PATTERNS AND DETRMINANTS OF ENERGY CONSUMPTION IN URBAN HOUSEHOLDS: THE CASE OF BODITI TOWN, WOLAITA ZONE, SOUTHREN ETHIOPIA

MSc THESIS

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A THESIS SUBMITTED TO

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IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN RENEWABLE ENERGY UTILIZATION AND MANAGEMENT

(SPECIALIZATION: RENEWABLE ENERGY UTILIZATION AND MANAGEMENT)

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APPROVAL SHEET-I

This is to certify that the thesis entitled “patterns and determinants of energy consumption in urban households: The case of Boditi town, Wolaita Zone, Southern Ethiopia” submitted in partial fulfillment of the requirements for the degree of Master of science with specialization in renewable energy utilization and management of the environmental studies, The graduate program of the department of Environmental Science, Hawassa University, Wondo Genet College of Forestry and Natural Resources, and has been carried out by Mihretu Bergene ID No. M.Sc./ReUM/R009/09, under my supervision. Therefore, I recommend that the student has fulfilled the requirements and hence hereby can submit the thesis to the department.

Dr. Yemiru Tesfaye	________________________	____________________
Name of Supervisor	Signature	Date

APPROVAL SHEET-II

We, the undersigned, members of the Board of Examiners of the final open defense by Mihretu Bergene have read and evaluated his thesis entitled "patterns and determinants of energy consumption in urban households: The case of Boditi town, Wolaita Zone, Southern Ethiopia" and examined the candidate. This is, therefore, to certify that the thesis has been accepted in partial fulfillment of the requirements for the degree of Master of Science in Renewable Energy Utilization and Management at Hawassa University, Wondo Genet College of Forestry and Natural Resources.

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DECLARATION

I, Mihretu Bergene, hereby declare that this MSc thesis entitled patterns and determinants of energy consumption in urban households: The case of Boditi town, Wolaita Zone, Southern Ethiopia. This is my original work and has not been presented for a degree in any other University, and all sources of material used for this thesis have been duly acknowledged

Mihretu Bergene ________________ ________________

Name signature date

DEDICATION

I dedicate this research project to God almighty for his grace, mercy and blessings that have seen me through this Programme. To my beloved family for their love, support and encouragement throughout this Programme. To my loving parents, who have been a source of inspiration and have demonstrated to me how to live a life of humility, sacrifice and hard work. To my sisters and brother who have always been there for me. To all my loving wife Aregash Hegano, a big thank you for your support.

ABBREVIATIONS AND ACRONYMS

EE	Encarta Encyclopedia
EJ	Exajoule
EPA	Environmental Protection Agency
ESMAP	Energy Sector Management Assistance program
ETB	Ethiopian Birr
FAO	Food and Agricultural Organization
GDP	Gross Domestic Product
GJ	Gigajoule
IEA	International Energy Agency
KWH	Kilowatt Hour
LPG	Liquefied Petroleum Gas
MASL	Mean above Sea Level
MDGs	Millennium Development Goals
MJ	Mega Joule
PPS	probability Proportion to Size
UNDP	United Nation Development Program
WEC	World Energy Council
WEO	World Energy Organization
WHO	World Health Organization

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Patterns and determinants of energy consumption in urban households. The case of Boditi town, Wolaita Zone, Southern Ethiopia

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ABSTRACT

Poor quality and unavailability of baseline data on energy consumption seriously affects energy planning and policy related work and environmental protection. A large number of households faced limited, inefficient, and expensive energy options to meet their domestic activities. The main aim of this study is to investigate the current patterns of household energy consumption and expenditure in Boditi town in terms of major types of available energy sources for domestic use, to identify the determinants of energy consumption and expenditure among households and also to identify the major sources of energy available for household domestic use. Mixed methological approach were used in this study. Multi-stage sampling technique were applied to select the sample households. In the first stage, sample kebeles *were selected from the total kebeles randomly by using lottery method. In the second stage, sample households were selected by using sample determination formula of (Yemane, 1967) lastly, sample sizes are given for each kebele by using probability proportion to size (PPS) method*. For this study, *data were obtained from the randomly selected 358 sampling households. The method used to collect data was a questionnaire. The method used to analyze the data was a descriptive statistics and multivariate regression analysis. The outcome of this study shows that households used different fuel types for different domestic activities. The energy sources used by households include biomass fuels (fuelwood, charcoal and sawdust) and modern fuels (electricity, kerosene, dry cell battery and candle). The findings of this study show that household income and household size are the main variables which determine the amount of energy expenditure and consumption per households. Household size and income are statistically significant parameters with household energy expenditure, both biomass and conventional energy consumption and also gross household energy consumption. The amount of both gross and useful domestic energy consumed increases with the increase in household income.*

Keywords*: biomass energy, conventional fuels energy expenditure, energy consumption, Household,*

1. INTRODUCTION

1.1. Background of the study

Energy plays a great role in the lives of people across every aspect of human activity including agriculture, industry and social services and it is thus most important for sustaining people's livelihood (Clancy *et al*., 2003). Energy also plays a great potential role in a country's development and in achieving sustainable development (Adusei, 2012). Energy use in residential buildings is one of the major sources of carbon dioxide emissions produced by cities. Comprising between 16% and 50% of the total global energy consumption, most of the urban energy usage comes from building operations (Swan and Ugursal, 2009 and Perez *et al*., 2008). The crucial role of urban areas in shaping global energy demand, as well as the emergent urban leadership in climate change mitigation and adaptation, has stimulated growing attention to urban scale energy consumption information (Parshall *et al*., 2010).

According to (UNDP, 2009), without highly increasing the modern energy sources, no country has substantially reduced the poverty in modern times. The objectives of development can't also be achieved without access to modern energy, sustainable, affordable, and reliable energy services is central to addressing many of today's global development challenges. Therefore, improving households' access to energy and ensuring regular supply is considered to be central not only to achieve the MDGs but also, to improve the quality of life and sustain the socio-economic conditions of the people (Khandker et al., 2010). There is a strong argument that realization of development programs and reducing poverty are highly dependent on the universal access to modern energy that is affordable and reliable (Reddy, 2000).

Energy is deeply implicated in each of the economic, social and environmental dimensions of human development. Energy services provide an essential input to economic activity. It contributes to social development through education and public health and helps to meet the basic human need for food and shelter. Modern Energy services can improve the environment, for example by reducing the Pollution caused by inefficient equipment and processes and by slowing deforestation. But rising energy use can also worsen pollution, and mismanagement of energy resources can harm ecosystems. The relationships between energy use and human development are extremely complex (WEO, 2004).

Hence, lack of alternative energy sources and heavy reliance on traditional biomass like fuelwood affects the physical environment and results in forest degradation, deforestation and ultimately desertification. This is also a common problem for the developing countries including Ethiopia (Omar, 1994 and GTZ, 1998). This is clearly shown on the trend in the country's wood supply which has been declining at a faster rate to the point where the existing supply of fuelwood could not be able to accommodate the fuel demand of the country. As the urbanization continues and household income increases, the major source of fuel is expected to shift to modern fuel sources and as result, the urban area may be forced to take the commercial fuels to meet their energy need for their daily lives (Fikre, 1995).

However, many households of the area are suffering from a shortage of fuel in any case. Access to clean, affordable and sustainable energy is becoming the key question for most of the households in the area. The study was tried to address the patterns and determinants of energy consumption in the urban households.

1.2. Statement of the Problem

Understanding household energy consumption patterns is paramount in assessing energy efficiency development. The perceived government’s aim in addressing household energy issues may be attributed to the quality and amount of available data on household energy consumption, because poor quality and unavailability of baseline data on energy consumption seriously affects energy planning and policy related work and environmental protection (Lusambo, 2016) In most of the developing countries the drivers behind household energy consumption patterns are poorly understood.

An irregular supply of electricity undoubtedly creates huge inconvenience for its users and its use for baking and cooking is limited to very few households. There are sudden and frequent blackouts and voltage drops which can make electricity a very unreliable source of energy for use domestically and the users find it hard to predict its availability.

Most of Ethiopian households used traditional (biomass) energy sources for their domestic activities, as the major household energy source. According to the information from the (town administration office, 2016), the expansion of the town is increasing from time to time. This expansion attracts many people from the nearby rural areas to come and settle in the urban areas. As a result, the rate of energy demand increases at a higher rate. Particularly, the rising demand for fuelwood results in higher pressure on the woodland forests in the local area in order to meet the demand of energy for cooking and baking by urban households. Consequently, the high and direct dependence on biomass fuels mainly for baking and cooking purposes in the area was eventually contributed to unnecessary high level of forest resource removal which leads to growing shortage of biomass fuels and higher wood fuels prices.

To date, a number of studies (such as Reddy 2004; Nkomo 2007 and GIZ 2008) have shown that reliable and affordable energy remains an essential prerequisite for combating energy poverty at household level. Considering of this evidence, it seems that there is high level of energy consumption patterns at household levels, where they use disproportionately more biomass fuels. Still most urban households in the study area are the principal consumers of biomass fuel because they have limited access to such alternative fuels as kerosene and LPG.

This hinders their efforts to move out of poverty and seriously constrains their ability to improve their living situations.

Moreover, prices for commercial cooking fuels are already very high in the market for the majority of urban households. A substantial portion of the urban households continue to suffer as their incomes have not kept pace with the rising prices and face higher financial burden to meet their cooking demands. Therefore, meeting the energy requirements in sustainable manner continues to be a major challenge. The general aim of this study was to investigate the current patterns and determinants of household energy consumption and expenditure among urban households in terms of available energy source for domestic use.

1.3. Objectives of the Study

1.3.1. General objectives of the study

The general objective of this study was to assess the current patterns of household energy consumption in terms of major types of available energy sources for household use and also identify the determinants of households' energy expenditure and consumption in the study area.

1.3.2. Specific Objectives of the Study

- To describe the major sources of energy available for household domestic uses in the study area.
- To investigate the patterns of urban household’s energy consumption in the area
- To explain the determinants of energy consumption and expenditure among urban households in the study area.

1.4. Research Questions

In light of the above-mentioned research objectives, the study strived to answer the following key research questions.

- What are the major sources of available energy for household's domestic use?
- What are patterns energy consumption in the study area
- What determines household energy consumption and expenditure study area?

1.5. Significance of the Study

The findings of this study contribute to efforts towards development of efficient and modern energy services and consequently curb environmental problems and foster improved livelihoods of the poor households. Policy and decision makers might make use of the findings from this study to devise short-term, medium-term and long-term strategies for sustainable natural resource management. The public may also be made more aware of the situation on the ground and thus facilitate positive changes in their energy-related behavior and way of thinking and attitudes; and for prudent environmental management.

In addition to this, the study may help the urban development planners and responsive urban development programs and projects which had significant contributions for promoting sustainable urban development. Moreover, the study might provide the empirical finding which are important to identifying the patterns and determinants of energy consumption, the type of energy they use, the source of energy they adopt and the preference of household energy choice. Finally, the result of the study may give some direction or fill the knowledge gap of related energy expenditures and consumptions for the community, other researchers and stakeholders who want to conduct further research on the area of pattern and determinants of energy consumption in urban households.

1.6. Scope and limitation of the study

Energy consumptions of a household have a variety of impact with regard to ecological, environmental, economic, social, political, health and cultural concerns at national, regional, zonal and district levels. Climate change, indoor air pollution, deforestation, degradation etc. are the problems related to the use of energy. The study was conducted in Boditi town with the broad objective of assessing the current patterns of household energy consumption in Boditi town in terms of major types of available energy sources for household use. For the purpose of this study the energy sources considered are biomass fuels such as firewood, charcoal, sawdust and the conventional energy sources including electricity, kerosene, candle, and dry cell battery.

The major problem at the time of data collection was misunderstanding have restrained respondents from giving correct responses on questions related to income and few respondents were not willing to tell correct information about their current monthly income. There were also people without defined salaries and the incomes they got were from miscellaneous activities. Furthermore, it was also difficult to find some household heads in person since they were busy with their daily works. On the other hand, there is a geographical limitation to the study because of finance and time to tackle all the information and also it is hard to cover all the area. As a result, the study is only focused on the urban domestic households' energy consumption.

2. LITERATURE REVIEW

2.1. Concepts and types of energy

Energy is usually defined as power derived from the utilization of physical or chemical resources, especially to provide light and heat or to work machines. Forms of energy include mechanical, thermal, chemical, electrical, radiant and atomic. It is grouped as primary, secondary and final or useful energy (Robert *et al.,* 1995).

Energy sources can be renewable and non- renewable. Biomass based energy sources are mostly available in an unlimited amount in nature. Such energy sources are fuelwood, petrol plants, agricultural waste like biogas, animal dung, wind energy, water energy, tidal energy, geothermal energy, solar energy, etc. The non-renewable energy sources include petroleum, coal, natural gas, nuclear power and like (EPA, 2003). The non-renewable energy sources are limited in nature and can't be replenished easily (Aklilu D, 2005).

To study energy consumption, commercial and traditional energy sources are crucial. Commercial energy is the power used by commercial entities, as opposed to residential, industrial, or transportation energy. Businesses like retail stores or auto dealerships are examples of commercial energy end-users served by power utilities. Traditional fuels such as fuelwood, agricultural wastes, animal dung etc., are sources collected by other user and sold by the consumer without the involvement of any commercial activity (EE, 2003).

The renewable energy sources are a sustainable form of energy and can be easily replenished and abundant energy resources. It can be recycled in a natural process and can be used repeatedly without any running out (Getish *et al*., 2000). The remains of ancient plant and animal life during deep in the crust by the external pressure applied along period of time are fossil fuels such as oil, coal, and natural gas and are referred to as exhaustible energy sources. It can't be recycled in natural process and takes a long period to replenish (IEA, 2014).

Energy, the capacity to do work or the stored ability to perform work, exists in a number of different forms such as chemical energy, electrical energy, heat (thermal) energy, light (radiant) energy, mechanical energy, and nuclear energy (UNDP, 2009). Energy is important in our daily lives and simply derives from the fact that it provides Variety of essential human services. It is the means to the provision of basic needs such as cooking food, heating, cooling and lighting, the use of appliances, transportation and communication system such as radio, television, telephones and computers (IEA, 1999).

2.2. Energy consumption and supply at global level

At global scale more than 3 billion (nearly half of world human) deprived of access to modern energy alternatives. All of these people live in poor countries and depend on traditional biomass resources to meet their basic energy need. This has caused worsening health and environmental consequences. The Central premise of world energy strategy, thus, has aimed at shifting from the use of high-cost and environmentally damaging fossil fuels to cost-effective renewable energies that can be sourced from renewable resources (biomass, wind, hydro and solar) (Dawit, 2012).

In comparison with other regions such as Latin America, Middle East, Europe, and North America, Africa has one of the lowest per capita consumption rates. Modern energy consumption in Africa is very low and heavily reliant on traditional biomass. Between 1995 and 2001, per capita consumption of modern energy in sub-Saharan Africa remained small and stagnant; falling slightly from an average of 138 kgs of oil equivalent (kgoe) to 126 kgoe. About 13% of the world average of 979 kgoe (IEA, 1998; IEA, 2003).

Many analysts use the very low levels of modern energy consumption in Africa to argue that energy consumption is, by definition, not a major issue and its environmental impact should not be of significant concern. They argue that African policymakers should be more concerned by the continued under consumption of modern energy; an important indicator of high levels of poverty and underdevelopment. A more nuanced and differentiated assessment of energy consumption in Africa would show that certain regions (e.g. South Africa and North Africa) have experienced rapid growth in energy consumption that is somewhat similar to industrialized countries of Latin America and Asia. Even within sub-Saharan Africa, modern energy consumption is relatively high in urban areas due to rapidly growing demand for transport energy and electricity to power industrial and commercial enterprises. In the long-term (30-50 years), some African countries could experience the kind of rapid growth in energy consumption that is currently being observed in industrializing countries of Asia and Latin America resulting in significant adverse environmental impacts. In addition, sub-Saharan Africa's under consumption of energy (leading to serious food security and health problems) should also be an issue of concern. (IEA, 2014).

Africa's energy sector is best understood as three distinct regions (World Energy Council, 2003). They are North Africa, South Africa and sub-Saharan Africa. North Africa, which is heavily reliant on oil and gas, followed by South Africa which depends on coal and the rest of sub-Saharan Africa, largely reliant on traditional biomass (which is termed as combustible renewables and wastes). Reliance on traditional biomass energy is particularly high in sub-Saharan Africa, accounting in some countries for up to 95% of the total consumption. The very high figure registered for combustible renewable and waste energy consumption for sub-Saharan Africa reflects its heavy reliance on biomass energy primarily used at a household level. As at 2001, the share of biomass consumption was 81.18% in sub-Saharan Africa, 16.46% in South Africa and 4.06% in North Africa (IEA, 2003; Ekouevi, 2001).

Households require energy primarily for cooking, lighting and space conditioning. In Africa, cooking often accounts for between 90 and 100% of household energy consumption because of limited space conditioning loads. Household energy consumption levels and the types of energy used depends on a variety of factors, which include the availability and costs of energy sources (Karekezi and Kithyoma, 2002).

The transition from household energy consumptions of traditional energy to modern energy service affected by changes in household income. Some studies show that if the household income increases, it will increase the consumption of modern energy (Hosier and Dowd, 1987), (Pechauri and Spreng, 2002), (Gamtessa, 2003), (Lanzen *et al.*, 2004), (Barnes et al., 2004), (Shittu *et al.*, 2004), (Cohen *et al.*, 2005), (Atanassov, 2010), (Battarcharjee & Richard, 2011), (Foysal *et al.*, 2012) and (Estiri *et al.*, 2013)).

Positively, modern energy consumptions and household income relationships indicate, the modern energy is in the normal good group. The price of energy and energy appliance determines the consumption of energy (Battarcharjee and Richard, 2011). Demographic characteristics have high role in shifting energy consumptions of the household (Berhanu, 2000), household size and urbanization (Lanzen *et al.*, 2004) family size and access to fuel (Barnes *et al.*, 2004), social and cultural factors (Atanassove, 2010), and education (Gebreegziabher *et al.*, 2012), town gas, and firewood (biomass) and charcoal, briquettes. Kerosene consumption reduced a lot because of government policy and has been shifted into LPG since 2007.

2.3. Energy Supply and Consumption in Africa

Mostly Renewable and non-renewable energy is abundant in Africa. Despite its resource potential, however, there is lack of skilled manpower, capital investment, and modern technology. Most African countries have very low per capita energy consumption comparing energy consumption at the global level. The per capita energy consumption of Africa is far lower than the per capita energy consumption of the world average. These make the Africa go behind the other developed world (IEA, 1999). All the existence of the energy resource and the continent is mostly dependent on traditional biomass like fuelwood, plant residues, dung cake etc. and it mostly limited to modern energy resources (Karwekezi, 1997).

However, now a day the supply and demand of electricity in most of the African countries have been increasing with time because of the large industries, governments take parties, increase of capital investment (Norton, 1995). Africa accounts for 12 percent of the global population, but it consumes only 5.5 percent of global energy while Americans constitute 5% of the world's population but consume 24% of the world's energy (Wadjamsse, 2008).

Evidence on the cause of fuel poverty, the policy effectiveness that has been implemented and identifying some of the possible new ideas. As indicated, although fuel poverty is a serious and significant social problem in Western Europe, its acceptance has been slower and has been acknowledged by campaigners, academics and politicians since at least 1975 (Boardman, 2010).

The African household's energy consumption relies highly on traditional fuels (Bereket, 2000). Nationally, fuelwood and charcoal energy consumption in Ethiopia, Burkina Faso and Mali exceeds 90%. Fuelwood dependence for their household energy is up to 9 out of 10 (FAO, 1997). According to (FAO, 2000), Africa alone produces and consumes about half of the world's charcoal production, which is used as a domestic fuel in many of the urban areas and as a cooking fuel. It has also stated that, energy in rural areas of Africa by product charcoal account for 90 to 98 percent of the total household energy consumption. (FAO, 1997) has also estimated in this relation that about 100 million tons of wood are annually cut for charcoal production. Charcoal is made by small producers in simple earth kilns or pit kilns where the traditional production techniques lead to low conversion efficiency with high wastage.

2.4 Traditional Versus Modern Source of Energy Consumption

The term traditional and modern energy consumption has relative meaning. In the other words, some improved stoves in developing countries might be considered as traditional in developed countries. Moreover, the term traditional energy as used in this research refers to the direct very inefficient fuel types such as wood, charcoal, sawdust, 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. as.

2.4.1 Traditional Energy Consumption

Traditional household energy consumption patterns are mainly used of inefficient biomass fuels (fuelwood, charcoal, sawdust, plant residues, dung cake etc.) are source of traditional energy that have directly or indirectly has environmental problems such as soil erosion, degradation, deforestation, indoor air pollution etc. 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 degradation of essential nutrients that are necessary for soil fertility. Moreover, smokes from the use of fuelwood 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 are not equipped with separate living and cooking places relatively to developed countries since a majority of them do not have access to modern energy services (www.homepages.wmich.edu).

2.4.2 Modern Energy Consumption

Modern energy technology is the good technology to reduce the problem of waste management as compared to the traditional one. 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 (Karekezi, 2004).

2.5. Major Energy Consumption Patterns in Ethiopia

Most of the Ethiopian rural households highly dependent on fuelwood and animal 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). According to (Mekonen, 1998), Ethiopia has a huge potential of alternative energy resources but are still unutilized. Hence, it 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 biofuels (fuelwood, 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 biofuels are also consumed at the household level and mainly in rural areas relative to urban areas (as cited in Zenebe, 2007, p.3).

2.5.1. Energy Consumption patterns of Rural Households vs. Urban Households

Energy use is important for the welfare of households in developing countries. For most people in developing countries, energy comes from wood, dung, candles, and occasionally kerosene which are used for either cooking, heating or lighting. For most of these countries, more than 90% of the total household’s fuel is biomass. It is estimated that approximately 2.5 billion people in developing countries rely on biomass fuel to meet their cooking needs. Moreover, due to population growth and lack of new policies, the number is expected to increase to 2.6 billion by 2015 and 2.7 billion by 2030, which is about one-third of world's population (IEA 2006).

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 nonrenewable energy sources such as fossil fuel, coal, petroleum, natural gas and so on. However, the type of energy consumption might be determined by different factors such as income level, educational status, cultural preference and households' use of energy purposes such as cooking, lighting, boiling water and space conditioning and so on. In short, household's sources of energy consumption patterns in the world are diverse in nature. (Mfune and Boon, 2008), illustrates that a great disparity in energy consumption exists between the developed and developing countries. Hence, the latter has 80 percent of the world's population but consume only 30 percent of the world's commercial energy like electricity. However, many of developing countries are richly endowed with energy resources.

2.5.2. Determinants of Households' Energy Consumption

Rural households rely more on biomass fuels than those in urban areas, well over half of all urban households in sub-Saharan Africa rely on fuelwood, charcoal, or wood waste to meet their cooking needs (IEA, 2006). With increasing population and urbanization over time, urban household energy is an important issue for developing countries in general, and for poorer developing countries, such as Ethiopia, in particular.

Heavy reliance on urban households in sub-Saharan Africa on biomass fuels (such as woody biomass and dung) contribute to deforestation, forest degradation, and land degradation. This is partly because the use of these fuels in urban areas is an important source of cash income for people in both urban and rural areas. While the use of woody biomass as fuel and as construction material contributes to deforestation and forest degradation, use of dung as fuel implies that it might not be available for use as fertilizer thus contributing to land degradation and consequent reduction in agricultural productivity.

Use of biomass fuels for cooking is a major cause of health problems in developing countries due to indoor air pollution (Bruce *et al.*, 2000; Ezzati and Kammen, 2001). According to the World Health Organization (WHO, 2006), 1.5 million premature deaths per year are directly attributable to indoor air pollution from the use of solid fuels (IEA, 2006). Recognizing the adverse effects of the use of traditional biomass fuels, the United Nations Millennium Project recommends halving the number of households that depend on traditional biomass for cooking by 2015, which involves about 1.3 billion people switching to other fuels (IEA, 2006). One set of factors necessary for switching to other fuels particularly in poorer developing countries like Ethiopia is better availability of alternative fuels other than traditional biomass fuels. Such alternative fuels are generally available in the major cities of poorer countries, but access to such fuels is much more limited in rural areas and smaller cities in these countries. Household fuel choice also depends on other factors, which makes knowledge of the determinants of urban households' choice of fuel is important. In the literature on household energy demand and choice, it has been argued that households with low levels of income rely on biomass fuels, such as wood and dung, while those with higher incomes consume energy that is cleaner and more expensive, such as electricity. Those households in transition between traditional and cleaner and more efficient energy sources consume what are called transition fuels, such as kerosene and charcoal. While this is a simpler version of the energy ladder hypothesis, it is also presented in the literature with more elaborate intermediate steps (Hosier and Dowd, 1987; Barnes and Floor, 1999; Heltberg, 2005).

A related concept is fuel switching, where it is argued that introduction of superior fuels will phase out traditional fuels as households will switch to the former. (ESMAP, 2000), also presents a theory with a ladder of energy demand rather than those of fuel preferences, where more diversified demand for energy sources is explained in terms of the nature of appliances used and the purpose as incomes rise. Simple and linear associations between income and fuel preferences and demand represented by a ladder have been criticized as unrealistic because fuel preferences could be explained by other factors.

More recently, it has been argued that households in developing countries do not switch to modern energy sources but instead tend to consume a combination of fuels, which may include combining solid fuels with non-solid fuels as sources of energy. Thus, instead of moving up the ladder step by step as income rises, households choose different fuels as from a menu. They may choose a combination of high-cost and low-cost fuels, depending on their budgets, preferences, and needs (World Bank, 2003). This led to the concept of fuel stacking (multiple fuel use), as opposed to fuel switching or an energy ladder (Masera *et al.,* 2000; Heltberg, 2005).

2.6. Conceptual Framework of the study

This Figure shows the relationship between the consumption of energy into the major sources of energy that are categorized as traditional or biomass and modern energy sources. Biomass energy sources are fuelwood, charcoal and sawdust and the modern energy sources include electricity, kerosene, candle and dry cell battery. The relationship between energy consumption patterns divided into traditional and modern energy sources. They have their own determinants which are: family size, income, educational level, occupation, marital status, and age and house ownership. Most of the developing countries and their peoples were highly affected by high price or shortage of energy. Energy is a precondition to economic development. The prosperity that economic development brings, in return, stimulates demand for more and better-quality energy services. Many countries have established a virtuous circle of improvements in energy infrastructure and economic growth (EAD 2004).

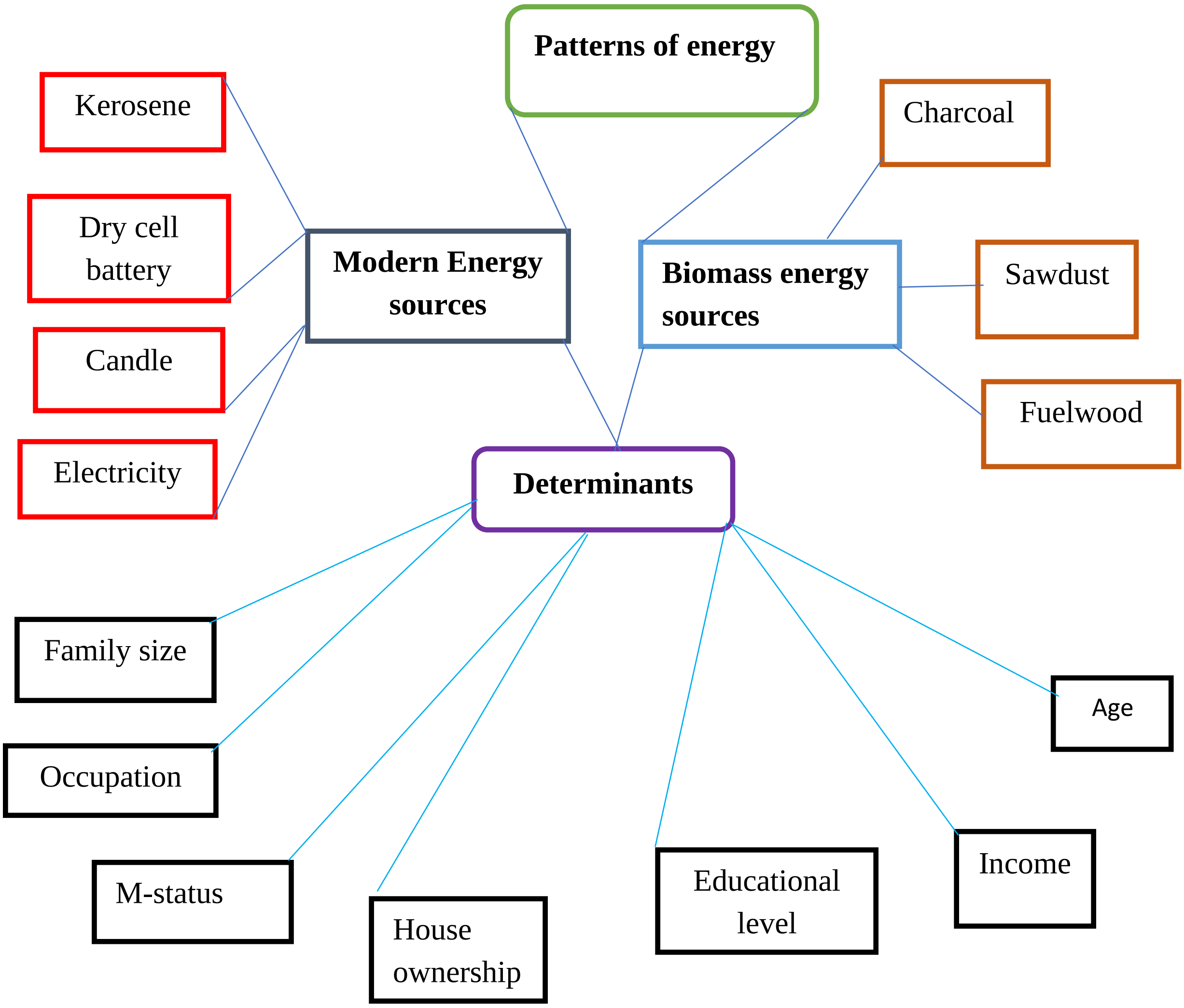


Figure 1: Conceptual framework of the study

3. MATERIALS AND METHODS

3.1. Description of the Study Area

Boditi Town which is the administrative center of Damot Gale district is one of the towns in Wolaita zone; Southern Nations, Nationalities, and Peoples' Region of Ethiopia within the coordinate of 7° 00′ N and 37° 50′ E and an altitude range of 1612 – 2964 m.a.s.l. It is bounded by Shasha-Gale Kebele in the north, Ade-Koisha Kebele in the south, Chawkare Kebele in the east and Sibaye-Korke kebele in the west. It is located in East Rift valley at a distance of 370 km to the south of Addis Ababa and at about 140 km to the west of Hawassa. The total land area coverage of the town is 15,255 ha with and the total population of the town in 2016, received from the local administrative office, was 53,662 (26,348 are males and 27,314 are females). Annual rainfall in the area ranges from 900 mm to 1400 mm with minimum and maximum temperatures of 12°c and 24°c (District report).

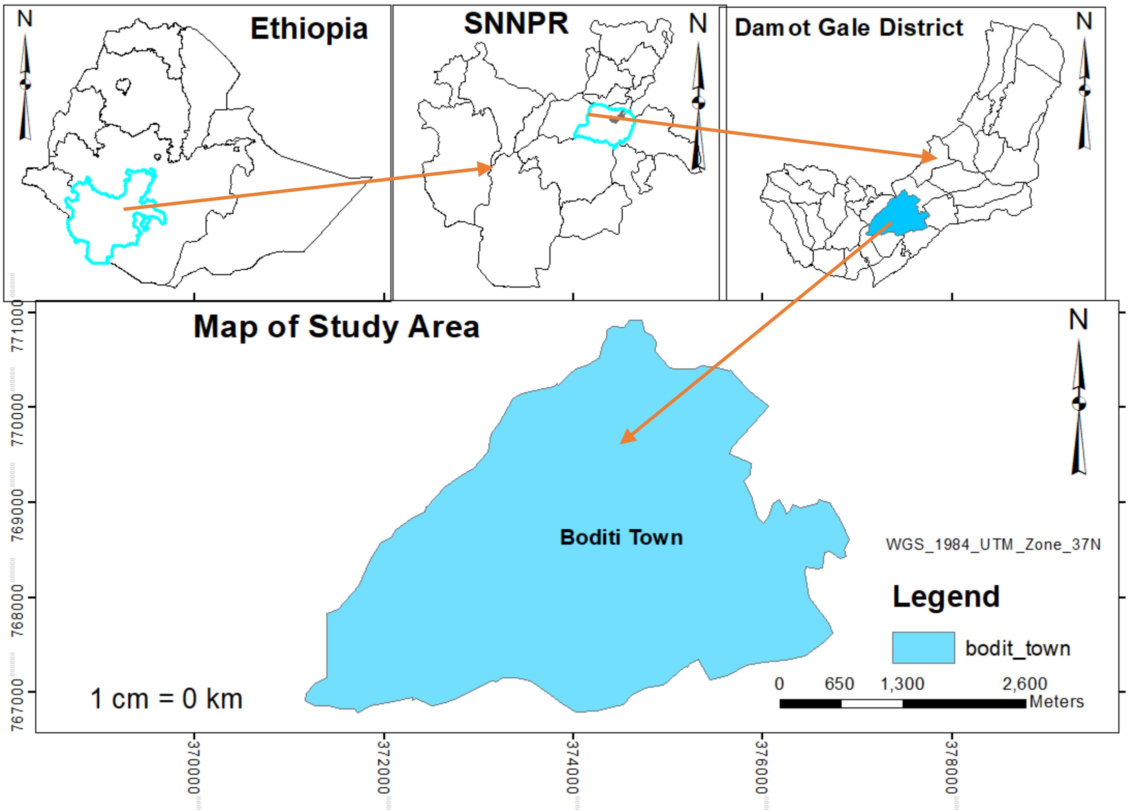


Figure 2: Map of the study area

3.2. Methodology

3.2.1. Research Design

The methodological approach used in this study was a mixed methodology. The overall purpose of designing this type of approach is very crucial that qualitative data are used to interpret the findings of a quantitative study (Creswell, 2003). Because this design begins quantitatively, investigators typically place greater emphasis on the quantitative methods than the qualitative methods.

Both qualitative and quantitative research methods are used in this study to address the questions raised in my research questions. The study focuses greater emphasis on the quantitative methods than the qualitative methods. For primary data collection, this research used a cross-sectional survey of urban households as the main methodological approach to collect information from selected households.

Moreover, both primary and secondary data were collected while the primary data was a cross-sectional data. The study covered a random sample of 358 households selected from three kebeles based on a Probability Proportional to Size (PPS). To achieve the objectives of the study, in the first stage the structured questionnaire was prepared for the household heads, the amount of energy they used for a different purpose has been measured, then the questionnaires was pre-tested at field level for further verification and modification. Training has been given for enumerators in order to acquire knowledge in the appropriate data collection. In the second stage, the actual data has been collected.

3.3. Types and source of Data

The major sources of data include both primary and secondary sources. Primary data was obtained through a household survey by using structured questionnaire. The questionnaire was first prepared in an appropriate format. Data collection was carried out through direct interview with the household heads for the survey data. In this procedure, the major stakeholders are the sampled households. The questionnaire was prepared for acquiring the information about the relationship between energy consumption and the determinants such as family size, income level, occupation, educational level, marital status, sex and household's expenditure of energy by type and source, the major source energy for domestic purpose. The secondary data has been collected from different sources such as census, regional and district documents, records and official documents of energy office. Documents from the Ministry of Energy and Water, and Annual Statistical information were also used. Relevant literature concerning households' energy consumption patterns and determinants was also reviewed. To obtain the required information, not only the primary data but also the secondary data sources such as the annual energy consumption reports among the urban households, previous studies related with energy consumption of urban household has been used.

3.4. Methods of Data Collection

This study was undertaken by the administering of a questionnaire that was balanced between open-ended and close-ended types of questions. This is used to obtain relevant information that allows flexibility to meet the intended objectives and used to not restricting respondents to the given options. The questionnaire was tested prior to fieldwork through discussion and cross review with enumerators. Any problems in the content of the questionnaires and other instruments were resolved during the pre-test.

Qualitative data were collected by using key informant interviews in order to gain insights into participants' opinions comprehensively and used to fill any further information that was not covered by the field survey.

Three key informants were selected from Town's Administration Office, Ethiopian Electric Utility local branch Boditi town, and Energy Offices purposively. The criteria for selecting these respondents were based on the position they held in their offices and the interviews were conducted in their respective offices. The key informant interviews with administrators were helpful for gathering useful data with greater depth as well as to triangulate the finding of the quantitative study. Secondary data were obtained from various published and unpublished documents of governmental and nongovernmental organization at different levels. Journals, books, newspapers, articles from internet were used as needed.

The questionnaires have been designed to capture both the actual and perceptional information from the households. The questions are basically aimed at gathering information about the household head of the family, household energy consumption pattern and determinants, the source of energy they used for different household activities and magnitude of the expenditure made by the household indifferent type of energy sources, and the factors influencing fuel supply, accessibility and consumption.

In the field work conducted, data on the consumption of energy resources for this study were gathered in terms of expenditure. Estimates of fuel consumption were made based on the respondents 'estimates of their monthly use.

Data was collected by: -

- Questionnaire
- Key informants Interview
- Measuring the amount of firewood, charcoal and sawdust. In this case, the measurements are undertaken by 10 samples from different venders of fuelwood, charcoal and sawdust by using the kilogram.

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

3.5. Sampling techniques

The entire urban households residing within the town are the target population for the study. In the town, there are eight kebeles and the total number of households are 8213 (town administration office, 2018). Multi-stage sampling technique were applied to select the sample households. For the purposes of sampling, kebeles of the town were categorized into two strata based on the number of households. Based on this category, five kebeles are categorized under stratum one (kebeles having more households) and the rest three are categorized under stratum two (small number of households). In the first stage, sample kebeles were selected from the total kebeles randomly by using lottery method. From Stratum one (kebeles having more households) two kebeles were selected, namely; Boditi-Hagaza and Gido-Boditi. From the second stratum (kebeles with small number of households) one kebele was selected, namely; Boditi Korke. In the second stage, sample households were selected by using sample determination formula of (Yemane, 1967). Lastly, sample sizes are given for each kebele by using probability proportion to size (PPS) method. A total of 358 sample households were selected from the sample kebeles. . There are 3443 household in these kebeles. Out of this, 1354 are residents of Boditi Hagaza kebele, 800 are residents of Boditi Korke and 1289 are those of Gido Boditi kebele.

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

Where; n = sample size,

N = the population size,

e = the acceptable sampling error

Assuming 95% confidence level and p = 0.05 are assumed

$$= \frac{3443}{1+3443(0.05)^2} \quad = 358$$

Table 1: Sample size determination of households

No	sample kebeles	No. of households	No. of sample households	Percent (%)
1	Boditi-Hagaza	1354	141	39
2	Gido-Boditi	1289	134	37
3	Boditi-Korke	800	83	24
	Total	3443	358	100

Source: own survey, 2018

3.7. Definition of operational variables

Table 2: Descriptions of dependent and independent variables

Dependent Variable	**Symbol**	**Description**
Energy consumption	EC	Total value of modern, traditional and gross energy consumed by households per month (MJ)
Energy expenditure	EE	Total value of household energy expenditure for modern, traditional and gross consumption(ETB)
Independent variable		**Description**
Household income	HI	Monthly household head income
Marital status	MS	Married (1), single (2), divorced (3), widowed (4)
Age of household head	AG	Age of household head in year
Household house ownership	HHO	Own house (1), rented from kebele (2), rented from private owner (3)
Gender	GE	Male (1), female (0)
Occupation	OC	Government employee (1), NGO employee (2), private job (3), unemployed (4)
Educational level	ED	Degree and above (1), college diploma (2), high school (3), elementary (4), illiterate (5)

3.8. Methods of Data Analysis

The study is about the patterns and determinants of energy consumption in urban households of Boditi town, Wolaita zone, Southern Ethiopia. As descriptive statistical method helps to assess the large variety of data related to the problem of study, descriptive statistics was used in the study. Responses to the structured questionaries' was provided quantitative data for this study.

Data were described using frequencies, percentages, mean, standard deviation, coefficient of variation and data results have been organized and presented in the form of tables, charts and graphs while to determine the relationship and to identify factors explaining household's energy consumption, multivariate regression model were used.

Data which was obtained from the targeted group has been entered into a computer by using SPSS statistical software and then it has been coded and analyzed by using techniques like percentages in order to look the pattern of energy source distribution, multivariate regression analysis to look if there is an association between energy expenditure and family income, family size, marital status, sex and occupation.

The analysis of data on patterns of energy consumption can be expressed either in terms expenditure (ETB) or as the amount of energy consumed in terms of heat values of energy (mega-joules). Energy can be measured in terms of Joules, kilo watt- hours, mega calories (MCA), barrels of equivalent or tons of coal equivalent, kilogram of wood equivalent and so on (Robert, *et al*, 1995). The amount of energy consumed from each specific energy sources can be estimated by converting its expenditure into heat values.

Therefore, for conversion mechanism total expenditure of each household fuel is multiplied by the constant to get the heat values consumed by households.

3.8.1. Model specification

Multivariate regression model was used to analyze the determining factors or predictor variables and different household energy expenditure and energy consumption or dependent variable

The multivariate regression equation is as follows:

$y_i = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 \dots \dots . \beta_k x_k + u$ ....eq (1)

Where y_i is the predicted or expected value of the dependent variable, x_1 through x_k are distinct independent or predictor variables, β_0 is the value of Y when all of the independent variables (X_1 through X_n) are equal to zero, and β_1 through β_k are the estimated regression coefficients. Each regression coefficient represents the change in y_i relative to a one-unit change in the respective independent variable. In the multivariate regression situation, b_1, for example, is the change in y_i relative to a one-unit change in x_1, holding all other independent variables constant (i.e., when the remaining independent variables are held at the same value or are fixed). Again, statistical tests can be performed to assess whether each regression coefficient is significantly different from zero.

Multivariate regression analysis can be used to assess whether there is variability between variables or not , and, since it allows us to estimate the association between a given independent variable and the outcome holding all other variables constant, multivariate regression also provides a way of adjusting for or accounting for potentially confounding variables that have been included in the model.

4. RESULTS AND DISCUSSION

4.1. Demographic characteristics of sample households

Table 3: Demographic characteristics of sample households

Marital status	Frequency	Percent (%)
Single	50	13.97
Married	218	60.89
Divorced	43	12.01
Widowed	47	13.13
Total	358	100
Sex	**Frequency**	**Percent (%)**
Male	233	65.1
Female	125	34.9
Total	358	100
Educational level	**Frequency**	**Percent (%)**
Degree and above	162	45.25
College diploma	110	30.73
High school	59	16.48
Elementary	19	5.3
Illiterate	8	2.24
Total	358	100

Source: own survey, 2018

Out of the total sample households (358), 218 (60.89%) were married and the rest 50 (13.97%) were single, 47 (13.13%) were widowed, and 43 (12.01%) were divorced.

A large number of respondents who involved in the questionnaire were male household heads 233 (65.1%) and the rest 125 (34.9%) were female household heads

From table 3, 162 (45.25%) were holders of degree and above. The rest 110 (30.73%), 59 (16.48%) and 19 (5.3%), respectively were holders of college diploma, high school and elementary education. Out of the total sample households, only 8 (2.24%) were illiterate.

4.1.1. Socioeconomic characteristics of sample household

Table 4: Socioeconomic characteristics of sample household

Occupational status	**Frequency**	**Percent (%)**
Government employee	226	63.13
Private job	89	24.86
NGO employee	34	9.5
Unemployed	9	2.51
Total	358	100
Income level	**Frequency**	**Percent (%)**
Low income(>2500	93	26
Medium income (2501-4500)	197	55
High income (>4500)	68	19
total	358	100
House ownership	**Frequency**	**Percent (%)**
Own house	181	50.56
Rented from private owner	125	34.92
Rented from kebele	52	14.52
Total	358	100

Source: own survey, 2018

From table 4, more than half of the household heads 226 (63.13%) were government employees and the rest 89 (24.86%) were engaged in their private jobs. The other 34 (9.5%) were NGO employees. Only 9 (2.51%) of the household heads were unemployed.

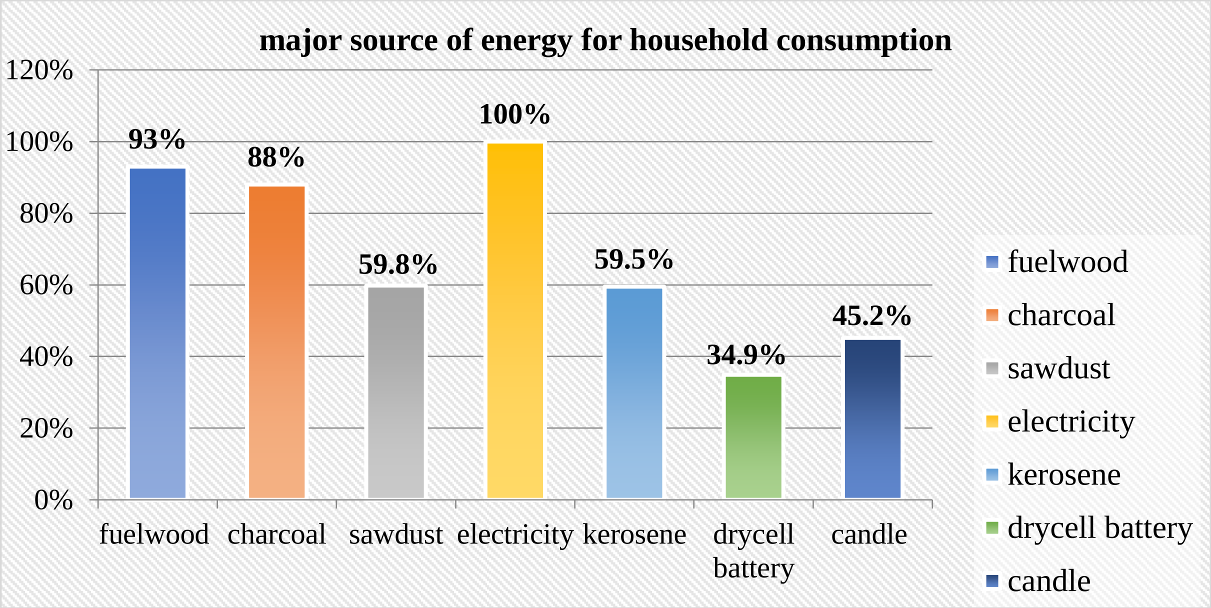
Depending on the monthly income of households the level of income is categorized as low income (≤2500), medium income (2501-4500) and high income (>4500). According to this category, 55% of sample households are categorized under the medium income rate, 26% are under low income and the rest 19% are under high income.

Almost half of the total sample households 181 (50.56%) had their own house and the rest 125(34.92%) were rented from private owner and 14.52% were rented from kebele.

4.2. Major source of energy for household's energy consumption

A variety of energy sources are available for different domestic activities. For different domestic activities, households consumed different energy sources depending on its ease of access.

Figure 3: Proportion of the households consuming the major sources of energy



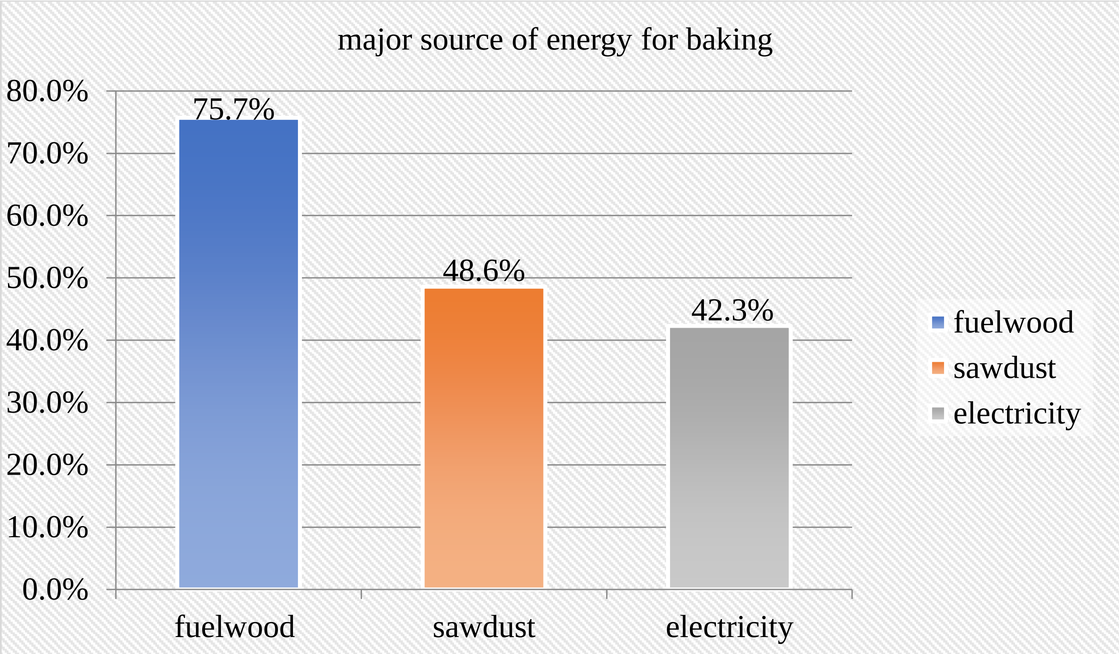
Source: own survey, 2018

Electricity was the dominant energy sources for all urban households. Out of the total sample households, 358 (100%) or almost all sample households consumed electricity as their primary energy sources for domestic activities. The other dominant energy sources in the area was fuelwood and charcoal. From the total sample household, 332 (92.7%) used fuelwood as their major energy sources whereas 315 (88%) used charcoal for different domestic activities. In addition to these, households consume the other energy sources such as sawdust, 214 (59.8%), kerosene, 213 (59.5%), dry cell battery, 125 (34.5%) and candle, 162 (45.2%).

4.2.1. Household's major energy sources for baking activity

Baking was an important domestic activity in the study area. For this activity household used different energy sources depending on its access.

Figure 4: proportion of household's major energy sources for baking



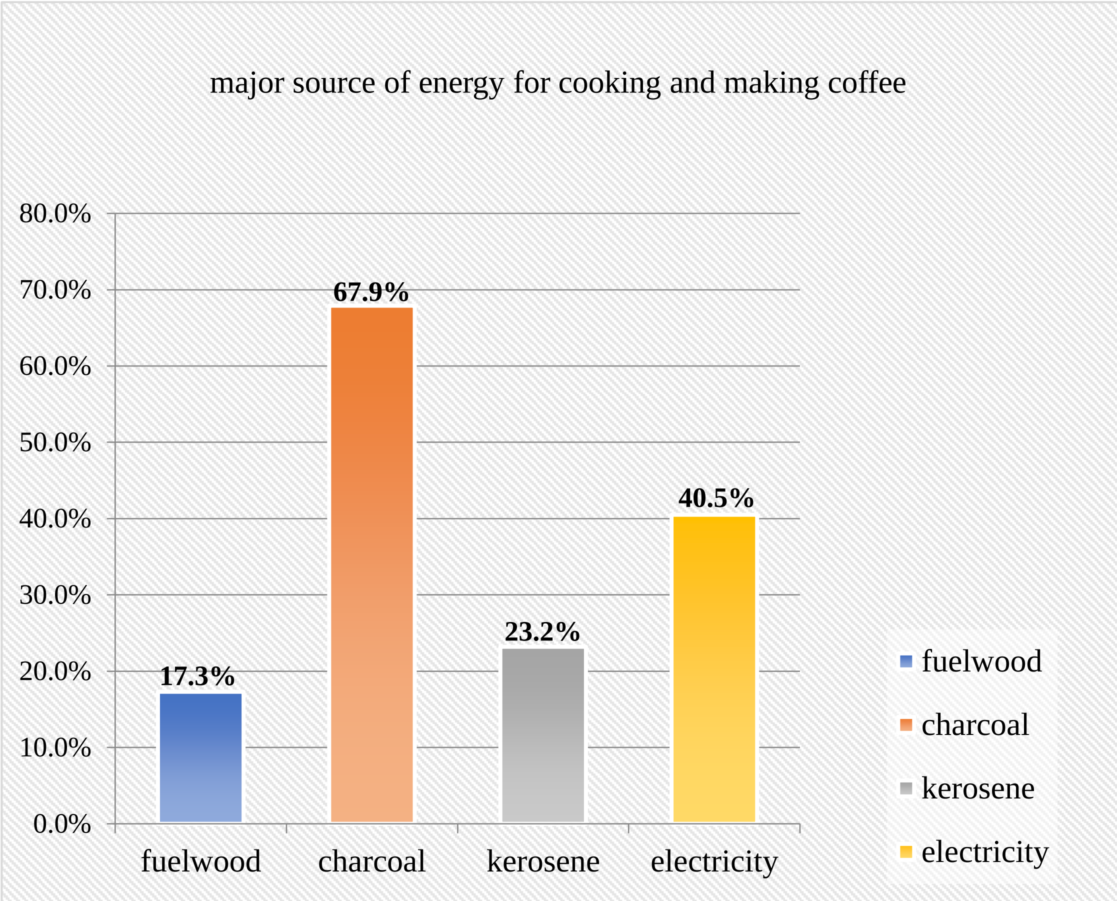
Source: own survey, 2018

Out of the total sample household, 271 (75.7%) of households in the study area was used fuelwood as the primary energy sources for baking activity. The other important energy sources used by the households for baking activity includes sawdust, 174 (48.6%) and electricity, (42.3%).

4.2.2. Household's major source of energy for cooking and making coffee

Among the major domestic activities cooking and making coffee was the most common household activities in the study area. For this activity's household used different energy sources. Charcoal was the common energy sources used for cooking and making coffee. Out of the total sample households 67.9 % used charcoal as their primary energy sources for coking and making coffee. Another common energy source used by urban household include electricity, (40.5%), kerosene, (23.2%) and fuelwood, (17.3%).

Figure 5: proportion of household's major energy sources for cooking and making coffee

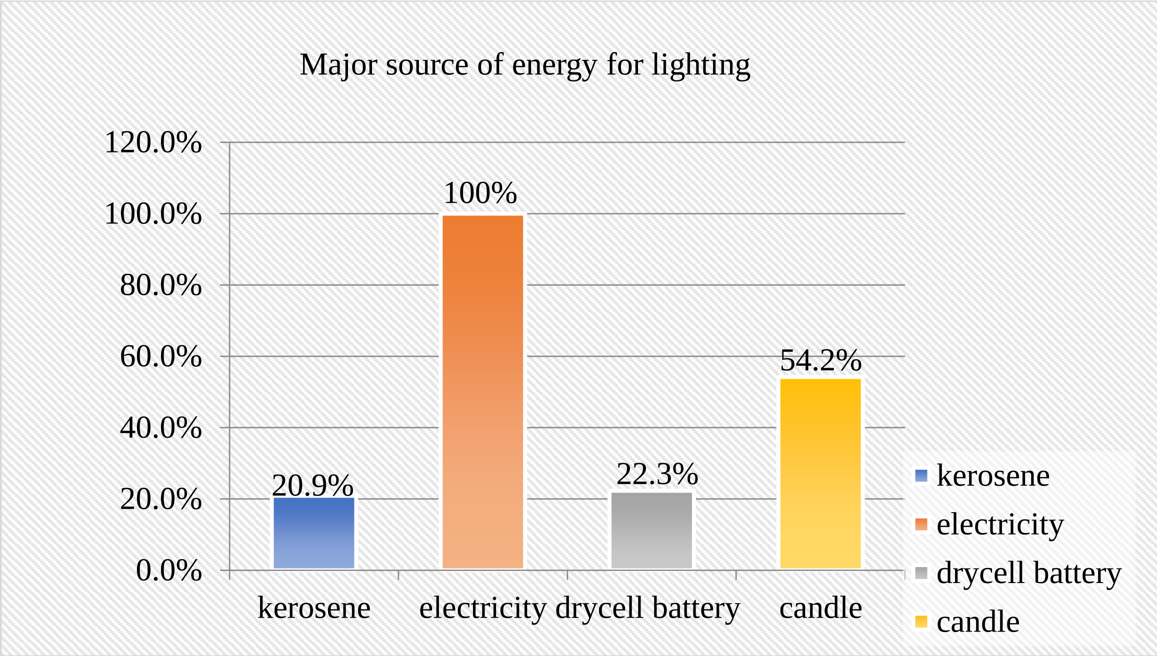


Source: own survey, 2018

4.2.3. Household's major energy sources for lighting

Lighting is the primary domestic activities in all and urban areas. Electricity was the well-known energy sources for lighting in the area. All sample households in the study area used electricity for their lighting activity. When electricity is unavailable, household used different optional energy sources for lighting. These optional energy sources include candle, 194 (54.2%), dry cell battery, 80(22.3%) and kerosene, 75 (20.9%).

Figure 6: proportion of household's major energy sources for lighting.



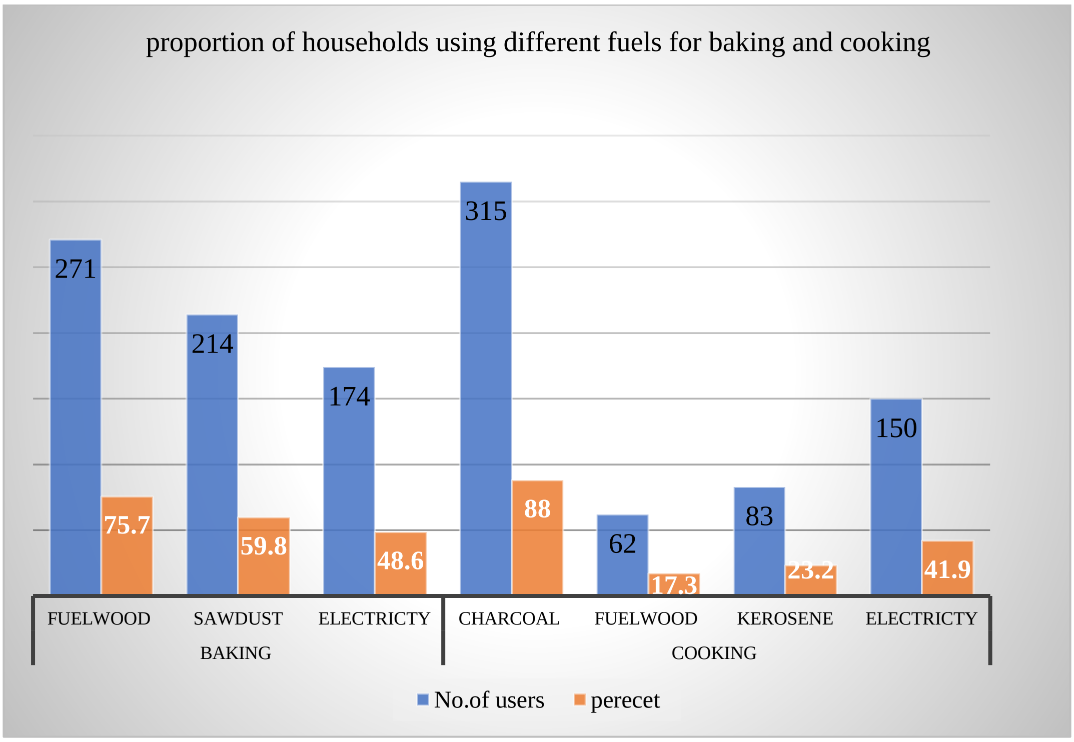
Source: own survey, 2018

4.2.4. Household domestic Activities

The most important household domestic activity in the study area was baking *injera*. For baking *Injera*, the dominant fuel type used by households was fuelwood. From the total sample households, 271 (75.7%) used fuelwood for baking *Injera*. The other energy sources used by households for baking *Injera* include sawdust, 214 (59.8%) and electricity, 174 (48.6%).

Households in the study area mainly used different fuel types for cooking purpose. Among these fuels the most important one was charcoal. From the total sample households, 88% used charcoal for cooking different food items. The energy sources for cooking different food items were fuelwood (17.3%), kerosene (23.2%) and electricity 150 (41.9%).

Figure 7: proportion of households using different fuels for baking and cooking



Source: own survey, 2018

Generally, the evidence from the present study has revealed several household fuels: fuelwood, charcoal, sawdust, electricity, kerosene, dry cell battery and candle. Of the above-mentioned fuels, the main ones are electricity (used by 100% of the households), fuelwood (used by 92.7% of the households), charcoal (used by 88% of the households), sawdust (used by 59.8 of the respondents), kerosene (used by 52.2% of the households), candle (used by 45.2% the households) and dry cell battery (used by 34.9% of the households). Charcoal and electricity are the main cooking fuels in the study area. The households used a fuel mix different fuel items for their domestic activities.

4.3. Pattern of household energy consumption

All the modern or conventional fuels such as electricity, kerosene, candle and dry cell battery and the traditional ones, fuelwood, charcoal and sawdust of their heat value for the domestic purpose have been briefly explained in this section.

4.3.1. Consumption of fuelwood

Biomass fuels such as, fuelwood, charcoal and sawdust account the highest share of total household's energy consumption. The most important of all the domestic biomass energy resource is fuelwood. Among 358 sampled households who completed and responded to the questionnaire, 92.7% used fuelwood for their domestic purpose and the rest 7.3 percent were non-users. Therefore, fuelwood was the major source of domestic energy for households in the study area for baking, cooking, and boiling besides the need for other purposes.

About 90% of sampled households who used fuelwood for their domestic activity, obtained it through purchasing. Households mainly bought fuelwood from both male and female vendors from nearby rural areas. Only 10 percent of households collected fuelwood by their own from nearby forest areas.

In low income households, the frequency of purchase is generally higher because of the purchase of fuelwood was more than once in a month and they only afforded to buy in small amount. Fuelwood consumption was often measured in donkey loads in the study area. Enumerators would need to weight a typical donkey load. Two bundles of fuelwoods are loaded on single donkey. Data shows that most households in area consumed between 1-4 bundles of fuelwood per month. Each bundles of fuelwood ranges in weight from 25-30 kg.

In the field work conducted, the price of fuelwood ranged from 200 ETB per 60 kg (3.33 ETB per kg). That means, a household bought 0.3 kg of fuelwood for one ETB. According to the standards of national energy committee, one kg of fuelwood provides a heat value of 15.072MJ. Therefore, a household could get 4.52 MJ (15.072*0.3) gross heat values of fuelwood for one ETB (annex4). This constant is important to convert household's expenditure on fuelwood into gross heat values (MJ).

4.3.2. Consumption of charcoal

Charcoal is another important source of domestic energy in the area. Out of the total sample households, 88% used charcoal and only 12 percent of the respondents are non-users. 42.9 % of sample households who are the user of charcoal for their domestic purpose purchased sack of charcoal from vendors who delivered it directly to them from rural areas. About 22.5% obtained it from local market and the rest 34.6% of the household obtain charcoal from shop.

The price of charcoal in the area ranges from 350 ETB per 100kg (3.5 ETB per kg). One kg of charcoal provides a heat values of 29.73 MJ. This shows that a household bought 0.29kg of charcoal for one ETB. So, a household get 8.62 MJ (29.73*0.29) heat values of charcoal for one ETB (annex 4).

4.3.3. Consumption of sawdust

Another source of household's domestic energy is sawdust. About 59.8 percent of sample households in the area used this resource. Mainly, all the total users of sawdust obtained it from the sawdust vendors who delivered it from wood processing workshops. The average price of sawdust was 1.5 ETB per kg. Thus, a household bought 0.67kg of sawdust for one ETB. One kg of sawdust delivers 16.75MJ of heat values of sawdust. So, a household could get 11.22MJ (0.67*16.75) heat values of sawdust for the expenditure of one ETB (annex 4).

Table 5: Cost and price of each biomass fuels per kilogram

Types of biomass fuels	No. of users	Proportion of users	Price of fuel per kg (ETB)	Cost of fuel (ETB)
Fuelwood	332	0.386	3.33	1.286
Charcoal	315	0.366	3.5	1.281
Sawdust	214	0.248	1.5	0.372
Total	861	1	8.33	2.939

Source: field survey, 2018

In order to get the average price of all biomass fuels, first the number and the proportion of each fuel users were identified, secondly, the price of each biomass fuels was multiplied by the corresponding proportion of consumers and thirdly, the products were summed to get the price of all biomass fuels in the area.

4.3.4. Consumption of Electricity

All households in the survey area were asked about the availability and access of electricity. The majority of the respondents responded that electricity is readily available and the majority of those who responded to this item felt that access to electricity supply. About 18.2% of the total sample households got their electric access directly from local Ethiopian electricity utility (EEU), Boditi branch through power grid connected and 37.5% did not source electricity directly from the Ethiopian electricity utility (EEU) rather they shared it from their neighbors. The rest 44.3% users had their own electric meter. The survey indicated that the sample households benefited from owning of the electric meter compared with those who do not owned. Among the sampled households who do not have electric meter were asked to suggest that reasons why they could not own for themselves. Accordingly, 58.7 percent reported that it is due to low income. About 30.3 % responds that there is a big problem in management of local electricity utility workers of the area when they distribute the electric meter for the customers. The rest 11percent stated that they are living in rented houses. Key informants from the EEU, Boditi branch stated that there is a huge budget constraint to distribute the electric meter for all households who want it.

The price of electricity was based on fixed rate of payment for electricity consumed. The payment rate of electricity varies in slabs of the total amount of electricity consumed. The monthly rate of payment per KWh varies from 0.273 ETB if the electricity consumption was 50 KWh and less to 0.6943 ETB for above 500 KWh. For example, if the monthly consumption of the customer Mr. Kebede Alemu be 120 KWh. The monthly bill of Mr. Kebede Alemu was generated with a price tag of 63.316 ETB.

- Consumption KWh = 50*0.273+50*0.3564+20*0.4993= 41.456
- Service charge = 1.4+3.404+6.82+10.236 =21.86
- Total = 63.316 ETB (annex 1).

Table 6: Average Price of Electricity in the study area (per kWh)

Rate of payment (ETB/KWh)	Monthly electricity consumption (KWh)	No. of users	No. of users (In %)	Average price (ETB)
0	free	3	0.84	0
0.27	≥50	67	18.71	0.051
0.36	51-100	140	39.1	0.141
0.5	101-200	128	35.75	0.179
0.55	201-300	20	5.59	0.031
Total		358	100	0.402

Source: Ethiopian Electricity Utility, Boditi Branch 2018

The survey data indicated that the average price of electricity paid by households was 0.402 ETB per KWh. Since 0.402 ETB was equivalent to one KWh, one ETB was equivalent to 2.49KWh. Thus, a household bought 2.49KWh of electricity for one ETB. One KWh of electricity was equivalent to 3.6 MJ of energy. Therefore, one ETB a household could bought a heat value of 8.96 MJ (3.6*2.49) (annex 4).

4.3.5. Consumption of kerosene

Kerosene is another source of domestic fuel in the area. Out of the total sample household 52.2 percent were users of kerosene. Almost all users of kerosene utilized it for both cooking and lighting. Out of this user 51.9% are able to purchase it from petrol station and the rest 25.7% and 36.4% obtained it from local market shop respectively. Those users who obtained kerosene from petrol station bought a liter of kerosene by 17 ETB where as those who obtained it from local market and shop bought one liter by 19 ETB. Thus, the average price of kerosene in the study area was 18 ETB. Thus, 0.056 liter of kerosene was obtained for one ETB. One liter of kerosene delivers 33.62MJ of heat value. Therefore, 0.056 liter of kerosene delivered 1.88MJ (0.056*33.62) of heat value (annex 4).

4.3.6. Consumption of candle and dry cell battery

Dry cell battery and candle also could be considered as another conventional fuel sources of domestic energy. The survey indicated that, the price of a candle was 7 ETB in the study area. A household bought 0.143 ($1/7^{th}$) of the piece of a candle for one ETB. One piece of a candle delivered 1.88MJ of het energy. Therefore, a household could get energy value of 0.27MJ (0.143*1.88) for the expenditure of one ETB on a candle (annex4).

In study area, the price of a dry cell battery was 6 ETB. One piece of a dry cell battery has an energy value of 0.0096 MJ. A household bought $1/6^{th}$ (0.167) piece of dry cell battery for one ETB. Thus, a household delivered 0.0016 MJ (0.0096*0.167) of heat value for the expenditure of one ETB on dry cell battery (annex 4).

Table 7: Household’s mean monthly expenditure of each fuel item (in ETB and %)

Types of fuels		Energy expenditure	
		ETB	%
Biomass fuels	Fuelwood	179.15	32.1
	Charcoal	137.26	24.6
	Sawdust	77.81	13.9
	Total	394.22	70.6
Modern fuels	Kerosene	39.7	7.2
	Electricity	94.3	16.9
	Dry cell battery	13.6	2.4
	Candle	16.3	2.9
	Total	163.9	29.4
	Grand total	558.12	100

Source: field survey, 2018

As it can be seen from the finding in table 10, on average households spent 70.6% (394.22ETB) of their income for biomass fuels. From among this, 32.1% was spent for fuelwood. This is largest share when compared with other biomass fuels. The rest share 24.6% and 13.9% was for charcoal and sawdust respectively.

The average household mean monthly expenditure for conventional fuels was 29.4% (163.9 ETB). From this share, 16.9% was spent by electricity and it is a dominant conventional fuel in the area. The others 2.4%, 2.9%, and 7.2% were spent for dry cell battery, candle and kerosene respectively. The average gross mean monthly expenditure for all source of energy was 15.86% (558.12 ETB).

The ratio of the average household fuel expenditure (558.12 ETB) to the average income of households (3519.4 ETB) was 15.86%. The ratio of the average household expenditure on biomass fuel (394.22 ETB) and conventional fuels (163.9 ETB) to the average income of households (3519.4 ETB) was 12.2% and 4.66% respectively.

Generally, from the above table (10), biomass fuel expenditure shares the largest parts particularly for fuelwood, charcoal and sawdust when compared with conditional fuels in terms of monthly expenditure. So, it is better for the households if they shift from biomass based domestic fuel source to conventional ones to save the monthly energy expenditure for each type of energy and to economize their expenditure.

The main source of energy type used by almost 97.3% of the householders for cooking activities is largely from biomass fuels. Among the biomass energy resources, fuelwood and charcoal are by far the most used cooking fuels for a majority of urban households. The average monthly gross biomass consumption of households was 144.6 kg. From this, the biomass fuel consuming households used about 4.82 kg of biomass fuels per day.

Table 8: Household mean monthly gross consumption of biomass fuels (in kg and %)

Types of fuels consumed	per households kg	%
Fuelwood	53.5	37
Charcoal	39.23	27.13
Sawdust	51.87	35.87
Total	144.6	100

Source: field survey, 2018

From the above table (11), the mean monthly consumption of charcoal and fuelwood was 53.5 kg and 39.23 kg respectively. This shows that households consume 1.78kg of fuelwood for their daily activities. Whereas they consume 1.31kg of charcoal for daily activities. On the other hand, the mean monthly gross consumption of sawdust was 51.87kg. Therefore, households utilize 1.73kg of sawdust for their daily domestic activities.

Table 9: Household mean monthly gross consumption of conventional fuels by Unit

Types of fuel consumption	Electricity (KWh)	Kerosene (Lt)	Candle (piece)	Dry cell battery (piece)
Per household	178.3	2.99	2.3	2.4

Source: Field Survey, 2018

From table (12), the average monthly gross electricity consumed by households was 178.3 KWh. This means that, electricity consuming households utilize 5.94KWh of electricity per day. The mean monthly gross kerosene consumed by households was 2.99 liters. This indicates that kerosene consuming households utilize approximately 0.1liter of kerosene for their day to day activities.

Table 10: Heat value of all biomass fuel per kilogram (in MJ)

Types of biomass fuels	No. of users	Proportion of users	Energy content (MJ)	Share of heat value (MJ)
Fuelwood	332	0.386	15.07	5.82
Charcoal	315	0.366	29.73	10.88
Sawdust	214	0.248	16.75	4.15
Total	861	1	61.55	20.85

Source: Field Survey, 2018

From the above table (13), it can be seen that the average heat value for a kilogram of biomass fuels was 20.85 MJ.

Table 11: Household mean monthly gross energy consumption (in MJ and %) by Fuel

Types of fuel consumption		Gross energy consumption Per households	
		MJ	%
Biomass fuels	Fuelwood	803.7	20.4
	Charcoal	1183.2	30.1
	Sawdust	988.8	25.2
	Sub total	2975.7	75.7
Modern fuels	Electricity	876.8	22.3
	Kerosene	74.8	1.9
	Candle	0.026	0.0007
	Dry cell battery	3.7	0.09
	Sub total	955.326	24.2907
	grand total	3931.026	100

Source: own survey, 2018

Based on the gross energy heat value constants, the mean monthly household's gross energy consumption was estimated to be 3931.026 MJ. From this finding, households utilize 131.03MJ of energy from different types of fuels the used for their daily domestic activities. Out of this, consumption of biomass fuels shared the highest proportion (2975.7MJ) while the rest (955.326MJ) monthly household gross energy consumption was from convention fuels. This indicates that, the gross biomass consumption of households for daily activities was 99.19MJ whereas the gross consumption of conventional fuels was 31.84MJ. From this evidence the household's dependence on biomass fuels was much greater than that of conventional fuels.

On average 30.1% of household gross energy consumption was from the charcoal, 25.2% was from sawdust. Out of the total consumption of conventional fuels, electricity was shared highest proportion (22.3%). From this result, among household biomass fuel sources, charcoal was the most important biomass fuel sources whereas electricity was an important modern fuel source.

Generally, the above findings illustrate that households were highly dependent on fuelwood as a source of energy for cooking and baking activities in the study area. The evidence suggests that there are a number of factors which influence this situation. The main factors are poor availability of alternative sources of energy and the frequent black out of electricity in the area. The findings of this study support the energy stacking model, suggesting that while efforts to avail other sources of fuels alternative to fuelwood to the population in the study area are highly recommended, existing sources of fuel should concurrently be increased and used more efficiently. The support towards the energy stacking model coupled with high household dependency on fuelwood, is sufficient evidence that biomass fuel in general and fuelwood in particular will remain the major and in many cases the only source of household cooking and baking activities.

4.4. Determinants of household energy expenditure

Household energy expenditure can be determined by a variety of factors. These factors include household income level, number of household size, marital status and occupation.

From among these factors, household income and household size plays crucial role in the monthly expenditure of the energy.

Household energy expenditure can be affected by the income level of household. The mean monthly income and energy expenditure of low-income household was 2093.33 and 428.35 ETB, respectively. Whereas that of middle-income household was 3756.05 and 480.71 ETB and those of high-income household was 5875 and 550.95 ETB respectively. The mean monthly income of household in the study area was 5875.7ETB and the energy expenditure were 481 ETB.

Table 12: Multivariate regression results of household energy expenditure (in ETB)

	Unstandardized Coefficients				
variables	B	Std. Error	Beta	t-statistics	Sig.
Constant	354.499*	68.549		5.171	0.00
AG	2.175	1.026	-0.122	-2.12	0.162
FS	**121.59****	8.52	0.424	7.585	0.00
HI	**215.41***	0.008	0.037	4.53	0.017
MS	**110.32****	7.662	0.07	2.62	0.029
GE	10.783	17.081	0.032	0.631	0.528
ED	-20.008	14.469	-0.112	-1.383	0.168
OCC.	**79.32****	21.31	0.054	6.9	0.034
HHO	126.58	7.89	0.119	2.13	0.042

Dependent variable: household energy expenditure (ETB)

*p<0.01, **p<0.05: the test is significant at (p<0.01 and p<0.05)
Source: own survey, 2018

As shown in the table (12), higher income households consume energy that is cleaner energy sources like electricity whose energy efficiency is high for their domestic function, because they have high purchasing power. Whereas low income household afford traditional fuels and appliances whose energy efficiency is very low because of their low purchasing power. Another important factors that determine household energy expenditure was family size. The total number of family size in the sample household was 1662. The maximum and minimum number of household size in the area was 10 and 1 respectively. Therefore, large number household consume much amount of energy because they used more fuels in a single day for different purpose and the small number household consume less energy because of using small amount of fuel.

The most important factor that determine household's energy expenditure were income, marital status and household family size. As Income increases, households consume cleaner and expensive energy for household purposes. Therefore household's expenditure for different source of energy increases as income increase. On the other hand, low-income households consume traditional fuels that are having low price in nature. Therefore as income of household decreases, the monthly expenditure of energy for different source of fuels for domestic activities also decreases.

4.5. Determinants of biomass energy consumption

According to FAO (2009), macro factors influence household biomass energy consumption patterns at the aggregate level and indirectly. The direct determinants of household energy consumption patterns are found precisely at the level of households. The higher the level of education of household heads the higher the probability of consuming/using clean fuels. Mekonnen and Kohlin (2009) in their attempts to find the determinants of household fuel choice in major cities of Ethiopia estimated that higher education (secondary and post-secondary) promoted households to use electricity and kerosene more than wood and charcoal as cooking energy. This finding was also confirmed by (Ouedraogo, 2005) in his study of household preferences for cooking in urban areas in Ouagadougou of Burkina Faso. He found that households with a head that had higher education level had lower fuelwood adoption probability than households with a head with lower education level. Another study by Heltberg (2003) in Guatemala also found that education level of the household head had a very significant impact on wood consumption while at the same time encouraging demand for LPG. An examination of household energy consumption surveys shows that energy use and the choice of fuels in the households depends on most on household income and household size (Leach and Gowen, 1987).

Household size has been observed to be sometimes a more important determinant of household energy consumption than income. High income has been associated with more family members (more people contributing to household income), thus increasing total household consumption. High energy consumption is associated with higher income. High income countries consume more modern than traditional fuels.

Table 13: Multivariate regression results of household biomass energy consumption

Variable	Unstandardized Coefficients B	Std. Error	Beta	t-statistics	Sig.
Constant	1920.21**	502.01		5.67	0.00
AG	187.5	240.87	0.87	3.74	0.17
FS	**287.45***	55.79	0.93	7.84	0.00
HI	**145.48***	89.24	0.201	4.37	0.00
MS	28.98	44.96	0.035	0.65	0.52
GE	67.83	100.25	0.051	0.98	0.33
ED	**71.991****	84.91	0.072	0.85	0.029
OCC.	13.203	66.5	0.014	2.98	0.00
HHO	65.432	73.57	0.052	0.89	0.37

Dependent variable: Biomass energy consumption(MJ)
*p<0.01, **p<0.05: the test is significant at (p<0.01 and p<0.05)

The results show further that the model performance is statistically significant at ($p < 0.01$ and $p < 0.05$). The descriptors which are statistically significant determinants of household biomass energy consumptions are: family size ($p < 0.01$), educational level ($p < 0.05$) and household income ($p < 0.01$). The results indicate also that the constant parameter of the model should be included ($p < 0.05$).

The model summary of the regression contains the following information R =0.285, R Square =0.681 and Adjusted R Square = 0.591. From this information R square shows the degree of variation in dependent variable due to independent variables. Higher the value of R square higher the variation explained. In this case R square = 0.681 means that the independent variables in multivariate regression explains 68.1% of variation in dependent variable. In other word, 68.1% of variation in dependent variable is due to independent variables. This indicates that 68.1% of the household biomass energy consumption for different domestic activities were determined by the household income and family size.

The study showed that the higher the household size, the more the household used biomass fuels. It was evident that households with high number used charcoal which agreed to the findings by the FAO (2009), which showed that the direct determinants of household energy consumption patterns are found precisely at the level of households. Household size has been observed to be sometimes a more important determinant of household energy consumption than income. High income has been associated with more family members (more people contributing to household income), thus increasing total household consumption.

4.6. Determinants of modern energy consumption

The modern energy such as electricity, kerosene, dry cell battery and candle consumption of households for different domestic activities were determined by family size and income. The results show further that the model performance is statistically significant at ($p < 0.01$ and $p < 0.05$). The descriptors which are statistically significant determinants of household modern energy consumptions are: family size ($p < 0.01$) and household income ($p < 0.05$).

As increase, the use of modern and cleaner energy resources becomes more prevalent in urban households. For instance, while low income households rely mainly on biomass fuels for cooking; high income households use modern fuels such as kerosene, LPG and electricity (Karekezi and Kithyoma, 2002).

There are a significant and positive effects between modern household income and family size. The 69.5% of modern energy consumption of household was determined by income and family size. So, the rise of household income and family size affects the monthly consumption of modern energy.

Table 14: Multivariate regression results of household modern energy consumption

	Unstandardized Coefficients				
Variable	B	Std. Error	Beta	t- statistics	Sig.
Constant	**1640.52****	304.31		4.67	0.00
AG	187.5	240.87	0.87	3.74	0.17
FS	**147.26***	78.96	0.93	5.84	0.00
HI	**223.56***	65.55	0.201	6.5	0.00
MS	**78.98****	81.66	0.035	3.65	0.028
GE	67.83	100.25	0.051	0.98	0.33
ED	58.22	87.55	0.072	0.85	0.397
OCC.	**73.59****	44.32	0.014	2.98	0.00
HHO	65.432	73.57	0.052	0.89	0.37

Dependent variable: gross household energy consumption (MJ)

*$p<0.01$, **$p<0.05$: the test is significant at ($p<0.01$ and $p<0.05$)

These findings reveled that, the transition from household energy consumptions of traditional energy to modern energy service affected by changes in household income. According to (Hosier and Dowd, 1987), as household income increases, it will increase the consumption of modern energy

Positively, modern energy consumptions and household income relationships indicate, the modern energy is in the normal good group. Demographic characteristics have high role in shifting energy consumptions of the household (Berhanu, 2000), household size (Lanzen *et a.l.*, 2004) family size and (Barnes *et al*., 2004)

4.7. Determinants household gross energy consumption

Various factors influence patterns of household energy consumption. The most important factors in household energy consumption patterns include household income, household size and house ownership of the house they live.

Table 15: Multivariate regression results of gross household energy consumption

Variables	Unstandardized coefficients B	Unstandardized coefficients Std. Error	Beta	t-statistics	p-value
Constant	2708.587*	474.995		5.702	0.003
AG	12.175	7.108	-0.156	-2.698	0.117
FS	**172.53****	36.348	0.422	7.501	0.005
HI	**148.48***	0.057	0.041	3.85	0.001
MS	**95.44***	53.088	0.081	2.61	0.021
GE	18.092	118.361	0.008	0.153	0.879
ED	**112.95****	98.256	0.17	3.87	0.029
OCC.	4.935	78.52	0.004	0.063	0.95
HHO	**168.769***	86.868	0.109	1.943	0.002

Dependent variable: gross household energy consumption (MJ)

*p<0.01, **p<0.05: the test is significant at (p<0.01 and p<0.05)

The results show further that the model performance is statistically significant at ($p < 0.01$ and $p < 0.05$). The descriptors which are statistically significant determinants of household energy consumptions are: family size ($p < 0.05$), household income ($p < 0.01$) and household house ownership ($p < 0.01$). The results indicate also that the constant parameter of the model should be included ($p < 0.01$).

High income household consume more energy from different energy sources for the domestic activities than low income households. This is because of their high purchasing power. Any change related to the income of households affects the monthly consumption energy. Family size is another factor that influence the monthly total household energy consumption. Large family households afford more fuels to bake and cook the food the items more than one time a day to compensate with their family numbers. So, this increases the total household energy consumption. The other important factor was house ownership of household head. The household heads that rent house from private owner or kebele don't have own access of electricity because he is dominated by the owner of the house. This means he don't use the electricity for the cooking and baking purposes. So, they tend to shift other fuel sources for their different domestic activities; especially biomass energy sources.

The maximum and minimum total household energy consumption in the area were 6983.92 and 251.52 M. The total consumption was 1207630.87 whereas the average consumption was3345.24. The 71.8% of the total household energy consumption was due to household income, family size and house ownership.

It was found that the statistically significant factors are: household income ($p < 0.001$): households with high income consume more energy than the low income households, family size ($p < 0.001$): households with large number of family consume more energy than the small one because of the used more fuels to bake and cook more one time a day, household house ownership ($p < 0.05$): households with his or her own house consume more energy than the rented one due to having full access.

4.8. Households mix of energy sources for domestic activities

More recently, it has been argued that households in developing countries do not switch to modern energy sources but instead tend to consume a combination of fuels which may include combining solid fuels with non-solid fuels as sources of energy. Thus, instead of moving up the ladder step by step as income rises, households choose different fuels as from a menu (Mekonnen and Köhlin, 2008). They may choose a combination of high-cost and low-cost fuels, depending on their budgets, preferences and needs (World Bank, 2003). This led to the concept of fuel stacking (multiple fuel use) as opposed to fuel switching or an energy ladder (Masera *et al*., 2000; Heltberg, 2005)..

4.8.1. Households mixed consumption of energy sources for baking

Table 16: Percentage of households a mix of energy sources for baking purpose

Household fuel mixes	No. of users	Percent (%)
Fuelwood+ Electricity	118	32.96
Fuelwood+ Sawdust	139	38.83
Sawdust+ Electricity	60	16.76
Fuelwood+ Sawdust+ Electricity	41	11.45
Total	358	100

Source: Field Survey, 2018

Households in the study did not depend on only a single source of energy for their baking activity. This means, they used a mixed source of more than one energy sources. When electricity off, they shift to sawdust.

4.8.2. Households consumption a mix of energy sources for cooking

Households used a mix of fuelwood, charcoal, electricity and kerosene in the different forms of combination to satisfy their demand for cooking activities. From the sample households, 22% used charcoal and electricity for cooking purpose.

Table 17: Percentage of households consuming a mix of energy sources for cooking

source of energy	No. of users	Percent (%)
Charcoal+ Fuelwood	77	21.5
Charcoal+ Electricity	79	22
Charcoal+ Kerosene	39	10.9
Kerosene+ Fuelwood	18	5
Kerosene+ Electricity	32	8.94
Charcoal+ Fuelwood+ Kerosene	19	5.3
Fuelwood+ Electricity	24	6.7
Charcoal+ Fuelwood+ Electricity	25	6.98
Fuelwood+ Electricity+ Kerosene	12	3.36
Charcoal+ Electricity+ Kerosene	20	5.58
Charcoal+ Electricity+ Kerosene+ Fuelwood	13	3.65
total	358	100

Source: Field Survey, 2018

4.8.3. Households consumption a mix of energy sources for lighting

Table 18: Percentage of households consuming a mix of energy source for lighting

source of energy	No. of users	Percent (%)
Electricity+ Kerosene	104	29
Electricity + Candle	153	42.7
Electricity + Dry cell battery	24	6.7
Electricity + Kerosene+ Candle	39	10.9
Electricity+ Kerosene+ Dry cell battery	28	7.8
Electricity+ Kerosene+ Candle Dry cell battery	10	2.9
Total	358	100

Source: Field Survey, 2018

Households in the study area used a combination of different fuel types for lighting purpose depending up on its accessibility and expenditure. Out of the total sample households, 42.7% used the combination of electricity and candle for the demand of lighting. Only 2.9% households used a mix of Electricity, Kerosene, Candle and Dry cell battery.

5. CONCLUSION AND RECOMMENDATION

5.1. Conclusion

Multiple sources of energy are commonly used by individual households for day to day household energy requirement which include biomass energy sources (fuelwood, charcoal and sawdust) and modern sources (electricity, kerosene, candle and dry cell battery)

The largest share of household energy comes from fuelwood which accounts for 92.7% from all sources of energy for cooking and baking activities. Generally, Fuelwood and sawdust are the most dominant biomass energy sources for baking activities in the study area whereas charcoal is the important energy sources for cooking.

The amount of household energy expenditure was determined by income, family size and occupation. Higher income households expend large amount of monthly income for energy. The consumption of biomass energy decreases as the household income increases. Low-income households highly depend on biomass fuels as their low purchasing power and high-income households tend to shift modern fuel sources having of high purchasing power.

Among household energy sources for lighting, Electricity stands the first in household energy consumption for lighting. All sample households in the area used electricity for domestic lighting activity.

Household income and household size are the main variables which determine the amount of energy expenditure and consumption per households. As the household income increases, the gross and useful domestic energy service consumed increases. The total expenditure on all types of fuels was positively related with the income of households and size. These are also determinants of household energy consumption.

5.2. Recommendation

Based on the finding of this study and for the improvement the urban household energy utilization, the following recommendations are forwarded.

In the study, the largest share of domestic and household gross energy consumed comes from traditional fuels. The use of traditional fuels emits indoor air pollution and this affects the health of households. Therefore, it is better to households tend to shift and consume the largest share of domestic and gross energy from modern energy to save the largest consumption of energy, money and to consume pure and secure energy for their domestic activities. A sustainable supply of energy materials for the household energy source is needed. Give different awareness about the alternative energy source and environmental protection through encouraging conservation of natural vegetation that is growing trees as environmental wellbeing must be strengthened. The households of the study area, particularly the respondents are highly dependent on traditional fuels that are risky for respiratory organ, globally, two million people die prematurely as a result of indoor air pollution associated with the inefficient burning of biomass. Chronic obstructive respiratory disease resulting from indoor air pollution kills one million people each year. Particulate matter inhaled from indoor air pollution is the cause of 50% of pneumonia deaths among children under the age of five (WHO, 2006). So, the stockholders should be encouraged to use clean energy sources instead of using biomass fuels. The pressure on forest and soil resources could be reduced and the demand for more supply of fuels can easily be met. People should aware the modern flues are cheaper than traditional fuels in terms of useful energy services and with high-efficiency level. So, lower income households should be provided with appliances of modern fuels with better efficiency at a reasonable price to make them use modern fuels. It also environmentally friend practice.

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LIST OF APPENDICES

Annex 1: tariff of electricity for domestic use (energy/Kwh)

No	category	Monthly Consumption range (Kwh)	Rate/ETB
1	1st block	0-50	0.273
2	2nd block	51-100	0.3564
3	3rd block	101-200	0.4993
4	4th block	201-300	0.55
5	5th block	301-400	0.5666
6	6th block	401-500	0.588
7	7th block	>500	0.6943

Source: www.eepco.gov.et

Annex 2: service charge of electricity for domestic use (energy/Kwh)

No.	Types of service	Monthly consumption range	Rate/ETB
1	Single phase	0-25	1.4
2		26-50	3.404
3		51-105	6.82
4		106-300	10.236
5		>300	13.652
6	Three phases		17.056
7	Active phases		37.564

Source: www.eepco.gov.et

Annex 3: Cost and conversion factor calorific value of (energy contents) varies fuel types

Fuel type	Unit	Energy content (MJ/unit)	Average price (ETB)	Constants to convert expenditure into gross energy content (MJ)
Fuelwood	kg	15.072	3.33	4.52
Charcoal	kg	29.73	3.5	8.62
Sawdust	kg	16.75	1.5	11.22
Electricity	kwh	3.6	0.387	9.3
Kerosene	lt	33.62	18	1.88
Dry cell battery	piece	0.01	6	0.0016
Candle	piece	1.88	7	0.27

Source: UNDP, 2009 & MoWE, 2011

Annex 4: Average Price of Electricity per kWh

Source: Ethiopian Electricity Utility, Boditi Branch 2018

Rate of payment (ETB/KWh)	Monthly electricity consumption (KWh)	No. of users	No. of users (In %)	Average price (ETB)
0	free	3	0.84	0
0.27	≥50	67	18.71	0.051
0.36	51-100	140	39.1	0.141
0.5	101-200	128	35.75	0.179
0.55	201-300	20	5.59	0.031
Total		358	100	0.402

Source: own survey

Annex 5: Descriptive statistics

Variables	Mean	Std. Deviation	N
Household size	4.6	1.73	358
Household income	4618.7	3274.21	358
Age of household head	42.9	9.09	358
Monthly energy expenditure (ETB)	480.4	162.26	358
Monthly energy consumption	3343.7	1115.38	358

Source: Author, 2018

Annex 6: Multivariate regression results of household biomass energy consumption (MJ)

	Unstandardized Coefficients				
Variable	B	Std. Error	Beta	t-statistics	Sig.
Constant	1920.21**	502.01		5.67	0.00
AG	187.5	240.87	0.87	3.74	0.17
FS	**287.45***	55.79	0.93	7.84	0.00
HI	**145.48***	89.24	0.201	4.37	0.00
MS	28.98	44.96	0.035	0.65	0.52
GE	67.83	100.25	0.051	0.98	0.33
ED	**71.991****	84.91	0.072	0.85	0.029
OCC.	13.203	66.5	0.014	2.98	0.00
HHO	65.432	73.57	0.052	0.89	0.37

Dependent variable: Biomass energy consumption(MJ)
*p<0.01, **p<0.05: the test is significant at (p<0.01 and p<0.05)

Annex 7: Multivariate regression results of household modern energy consumption (MJ)

	Unstandardized Coefficients				
	B	Std. Error	Beta	t- statistics	Sig.
Constant	**1640.52****	304.31		4.67	0.00
AG	187.5	240.87	0.87	3.74	0.17
FS	**147.26***	78.96	0.93	5.84	0.00
HI	**223.56***	65.55	0.201	6.5	0.00
MS	**78.98****	81.66	0.035	3.65	0.028
GE	67.83	100.25	0.051	0.98	0.33
ED	58.22	87.55	0.072	0.85	0.397
OCC.	**73.59****	44.32	0.014	2.98	0.00
HHO	65.432	73.57	0.052	0.89	0.37

Annex 8: Multivariate regression results of gross household energy consumption (MJ)

	Unstandardized coefficients				
Variables	B	Std. Error	Beta	t-statistics	p-value
Constant	2708.587*	474.995		5.702	0.003
AG	12.175	7.108	-0.156	-2.698	0.117
FS	**172.53****	36.348	0.422	7.501	0.005
HI	**148.48***	0.057	0.041	3.85	0.001
MS	**95.44***	53.088	0.081	2.61	0.021
GE	18.092	118.361	0.008	0.153	0.879
ED	**112.95****	98.256	0.17	3.87	0.029
OCC.	4.935	78.52	0.004	0.063	0.95
HHO	**168.769***	86.868	0.109	1.943	0.002

Annex 9: Data sheet for demographic information of households

Kebele name_______________ No. of sampled household___________

Kebele code________________ Date__________

No. of households___________

HH-No.	Age	family size	HH_imonthly income	Gender	Educational level	M_status	Occupation	House ownership

Annex 10: Data sheet for fuel type consumed by households

Kebele name_______________ No. of sampled household___________

Kebele code________________ Date__________

HH_No.	Types of fuel consumed	Amount in their unit	Average monthly expenditure (ETB)	Heat value delivered (MJ)
	fuelwood			
	charcoal			
	sawdust			
	kerosene			
	candle			
	dry cell battery			
	electricity			
	total			
	fuelwood			
	charcoal			
	sawdust			
	kerosene			
	candle			
	dry cell battery			
	electricity			
	total			

Annex 11: Data sheet for source of fuel for households

Kebele name_______________ No. of sampled household___________

Kebele code________________ Date__________

No. of households___________

HH_No.	Fuel type	source	How they obtain	Purpose	User	Not user
	fuelwood					
	charcoal					
	sawdust					
	kerosene					
	candle					
	dry cell battery					
	electricity					
	fuelwood					
	charcoal					
	sawdust					
	kerosene					
	candle					
	dry cell battery					
	electricity					

Annex 12: Some of the photo taken from the research work

Photo: fuelwood loaded by a donkey (source: own photo, 2018)

Photo: baking *injera* on traditional or open plate stoves (source: own photo)

BIOGRAPHICAL SKETCH

Mihretu Bergene Dola was born in Wolita Zone, Southern Nation, Nationalities and Peoples Region, Ethiopia on April, 4 1980. After completed his elementary and secondary school, he attended Hawassa University, Wondo Genet College of Forestry and Natural Resource and received his B.Sc. degree in Geographic Information Science with Great distinction on July, 2012. Then he employed in Wondo Genet College of forestry and Natural Resources, Hawassa University as Graduate Assistant I & II from October 2012- October 2014 and Assistant lecturer from October 2014- October 2015. The author was participated in short term training and workshops in Ethiopia. For example, he obtained many certificates on GIS and also obtained Certificate of Environmental protection and climate change mitigation from DAAD Alumni workshop. In 2017, he joined Wondo Genet College of Forestry and Natural Resources, Hawassa University, for his M.Sc. degree study in Renewable Energy Utilization and management.