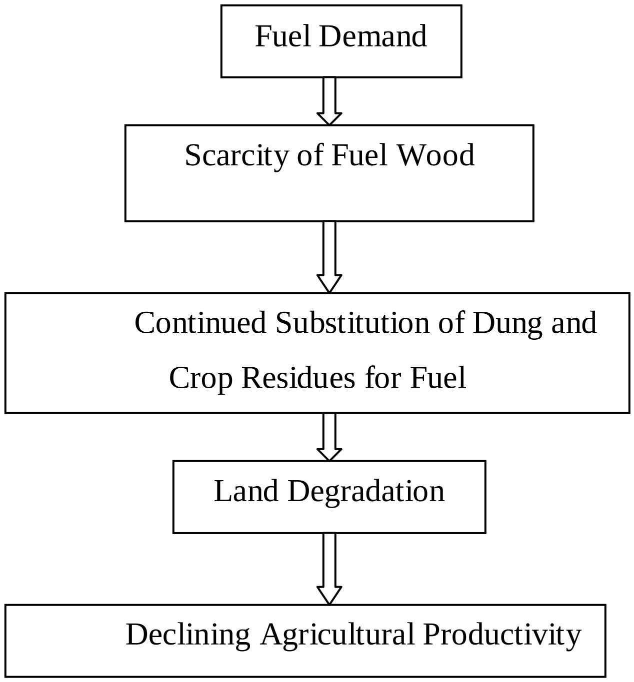


Figure 2.1 Biomass fuel consumption and its impact (Source: Zenebe, 2007)

Moreover, Zenebe (2007, p. 5), had clearly illustrated that:

> *"The above conceptual model helps us to visualize the channels through which the fuel problem affects land quality (degradation) and agricultural productivity. After many years of deforestation, about 12 percent of the country's surface is covered with forests (FAO, 2006) compared to 40 percent some 100 years ago. Among all others, the use of inefficient stoves also contributed to the deforestation. Fuel wood has increasingly been replaced by dung and crop residues. This burning (removal) of dung and crop residues which were previously sources of soil humus and fertility in turn resulted in a progressive decline in land quality and agricultural productivity. This has increased farmers' vulnerability to shocks, food insecurity and poverty (Amsalu, 2006). The reduction in agricultural productivity from lost nutrients associated with the use of animal dung for household fuel in Ethiopia accounts for about 7 percent of agricultural GDP (Berry et al., 2003). The use of animal dung for fuel is so widespread and severe especially in the northern parts of the country. The growing shortage of fuel wood for household consumption in these areas has led to most of the dung produced in the area being principally used for cooking."*

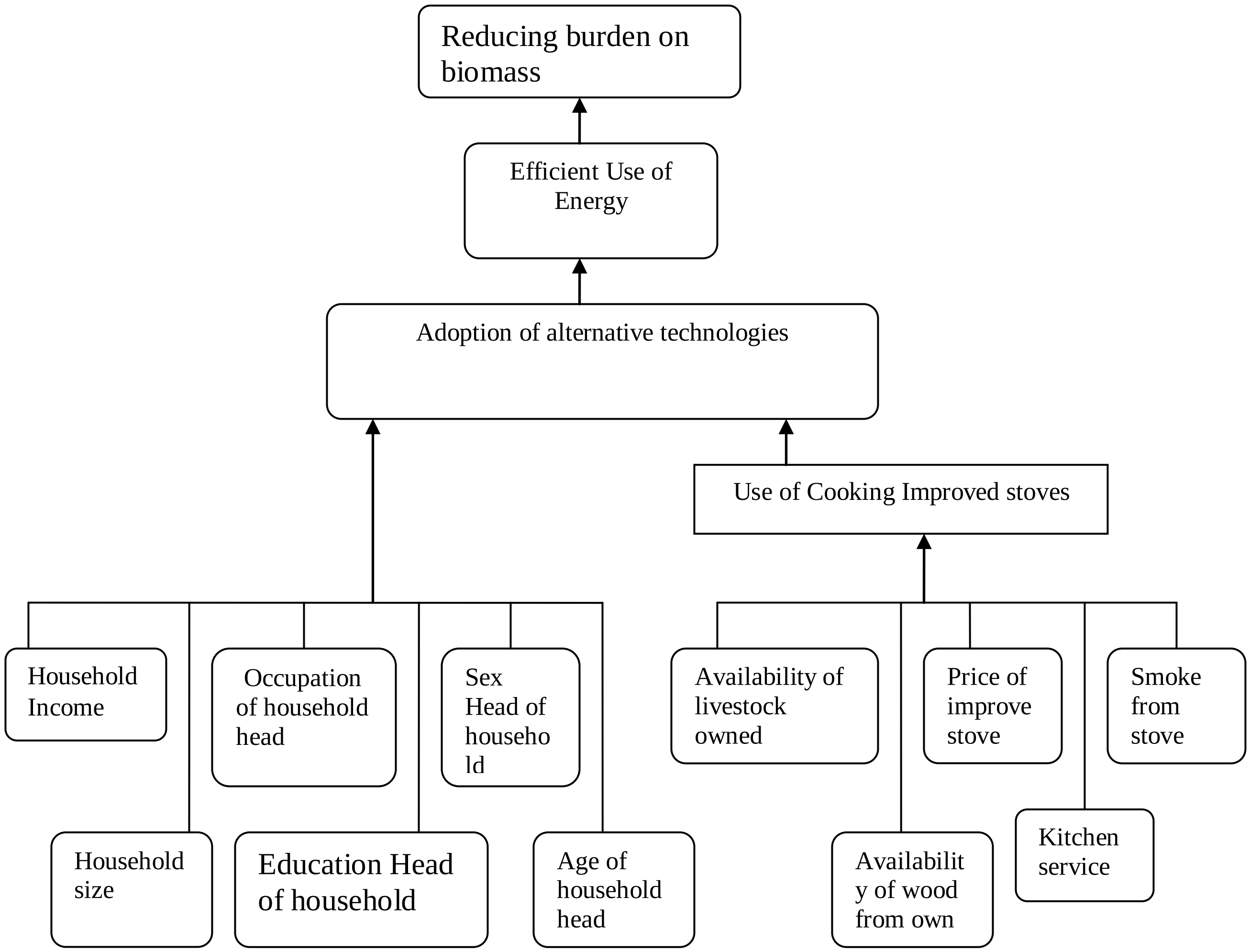


Figure 2.2 Conceptual Frame work

The conceptual framework presented above show relationships that exists among various variables to be investigated through the research. It is postulated that efficient use of household energy through adoption of alternative technologies leads to safe household energy consumption. Efficient use of energy is affected by factors like household income, household size, occupation of household head, educational status of household head, gender of household head, price of improved stove, availability of wood, availability of livestock owned, kitchen service and smoke from stove at household level.

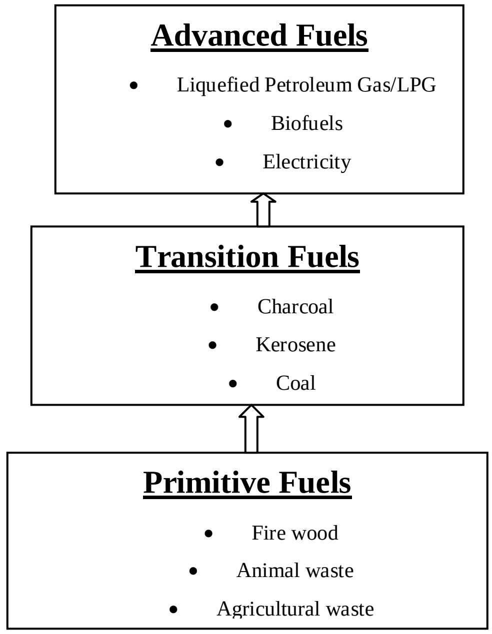


Figure 2.3 Energy ladder Model

According to Davis (1998) and Heltberg (2005) have indicated that

> *"The energy-ladder model has emphasized the role of income in determining fuel choices. However, it appears to imply that a move up to a new fuel is simultaneously a move away from previously used fuels. An energy-demand ladder, as incomes rise, households' demand for fuel is guided by the nature of appliances used and that fuel choice and demand depends on the purpose. This idea of an energy-demand ladder has also been criticized, since the widespread use of multiple fuels for a particular purpose (such as cooking) has suggested the presence of fuel stacking for a given purpose (as cited in Alemu, M. and Köhlin. G, 2008)."*

Moreover, a study by WHO (2006), point out that families are faced with an impossible dilemma: don't cook with solid fuels, or don't eat a cooked meal. Being poor attack half of humanity to dependence on polluting household energy practices. With increasing prosperity, cleaner, more efficient and more convenient fuels are replacing, step-by-step, traditional biomass fuels and coal. Moreover, shifting to an upward energy ladder tends to occur step by step as most low- and middle-income households use a combination of fuels to meet their cooking needs.

Chapter III: Methodology

The overall objective of the study was to assess household energy consumption patterns. This study looks at the existing problems of household fuel consumption at household level in Enderta in order to propose possible solution such as efficient energy consumption patterns at household level. The exploratory approach was employed as a method for the study as it allows the researcher to investigate, examine, explore and identify typical problems that need to be removed in order to enhance improve energy consumption patterns.

This study utilizes different data sources from the rural areas of the Enderta woreda. Moreover, with the diversity of research questions need to look a multi dimensionality of the data that including fuels used and technological considerations such as use of improved stoves.

3.1 Study Area

Enderta is located in South East zone of Tigray, the woreda one of the few highly populated areas in Ethiopia and its total population estimated 129,876 male 64,125 (49.3%) and female 65,751 (50.7%) (May 2007). Number of family heads 28,432, male 18,879 and female 9,553 (may, 2007). Enderta bounded in the north by Kelteie Awelaielo woreda, in the east by the Afar Woreda Abeala, in the south woreda Sehartie Samere and Hentalo Wajerat and in the west side by Degua Tenben. The total area of the woreda is 93,048 km^2 and Altitude in the area ranges from 1400m to 1800m (Almaz, 2008).

Enderta woreda 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.

3.2 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 woreda. 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 tabias1 based on a Probability Proportional to Size (PPS). To achieve the objectives of the research, in first stage survey questionnaire were prepared then the questionnaires were pre-tested at field level for further verification and modification. Training was given for enumerators. In the second stage the actual data were collected. Finally, data were analyzed using STATA 10 software for data entry. Before data entry was desk work involving data editing and data coding.

3.3 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.

The data at household level were collected to get a comprehensive picture of socio-economic conditions, energy use pattern, housing characteristics, cooking behavior and environmental considerations. Energy use pattern included information on consumption of bio-fuels and commercial fuels for cooking, place of cooking fuel, time and effort involved in cooking, progress along the energy ladder, etc. Housing characteristics included information on number of rooms, type of house and type of kitchen, location of kitchen, and number of doors and windows in the kitchen. Further information was collected on cooking behavior, including number of meals cooked using different fuels in a day, hours of cooking, cooking involvement in different age groups and type of involvement. Moreover, people's willingness for the type of intervention, reason for not using clean fuels, willingness to pay for additional amount of clean fuel and additional demand for biogas technology, solar heating and wind power were also addressed.

[1] Tabia/Kebele is an equivalent with lowest administrative units

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

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

Each sample Kebele/Tabia was randomly selected from 17 Kebeles/ Tabias through Simple Random Sampling (mainly lottery) method. Key informants from each community were selected on the basis of purposive sample technique.

3.4 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 woreda was purposively selected since the woreda is populous and cutting trees for charcoal purposes is a common practice. In the second stage, three Tabias were selected from 17 Kebeles randomly through simple lottery method such as Debri, Mayambesa, Felegeselam in order to accommodate household heads. Finally, the researcher has 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 Tabias and the sampling frame were collected from both Enderta woreda and Tabia administration.

Table 3.1: The distribution of sample sizes of household heads in selected kebeles

Name of kebele	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: Survey (Enderta woreda administration, 2003 E.C)

3.5 Instruments and Procedures for Data Collection

Data were collected using the following instruments:

a) Questionnaire for household head
b) Interview checklist for Kebele leaders and development Agents
c) Interview checklist for key informants

All questionnaire and scheduled interview items were pre-tested for usefulness and relevance and functionality. As a result of the experience gained during pre-testing some items in each instrument were further improved.

3.5.1 Questionnaire

As mentioned above, since the principal purpose of this study was to assess household energy consumption patterns, the possible instruments used to collect information in such method was questionnaire based- interview. Questionnaire was very useful to study in breadth and to give an overview about the issue to be studied. The questionnaires for all respondents were contained closed items and open ended question. The questionnaire was designed in English and a two-day training session was conducted for the enumerators before going into the field and the questionnaires were checked and verified in the field by the field supervisors.

3.5.2 Interview

The interview was probably the most widely used as a means of collecting data in survey research methods. A statement by Kerlinger (1975) may be quoted to illustrate this point:

> *" The best instruments available for sounding people's behavior future intentions, feelings, attitudes and reasons for behavior would seem to be the structured interview coupled with on interview schedule that includes open - end, and closed-end and scale items (kerlnger,1965.76; Alemayehu, 2003)"*

In this respect, schedule interview was prepared for key informants to formulate personal perspectives in their own words.

Model Specification

This thesis 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^* :

$$\mathbf{Y}_i^* = \alpha + \beta' \mathbf{X}_i + \varepsilon \qquad (1)$$

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:

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

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.

3.6 Methods of Data Analysis

In the educational research there are various methods and procedures for data analysis the application of a certain procedure and methods on several facts like the nature of the problem, the purpose of the study, the instrument used, the data collected etc.

In this study, both descriptive statistics and econometric model were adopted. Descriptive statistics was used to describe relevant aspects of observable facts about the variables and provide detailed information about each relevant variable. At this stage, percentage, mean, standard deviation, maximum and minimum values of the required variables were computed.

In this study different methods for analysis were used which was determined by the different objective of investigation. In most cases the data from household head and development agent questionnaires tabulated in the form of frequency and was computed using simple percentages. Items in questionnaire, which contains rank order, were tabulated using mean scale. The statements from scheduled interview were often used to substantiate the responses of questionnaire. In short, data analyses were made separately. For quantitative data STATA software is used to estimate probit model for analysis the determinants of adoption of improved energy technology. Interview results were presented by aggregating the responses.

Chapter IV: Results and Discussions

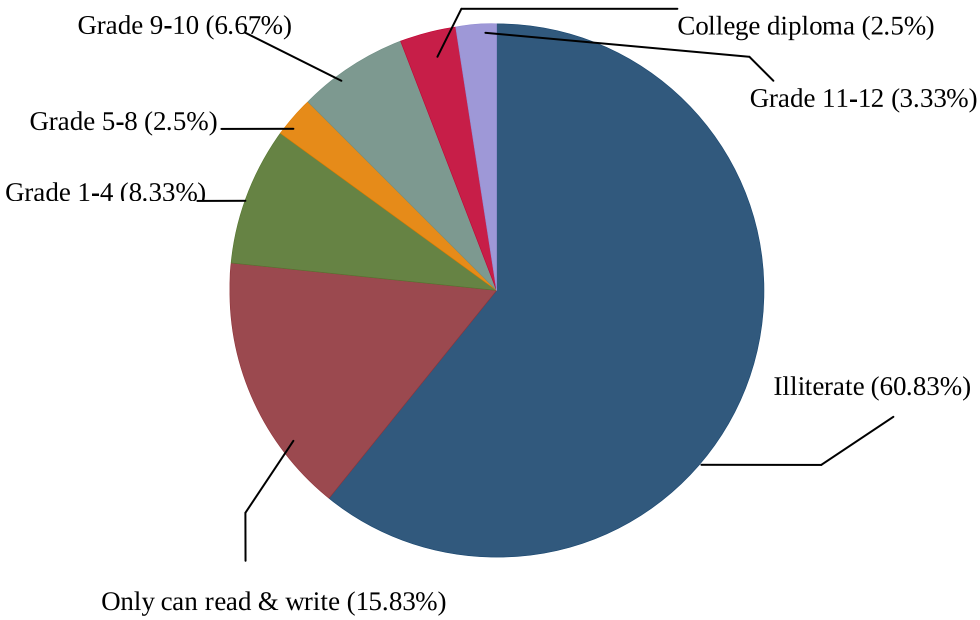
This chapter presents the findings using both descriptive statistics and econometric analysis of household energy consumption patterns such as main source of energy consumption, determinants of adoption alternative technologies in energy consumption and gender-energy interaction in the area of energy consumption. Thus, the result of the finding is presented using descriptive statistical tools such as mean, percentage and standard deviations with the help of an independent t-test and probit econometric model.

4.1 Discussion on Descriptive Statistics of the Survey Result

4.1.1 Education and Occupation of Household Heads

As in figure 4.1 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 Zenebe (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, Khandker and Samad (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.

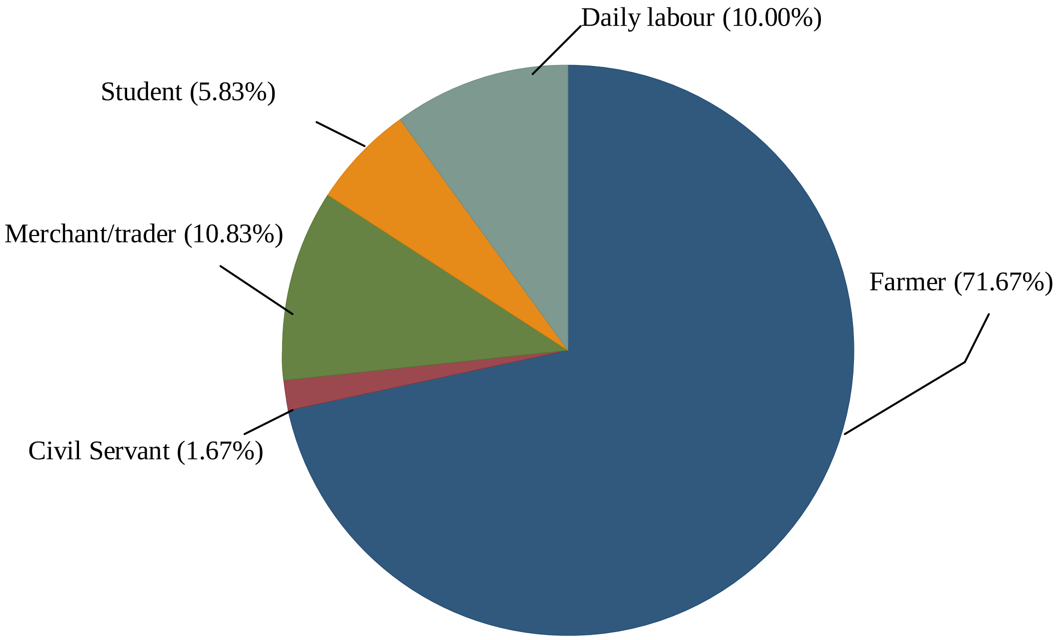
Figure 4.1 Overall educational statuses of the heads of household



Source: own survey, 2011.

Figure 4.2 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. 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 study (Masera, Saatkamp and Kammen, (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.

4.2 Overall primary occupations of heads of household



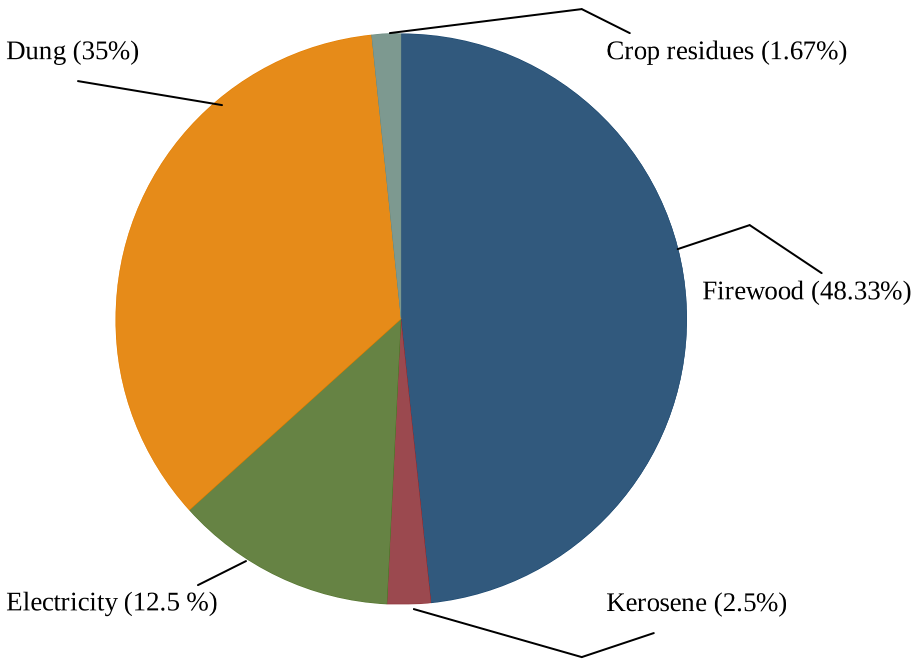
Source: own survey, 2011.

4.1.2 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* and heating. As clearly shown in figure 4.3 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 woreda. 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 4.3 Proportions of household's major energy consumption in the study area.



Source: own survey, 2011.

The characteristic of household fuel utilization is shown (below in table 4.1) 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 4.1, 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 4.1 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 Zenebe *et al.* (2010) 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 Zenebe *et al.* (2010) 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. 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 4.1: Proportion of Household Fuel Utilization (n= 120)

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

Source: own survey, 2011

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 4.2 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 Zenebe (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 4.2: Fuel sources, households involved and mode of acquisition of biomass energy sources (n=120)

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

Source: own survey, 2011.

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 (shown in table 4.3) 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 4.3: Availability of biomass in the last five years (n=120)

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

Source: own survey, 2011.

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 (below table 4.4) 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 4.4: Distance traveled, frequency and time spent for biomass collection (n=120)

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

Source: own survey, 2011.

The rank of households' use of energy sources for purposes of *mitad/mogogo*, general cooking and lighting are present in table 4.5, table 4.6 and table 4.7 respectively.

As indicated in table 4.5 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 4.5 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 4.5: Ranking households use of energy sources for *'mitad/Mogogo'* (n=120)

Variables	Wood		Dung		Crop residue		Electricity	
	Hhs with no access to modern fuel	Hhs with access to modern fuel	Hhs with no access to modern fuel	Hhs with access to modern fuel	Hhs with no access to modern fuel	Hhs with access to modern fuel	Hhs with no access to modern fuel	Hhs 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

Source: own survey, 2011.

In similar way, below table 4.6 concerning the ranking households using source of energy for cooking (preparing stew (wet), soup, making tea and coffee and so on), like in table 4.5, 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 4.6 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.

Table 4.6: Ranking households using sources of energy for cooking (preparing stew (wet), soup, making tea and coffee) purposes (n=120)

Variables	Wood		Dung		Crop residue		Charcoal		Kerosene		Electricity	
	Hhs with no access to modern fuel	Hhs with access to modern fuel	Hhs with no access to modern fuel	Hhs with access to modern fuel	Hhs with no access to modern fuel	Hhs with access to modern fuel	Hhs with no access to modern fuel	Hhs with access to modern fuel	Hhs with no access to modern fuel	Hhs with access to modern fuel	Hhs with no access to modern fuel	Hhs 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

Source: own survey, 2011.

Table 4.7 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 4.7 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 4.7, 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 4.7: Ranking households using source of energy for lighting (n=120)

Variables	Wood		Crop residue		Kerosene		Electricity		Dry cells		Candle	
	Hhs with no access to modern fuel	Hhs with access to modern fuel	Hhs with no access to modern fuel	Hhs with access to modern fuel	Hhs with no access to modern fuel	Hhs with access to modern fuel	Hhs with no access to modern fuel	Hhs with access to modern fuel	Hhs with no access to modern fuel	Hhs with access to modern fuel	Hhs with no access to modern fuel	Hhs 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

Source: own survey, 2011.

4.1.3 Alternative Energy Sources

Zenebe, (2007) 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 (in table 4.8), 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 4.8: Sample households towards access to information/training on alternative technologies in the area of energy consumption (n=120)

Variables	Energy saving devices		Biogas		Solar heating		Wind power		Improved stove	
	Hhs with no access to modern fuel	Hhs with access to modern fuel	Hhs with no access to modern fuel	Hhs with access to modern fuel	Hhs with no access to modern fuel	Hhs with access to modern fuel	Hhs with no access to modern fuel	Hhs with access to modern fuel	Hhs with no access to modern fuel	Hhs 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

Source: own survey, 2011.

As it can be seen from table 4.9, the finding shows that nearly equivalent with households with and with no access to information on improved stove however households with no access to information slightly greater than households with access to information on improved stoves. In the study area Kebele leaders were the main provider of information about improved stove hence 96.88 percent and 100 percent of households with no and with accesses to modern fuel respectively informed by kebele leaders with only least of the remaining households with no access to modern fuel 3.13% of informed by none governmental organization/GTZ.

However, the survey result shows that among aware households on the benefits of improved stove only 43.28 percent and 41.51 percent of households with no and with access to modern fuel respectively are adopted. In other words, majority of informed households about improved stoves did not adopted because of 56.72 percent and 58.49 percent of households with no and with access to modern fuel respectively did not adopted improved stove. The way of acquiring adopting improved stove by households with no access to modern fuel were 34.48%, 6.90%, 27.59% and 31.03% by cash, credit from producer, credit (from governmental or none-governmental organization) and free gift respectively. While adopter households with access to modern fuel were cash (63.64%), credit from producers (4.55%), credit (from NGO, Gov) (27.27 %) and free gift (4.55%). From this we can conclude that even if households are aware the important of improved stoves larger proportion of them did not adopted improved stoves.

Furthermore, Kebele leaders were the major provider of information on improved stove for rural households. Among way of acquiring of improved stove cash was the main means for both households with no and with accesses to modern fuel.

Table 4.9: Sample household’s access to information about improved stoves (n=120)

Variables	Do you have access to information on improved stove?	
	Hhs with no access to modern fuel	Hhs with access to modern fuel
	%	%
Yes	47.76	49.06
No	52.24	50.94

Source: own survey, 2011.

Below table 4.10, the finding revealed that the household’s perception on benefit of improved stove, larger proportion of adopter in both households with no and with access to modern fuel understood that very high improvement in speed of baking, contribution to reducing burden on biomass, fuel economy and reduces smoke/ashes. On the other hand, the data shows that improved stove adopter households are more advantages than non-adopter households hence the respondents are seen very high improvement in speed of baking, contribution to reducing burden on biomass, fuel economy and reduce smoke/ashes. This implies that could contribute reducing deforestation, land degradation and increasing agricultural productivity who are adopting improved stove households. This is supported by recent research (Damte and Koch, (2011)) in Ethiopia, distribution of more efficient stoves will help reduce pressure on biomass resources, increase land productivity by reducing crop residue and dung usage for fuel and improve family health. Moreover, the intervention is expected to benefit women and children, in particular, by reducing fuel collection workloads and limiting exposure to flame hazards and the emission of harmful pollutants.

Table 4.10 Improved stove adopter household's perception on advantage of improved stove

Advantage of improved stove	Speed of baking		Contribution to reducing burden on biomass		Fuel economy		Reduce smoke/ashes	
	Hhs with no access to modern fuel	**Hhs with access to modern fuel**	**Hhs with no access to modern fuel**	**Hhs with access to modern fuel**	**Hhs with no access to modern fuel**	**Hhs with access to modern fuel**	**Hhs with no access to modern fuel**	**Hhs with access to modern fuel**
	%	%	%	%	%	%	%	%
Very high improvement	86.21	95.45	62.07	77.27	58.62	40.91	68.97	50.00
High improvement	13.79	4.55	34.48	22.73	37.93	59.09	31.03	50.00
Moderate improvement	0.00	0.00	3.45	0.00	3.45	0.00	0.00	0.00
Low improvement	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
No improvement	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: own survey, 2011.

As it can be seen from table 4.11 larger proportions of households with no access to modern fuel have seen durability problem followed by local availability and hotness of external surface. Moreover, households with no access to modern fuel have identified affordability and installation limitation of improved stoves. On the other hand, the preponderance of households with access to modern fuel that have identified hotness of external surface the main limitation of improved stove, followed by durability and installation. Local availability and affordability limitations are also identified by households with access to modern fuel. Despite the limitation of improved stove, majority of both households with no and with accesses to modern fuel strongly agreed that use of improved stove benefits greater than limitation since nearly all improved stove adopter sample households recognized that it helps to very high improvement in speed of baking, contribution to reducing burden on biomass, fuel economy and reduce smoke/ ashes.

Table 4.11: Improved stove adopter household's perception on limitation of improved stove

Limitation of improved stove	Hhs with no access modern fuel	Hhs with access to modern fuel
	%	%
Affordability	6.90	4.55
Local availability	24.14	4.55
Durability	44.83	31.82
Installation	6.90	13.64
Hotness	17.24	45.45

Source: own survey, 2011.

4.1.4 Gender and Energy Interaction

There is a strong linkage between gender and energy dimension to the fuel wood issue. By tradition, it is the responsibility of women and children to collect fuel wood, while the marketing of fuel wood, where relevant, is dominated by men. Rural women spend the majority of their time on survival activities such as cooking, fuel wood collection and food preparation (Damm, O. and Triebel, R., 2008). In this study, also as it can be seen (in below table 4.12) the highest contribution of households with no access to modern fuel collection of fuels are done by mothers, followed by daughters and child boys. While in households with access to modern fuel the highest contribution of fuel collection of fuels are done by daughters, followed by child boys and mothers.

In similar way, as clearly seen from (below table 4.12 column 3), the highest contribution to split of wood fuel for household's energy consumption purposes were done by fathers in both households with no and with access to modern fuel, followed by daughters and child boys third. Relatively the contribution of split wood fuel purposes by mothers less than fathers, daughters and sons in both households with no and with accesses to modern fuel.

Below table 4.12 indicates that majority of preparation of food were done by mothers in both households with no and with access to modern fuel followed by daughters and servants. Almost fathers and child boys do not have contribution of food participation in both households with no and with modern fuel. This implies women are recognized as the primary source of biomass energy collectors as well as the emission receiver. Hence cooking food is considered as women's task and is generally conducted by women though the male helps her but staying near the fire is always women and the children.

Table 4.12: Household energy collection patterns and participant in preparation of food (n=120)

Participant	Fuel collector		Participant in split of wood fuel		Participant in preparation of food	
	Hhs with no access to modern fuel	Hhs with access to modern fuel	Hhs with no access to modern fuel	Hhs with access to modern fuel	Hhs with no access to modern fuel	Hhs with access to modern fuel
	%	%	%	%	%	%
Father	13.43	7.55	53.03	50.94	1.49	0.00
Mother	34.33	24.53	9.09	1.89	92.54	92.45
Child boy	17.91	26.42	18.18	20.75	0.00	0.00
Daughter	29.85	35.85	19.70	24.53	4.48	1.89
Relative	4.48	5.66	0.00	0.00	0.00	1.89
Servant	0.00	0.00	0.00	1.89	1.49	3.77

Source: own survey, 2011.

4.1.5. 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 4.13. 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 (below in table 4.13). 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 4.13 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 4.13 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 (Melessaw *et al*., 2009: 51 as cited in Gebremeskel, (2010)). The distribution of the sample household heads by economic variables is given in below table 4.13.

Table 4.13, 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*[2]' 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.

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

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

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.

Below table 4.13 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 4.13) 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%.

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 4.13: Overview of demographic, economic and access to facilities characteristics of sample households decision on energy consumption (n=120)

Variable Name	Hhs with no access to modern fuel		Hhs 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.

Source: own survey, 2011.

4.1.6 Comparison of Improved Stove Adopters and Non-adopter Households

As we can be seen in below table 4.14 concerning the demographic characteristics of households, average age is 36.63 and 36.91 years old for adopter and non-adopter improved households respectively. This difference is statistically not significant. In similar way, the mean family size of improved stove adopter household is 6; the mean family size of non-adopter improved stove household is 6.06. This difference is also statistically not significant. In similar fashion, concerning the sex of household head is 60.78 percent of adopter of improved stove households are male headed of household while non-adopter of improved stove households are account 55.07 percent are male headed of household. This difference is statistically not significant too.

Table 4.14 indicates that concerning educational status of household, the result of the survey illustrates that 50.98% of the household heads are found illiterate with 23.53 percent can simply read and write while about 25.48 percent the households attain formal education from grade one up to college diploma are improved stove of adopter households whereas non-adopter of improved stove households the result of the survey illustrates that more than half of (68.12%) of the household heads are found illiterate with only 10.14 percent can simply read and write while only 21.75 percent the households attain formal education from grade one up to college diploma. This difference is statistically significant at 10%. We can conclude that education is very important to adopt improved stove for rural household's energy consumption patterns.

A table 4.14 also presents the detail economic characteristics of households, 25.49 percent and 30.43 percent are found improved stove adopter and non-adopter households respectively employed out of farming activities with the remaining being employed in farming activities. This difference is statistically not significant. In similar way, the mean per capita expenditure of improved stove adopter household is 402.35; whereas the mean per capita expenditure of non-adopter improved stove household is 349.62. This difference is also statistically not significant.

Table 4.14 also shows that average farm size is 1.92 and 1.10 *timad* for improved stove adopter and non-adopter households respectively. This difference is statistically highly significant at 1%. Similar fashion, on average total livestock hold is 2.66 and 1.29 TLU for improved stove adopter and non-adopter households respectively. This difference is also statistically significant at 5%. This implies that improved stove adopter households have larger farm size and livestock this help to better opportunity acquire improved stove adopter than non-adopter households because farm and livestock is wealth.

Below table 4.14 detail shows that improved stove adopter households have 86.27% access to credit services while non-adopter improved stove households have 66.67% access to credit services. This difference is statistically significant at 5%. This implies that relatively improved stove adopter households have better access to credit service than non-adopter improved stove households. In similar way, is 100% and 10.14% for improved stove adopter and non-adopter improved stove households respectively have access to information on improved stove. This difference is also highly statistically significant at 1%. This implies access to credit services and access to information on improved stove motivates/helps to adopt improved stove in the study area.

In addition, table 4.14 shows that access to kitchen service is 49.02%, 21.57% and 29.41% improved stove adopter households are install on separate kitchen, outdoor and in home respectively while non-adopter improved stove households cooking place is 28%, 14% and 27% on separate kitchen, outdoor and in living room respectively. This difference is statistically not significant too. In similar way, the average distant from the household's home to the agriculture extension center for improved stove adopter and non-adopter households is 1.97 km and 2.15 km respectively; this mean difference is statistically not significant. However, the mean distant from the households' home to the health extension center for improved stove adopter households is about 1.57 km; the mean distance traveled by about non-adopter improved stove households is about 2.33 km. This difference is statistically significant at 1%. This implies that improved stove adopter households are close to health extension center as result, have better opportunity to acquire the services than non-adopter improved stove households.

The average distance from the household's home to the road is 2 km for improved stove adopter households; the mean distance traveled by about non-adopter improved stove households is 2.42 km. This difference is statistically not significant. In similarly way, the average distant from household's home to market services for improved stove adopter household is 11.44 km, while the mean distance traveled by access to non-improved stove adopter households is 11.99 km. In similarly way, this difference is also statistically not significant.

Table 4.14: Demographic, Economic and Access to Facilities Characteristics of Sample Households Decision on Improved Stove adoption (n=120)

Variable Name	Adopter		Non-adopter		t-test
	Mean	Std. Dev.	Mean	Std. Dev.	
Age of household head	36.63	9.62	36.91	12.36	-0.14
Family size of household	6.00	1.93	6.06	2.09	-0.16
Sex of household head	0.39	0.49	0.45	0.50	-0.62
Education of household head	0.49	0.50	0.32	0.47	1.91*
Occupation of household head	0.26	0.44	0.30	0.46	-0.59
Per capital expenditure	402.35	224.47	349.62	261.76	1.16
Farm size measured in timad	1.92	1.45	1.10	1.29	3.27***
Total livestock measured in TLU	2.66	4.07	1.29	2.53	2.27**
Access to credit	0.14	0.35	0.33	0.48	-2.49**
Access to improved stove information	0	0	0.90	0.30	-21.08***
Access to kitchen service	0.80	0.87	0.99	0.90	-1.11
Distance from agriculture extension	1.97	1.56	2.15	1.43	-0.66
Distance from health extension	1.57	0.92	2.33	1.74	-2.84***
Distance from road	2.00	1.57	2.42	1.94	-1.26
Distance from market	11.44	5.04	11.99	5.15	-0.58

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

Source: own survey, 2011.

4.2 Econometric Result and Discussions

4.2.1 The Determinants of Adoption of Improved technology Assessment Results of 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. 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 and adoption of improved stove are presented in table 4.15 and table 4.16 respectively.

Below table 4.15, 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 4.15 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 4.15) 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.

As clearly shown in table 4.15, 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%.

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%.

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[3].

[3] See annex 3.2,3.3,3.4 page 77

Table 4.15: Probit model estimates of use of modern energy sources (n=120)

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.

Source: own survey, 2011.

As indicated in the below table 4.16, the educational level of the household head has significant effect on the decision of adoption of improved stove negatively at 10% level of significance. When household head's educational level increased by one; the probability of adoption of improved stove will decrease by 25.4%.

Table 4.16, that access to credit service has positively significant effect for the household to adopt improved stove at 5% level of significance. This implies that the access to credit service increases by one, the probability of adoption of the improved stove will increase by 26.9%. This implies that credit service helps to adopt improved stove in the study area.

It is also evident; (from table 4.16) livestock ownership has significant impact on adoption of improved stove positively at 10% level of significance. This implies that as livestock ownership increased by one TLU, the probability of adoption of improved stove will increase by 18.4% in household heads.

As it may be clearly presented in table 4.16, the distance from the head of the household home to firewood collection have positive effect on the adoption of improved stove decision of households at statistically significance level of 1%. As distance from the head of the household home to firewood collection increased by one kilometer, the probability of adoption of improved stove will increase by 1.4%. Hence improved stove very important for contribute reductions in the demand of biomass resources, hence helps to use in fuel economical moreover, combating land degradation, thus mitigating the effects of drought, as well as having the potential to yield improvements.

The model fitness, the variability of the variances of error term and the multicollinearity is tested and the result shows that the model has 70.00% predicting power and it is free from hetreoscadesticity and multicollinearity. Hence these assure that the model specification is feasible and accurate[4].

Table 4.16: Probit regression of the adoption of an improved stove in the study area (n=120)

Explanatory Variable	*Coefficient*	*Std. Err.*	*Z*	**Marginal effect (dy/dx)**
Per capital expenditure	-0.0003	0.000	-0.70	-0.0001
Family size	0.058	0.035	0.64	0.022
Educational level of hhh	-0.658	0.135	-1.88*	-0.254
Occupation of hhh	0.495	0.131	1.40	0.184
Sex of respondent	0.282	0.110	0.99	0.108
Access to credit service	0.755	0.107	2.52**	0.269
Age of hhh	-0.002	0.005	-0.11	-0.001
Livestock ownership	0.478	0.112	1.65*	0.184
Wood collection from own farm	0.274	0.351	0.31	0.108
Distance wood collection from home	0.037	0.005	2.99***	0.014
Distance crop residue from home	-0.005	0.006	-0.33	-0.002
Distant dung collection from home	-0.002	0.001	-0.56	-0.001
Distant charcoal collection from home	-0.005	0.003	-0.73	-0.002
Kitchen service	-0.066	0.060	-0.43	-0.026
Smoke/ashes	-0.664	0.250	-1.04	-0.260
Constant	-0.830			

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

Source: own survey, 2011.

[4] See annex 4.2, 4.3, 4.4 page 79

4.3. Interview Result Discussions

4.3.1. Kebele Leaders and Development Workers

Interview is the most widely used as a means of collecting data in survey research methods.

Almost all Kebele leaders and development workers acknowledged that biomass source of energy such as dung and wood including small branches, leaves, twigs, roots, and charcoal and also crop-residues are found the main source of energy consumption in the study area used for baking *injera* and cooking. Furthermore, the respondents identified that 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 the main source of energy consumption for purpose of lighting with respect other sources of energy by households with access to modern fuel.

Based on the major sources of energy consumption the respondents recognized that the problem of deforestation, cutting of big trees leads to high depletion of the forest resources in Enderta woreda. Additionally, the respondents are also identified the problem of smoke or ashes leads source of indoor air pollution furthermore spend a lot of time for collection of fuel that could participate in productive activities.

Larger proportions of both kebele leaders and development workers have agreed that rural households do not have alternative sources of energy in rural Enderta woreda. However, both kebele leaders and development workers told that rural households with access to electricity service could use electricity as alternative source of energy for different purposes such for electric *mitad*, general cooking. Moreover, both respondents agree that distribution of *mirt* improved stove, use of electric *mitad* and adopting different alternative energy sources such as wind power, solar heating, biogas technology and geothermal may perhaps improved the current energy consumption patterns in Enderta woreda.

Furthermore, both of kebele leaders and development workers are strongly agree that government collaboration with development partner none-governmental organization particularly GTZ have plans to change the present energy consumption patterns based on *mirt* improved stove distribution to rural households. Besides, both kebele leaders and development workers currently are doing awareness creating the importance of *mirt* improved stove to the rural households to improving household's energy consumption patterns in Enderta woreda. In addition, they are doing expanding electricity to rural households near to small town.

Practically, majority of respondents have seen *mirt* improved stove intervention to improved rural households energy consumption patterns but not enough. Some households with access to electricity service are agreed that there is enhancement towards household energy consumption patterns. Some respondents are also recognized that electricity is the only alternative source of energy for the local people; the locality people's perception towards electricity that helps to reduce smoke hence previously kerosene was their main source of energy for purposes of lighting.

4.3.2. Key Informants

The result of key informants based on their experience some of them are agreed that there is improvement of household energy consumption hence there is introduction of electricity and *mirt* (improved stove). However, majority of the key informants are strongly agreed that there is no improvement of household's energy consumption hence due to scarcity of fuel wood leads continued substitution of dung for fuel subsequently increasing smoke. Moreover, majority of key informants based on their experience do not have alternative source of energy but few of them have agreed that electricity could use it as alternative source of energy.

Key informants also agreed like the interview results of kebele leaders and development workers, dung and firewood are found the main sources of household energy consumption for purposes of cooking and baking *injera* while kerosene, electricity and dry cells are used for households' purpose of lighting. The major ground used sources of energy consumption is easily accessible, cultural preference and convenience source of energy consumptions.

Majority of key informants are told that they could not possible save energy at home but few of key informant understood that the possibility of saving energy at home through switch off the light rural households with access to electricity. In addition, only few key informants based on their experience are observed that enhancement towards efficient utilization of energy consumption through *mirt* improved stove adoption.

Chapter V: Conclusion and Recommendations

5.1. Summary of Main Findings and Conclusions

The general objective of the study was to assess the household energy consumption patterns in the case of rural area of Enderta woreda, Tigray Regional State. To achieve the objectives of the research both primary and secondary data from different sources and field work were collected. The key premises of the investigation are major source of energy consumption, determinants of adoption of improved technologies in household energy consumption, as well as gender issues in the context of energy user related constraints are outputs of the research.

Based on the information gathered and analyzed the following major points could be generalized on households energy consumption patterns in the study area.

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 woreda. 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.

The results of the study shows that on average 12.94 km, 2.72 km, 32.61 km and 11.45 km households traveled for collection of firewood, crop residues, dung and charcoal respectively per week. In the other words, on average 8.48 and 7.98 hours spent for collecting firewood and dung per week respectively. This implies that households' in the study area are spent significant amount of time for collecting fuel that could be used for other productive purposes.

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 woreda is in an infant stage. Hence, all a sample households selected in three Tabias of Enderta woreda does not have access information on biogas technologies, solar heating and wind power. Furthermore, the survey result shows that among informed improved stove households' adopters are only 43.28%

and 41.51% from households with no and with access to modern fuel respectively. With respect to improved stove adopter households are more advantages in terms of high improvement in speed of baking, contribution to reducing burden on biomass, fuel economy and reduce smoke/ashes as compared to non-adopters.

The finding also shows that fuel collection patterns were done by women, daughters and child boys. However, the highest contribution of split of wood for household's energy consumption purposes was done by men. While larger proportion of preparation of food were done by women followed by daughters and servants but almost men and child boys do not have contribution of food preparation this implies that women are recognized as the primary source of biomass energy collector as well as the emission receiver.

The result of study reveals that mean age of the household is 39 and 34 years for households with no and with access to modern fuel respectively, there is a significant difference between households with no and with access to modern fuel this implies that those younger families' more beneficial using modern source of energy than older families. In similar way, the occupational status of household heads, only 11% of households with no access to modern fuel found to be engage on out of farming activities, while 43.40% of households with access to modern fuel is found to be employed out of farming activities, this difference is highly significant this implies that households with access to modern fuels are more employed out of farming than households with no access to modern fuels which helps to adopt modern source of energy.

Moreover, the average distance from the household's home to the agriculture extension center for households with no and with access to modern fuel is about 2.4 km and 1.7 km respectively. In similar way, the mean distance from the households' home to the health extension center for households with no access to modern fuel is about 2.3 km; while households with modern fuel is 0.9 km. This mean difference is highly significant. Therefore households with access to modern fuel are close to agriculture extension center and health extension center have better opportunity to acquire the services than households with no access to modern fuel.

The result of the survey illustrates that 49.02 percent of the households attain formal education from grade one up to college diploma of adopter of improved stove households whereas non-adopter households only 31.88 percent the households attain formal education from grade one up to college diploma. With respect to the educational status indicates that adopters are significantly literate than non-adopters. In similar way, the improved stove adopter households have 86.27% access to credit services while non-adopter households 66.67% access to credit services. This difference is significant between adopter and non-adopter access to credit service. With respect to access information on improved stove 100% and 10.14% for adopter and non-adopter households respectively have access information. The finding on access to information improved stove indicates that adopters are significantly having more information than non-adopters.

The educational level of the household head has significant impact on the decision of consumption of modern source of energy. When household head’s educational level increased by one, the probability of consumption of modern source of energy will be increase by 58.2%. However, sex of female headed of household has a negative influence on consumption of modern sources of energy decision.

5.2. Recommendations and Policy Implications

The heavy dependence and inefficient utilization of biomass resources of energy have resulted in high depletion of firewood, crop residue, dung and charcoal in the last five years in Enderta woreda. 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, the result shows that households spent significant amount of time for fuel collection. And also, all a household do not have access to information on alternative technologies like biogas, wind power, solar heating and energy saving devices. 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.

Improved stove adopter household are identified durability, local availability, and affordability limitation of improved stoves. The government and other development partners need to assist producers through different mechanisms such as information, training for local communities and access to credit provision schemes.

Furthermore, despite of government and non-government organization have been tried to create gender awareness in Ethiopia but in Enderta woreda fuel collection patterns and food preparation were done by women and children this implies women were recognized as the primary source of biomass energy collector as well as the emission receiver. As a result, gender issues need to be addressed with adequate focus in the context of energy use.

Although there is introduction of electricity for some rural households because the government cannot simply afford to electrify for all rural areas, even nearly all sample rural households with access to electricity, they do not used for baking injera/ electric mitad, this implies that maximum effort must be exerted to change the prevailing attitude through providing access to electric mitad, by creating access to credit service opportunity and give incentive to motivate use of electric mitad helps to reduce burden on biomass sources of energy.

5.3. Implication for Future Research

The following research need to be addressed for future work in the study woreda.

- Challenges and opportunities of renewable sources of energy (biogas technology, solar heating, wind power and the likes)
- Improved stove penetration rate in Enderta woreda
- Obstacles of use of electric mitad in rural households in Enderta woreda.

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Annex1-Questionnaire for household heads

Mekelle University
College of Business and Economics
Department of Management

Questionnaire for rural household energy consumption patterns survey, 2010/11 academic year.

<u>The objective of questionnaire</u>

In order to understand household energy consumption patterns, the researcher attempted to do a study on "household energy consumption patterns: the case of Enderta woreda, Tigray." Your answer would help the researcher to assess household energy consumption patterns. In addition to that your answers will also help researcher to see the status and trend of energy consumption in the woreda and forward some valuable recommendations. I am assuring that your answer will not be used for any other purpose but only for academics.

THANK YOU VERY MUCH IN ADVANCE FOR YOUR TIME AND COOPERATION.

Section 1

Write the appropriate answer for each question on the space provided.

1. Questionnaire number ___________________________
2. Kebele/Tabia_____________________________
3. Name of enumerator_____________________________
4. Signature_______________________________________
5. Date____
6. Name of Supervisor____________________________
7. Supervisor signature_______________________

Section 2: Demographic Characteristics of Household

01	02	03	04	05	06	07	08
S.N	Relation to household head	Sex	Age	Marital status	Family size	Educational level	Primary occupation
1							

02: 0. Spouse 1. Son 2. Daughter 3.Father/Mother of couples 4. Relatives 5. Other

03: 0. Male 1. Female

05: 0. Married 1. Unmarried 2. Divorced 3. Widowed

07: 0. Illiterate 1. Only can read and write 2. Grade 1-4 3. Grade 5-8 4. Grade 9-10
5. Grade 11-12 6. College diploma 7. Bachelor degree and above 8. Other (specify)

08: 0. Farmer 1. Civil Servant 2. NGO worker 3. Merchant/trader 4. Student
5. Daily laborer 6. Other (Specify)

Section 3: Access to civil services

What is the distance of the agricultural extension center from your home? (in km or hour)	What is the distance of the health extension center from your home? (in km or hour)	What is the distance of the road from your home? (in km or hour)	What is the distance of the market from your home? (in km or hour)	Do you have access to credit? 0. Yes 1. No

Section 4: Energy source

1. What is the main type of fuel you use for cooking?
   0. Firewood [ ] 1. Kerosene/diesel [ ] 2. Charcoal [ ] 3. Electricity [ ]
   4. Dung [ ] 5. Crop residues [ ] 6. Other (Specify)……………………………
2. What type (s) of energy source do you often use in your home for lighting?
   0. Kerosene [ ] 1. Electricity [ ] 2. Candle [ ] 3. Crop residues [ ] 4. Firewood [ ]
   5. Dry cells [ ] 6. Other (Specify) …………………………………………
3. What type (s) of energy source do you often use in your home for baking injera?
   0. Firewood [ ] 1. Electricity [ ] 2. Dung [ ] 3. Crop residues [ ]
   4. Other (Specify)……………………………
4. Which of the following energy resource do you often use in your home?
   0. Firewood [ ] 1. Kerosene/ diesel [ ] 2. Charcoal [ ] 3. Electricity [ ] 4. Dung [ ]
   5. Crop residues [ ] 6. Other (Specify)………………………

4.1 According to question number 4, why do you prefer this source of energy?
   0. Convenience [ ] 1. Cheap [ ] 2. Cultural preference [ ] 3. Easily accessible [ ]
   4. Other (specify)………………………………

5. Do you have access to electricity in your home? 0. Yes [ ] 1. No [ ]

   5.1 If yes question number 5, do you use it for baking injera? 0. Yes [ ] 1. No [ ]

6. Do you have access to other alternative energy source(s)? 0. Yes [ ] 1. No [ ]

6.1 If yes question number 6, do you have? 0. Biogas [ ] 1. Solar heating [ ]
   2. Wind power [ ] 3. Other (specify)…………………………………………...

7. Which combination of fuel source do you use in your household and why?

	Combination	Tick or (X)	Cost	Convenience	Availability	Other
A	Firewood to kerosene					
B	Firewood to dung					
C	Firewood to crop residue					
D	Firewood to electricity					
E	If other (specify)					

8. Where do you collect your fuel wood? 0. Own farm [ ] 1. Free space [ ]
   2. Community forestry [ ] 3. Purchasing/buying [ ] 4. Other (specify) ……………
9. Do you have planted trees on your farm land for fuel wood purpose?
   0. Yes [ ] 1. No [ ]
10. Where do you collect your fuel dung? 0. Buying [ ] 1. Self collecting [ ]
    2. No use [ ]
11. Where do you collect your fuel crop residue? 0. Buying [ ] 1. Self collecting [ ]
    2. No use [ ]
12. Do you have livestock? 0. Yes [ ] 1. No [ ]

12.1 If yes in questionnaire number 12, what type and how many do you have?

Livestock	Tick or (X)	Number
Cow		
Oxen		
Bull		
Heifer		
Calf		
Camel		
Horse/ Mule		
Donkey		
Sheep/Goat		
Chicken		
Other (Specify)		

13. Distance traveled and time spent to collect biomass

01	02	03	04	05
Fuel type	Availability of biomass in the last 5 years	Distance traveled in one trip to collect fuel (in km)	Total time taken for collecting fuel in one trip	How often do you collect fuel per week
Fuel wood				
Crop residue				
Cow dung				
Charcoal				
Tree residue (leaves)				
Other (specify) …………………...				

02: 0. More available 1. Same as before 2. Less available

05: 0. Once 1. Twice 2. 3 times and above 3. None 4. Other (specify)

14. Rank the following energy sources depending on the purpose of fuel used in your daily life.

Purpose of fuel used	Fire wood	Dung	Crop residue	Charcoal	Kerosene	Electricity	Dry cells	Candle	other (Specify)
Mitad baking									
Cooking									
Lighting									
Heating									

Rank: 1. Very important 2. Important 3. Less important 4. No use

15. Do you think that is there improvement in your home energy consumption patterns in the last five years? 0. Yes [ ] 1. N0 [ ]

15.1 If yes question number 15, how? 0. Access to electricity [ ]
1. Access to improved stove [ ] 3. Biogas [ ] 4. Other (specify)………………………

16. Household energy consumption patterns in the last five months (Nov-March)

Purpose of fuel used	Nov	Dec	Jan	Feb	March
Mitad baking					
cooking					
Lighting					
Heating					

0.Fire wood 1. Dung 2. Crop residue 3. Charcoal 4. Kerosene 5. Electricity 6. Dry cells
7. Candle 8. Other (specify)

Section 5: Technological Consideration

17. Do you access to information about improve stove? 0. Yes [ ] 1. No [ ]

17.1 If yes in question number 17, where do you get it? 0. NGO/GTZ [ ]
1. Kebele leaders [ ] 2. Development agents [ ] 3. Private cooperatives [ ]
4. Other (specify)……

18. Do you have improved stove in your home? 0. Yes [ ] 1. No [ ]

18.1 If yes question number 18, how did you get it? 0. Cash [ ] 1. Credit (producer) [ ]
2. Credit (NGO, Gov) [ ] 3. Free/gift [ ] 4. Other (specify)…………………

18.2 If yes question number 18, what do you fell the overall change in your family's participation in improved stove?

	4=Very high improvement	3=High improvement	2=Moderate improvement	1=Low improvement	0=No improvement
Speed of baking					
Contribution to reducing burden on biomass					
Fuel economy					
Reduce smoke/ashes					

18.3 If yes question number 18, what is the main limitation of improved stove?

0. Affordability [ ] 1. Local availability [ ] 2. Durability [ ] 3. Installation [ ]
4. Hotness of external surface [ ] 5. Other (specify)…………………………

19. Do you have access to training on energy saving devices? 0. Yes [ ] 1. No [ ]

20. Do you have access to training/information on any of the following?

	Yes	No
Solar heating		
Biogas technologies		
Wind Power		
How to save energy		
Improved stove		
other (specify)		

Section 6: Socio-economic status

21. How many rooms are there in your home? 0. One [ ] 1. Two [ ] 2. Three [ ]
3. Four [ ] 4. Five [ ] 5. Other (specify)………………………………..

21.1 Observe building main material **wall**, 0. Mud [ ] 1. Concrete [ ]

2. Mud and stone [ ] 3. Stone [ ] 4. Wood [ ] 6. Other (specify)……………..

21.2 Observe building main material **Roof**, 0. Concrete/cement [ ] 1. Earth/mud [ ]

2. Tin [ ] 3. Plastic sheet [ ] 4. Straw/grass [ ]

22. Where do you cook your food? 0. Separate kitchen [ ] 1. Open space/ outdoor [ ]

    2. In home/living room [ ] 3. Other (specify)………………………………

23. Is there a problem of smokes/ashes in your sources of energy consumption?

    0. Yes [ ] 1. No [ ]

23.1 If yes question number 23, what kind of energy source do you use? 0. Wood [ ]

1. Dung [ ]2. Crop residue [ ] 3. Kerosene [ ] 4. Other (specify)………………

24. Do you have your own land? 0. Yes [ ] 1. No [ ]

    24.1 if yes question number 24, how many Tsmdi do you have?.............................

Section 7: Gender and Energy interaction

25. Who is the head of the household? 0. Husband [ ] 1. Wife [ ] 2. Other (specify)….

25.1 If the answer for question number 25 is the husband, why is he the household head?

0. Because he is the major contributor for the household expenditure [ ]
1. By the existing tradition (culture) [ ]
2. Other (specify)…………………

26. Who is responsible to collect fuel source in your home? 0. Father [ ] 1. Mother [ ]

    2. Child boy (s) [ ] 3. Daughter (s) [ ] 4. Relative (s) [ ] 5. Other (specify)…………

27. Who is responsible for cutting of wood for fuel purposes in your home?

    0. Father [ ] 1. Mother [ ] 2. Child boy (s) [ ] 3. Daughter (s) [ ] 4. servant(s) [ ]

    5. Other (specify)……………

28. Who is responsible preparation of food in your home? 0. Father [ ] 1. Mother [ ]

    2. Servant(s) [ ] 3. Child boy (s) [ ] 4. Daughter (s) [ ] 5. Relatives [ ]

    6. Other (specify)………………………….

29. How often do you cook meals per a day?

    0. Once [ ] 1. Twice [ ] 2. Three times [ ] 3. Four and above times [ ]

30. How often do you bake injera per a week?

    0. Once [ ] 1. Twice [ ] 2. Three [ ] 3. Four and above times [ ]

Section 8: Household food and non-food consumption and expenditure

31. Food consumption and expenditure

Item consumed		From Purchase			From own Production			Food aid such as food for work, emergency etc		
		Quantity kg, lit, No	Price	Value (in birr)	Quantity kg, lit, No	Price	Value (in birr)	Quantity kg, lit, No	Price	Value (in birr)
Cereals	Barley									
	Wheat									
	Teffe									
	Maize									
	Sorghum									
	Dagussa									
	Others									
	Sub total									
Pulses	Peas									
	Beans									
	Lentils									
	Chickpeas									
	Flax									
	Others									
	Sub total									
Vegetables	Onions									
	Potatoes									
	Tomatoes									
	Others									
	Sub total									
Fruits	Orange									
	Lemon									
	Papaya									
	Others									

	Sub total									
Species	Salt									
	Karia/peppe r									
	Kimem									
	Others									
	Sub total									
Cooking item	Cooking oil									
Livestock products	Milk									
	Butter									
	Meat									
	Chickens									
	Eggs									
	Sub total									
Others foods	Pasta									
	Macaroni									
	Rice									
	Others									
	Sub total									
	Coffee									
	Sugar									
	Honey									
	Sub total									

32. Non-food expenditure

		Value in birr
Educational expenditure	Exercise books and books	
	Pens and Pencils	
	Tuition fees	
	Transportation for school	
	Others	
	Sub total	
Expenses on clothing	Cloths	
	Shoes	
	Others	
	Sub total	
Other expenses	Medical expenses including veterinary	
	Expenditure on water	
	Fuel	
	Equipment and furniture	
	Jewelry	
	Social occasions and festivals	
	Any payments such as credit, insurance etc	
	Cleaning expenditure such as soap, shampoo, omo etc	
	For fertilizers	
	Others	
	Sub total	
	Grand total	

Annex 2- Checklist Questions

Checklist questions for Kebele leaders and Development agents

1. What is the main type of source of energy consumption in your area?

1.1 What are problems using the current source of energy consumption?

1.2 Are there alternative energy sources in your area? If ye list them

2. How do you think should the current energy consumption be improved?
3. Do you plan to change the present energy consumption patterns? If so, explain
4. What are you going to do to achieve/ improved household energy consumption patterns? List and why?
5. Is there any intervention to improve household energy consumption patterns?

5.1 If yes, is there any enhancement towards household energy consumption? How?

6. What alternative energy sources are for the local people?

6.1 How do people in the locality perceive the use of alternative energy sources?

Checklist question for key informants

1. In your experience, is there improvement of household energy consumption? If yes, how?
2. Are there alternative energy sources?
3. What are your major sources of household energy consumption? Why?
4. Is it possible to save energy at home? If yes how?
5. In your experience, have you ever observed any enhancement towards efficient utilization of energy consumption? If yes how?

Annex 3- Result of Probit Model on Household Energy Consumption

```
. probit Source_energy pcapexp family_size educational_level occupation Sex acce_c
> redit Age total_livestock ownland_wood dist_wood dist_crop dist_dung dist_char c
> ook_place problem_smok_as owner_istove means_istove

note: ownland_wood != 1 predicts failure perfectly
      ownland_wood dropped and 5 obs not used

note: problem_smok_as != 0 predicts success perfectly
      problem_smok_as dropped and 6 obs not used

note: dist_crop != 0 predicts failure perfectly
      dist_crop dropped and 11 obs not used

Iteration 0:   log likelihood = -67.846768
Iteration 1:   log likelihood = -40.778601
Iteration 2:   log likelihood = -36.838707
Iteration 3:   log likelihood = -36.117477
Iteration 4:   log likelihood = -36.081023
Iteration 5:   log likelihood = -36.080915

Probit regression                                 Number of obs   =         98
                                                  LR chi2(14)     =      63.53
                                                  Prob > chi2     =     0.0000
Log likelihood = -36.080915                       Pseudo R2       =     0.4682
```

Source_ene~y	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
pcapexp	-.0009737	.0007778	-1.25	0.211	-.0024981	.0005508
family_size	.0335505	.0977932	0.34	0.732	-.1581206	.2252217
educationa~l	1.640057	.5427799	3.02	0.003	.5762278	2.703886
occupation	.6463673	.5156148	1.25	0.210	-.3642191	1.656954
Sex	-.6560682	.4040352	-1.62	0.104	-1.447963	.1358262
acce_credit	.8398391	.5226898	1.61	0.108	-.184614	1.864292
Age	-.0105834	.0189044	-0.56	0.576	-.0476353	.0264684
total_live~k	.1535449	.0895881	1.71	0.087	-.0220446	.3291344
dist_wood	-.0499583	.0187657	-2.66	0.008	-.0867385	-.0131781
dist_dung	-.0130443	.005503	-2.37	0.018	-.02383	-.0022587
dist_char	.0366837	.0136895	2.68	0.007	.0098528	.0635146
cook_place	.3855831	.2003212	1.92	0.054	-.0070394	.7782055
owner_istove	.6898665	.8464421	0.82	0.415	-.9691295	2.348862
means_istove	-.0471231	.2671386	-0.18	0.860	-.5707051	.476459
_cons	-.4057628	1.171763	-0.35	0.729	-2.702377	1.890851

Annex 3.1- Result of Marginal Effect after Probit

```
. mfx

Marginal effects after probit
      y  = Pr(Source_energy) (predict)
         =  .49193344
```

variable	dy/dx	Std. Err.	z	P>|z|	[95%	C.I.]	X
pcapexp	-.0003884	.00031	-1.25	0.211	-.000997	.00022	353.154
family~e	.013382	.03901	0.34	0.732	-.063071	.089835	5.90816
educat~l*	.5815564	.148	3.93	0.000	.291481	.871632	.387755
occupa~n*	.2522594	.19168	1.32	0.188	-.12343	.627949	.316327
Sex*	-.25644	.15189	-1.69	0.091	-.554139	.041259	.418367
acce_c~t*	.3206918	.18176	1.76	0.078	-.035552	.676936	.265306
Age	-.0042213	.00754	-0.56	0.575	-.018995	.010552	36.6429
total_~k	.061243	.03576	1.71	0.087	-.008836	.131322	1.27582
dist_w~d	-.0199264	.00748	-2.66	0.008	-.034584	-.005269	12.0612
dist_d~g	-.0052029	.00219	-2.37	0.018	-.009501	-.000904	34.8367
dist_c~r	.0146317	.00547	2.68	0.007	.003918	.025345	8.94898
cook_p~e	.1537939	.07989	1.93	0.054	-.00279	.310378	.979592
owner_~e*	.2686217	.31423	0.85	0.393	-.347257	.884501	.612245
means_~e	-.0187955	.10655	-0.18	0.860	-.227631	.19004	2.90816

(*) dy/dx is for discrete change of dummy variable from 0 to 1

Annex 3.2- Link Test for Model Specification

```
. lstat

Probit model for Source_energy

              -------- True --------
Classified |         D            ~D  |      Total
-----------+--------------------------+-----------
     +     |        35             8  |         43
     -     |        12            43  |         55
-----------+--------------------------+-----------
   Total   |        47            51  |         98

Classified + if predicted Pr(D) >= .5
True D defined as Source_energy != 0
--------------------------------------------------
Sensitivity                     Pr( +| D)   74.47%
Specificity                     Pr( -|~D)   84.31%
Positive predictive value       Pr( D| +)   81.40%
Negative predictive value       Pr(~D| -)   78.18%
--------------------------------------------------
False + rate for true ~D        Pr( +|~D)   15.69%
False - rate for true D         Pr( -| D)   25.53%
False + rate for classified +   Pr(~D| +)   18.60%
False - rate for classified -   Pr( D| -)   21.82%
--------------------------------------------------
Correctly classified                        79.59%
--------------------------------------------------
```

Annex 3.3- Mullticollinearity Test

```
. vif

    Variable |       VIF       1/VIF
-------------+----------------------
owner_istove |      4.63    0.216040
means_istove |      4.45    0.224558
educationa~l |      1.87    0.535624
ownland_wood |      1.77    0.563772
 family_size |      1.72    0.582340
  occupation |      1.71    0.585108
   dist_crop |      1.70    0.589929
     pcapexp |      1.51    0.664152
problem_sm~s |      1.47    0.679476
total_live~k |      1.46    0.683792
         Age |      1.45    0.690010
 acce_credit |      1.43    0.701424
   dist_wood |      1.37    0.729356
         Sex |      1.28    0.780803
   dist_dung |      1.25    0.797912
  cook_place |      1.22    0.818199
   dist_char |      1.20    0.835028
-------------+----------------------
    Mean VIF |      1.85
```

Annex 3.4- Hetroscadestcity Test

```
. hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of Source_energy

         chi2(1)      =     0.10
         Prob > chi2  =   0.7501
```

Annex 4- Result of Probit Model on Improved Stove Decision

```
. use "C:\Users\Toshiba\Desktop\All file folder\STATA DATA\Warkaw Leg.dta", clear

. probit owner_istove pcapexp family_size educational_level occupation Sex acce_cred
> it Age livestock ownland_wood dist_wood dist_crop dist_dung dist_char cook_place p
> roblem_smok_as

Iteration 0:   log likelihood = -81.822553
Iteration 1:   log likelihood = -68.140746
Iteration 2:   log likelihood = -67.695408
Iteration 3:   log likelihood = -67.693058
Iteration 4:   log likelihood = -67.693058

Probit regression                                 Number of obs   =        120
                                                  LR chi2(15)     =      28.26
                                                  Prob > chi2     =     0.0200
Log likelihood = -67.693058                       Pseudo R2       =     0.1727
```

owner_istove	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
pcapexp	-.0004344	.0006249	-0.70	0.487	-.0016592	.0007903
family_size	.0576145	.090026	0.64	0.522	-.1188332	.2340622
educationa~l	-.658239	.3579569	-1.84	0.066	-1.359822	.0433435
occupation	.4945702	.3720197	1.33	0.184	-.2345751	1.223715
Sex	.2822189	.2900351	0.97	0.331	-.2862395	.8506773
acce_credit	.7550808	.3389869	2.23	0.026	.0906787	1.419483
Age	-.0014658	.0138226	-0.11	0.916	-.0285576	.0256259
livestock	.477922	.2949182	1.62	0.105	-.1001071	1.055951
ownland_wood	.2738691	.8808656	0.31	0.756	-1.452596	2.000334
dist_wood	.0367186	.012385	2.96	0.003	.0124445	.0609927
dist_crop	-.0048701	.0149492	-0.33	0.745	-.0341701	.0244299
dist_dung	-.0020095	.0035701	-0.56	0.574	-.0090068	.0049878
dist_char	-.0050374	.0069394	-0.73	0.468	-.0186384	.0085636
cook_place	-.0658701	.1543845	-0.43	0.670	-.3684582	.236718
problem_sm~s	-.6639974	.6708874	-0.99	0.322	-1.978913	.6509178
_cons	-.8295941	1.21997	-0.68	0.496	-3.22069	1.561502

Annex 4.1- Result of Marginal Effect after Probit

```
. mfx

Marginal effects after probit
      y  = Pr(owner_istove) (predict)
         =  .59756677
```

variable	dy/dx	Std. Err.	z	P>|z|	[95%	C.I.]	X
pcapexp	-.0001681	.00024	-0.70	0.486	-.000642	.000305	372.03
family~e	.022294	.03486	0.64	0.522	-.046031	.090619	6.03333
educat~l*	-.2541215	.13504	-1.88	0.060	-.51879	.010547	.391667
occupa~n*	.1836691	.1308	1.40	0.160	-.072703	.440041	.283333
Sex*	.1082775	.10979	0.99	0.324	-.106909	.323464	.425
acce_c~t*	.2687568	.10656	2.52	0.012	.059912	.477601	.25
Age	-.0005672	.00535	-0.11	0.916	-.01105	.009916	36.7917
livest~k*	.1838119	.11167	1.65	0.100	-.035059	.402683	.525
ownlan~d*	.1081211	.35098	0.31	0.758	-.579782	.796024	.958333
dist_w~d	.0142083	.00475	2.99	0.003	.004892	.023524	12.9417
dist_c~p	-.0018845	.00578	-0.33	0.745	-.013219	.00945	2.71667
dist_d~g	-.0007776	.00138	-0.56	0.574	-.003485	.00193	32.6083
dist_c~r	-.0019492	.00268	-0.73	0.468	-.007208	.00331	11.45
cook_p~e	-.0254885	.05973	-0.43	0.670	-.142563	.091586	.908333
proble~s*	-.2598422	.24966	-1.04	0.298	-.749164	.22948	.058333

(*) dy/dx is for discrete change of dummy variable from 0 to 1

Annex 4.2- Link Test for Model Specification

```
. lstat

Probit model for owner_istove

              -------- True --------
Classified |         D            ~D  |      Total
-----------+--------------------------+-----------
     +     |        52            19  |         71
     -     |        17            32  |         49
-----------+--------------------------+-----------
   Total   |        69            51  |        120

Classified + if predicted Pr(D) >= .5
True D defined as owner_istove != 0
--------------------------------------------------
Sensitivity                     Pr( +| D)   75.36%
Specificity                     Pr( -|~D)   62.75%
Positive predictive value       Pr( D| +)   73.24%
Negative predictive value       Pr(~D| -)   65.31%
--------------------------------------------------
False + rate for true ~D        Pr( +|~D)   37.25%
False - rate for true D         Pr( -| D)   24.64%
False + rate for classified +   Pr(~D| +)   26.76%
False - rate for classified -   Pr( D| -)   34.69%
--------------------------------------------------
Correctly classified                        70.00%
--------------------------------------------------
```

Annex 4.3- Mullticollinearity Test

```
. vif

    Variable |       VIF       1/VIF
-------------+----------------------
educationa~l |      1.80    0.554150
 family_size |      1.79    0.559797
ownland_wood |      1.72    0.582453
   dist_crop |      1.71    0.585065
  occupation |      1.68    0.595518
     pcapexp |      1.49    0.669560
         Age |      1.45    0.687598
problem_sm~s |      1.42    0.702962
   livestock |      1.40    0.715659
 acce_credit |      1.32    0.758294
         Sex |      1.30    0.769142
   dist_wood |      1.29    0.777569
   dist_dung |      1.25    0.802819
  cook_place |      1.21    0.823455
   dist_char |      1.18    0.848779
-------------+----------------------
    Mean VIF |      1.47
```

Annex 4.4- Hetroscadestcity Test

```
. hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of owner_istove

         chi2(1)      =     2.57
         Prob > chi2  =   0.1087
```

Annex 5-Conversion factors used to estimate tropical livestock unit

Animal category	TLU	Animal category	TLU
Calf	0.25	Donkey young	0.35
Heifer	0.35	Camel	1.25
Cow and ox	1.00	Sheep and goat (adult)	0.13
Horse	1.10	Sheep and goat (young)	0.06
Donkey adult	0.70	Chicken	0.013

Source: (Gebremeskel, 2010)