JIMMA UNIVERSITY

COLLEGE OF PUBLIC HEALTH AND MEDICAL SCIENCES

DEPARTMENT OF ENVIRONMENTAL HEALTH SCIENCE AND TECHNOLOGY

Household Energy Consumption Pattern and Its Implication on Socio-economic and Environment in Nekemte Town

A REASEARCH PAPER SUBMITTED TO THE DEPARTMENT OF ENVIRONMENTAL HEALTH SCIENCES AND TECHNOLOGY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS OF DEGREE OF MASTER OF SCIENCE IN ENVIRONMENTAL HEALTH SCIENCE AND TECHNOLOGY, SPECIALITY IN ENVIRONMENTAL TECHNOLOGY

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March, 2014

Jimma, Ethiopia

DECLARATION

I, the undersigned, declare that this thesis is my original work that has not been presented for a degree in this or any other university and that all sources of materials used for the thesis have been fully acknowledged.

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Name of the institution: Jimma University

Date of submission: __________________

This thesis has been submitted for examination with my approval as University advisor

Name and signature of the first advisor

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Name and signature of the second advisor

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ABBREVIATIONS

CO_2-e	Carbon dioxide equivalent
GWC	Global Warming Commitment
GWP	Global Warming Potential
HH	Household
HHH	Household Head
Ktoe	Kilotons of oil equivalent
MDG	Millennium Development Goal
PIC	Products of Incomplete Combustion
TSF	Three stones fire
WHO	World Health Organization

ABSTRACT

In many developing countries, household energy consumption causes tremendous damage to the environment and human health. The main energy source in urban communities in Ethiopia and elsewhere in developing countries is biomass fuel consisting of wood, charcoal, leaves, and agricultural residues. The variation on their consumption pattern may have significant environmental and socio-economic impacts. Hence, the aim of the current study is to determine the household energy consumption pattern and its socio-economic and environmental implication in Nekemte town. A cross sectional survey was conducted from July 8–14, 2013 on 415 households systematically selected from 6 sub-cities of the Town. A questionnaire involving households' fuel use, conversion facilities and socio-demographic factors were used to collect the information. The study revealed that the common household energy sources used for cooking were biomass fuels, kerosene and electricity. About 61% of the household uses biomass energy for basic cooking *Injera* services and almost all households use electrical energy for lighting except during the blackout. Availability of firewood, lack of own electric connection, assumption that firewood is less costly were identified as factors affecting the level electricity of cooking. Annually about 20 thousand tons of biomass of which 10128 tons firewood and 3527tons charcoal) are used in the town, implies that about 1200 hectares of forest is lost and 25483 tons of CO_2-e is emitted to the atmosphere. It can be concluded that availability of electricity does not guarantee the availability for cooking and other factors needs to be considered.

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Contents **Page**

List of Tables Page

List of Figures Page

CHAPTER 1: INTRODUCTION

Energy is the agent for changing the state of any system; from poverty to wealth, from weak economy to strong economy, from nothing to productivity, from insecurity to safety and so on (Otieno & Awange 2006). Energy consumption level is used as the criteria to indicate the economic and social development level of a certain region. Energy is one of the essential inputs for socio-economic development. (Kanagawa & Nakata 2008) concluded that energy influences socio-economic condition of developing countries and showed the link between house hold energy and the living standard in particular; access to modern energy like electricity will drastically improve the quality of life of those who do not have yet. Energy access improvement influences significantly socio-economic factors such as health and education.

Energy consumption has become a critical factor driving resource exploitation and environmental change (Gebreegziabher 2007; IEA 2006). In most areas of developing countries in particular, energy consumption has caused a series of environmental and economic problems. Not only does energy consumption increase the direct economic payment of households, but also energy collection results in family members losing opportunities to increase income. Excessive consumption of biomass energy has resulted in degradation of forest and grass vegetation, accelerated soil erosion, and changed ecosystem substance cycles (Enger & Bradley 2004).

In developing countries a large part of energy sources are burnt in inefficient cooking stoves(IEA 2006). The use of traditional bioenergy systems has several serious negative socio-economic and environmental impacts. Traditional bioenergy systems lead to high greenhouse gas emissions. Because of the incomplete combustion of wood-fuels, 10–20% of the carbon released is in the form of methane (CH_4), nitrous oxide (N_2O), carbon monoxide (CO) and non-methane hydrocarbons (NMHC). These compounds are referred to as products of incomplete combustion (PIC) which, if they had been burned, would have released additional heat in converting completely to carbon dioxide(Bruce et al. 2002; Li et al. 2009; Smith et al. 2000). They have much higher global warming potential than carbon dioxide (i.e. they have a greater climate change impact)(Smith et al. 2000).The combined impact of the five emissions is called the Global Warming Commitment (GWC). According to the(IPCC 2006), the 100-year global warming potentials of methane(CH_4), nitrous oxide(N_2O) and carbon monoxide (CO) are 7.6, 300 and 1.9 times that of carbon dioxide, respectively. The international negotiations surrounding the Kyoto Protocol currently use 100-year time horizons for Global Warming Potentials (GWPs). The CO_2 equivalent emissions of these Green House Gases are summed as an indicator of climate change(Barker 2007; IPCC 2006).

Indoor air pollution from household energy use is a leading environmental health risk(Bruce et al. 2002; WHO 2006). Indoor smoke in particular produces obvious impact on the health of the members of the family. Women and children tend to face the heaviest burden in terms of the health costs of using these fuels because they are involved most in the task of cooking and spend more time indoors and are therefore exposed more to the indoor air pollution associated with the inefficient combustion of bio-fuels. There is now strong evidence to support a link between indoor air pollution and health ailments(Bruce et al. 2002; IARC 2010;Ng et al. 2011). Environmental degradation due to deforestation, desertification and the consumption of energy sources, health hazards due to the consumption of biomass fuels and distributional concerns are emerging issues with the rising demand for energy. These issues eventually have ensued serious welfare impacts on households. Samuel 2002 depicted that Ethiopia has experienced heavy dependence on traditional energy consumption, with all the negative repercussions associated with it. On the other hand, Zenebe et al. 2011concluded that by large, lighting from electricity is the dominant end use in the domestic sector and the use of electricity for baking is limited to larger towns and to a very limited number of households, which also implies an increased pressure on local forests.

Technologies are reasonably well-established for ‘‘improved cook stoves’’ that burn biomass more cleanly and efficiently, and could thus help mitigate the above problems from household energy consumption in developing countries (Masera O, et al. 2007).

Rural households almost entirely rely on the traditional fuels whereas the share of modern fuels in urban households’ consumption is about 20 percent (Gebreegziabher 2007). Thus, the extent of dependence on traditional fuels is very high. For instance, consumption of biomass fuel has been increasing at average annual increment of 2.5% (Mekonnen 2000). In the urban households of developing countries, LPG is the most widely cooking fuel used, followed by biomass and kerosene (Pachauri 2007).

According to (NMSAE 2001) the energy sector in Ethiopia is composed of three main sub-sectors: biomass, petroleum and electricity. Energy consumption of the country is satisfied by wood fuel (77%), Dung (7.7%), Crop residue (8.7%), Bagasse (0.06%), Charcoal (1.15%), Electricity (1%), and Liquid Petroleum Gas (LPG) (0.05%), Oil products (4.8%). This implies that about 95 per cent of the energy supply of the country comes from biomass sources whereas petroleum and hydro-electricity constitute the bulk of the modern energy supply source, with petroleum accounting for the lion's share (about 4%) and electricity supplying about 1%.

Over half of all urban households in sub-Saharan Africa rely on fuel wood, 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. Being one of the poorest countries of the world, Ethiopia’s experience is not an exception. Furthermore, the excessive deforestation, which led to the depletion of tree stock, caused what is known as the household energy crisis in Ethiopia (Samuel 2002;Zenebe 2007). The cost of firewood increased, thus, challenging the already staggering living condition. (Zenebe 2007) showed that the possibility of energy crisis of the country. The most important issue in the future of Ethiopia is the supply of fuels, the associated deforestation and the negative impact of loss of agricultural resources on which much of economic activities of the country rely on according to the estimates of (Zenebe 2007). This problem is one of the major problems affecting the future of Ethiopia and hence should stand as the nations’ top priorities to be considered by policy makers.

On the other hand, Millennium Development Goal (MDG) emphasizes the central role of energy services for development and it is clear that energy access is vital for achieving the MDGs, though it requires a considerable challenge to avert the current trends in traditional biomass use in developing countries(UNDP 2006). Recognizing the adverse effects of 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).

There are barriers affecting the adoption of modern technologies and preventing the implementation of the efficient energy policy. Anozie et al. 2007; Mekonnen & Köhlin 2008 pointed out the existence of weak institutional framework for implementing energy efficient policies and strategies, general lack of awareness by consumers on the compelling need to conserve energy, lack of supply logistics and dependability of supply, taste, preferences, cost, cooking and consumption habits, limited availability of energy efficient technologies are some the problems affecting cope upping with trends of technologies. Kebede et al. 2002 examined domestic energy demand pattern in ten large cities and towns in Ethiopia. They concluded that urban-specific factors other than income such as fuel availability and climate appeared to be important in determining demand for modern energy.

The seriousness of the problem of household energy crisis is obvious. According to Samuel 2002 referred The Federal Democratic Republic of Ethiopia has clearly put in its Energy policy document (1994) that it envisages for transforming the energy consumption pattern from the traditional to modern fuel and energy conservation in all types of uses.

In order to address the impact of household energy consumption and to achieve the above policy objective, a detailed knowledge of the energy consumption pattern of households and the house hold characteristics of the town is vital. Different studies were carried out on household energy consumption in urban Ethiopia by (Alem et al. 2013; Gebreegziabher 2004; Gebreegziabher et al. 2011; Gebreegziabher 2007; Kebede et al. 2002 and Samuel 2002). Many of the studies have covered issues of energy. Kebede et al. 2002 figured out the affordability of modern energy in major cities of Ethiopia by estimating cost of energy. Samuel 2002 analyzed household consumption and its demand by comparing traditional against modern energy sources with respect to income. Zenebe 2007; Zenebe et al. 2010 emphasized insights into urban fuel demand, by looking at fuels in terms of the pressure and the problem of deforestation.

However, households in different corners of the country have different household characteristics, and other social related factors affecting energy preferences. As a result, very little is known about the energy consumption pattern of households in Nekemte town. This paper addresses the gap by identifying the household energy consumption pattern and its implications on environment and socio-economic characteristics. Also, this is one of the studies those should be conducted in different parts of Ethiopia to find out factors affecting household energy choices and their implication. Therefore, it will significantly contribute to the existing literature.

1.2 Research Questions

The study will intend to answer the following areas of questions:

1. What are the current household energy trends in Nekemte town?
2. What factors determine household preference toward household energy sources?
3. What are the different types of cooking stoves utilized in the house holds?
4. What is the environmental implication of household energy consumption pattern in Nekemte town?
5. What are the household's characteristics and its association with the pattern of household energy consumption in the town?

1.3 Significance of the study

This study is expected to give up-to date information on the existing energy consumption pattern in the town. That is after the accomplishment of this study, socio-economic status and its negative effect on the household energy consumption was revealed. Thus, the outcome of the study benefits the concerned policy makers to make plan and evaluations of house hold energy consumption pattern and the implication it has on socio-economic and the environment based on the existing levels of energy consumption.

It also helps other researchers and the university's communities to use as a reference for further research under the study subject.

CHAPTER 2: LITERATURE REVIEW

2.1 The type of fuels used in households for energy services

According to (IARC 2010; IEA 2006;Reddy and Srinivas 2009) wood, crop residues, dung, kerosene and in rare case electricity and the likes are common energy sources for poor households in developing countries. Households generally use a combination of energy sources for cooking that can be categorized as traditional (such as dung, agricultural residues and fuel wood), intermediate (such as charcoal and kerosene, candle) or modern (such as LPG, biogas, ethanol gel, plant oils, di-methyl ether (DME) and electricity)(IEA 2006). Electricity and petroleum products are the two modern fuel sources available in Ethiopia. The public utility EEPCO (Ethiopian Electric Power Corporation) is the supplier of electricity and, lighting is the dominant end use in the domestic sector (Zenebe et al. 2010).

All in all, the efficiency and the environmental concerns of energy use can be progressed by the 'energy ladder'(UNDP 2004). It is a framework for examining trends and impacts of household fuel use and ranks these fuels along a spectrum running from simple biomass fuels (dung, crop residues, wood) through fossil fuels (kerosene and gas) to the most modern form (electricity). The concept of energy ladder hypothesis states that people with low incomes generally use traditional fuels as their main cooking fuel and people with higher incomes tend to use modern fuels. Results of the energy demand studies reveal that the movement of energy consumption from traditional sources to more sophisticated sources along an imaginative ladder is with the improvement in the socio- economic status of households. There is evidence to show that people in urban areas use more kerosene, LPG, and electricity. It also suggested that price-based and quantity-based government policies tend to influence the urban fuel demand patterns more than does the household income level(Bhatia 1988).

Furthermore, Masera et al. 2000 depicted that the choice of a fuel by households depends on own price, the prices of the related fuels, appliances used, the efficiency of the fuels and household characteristics.

2.2 The amount of fuel energy used among households

According to the best available figures, household energy use in developing countries totaled 45,780GJ in 2004, almost 10% of world primary energy demands. Most of this energy is used for cooking, as well as heating and lighting(IEA 2006). Household use of biomass in developing countries alone accounts for almost 7% of world primary energy demand. There are enormous variations in the level of consumption and the types of fuels used. While a precise breakdown is difficult, the main use of energy in households in developing countries is for cooking, followed by heating and lighting. Because of geography and climate, household space and water heating needs are small in many countries. Electricity is mainly used for lighting and small appliances, rather than cooking, and represents a small share of total household consumption in energy terms(IEA 2006; Zenebe 2007).

Two billion people, about 40% of the total world population, depend on fire wood and charcoal as their primary energy source(IEA 2006). Of these people, three-quarters (1.5 billion) do not have an adequate and affordable supply. Most of them are in the less developed countries where they face a daily struggle to find enough fuel to cook their food. The problem is intensifying because rapidly growing populations in many developing countries create increasing demands for fire wood and charcoal from a diminishing supply(Cunningham MA et al. 2003).

According to Millennium Project 2005,the minimum house hold energy needs of sub-Saharan Africa and South Asia countries corresponds to about 50 kilograms of oil equivalent (Kgoe) of annual commercial energy per capita; this estimate is based on the need for approximately 40kgoe per capita for cooking and 10kgoe used as fuel for electricity. Furthermore, the number and distribution of people who rely on traditional biomass fuels for cooking and heating classify the nations as energy poor. The poorest households spend a large portion of their total income and human resources on energy because some forms of energy are absolutely essential to meeting such basic needs as cooked food(Barnes et al. 2010).

2.3 End-use energy and Efficiency of fuels

The energy end-uses of a household refer to energy consumption for cooking, home heating, refrigeration, lighting, recreation, and private vehicle use, all of which satisfy families' basic living requirements and improve the quality of life (AFREPREN 2004). Useful energy refers to work harnessed for the purpose of which the fuel is consumed. In the case of cooking, useful energy is the heat actually used for heating the food/transmitted to the food-cooking process(Barnes & O'Sullivan 2007).

Energy consumption can be measured at various levels of the energy supply chain. For example, final or end-use energy is the energy sold to final consumers who are not part of the energy industry, i.e. those that buy energy for their own use and not for sale to a third party (be it in the same form or not); the energy delivered to consumers to satisfy their energy needs and does not include the energy losses due to conversion and distribution. Kerosene in a 10-litre canister, electricity at 220 volts supplied to the electricity counter of a residence and collected wood, ready to use, are examples of energy at the end-use level (Pachauri 2007; Ugursal 2013).

Fuels differ in their energy densities and efficiency. Modern fuels such as LPG have the highest energy content per kilogram of fuel at approximately 45 MJ/kg. In contrast, crop residues and dung have energy densities of about 14 MJ/kg of fuel. The efficiency of a fuel is measured by the amount of energy used for cooking compared with that which escapes from the stove without actually heating the food. The efficiency of cooking with LPG is estimated to be approximately 60% compared with only 12% for agricultural residues burnt in traditional stoves. This is one of the reasons that commercial fuels such as LPG are considered to be superior to crop residue and dung. All fuels are burned in various types of device to provide the heat necessary for cooking. The device can be relatively efficient or inefficient and be associated with high or low levels of pollution. As indicated in Table 1, conversion efficiencies for kerosene stoves range from 35% for wick stoves to 55% for pressure stoves; those for fuel wood stoves range from 15% for traditional stoves to 25% for improved stoves. Improved stoves have the potential to reduce indoor air pollution levels, to burn wood or other biomass more efficiently and sometimes to reduce average cooking times(Barnes & O'Sullivan 2007; IARC 2010). The annual amount of energy required for cooking varies with the type of food, fuel, and stove used and the specific cooking practices of a household(Millennium Project 2005).The annual energy requirement for a family of five is about 5 gigajoules of useful energy (i.e. energy "into the pot")(Barnes & O'Sullivan 2007).

Table 1: Typical efficiencies at the final consumption stage of cooking

Fuel source	Energy content (MJ per kg)	Conversion efficiency (%)	Useful energy at final consumption stage of cooking (MJ per kg)	Approximate quantity of fuel necessary to provide 5 Gigajoules of useful energy for cooking (Kilograms)
LPG	45.5	60	27.3	180
Natural gas	38 MJ/M³	60		219 M³
Kerosene (pressure)	43.0	55	23.6	210
Kerosene (wick)	43.0	35	15.1	330
Biogas (60% methane)	22.8 MJ/M³	60		365 M³
Charcoal (efficient)	30.0	30	9.0	550
Charcoal (traditional)	30.0	20	6.0	830
Bituminous coal	22.5	25	5.6	880
Fuelwood (efficient), 15% moisture	16.0	25	4.0	1250
Fuelwood (traditional), 15% moisture	16.0	15	2.4	2000
Crop residue (straw, leaves, and grass), 5% moisture	13.5	12	1.6	3000
Dung, 15% moisture	14.5	12	1.7	2900

Miah et al. 2011 showed that on an average 229 kg biomass, 10 L LPG, 281 kWh electricity, 4 L kerosene, 0.23 kg candle, and 34 L of petrol were used per household per month in different sub-urban and urban areas of Noakhali in Bangladesh.

Recently, according to (Lighting Africa 2012) Ethiopia's energy consumption was estimated at about 31,050 kilotons of oil equivalent (Ktoe) in 2009 with a per capita energy consumption of 0.4 Ktoe. The national energy balance is dominated by a heavy reliance on traditional biomass energy (wood fuels, crop residues, and cattle dung), which accounts for 92 % of total energy consumed. Petroleum and electricity contribute only 7% and 1%, respectively. Mostly, the shortage of energy supply of Ethiopia is covered by forest clearing and overcutting (Zenebe 2007). Furthermore, the energy requirements of a large and fast growing population and the fact that the major proportion is supplied by traditional energy sources have serious implications on the natural resources.

Of the various end-uses, baking *Injera* and normal cooking are the two most important uses in urban domestic fuel consumption in Ethiopia. Included in normal cooking is preparing or cooking sauce, soup, or stew (*Wet*) from meat, vegetables, or other comestibles to eat with *Injera*. In general, *Injera* baking is the major consumer of fuel wood and accounts for over 50 percent of the total household fuel consumption (Gebreegziabher 2004).

2.4 Household's appliances

Energy conversion technology is a key aspect of household energy use (Zuzarte & Schlag 2008). Cooking foods in developing countries use one of three different methods for cooking their food: the open fire, an upgrade to the open fire, and a basic stove. Open fires usually consist of three stones, and this method of cooking can be found in at least some communities of every country, according to (Foley 1983). Foley describes the upgraded open fire as one in which shielding has been provided for the fire or a platform has been built for convenience. The third cooking systems in developing countries are the actual stoves and these stoves vary in their design. Some designs are thousands of years old and range in materials from mud or pottery in Asia, metal "jikos" and "forneaux" in East and West Africa, and other brick and mud varieties (Foley 1983). Two types of stoves are used for cooking with kerosene: wick stoves and pressurized stoves (Bailis et al. 2005).

According to (EnDev2012) millions of Ethiopians cook their daily meal on open fires surrounded by three-stone fire (TSF), cooking stoves such as traditional charcoal stove, Ethiopian *Injera Mitad, Mirt* stoves, Modified charcoal stoves, Kerosene stoves, Ethiopian Electric *Injera Mitad* for baking *Injera*; *Biret Mitad* made of cast iron/ steel for preparing and making coffee, and *Kolo*. And, the commonly used cooking utensils in our country include: Cooking aluminum pots and clay pots (*Dist*), are used for cooking most of the stew (*Wet*) as well as for making tea and boiling water, Coffee pot (*Jebena*) of clay for making coffee (Gebreegziabher 2007; Nebiyu 2009). In general, the most frequently used fuel wood technology in developing countries remains the open fire (Masera et al. 2008).

2.5 Determining factors of household energy consumption pattern

To understand why people use various types of fuels, it is necessary to understand the factors that contribute to the overall choice of energy use. Household energy consumption levels and the types of energy used depend on a variety of factors which include the household characteristics, the availability and the disposable income on the energy sources, and community characteristics such as economy, society, culture, local energy, and climate (Barnes et al. 2010; WEC 1999).

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 (WHO 2006). While this is a simpler version of the "energy ladder hypothesis," it is also presented in the literature with more elaborate intermediate steps (Heltberg 2004; Hosier, R.H. & Dowd 1987).

Accordingly, (Barnes & O'Sullivan 2007) present a theory with a ladder of energy demand, rather than 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. Urban 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. This led to the concept of fuel stacking (multiple fuel use), as opposed to fuel switching or an energy ladder (Heltberg 2004; Masera et al. 2000). As in the case of Mexico, as shown in (Masera et al. 2000) fuel stacking could be important in urban Ethiopia because households there have limited options for fuel, as well as stoves to bake *Injera* ,although there are more options for cooking other foods.

Moreover, (Alemu & Köhlin 2008) found that households in major cities of Ethiopia generally used more fuel types as their incomes increased, instead of completely switching to another fuel type. Such behavior is associated with the fact that while households were more likely to afford to buy additional cooking stoves if new fuel types required them, there were also various other reasons to do so, including preferences for a particular fuel type used for a particular type of food, for a particular time or occasion, for convenience, or due to uncertainty about the supply of a fuel type. (AFREPREN 2004; Dzioubinski & Chipman 1999) emphasized the consideration of cultural preferences of fuel types of the households.

Over all, different works of (Heltberg 2004; Reddy 2007; Reddy & Srinivas 2009) showed that household energy preference and consumption pattern should be understood with the influence of economic condition, family size, sex and age distribution of the households members, age of the holdings, nature of the occupation, education attainment of the principal wage earner and of the family members and the frequency of cooking in developing countries such as in India, Nepal and Sri Lanka. Reddy 2007 showed that there is strong relationship between level of education and the preference of the efficient energy carriers in India.

Government policies to control distribution of fuel types and production and distribution of energy appliances directly and indirectly affect household energy choices (Barnes et al. 2010). Reliability of the energy supply is another factor affecting the household's energy use. Unreliable modern energy supply in many regions forces households to adopt multiple fuels and resort to wood fuel that is locally gathered (Masera et al. 2000). For example, unreliability of kerosene in Myanmar causes people to rely on wood fuel although its price is three times the price of kerosene (Barnes et al. 2005).

Some researches show that most energy intervention strategies have focused on increasing the availability of modern fuels, the reliability of the fuel distribution network, reducing the price of modern fuels through subsidies and dissemination of end-use technologies. But, the cost of modern fuels is often too high for the poorest households to afford as revealed by (Kebede et al. 2002) in the major cities of Ethiopia. Regulating production and distribution of both fuel types and energy appliances affect household energy choice. In China, a restriction on traditional bio-fuel consumption caused people to adopt coal as their main fuel(Wang XH 2005).

2.6 Fuel wood and Deforestation

The household energy pattern in many developing countries is characterized by the predominant use of traditional biomass fuels (Zuzarte & Schlag 2008). The most common energy sources are wood fuels such as firewood and charcoal but households also fall back on agricultural residues or animal wastes in the event where alternatives are unavailable. The dominance of firewood is explained due to its low cost or being free for collection in many cases as well as due to the lack of suitable alternatives (IEA 2006).

Forests are the main sources of livelihood for many poor households in developing countries, particularly in Africa. Like other many developing countries, forests are a very important source of energy for both rural and urban households in Ethiopia (Zenebe 2007). Urban centers have long been dependent on rural hinterlands for their fuels (Barnes et al., 2004). Charcoal and firewood are collectively referred to as fuel wood, a major source of cooking and heating energy for most urban households in sub-Saharan Africa(Gumbo et al. 2013).

The loss of the world's forests is a pressing environmental issue (Enger & Bradley 2004). The global forest area is decreasing by 0.2% per year. The rate of deforestation is greatest in Africa, where the area of forested land decreases by about 0.6% per year (Zuzarte & Schlag 2008). At national level, Ethiopia has about 3337988 hectares of forests (FAO 2010). Despite the contribution of the forests to the livelihoods of the people and the country as a whole, the country losses about 141,000 hectares of forest each year (FAO 2010). Rapid exploitation of resources has negative environmental consequences and in some cases has been incurable. According to (Enger & Bradley 2004), 40 years ago forests covered 40% of Ethiopia, today forest covers only one percent and deserts are expanding.

But, for a country with a population of 80 million people, forest degradation and deforestation are serious environmental problems that negatively affect the welfare of the people (Zenebe 2007). In Ethiopia, many factors contribute the forest deforestation problem. The heavy reliance on biomass fuels has been one of the prime causes of forest degradation and deforestation in Africa in general and Ethiopia in particular (Teketay 2013; World Growth 2009).

Concern about deforestation impacts from cooking is consequently now generally addressed at a regional or local scale. Of growing concern now, however, are the adverse environmental consequences of the charcoal supply chain in many sub-Saharan African nations(Girard 2002). Among biomass fuels harvested, charcoal production is the major threat to the forests in developing countries specially Africa. For example,(Gumbo et al. 2013; Mugo & Ong 2006) reported that charcoal production is a big threat because it targets specific preferred species found in natural forests and woodlands in Eastern Africa cities. Mwampamba 2007 on his study concluded that charcoal consumption is a real threat to the long-term persistence of forests in Tanzania and proposes policy interventions for alleviating forest loss. Furthermore,(Girard 2002) revealed that charcoal production had resulted in noticeable removal of tree cover around the cities of East Africa, and in some cases resulted in total clearing of land.

Apart from this, (Bahru et al. 2012) revealed that endemic species such as *Acacia nilotica*, *Acacia tortilis* used for production of high quality charcoal around the semi-arid Awash National Park, Ethiopia which have long growth time were used; and due to their scarcity, the charcoal producers are more inclined towards the harvesting of other endemic species. These tree species are slow growing and are therefore particularly vulnerable to overexploitation. One great concern, also that unlike fuel wood, charcoal is most often produced from living forest resources (Girard 2002). Furthermore, fuel wood collection in rural areas was largely in the form of dead wood or twig wood, without cutting the entire trees (Chidumayo 1997;Frey & Neubauer 2002). Therefore, the direct environmental impact of charcoal production is caused by the felling of living trees to produce charcoal (NTL 2002).

For many urban poor, charcoal provides a reliable, convenient and accessible source of energy for cooking at a stable cost. While electricity and gas may be considered the most desired cooking fuels in urban areas, even if these are available most poor households cannot afford the energy resource (NPSB 2010). Since kerosene is not always available or too costly for many this leaves charcoal as the most readily available fuel. In addition, even in cases where petroleum fuels are used, charcoal is often used as a backup fuel or the main fuel for preparation of certain foods insignificant amounts (Mugo & Ong 2006).

On the other hand, (Zuzarte & Schlag 2008) summarized literature that a reduction in households' dependency on wood fuels has the potential to reduce the rate of Sub-Saharan deforestation greatly. However, with the expected increase in demand for charcoal forest covers are most likely to deplete even further. With the growing rate of deforestation, its impacts will be enhanced as well and the tendency to fell more trees has been and will continue to increase in the absence of any affordable alternatives. Thus the use of forest biomass for charcoal making could still represent a threat to the future of the resources in local terms, especially in certain situations with high demand (for instance the periphery of large urban zones with low resources) and lack of proper forest management practices and regulations.

Local environmental impacts of biomass consumption are associated with the inefficient use of fuel wood, especially surrounding growing urban areas (ESMAP 2011). In developing countries like Ethiopia, charcoal is produced by traditional earth mound-wood staking and has an efficiency of 12-15% (EREDPC 2008). Inefficiencies in the production process results in consumers of charcoal using 4–6 times more wood than consumers of firewood (Kammen & Lew 2005; Mwampamba 2007;Van der Plas 1995).

Eleven to twenty per cent of deforestation in developing countries can be attributed to charcoal production(NTL 2002). Clearly, charcoal production contributes to the deforestation of Ethiopia but both processes are difficult to quantify: the extent of deforestation and the contribution to it by charcoal making. But, (VanAsperen 2001) provides a useful formula: 50,000 ton of charcoal = 16,600 ha of forest = 26.7 million trees.

CHAPTER 3: OBJECTIVES OF THE STUDY

3.1. General Objective

The main objective of this study is to assess household energy consumption pattern and its implication on the socio-economic and environment in Nekemte town.

3.2 The Specific Objectives

- To determine the types of fuels used in the households.
- To determine the amount of energy sources used in households.
- To identify factors affecting the households to use such energy sources.
- To determine socio-economic and environmental implication of household energy use.

CHAPTER 4: METHODS

4.1 Study area

Nekemte City is located at about 333 kilometers West of Addis Ababa, the capital city of Ethiopia. Its absolute location ranges between 9^{0}04N latitude and 36^{0}30E longitude. Nekemte is found within the range of 1960 to 2170 meters above sea level which shows that it experiences *Dega* and *Woyina-Dega* agro- climatic conditions. With regard to relative location, however, Nekemte is the Capital of East Wollega zone, and located in Oromiya National Regional State.

Nekemte city is situated under three slop structures: sloppy, ragged, and plain. About 68.4% of Nekemte and its environ is medium sloppy, 26.1% is ragged, and 5.5% is plain. Therefore, much of the land of the city is sloppy which impedes swift expansion of the city for various social and economic activities. Nekemte is closely located in the Southwestern Highlands of Ethiopia where heavy rain fall is experienced almost throughout the year. It has five rainy months in a year, from May to September. Annual range of rainfall for Nekemte ranges from 1500- 2200 mm. Its annual temperature range varies from 14^{0}C-26^{0}C (Nekemte City Administration 2003).

Based on the CSA (2005), medium variant projection of 1994 population, in 2005 the total population of Nekemte was 84,506 of whom 42,121 male and 42,385 were female. According to the Town's Strategic Plan (2011), population growth rate is 4.11 % per year and this growth rate may continue in the foreseeable future given high young age population, high growth rate, and high rate of rural to urban migration. Moreover, the average size of a household of the city is estimated to be six.

Nekemte town is characterized by mutually contributing socio-economic problems. Ever increasing rate of population pressure from excessive immigrations, income shortage, urban poverty, unemployment, deforestation and desertification strikingly high and ever increasing HIV/AIDS prevalence rate are among the town's socio-economic problems according to the Town's Strategic Plan (2011). According to the Ethiopian Electric Power Corporation Nekemte branch, since 2000 the town has been supplied with 40MW electric power from Fincha'a Hydroelectric power for different purposes such as lighting and powering. The major source of income for the city's households include salaries, earning from self-employment, domestic work and causal labor, petty trade and pension. According to the information obtained from Nekemte Urban Municipality; house hold inputs such as safe drinking water, food items, and the problem of house hold energy are detrimental factors to the staggering living condition.

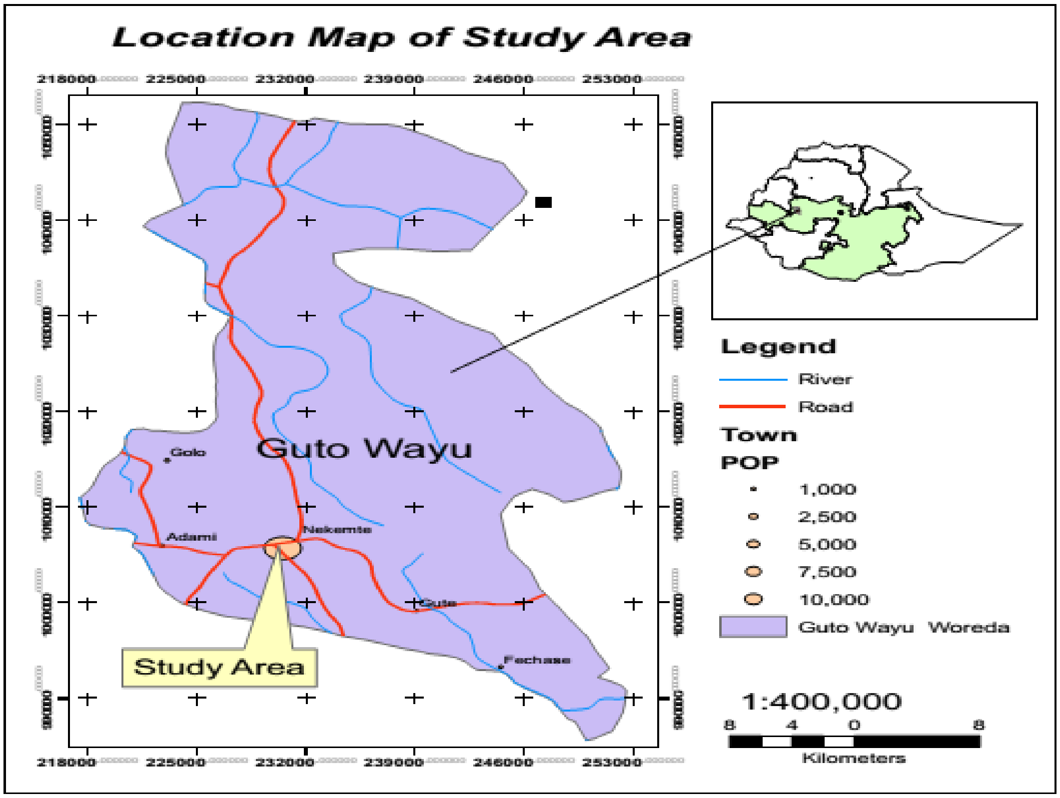

Figure 1: Location map of the study area

4.2 Study design and period

A cross sectional study design was used July 8th - 14th 2013 in Nekemte town to identify the households' consumption patter and its socio-economic and environmental implications.

4.3 Population

The source population for the study is the total number of households in the city which is about 14083 households

Table 2: Summary of the total households in Nekemte town

Sub-city	No. of households
Bakkanniisa Qasee	2211
Bakkee Jamaa	2148
Burqaa Jaatoo	2435
Calalaqii	2644
Dargee	2258
Qassoo	2387
Total no of houses in the city	14083

Source: Nekemte Sub-cities administration offices, 2010

4.4 Sample size and Sampling technique

4.4.1 Sample size determination

To determine sample size of households those to participate in the study, a sample technique which was developed by (Cochran 1977) to determine sample size (n) with the desired degree of precision (d) for general population, was used.

$$n = \frac{\left[Z_{\alpha/2} \sqrt{P\,(1-P))} \right]^2}{d^2}$$

Where:

n = Sample size

z = critical value 1.96

p = binomial parameter to estimate a population proportion is to be, 0.5

d = precision (marginal error) = 0.05

In calculating a sample size for a proportion, a value of 0.5 was used for the estimate of the population proportion; p=0.5 gives the largest sample size relative to any other value of p (unknown population proportion). As the sample size becomes larger, the value of marginal error is decreased. And, there is no previously done research in that particular study area. Due to these reasons the maximum value of binomial parameter, 0.5, is preferable.

The sample size was determined by assuming the binomial parameter (a sample proportion to estimate a population proportion) to estimate a population proportion to be 0.5, giving any particular out come to be with 5% marginal error and 95% confidence interval. Based on this assumption, the actual sample size for the study was computed using one-sample population proportion formula as indicated below.

Thus, the sample size is, $$n = \frac{\left[Z_{\alpha/2}\sqrt{P\,(1-P))}\right]^2}{d^2} = \left[\frac{1.96}{0.05}\right]^2 0.5 \times 0.5 \approx 385$$

Adding 10% non-response rate, the final sample size required for this study is about 424 households.

4.4.2 Sampling technique

Currently the town is divided into six sub-town administrative divisions. The sub-towns with their respective former *Kebeles are: Bakkanniisa Qasee (Kebeles 01 & 04), Bakkee Jamaa (Kebeles 06 & 09), Burqaa Jaatoo (Kebeles 07 & 11), Calalaqii (Kebeles 03 & 12), Dargee (Kebeles 02&10), and Qassoo (Kebeles 05 & 08).*

Knowing the composition of the population; the whole populations of households found in the town were stratified in to non-over lapping strata, in this case, sub-cities. Moreover, the stratification is on the basis of geographical (political) distribution of the town. i.e., the town divided into six different sub-towns: namely *Bakkanniisa Qasee, Bakkee Jamaa, Burqaa Jaatoo, Calalaqii, Dargee, Qassoo* and further, each sub-city from the town was selected. A proportion of sample from each stratum to give the actual sample size was taken. Stratification enables a partition of the surveyed population so that data can be disaggregated and relevant factors can be analyzed in greater detail (Leitman 1989).

Then, within each stratum, I utilized random systematic sampling method as far as lottery method is cumbersome due to the size of the sample. Individual household is chosen at regular intervals from the each sub-city. Lottery method used to select the first households in each sub-town

Table 3: Sample size taken from the total households found in Nekemte town

Sub-city	No of homes	Proportion of the actual sample taken from each sub-city/ stratum
Bakkanniisa Qasee	2211	67
Bakkee Jamaa	2148	65
Burqaa Jaatoo	2435	73
Calalaqii	2644	79
Dargee	2258	68
Qassoo	2387	72
Total no of houses in the city	14083	The actual sample size = 424

For the sake of understanding, the number of the households assigned from 1 to N, the maximum possible of household number, in each sub-city.

In such a manner, for households found in *Bakkanniisa Qasee* have got 1 to 2211 and the sample proportion from this sub-city is 67. The sampling fraction is: 67/2211 ≈ 1/34. Hence, the sample interval is 34. The number of the first household to be included in the sample is chosen randomly, for example by blindly picking one out of 67 pieces of paper, numbered 1 to 67. In short, every thirty fourth household is picked up to make the sample for this specific sub-city. The same pattern is followed for the rest sub-cities. For households located in *Bakkee Jamaa* applying the same pattern, 65/2148 ≈ 1/33; Hence, the sample interval is 33.Every thirty third household is picked up to give 65 households. For households found in *Burqaa Jaatoo* 73/2435 ≈1/33, every thirty third household is picked up to give 73 households; for households located in *Calalaqii*; 79/2644≈1/34, Every thirty fourth household is picked up to give 79 households; for households located in *Dargee*, 68/2258≈1/33 every thirty third household is picked up to give 68 households, for households located in *Qassoo*: 72/2387≈1/33, every thirty third household is picked up to give 72 households. And each and every interval picked up to constitute the actual sample size, 385 households.

Then, within each stratum, I utilized random systematic sampling method as far as lottery method is cumbersome due to the size of the sample. Individual household was chosen at regular intervals from the each stratum. The first household to be selected is taken at random among the households found in each sub- town.

Primary data were collected with the use of semi-structured questionnaire. Only household heads considered permanent residents of the households are eligible for inclusion in the surveys.

4.5 Study Variables

4.5.1 Dependent variable

- Effect of energy consumption pattern
- Implication of HHE consumption
- Types of cooking stoves used
- Types of fuel used

4.5.2 Independent variables

- Socio-economic characteristics
- Sex
- Age
- Religion
- Educational status
- Household ownership
- Occupation
- Income
- Family size
- Availability of energy sources
- Cost of the firewood
- Initial cost of Electric stove

- Cost of charcoal
- Cost of kerosene
- Lack of Electric meter

4.6 Data collection procedures

4.6.1 Data collection

Interviewer-administered data collection method was employed through formal questionnaire survey. Easily understandable questionnaire consisting sets of questions were administered to 415 household heads particularly to women. The questionnaire was intended to address the major aspects of household energy use pattern: like energy used for cooking, energy for lighting, energy for heating, availability and accessibility of energy sources and questions on the basic household characteristics and the respondent's socio-economic status. Questions regarding household energy use patterns were adopted from(Barnes & O'Sullivan 2007; Leitman 1989) and modified with respect to the circumstances of the area.

The questionnaire was prepared in English and then translated to *Afaan Oromoo* and again translated back to English to check for conceptual equivalence. One supervisor and five enumerators were trained and involved in data-collection.

4.6.2 Data quality management

Supervisor was assigned and checked the process of data collection by random spot-checking of 10% of the questionnaires to ensure reliability of the data. At the end of each data collection day, the supervisor checked all the filled questionnaires for proper completion. Then, the principal investigator checked all the data each day for completeness. Incomplete and unclear questionnaires have been returned to the data collectors to get it corrected.

All households participated in the survey were asked for their willingness for interview and oral consents prior to interviewing. Most of the interviewed people were actively cooperative during the surveying process.

4.6.3 Data analysis procedures

After the data were collected; they were checked for completeness, edited, and coded, entered to computer, cleaned, processed and analyzed using EpiData v 3.1 and SPSS version 20.0. The data that was obtained from household survey were analyzed with the help of descriptive statistics such as percentages, mean, standard deviation as well as different frequency tables and graphs were used to describe the study variables. Bi-variate analysis techniques was undertaken to describe variables and to check for correlations among the independent variables prior to running multiple regression models. The models were built using stepwise linear regression to identify the variables that significantly affected household energy consumption. Missing values were replaced with mean values for each variable. Multiple logistic regression analyses were also used to identify the variables that significantly affected energy use of household. This was done using three separate linear regression models for each of the following energy types: Choice of fuel wood, choice of charcoal, choice of kerosene. Besides, to control the effects of confounding variables a binary logistic regression was conducted. For the purpose of this study, statistical significance set at 95% confidence interval. And, qualitative data that were collected through interviews analyzed by narrating and interpreting the situation deeply and contextually so as to reflect the real picture of the particular area.

The emissions of greenhouse gases (GHG) in the form of CO_2-equivalent from the household energy consumption of all fuels can be determined by using the following model adopted from (IPCC 2006) which is based on the total amount of fuel combusted and default emission factors of different energy types as is shown below:

$$C = \sum_i \boldsymbol{EiMiKi}$$

Where C is the total CO_2-equivalent emissions, unit kg; E_i is the default CO_2-equivalent emission factor of stove type i, unit g/MJ; M_i is the total fuel consumption of energy type i, unit kg; K_i is the calorific value of energy type i, unit MJ/kg.

Note: 1.E_i is from 2006 IPCC Guidelines for National Greenhouse Gas Inventories and (Bhattacharya & Salam 2002); 2. K_i is from (Barnes & O'Sullivan 2007; NMSA 2001).

According to the (IPCC 2006), the 100-year global warming potentials of methane(CH_4), nitrous oxide (N_2O) and carbon monoxide (CO) are 7.6, 300 and 1.9 times that of carbon dioxide, respectively.

Finally the type and amount of energy used by households were connected to households' income and local environmental characteristics like deforestation and emission.

4.7 Dissemination of the Result

The result of this study will be presented to the Department of Environmental Health science and Technology, College of Public Health and Medicinal science, Jimma University, Publication in national or international journals will also be considered.

CHAPTER 5: RESULTS

5.1 Socio-demographic characteristics of the respondents

This survey collected data from the total of 415 (97.88%) visited households of Nekemte Town which have been classified into six sub-cities.The mean age of the HHHs was 44.92 years (SD ± 5.86), where 20.5%,61.0%,16.1% and 2.4% were between the age of 30 – 39 ,40 – 49, 50 – 59 and above 60 years respectively. Forty six point three per cent, 17.1%and 36.6 were Protestants, Muslim and Orthodox in religion respectively. Fifteen point nine per cent, 81.2 % and 3% have family size of less than or equal to 3, between 4 and 7 and greater than or equal to 8 respectively, but the average family size of the surveyed HHs is about 5.The survey showed different situations in terms of occupational status of household heads, the majority being daily laborer (26 per cent). Of the remaining group, 17 per cent were employed and the rest 8 per cent were house pension and retired. Educational level of the household heads was found out to be that 24 per cent were never to schooling and, the remaining 35 and 22.4 per cent of the groups had attended the primary and secondary schools respectively. Less than 19 per cent had post-secondary level. Regarding the total monthly income of the households, 23% of households had between 1500 -1999 and 18% of them had between 2000 - 2499 birr.

Summarized socio-demographic characteristics of the individuals in all surveyed households are displayed in the following table.

Table 4: Socio-demographic characteristics of the respondents

Characteristics	Frequency	Percent
Age		
30 – 39	85	20.5
40 – 49	253	61.0
50 – 59	67	16.1
Above 60	10	2.4
Religion		
Protestants	192	46.3
Islam	71	17.1
Orthodox	152	36.6

Family size		
=< 3	66	15.9
4 – 7	337	81.2
>=8	12	2.9
House ownership		
Private	389	93.7
Rented	26	6.3
Educational status		
Never to Schooling	100	24.1
Primary School	144	34.7
Secondary	93	22.4
Diploma	53	12.8
University Degree and above	25	6.0
Occupational Status		
Daily Laborer	107	25.8
Employed	70	16.9
House Pension and Retired	31	7.5
Monthly income of the family		
=<999	53	12.8
1000 - 1499	63	15.2
1500 - 1999	95	22.9
2000 - 2499	76	18.3
2500 - 2999	19	4.6
3000 - 3499	41	9.9
>= 3500	68	16.4

5.2 Household energy consumption pattern in Nekemte Town

5.2.1 Household energy types and usage pattern

Currently, households mainly use energy for cooking *Injera,* making *Wet*, making coffee, and lighting. The dominant energy used for domestic cooking in the study town is supplied as biomass (firewood, charcoal, crop residue, sawdust), and kerosene. Only few households solely depend on electricity for their cooking. The study found that, the households used various energy sources. About 61% of the households was used biomass such as fire wood (58.8%), crop residue and saw dust (2.2%) for cooking *Injera*. Charcoal forms the principal energy source for coffee and *wet* by 73 and 78 per cent of the households, respectively. Both charcoal and firewood constitute about 84 per cent of the energy used by households' for *wet.* Kerosene was used by about 14% of households (Table 5).

As shown in the data the majority of households depended on fuel wood for *Injera* baking. Several factors such as failure to have own electric meter, not having one's own house and the financial limitation of households to have electric stoves were identified for the heavy reliance on biomass energy. Therefore, HHs stuck on biomass fuels to fill their basic energy needs and as anticipated in Nekemte town, biomass was dominantly consumed at household level.

Table 5: Fuel types for different cooking services

Fuel Types	Cooking *Injera*		*Wet*		Coffee	
	No of HHs	%	No of HHs	%	No of HHs	%
Fire wood	244	58.8	46	11.1	65	15.7
Charcoal	-	-	302	72.8	324	78.1
Crop Residue and Saw Dust	9	2.2	-	-	-	-
Kerosene	-	-	58	14.0	23	5.5
Electric power**	162	39	9	2.2	3	0.7

**Current lighting energy consumption of the town relies on electricity, while the adoption of candle (71.1%) followed by wick lamps (24.3%) particularly as means of coping with power blackouts, was almost universal in the study area

The study estimated that annually on average about 1370 kg of biomass, about 1363kWh of electric energy, 30L of kerosene and 0.3kg of candle was used at household level. Annually, about 20 thousand tons of biomass is consumed in the town (see in the annexes).

The data in Table 6 show that Traditional three-Stone Fires (TFS), the modified three stone *Mitad (Mirt Mitad)* and Electric *Mitad* are commonly used cooking stoves. Roughly 61 per cent of the households cooked Injera with biomass stoves (TSF and *Mirt Mitad/Midija*); the rest households used Electric *Mitad*. Most of the households have more than one type of cooking stove. Charcoal stove is the most frequently used stove type (73%), followed by Kerosene Stove (14%), Three Stone Fire (11%) and Electric stove accounted 2.2% for making *Wet* in the Town.

Table 6: Types of cooking stoves

	Energy convertor	Frequency	Percent
Cooking *Injera*	TSF	151	36.4
	Mirt Mitad/Midija©	102	24.6
	TSF & Electric *Mitad*	80	19.3
	Mirt Mitad & Electric *Mitad*	82	19.7
Making *Wet*	TSF	46	11.1
	Charcoal stove	302	72.8
	Kerosene Stove	58	14.0
	Electric stove	9	2.2

5.2.2 Socio-economic dynamic of fuel-wood consumption in the Town

Households were asked about the sources of biomass fuel from where they get for domestic consumption. The survey showed that the majority of households (79 %) acquired their biomass fuels from market, and 19 and 2 % fulfill their biomass energy demand through freely collection in the environs as well as purchase in the local market. Time spent by household members on collecting firewood varied from 1 to 3 hours but majority (61%) of the household members spent on average up to five hours for a return journey. Most (68%) household members often travel long distances (return journey) of 18 to 22 KM to collect firewood. Very few (12%) travelled less than 8 KM in search for firewood. A considerable amount of the households (53.3%) spent between 81 and 120ETB per month on firewood, more than half of the HHs (59.4%) spent between 37and 72ETB per month on charcoal. About 90 % of respondents spent up to 4hrs for cooking food items and about children 44% were closer to the fire in the kitchen (Table 7).

Table 7: Socio-economic dynamic of fuel-wood consumption in the town

Variable	% response
Time (hours) spent on collecting firewood for one-way trip	
=<1.15	4.4
1.16 - 2.15	52.2
>2.15	43.3
Distance (KM) covered for one-way trip	
=<9	31.9
9 - 12	60.4
>12	7.7
Amount of money (ETB) spent per month on firewood	
40 – 80	43.8
81 – 120	53.3
>120	3
Amount of money (ETB) spent per month on charcoal	
=<36	13
37 - 72	59.4
>=73	27.6
Source	
Buy	79.0
Collect	19.0
collect and buy	2.0
Time spent in the kitchen(Hour)	
<3	50.1
3-4	49.2
> 4	0.7
Family members stayed in the kitchen while cooking	
Children	43.7
Females	55.8
Whole family and elders	0.6

Results from bivariate analysis revealed some of associations between variables.

HHHs who have no formal education have odds of 10.11times to use firewood as a source of energy than their counter HHHs who certified from colleges p-value 0.001 CI (5.098 – 20.055).

Being earned less than 1000 ETB per month is strongly associated with using firewood as sources of energy for cooking compared with earnings above 2000 ETB at household level OR=10.2 CI (4.071 – 25.556). Odds of households to use firewood were 8.7 times to be nearby than farther distances to get firewood.

Daily laborer, house-renting and retired HHHs have the odds of 10.5 times of merchant HHHs to use charcoal for cooking (p-value<0.001) with CI (5.808 – 18.982). HHs earning less than 1000 ETB monthly have odds of 4.6 times than those of HHs who earned greater than >2000 (p-value<0.001) CI(2.321 – 9.115).

Households spent more on fire wood have odds of 3.4 times of those spent less on firewood toward TSF for making *Injera* with p-value less than 0.0005 CI (0.152 – 0.583). There is evidence of association between using cooking stoves and family size. Larger family sizes are in favor of TSF than their smaller counter parts OR=2.14 p-value 0.004 CI (0.278 – 0.783). The availability of firewood strongly related to the utilization of TSF for cooking food items. HHs walking <=10 Km to firewood sources have 12.25 more likely to use fire wood than HHs walking >10Km, p-value less than 0.0005 OR CI (4.421– 33.944). HHs with no electric meter have 3.4 times odds of using TSF as a cooking stove (p-value 0.016, OR CI (1.254 – 9.216). Association between occupation of the household head and using three stone fires is significant. Merchant house hold heads have odds of 12.98 times of employed counter parts to TSF (p-value less than 0.001, OR CI (0.031– 0.191).

Had not been formal schooling, household heads have odds of 2.6 times than certifying from colleges p-value less than 0.001, OR CI (0.031– 0.191) and HHHs who finished primary school have odds of 3.43 times than completing colleges to make *Wet* with charcoal stove. Daily laborers, house-renting and retired household heads have odds of 2.1 times of merchant HHHs p-value less than 0.001, OR CI (1.448– 2.950), employed house hold heads have odds of 3.1 times of merchant counter parts to charcoal stove (p-value less than 0.001, OR CI (1.805 – 5.384). Earning less than 2000 birr has odds of 2.9 times of earning greater than 2000 birr p-value less than 0.0001, OR CI (2.046, 4.12) to use charcoal stove for making *Wet*. Smaller family size tends to use charcoal stove than larger families. A family size of less than four have odds of 2.7 times that of greater than six family members p-value less than 0.0001, OR CI(1.551 – 4.584).

5.3 Factors affecting the households to use fuel type

Multiple-regression was conducted to identify the variables that significantly affected household energy use for cooking. Since fuel-wood, charcoal and kerosene are the major sources of energy for cooking and due to the fact that they have negative impact on social and environmental aspects, the analysis was conducted separately for each one of the three fuels. Given that not all households use all types of energy, factors affecting the choice of energy sources were identified. This was done using three separate multiple regression models for each of the following types of energy used: fuel wood, charcoal, kerosene.

5.3.1 Fire Wood

Table 8: Factors affecting choice of fire wood as energy source

Coefficients [a]								
		Un standardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B	
Model		B	Std. Error	Beta	T	Sig.	Lower Bound	Upper Bound
1	Cost of firewood	0.114	0.023	0.316	4.921	0.001	0.069	0.160
	Availability of firewood	0.288	0.035	0.668	8.251	0.001	0.219	0.357
	Family size	0.168	0.025	0.439	6.658	0.001	0.118	0.218
	House ownership	0.192	0.051	0.243	3.791	0.001	0.093	0.292
	HH having electric meter *(Qoxari)*	0.118	0.055	0.149	2.123	0.034	0.009	0.227

a. Dependent Variable: Household using firewood as sources of energy for cooking

5.3.2 Charcoal

The variable cost of charcoal had the smallest impact which is negative(-0.200) (Table 9), indicating that more monthly expenditure on charcoal will decrease the likelihood of using it as energy source because high price will make households to switch to other energy sources to fill their basic requirements.

Table 9: Factors affecting choice of charcoal as energy source

Coefficients [a]

Model		Un standardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B	
		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound
1	Availability of firewood	0.140	0.028	0.254	5.041	0.002	0.086	0.195
	HH Income	0.101	0.020	0.251	5.015	0.004	0.061	0.141
	Family size	0.074	0.022	0.151	3.351	0.001	0.031	0.117
	HH having electric flow meter	0.200	0.044	0.198	4.521	0.000	0.113	0.287
	Cost of charcoal	-0.088	0.022	-0.200	-4.066	0.000	-0.131	-0.045
	Educ. level of HHH	0.033	0.011	0.058	3.135	0.002	0.012	0.054
	Cost of firewood	0.050	0.018	0.109	2.756	0.006	0.014	0.086

a. Dependent Variable: Household using charcoal as sources of energy for cooking

5.3 .3 Kerosene

Level of education of HHH was positively significant CI (0.004, 0.080), $p<0.05$), which implies that the educated people were more likely to increase their usage of kerosene (Table 10).

Table 10: Factors affecting choice of kerosene as energy source

Coefficients [a]

Model	Un standardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B	
	B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound
Level of education of HH	0.042	0.019	.0168	2.187	0.029	0.004	0.080

a. Dependent Variable: Household using kerosene as sources of energy for cooking

5.4 Factors affecting the households to use cooking stoves

Multiple-regression of cooking stoves showed that factors such as availability of firewood, income of the house hold, fuel type, house ownership and family size are significant to determine the type of cooking stoves used by households. Regarding cooking stoves for making *Wet*;

availability of firewood, the amount of money spent on firewood and occupation of the HHH are those significant factors in study area as shown below.

Table 11: Factors affecting the use of *Injera* cooking stoves

Coefficients [a]

Model		Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B	
		B	Std. Error	Beta	T	Sig.	Lower Bound	Upper Bound
1	Availability of Firewood	0.356	0.046	1.049	7.721	0.000	0.265	0.446
	HH Income	-0.284	0.029	-1.148	-9.939	0.000	-0.340	-0.228
	Fuel type	-0.120	0.019	-0.432	-6.459	0.000	-0.156	-0.083
	House Ownership	0.313	0.069	0.502	4.562	0.000	0.178	0.448
	Family Size	0.118	0.034	0.392	3.465	0.001	0.051	0.185

a. Dependent Variable: cooking stoves for *Injera*

Table 12: Factors affecting cooking stoves for *Wet*

Coefficients [a]

Model		Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B	
		B	Std. Error	Beta	T	Sig.	Lower Bound	Upper Bound
1	Availability of Firewood	0.211	0.047	0.440	4.467	0.000	0.118	0.304
	Cost of firewood	0.107	0.038	0.266	2.848	0.005	0.033	0.181
	HHH Occupation	0.059	0.024	0.162	2.469	0.014	0.012	0.106

a. Dependent Variable: cooking stoves for making *Wet*

5.5 GHG emissions from Household energy consumption

Using equation (2), the amount of GHG emitted by households can be easily calculated. Fire-wood, crop residue, sawmill residue, charcoal and kerosene are commonly used in the households for cooking. According to the given model, combined with the data from Tables 5 the amount of GHG emitted by each household can be quantitatively determined.

Table 13: Total annual CO_2-e emitted from Nekemte Town per household

Fuel Type	Amount of Fuel (Kg)	Type of stoves	Efficiency of the stoves (%)	Calorific Value(MJ/Kg)	Emitted gCO_2-e $MJ^{-1}{}_{useful\ energy}$	Annual Emitted CO_2 equivalent(g)
Fire-wood	431.502	TSF	11 - 15	16	109.7	757372.3104
	287.668	Improved TSF	24		73.9	340138.6432
Crop Residue	69.58	Improved	21	15	41.9	43731.03
Sawmill Residue	330.84	TSF	11	14.5	19.1	91626.138
Charcoal	250.44	Improved	27- 30	30	16.7	125470.44
Kerosene	30	Wick kerosene	35 - 45	43	349.7	451113
Total						1809452

Annually, about 25483 tons of CO_2-e was emitted from the town.

Fire wood and kerosene are the main sources of CO_2-e emissions from household energy use accounting for more than 86% of the total energy related CO_2-e emissions in the study area.

UNIT 6: DISCUSSION

6.1 House Hold Energy Consumption Patterns in Nekemte Town

Prior works have documented the patterns of house hold energy consumption in major cities of Ethiopia (Alemu& Köhlin 2008; Gebreegziabher 2004; Gebreegziabher 2007; Kebede et al. 2002; Samuel 2002). In this study, we assessed the current household energy consumption of Nekemte town and factors affecting the pattern and its implication. Cooking with biomass is almost ideal in the surveyed HHs. About 61% of the HHs used biomass for cooking *Injera* and about 84% of the HHs used biomass for making *Wet*. This finding is lower than what have been found in Jimma (Degnet 2007) and larger than that of Woraeta town (Asres 2012) and Addis Ababa (Asfaw & Demissie 2012).This discrepancy may be attributed to the unavailability of firewood in the study area and the dissemination of improved stoves elsewhere in Woraeta town and overall increased consumption of modern fuel in Addis Ababa. Reluctance to discontinue cooking with fuel-wood may also be due to taste preferences and the familiarity of cooking with traditional technologies (IEA 2006).

6.2 Factors affecting Household Energy

Research into the area of energy consumption has demonstrated that socio-demographic variables such as income, household size, age can be highly related to household energy use (Abrahamse & Steg 2011).The recent result from (Alem et al. 2013) shows that households' economic status, price of alternative energy sources, and education are important determinants of fuel choice in urban Ethiopia. Cooking is an important end-use in which one finds strong and often highly specific fuel type preferences.

6.2.1 Choice of fire wood

In the analysis for households using fire wood as a source of energy for cooking, by using the independent variables such as: cost of firewood, family size, availability of firewood, house ownership and household having an electric meter are those variables significantly influencing the use of fire-wood as energy source and (Table 8) which is in line with research done in

Jimma(Degnet 2007). Family size is positively significant to affect the choice of firewood as a principal energy carrier. This is in line with the studies done in Woldia Town, North Wollo Administrative Zone, Ethiopia (Worku 2004) and in Kalisizo Sub-County, Central Uganda (Godfrey et al. 2010) showed that household family size and the firewood consumption were related. Generally, large household family size is naturally expected to increase firewood consumption because of increased energy demand. Moreover, the result was consistent with (Song et al. 2012) household wood energy consumption was influenced primarily by household size and level of income in urban areas. This implies that more fuel energy is consumed to accommodate more cooking for the members of the household and Injera making and with the rise of income levels, energy consumption increases.

Availability of firewood was positively significant ($p<0.05$) which implies that HHs who had access to get firewood were more likely to increase their usage of firewood. According to (Barnes et al. 2010) increase in the cost of fuel-wood($p<0.005$) decreases biomass consumption in Bangladesh but in case of Nekemte town the cost of firewood and the choice of firewood are positively related. This revealed that the consumption of firewood for cooking increases even though the cost of firewood is high. The discrepancy is attributed to different socioeconomic factors between the two countries. But, it appears that fuel preferences for cooking is an important influencing factor for continuing use of biomass energy of the households despite the accessibility to other energy sources. This finding is in line with what have been found elsewhere. For example, it was reported that households in Northeast Thailand, regardless of their extent of urbanization, strongly prefer to use firewood or charcoal for long cooking time and more of cultural preference (Nansaior et al. 2011). Income and level of education of the household head affect the pattern of household energy consumption. This finding is consistent with earlier findings; Ajao A.O 2011 found that irrespective of the educational status of the household heads, economic status was important in determining the choice of energy made by households in Ogbomoso metropolis in Nigeria. Conventionally, illiterate household heads are expected to have limited understanding of some environmental and health hazards that are associated with charcoals and fire-wood usage. They are also likely to have lower income. And growing incomes in conjunction with other socio-economic factors are seen as determining factors for the households fuel switch and choice toward cleaner energy sources(Barnes et al. 1994; IEA 2006; UNDP 2006). House ownership and having own electric meter (*Qoxari*) possibly limited the households to use firewood as energy source; this may be due to a fact that those HHs cannot use electric energy for cooking from neighboring HHs, as HHs those who have not *Qoxari* complained during survey. This is in line with a study done in Jimma(Degnet 2007) found that non-home owners would be restricted to rely more on traditional fuels than homeowners do.

6.2.2 Choice of charcoal

The variable cost of charcoal had the smallest impact which is negative(-0.200) (Table 9), indicating that more monthly expenditure on charcoal will decrease the likelihood of using it as fuel because high cost of the charcoal will make households to switch to other energy sources. Similarly, it may also indicate scarcity of charcoal due to ever increasing local deforestation from cutting trees for charcoal production as revealed by (Girard 2002) in Africa or higher tendency of HHs switching to more clean energy sources. On the other hand, the variables availability of firewood and income of house hold are positively significant ($p<0.005$) and again strongly affect the consumption of charcoal as a source of energy. In case of the availability of firewood; it implies that as the length of distance to get firewood increases, the more the likelihood of HHs to use charcoal for cooking. Family size is positively significant ($p<0.001$); this may be due to the fact that the larger the family size, the more energy used by HHs to satisfy the basic need of energy for cooking in addition to other sources. The result thus corroborated that of other recent studies. Farsi et al. 2006;Mekonnen & Köhlin 2008 showed that several factors such as income, price, education of the household head are found to be important in determining household fuel choice in urban households of India and in major cities of Ethiopia. This may attributed to better education of the household members increases the aware of energy scarcity and households are more likely to choose charcoal as back-up or supplemental use to other fuel types. And HHs having own electric meter (*Qoxari*) is positively significant ($p<0.001$) implying that having not own electric meter (*Qoxari),* HHs consumed more charcoal to fill their energy needs. Similar study done in Woldia, North Wollo Zone (Worku 2004) revealed that households who did not have their own electric meter impeded from using the electric services, as they demanded and limited to less efficient fuel sources like biomass.

6.2.3 Choice of Kerosene

Level of education of HH was positively significant CI (0.004, 0.080), $p<0.05$), which implies that the educated people were more likely to increase their usage of kerosene. This is consistent with the study done by (Mekonnen & Köhlin 2008) probing in their study conducted at seven major cities of Ethiopia, association between demographic indicator and fuel use pattern reveals that, households with a more educated member were more likely to have non-solid fuels as their main fuel. This may be better education of the household head increases the awareness of households of the negative health impacts associated with the use of firewood and charcoal, and also the advantages of modern fuel use such as kerosene, in terms of efficiency and convenience (Table 10).

6.3 Factors affecting households' cooking stoves use

The reasons for choosing different energy types include ease of handling, as well as relative costs and the availability of fuel types and convertors.

The availability of firewood was positively significant CI (0.446, 0.265), $p<0.05$), the availability and accessibility of energy supplies are major contributing factors to fuel choice and hence energy convertors as shown in (Bereket and Ikhupuleng 2002). For instance, biomass stove use is prevalent in rural regions of the developing world, particularly in places where traditional fuels are available locally as in indicated by(Fitzgerald et al. 1990). Scarcity of traditional biofuels strongly affected energy use and household welfare. As the distance to get firewood increased the HHs had preferred to avoid the use of TSF. Income of the household CI (-0.228, -0.340), $p<0.05$), was significantly affecting the type of energy convertor used. The negative sign of standardized coefficient indicated that HHs earned more income prefer modern cooking stoves such as kerosene stove and electric *mitad*. This implies that household status also influences household energy use patterns. Evidence shown by (Gebreegziabher 2010; Masera et al. 2000) in Ethiopia and rural Mexico, modern stoves play a role as ‘‘status symbols’’ and purchasing them is perceived as parallel with higher social status. The type of fuel used was another factor that determined the choice of energy convertors. Even when energy devices are affordable, people may still not prefer them due to their incompatibility with their existing energy service condition.

And (Barnes et al. 2005) note that service availability and the initial cost of service is far more important than monthly electricity payments or the income level of consumers.

6.4. Implication of Household energy consumption in Nekemte town

One of research questions of the study is to show household energy consumption of Nekemte town as the socio-economic characteristics of the households and the environment. Household energy consumption is not in itself a cause for concern for example biomass consumption. However, when resources are harvested unsustainably and energy conversion technologies are inefficient; the way in which resources are used to provide energy services — cooking, heating and lighting— often has a serious impact on health, economic productivity and the environment particularly in developing countries (IEA 2008; WEO 2006).

6.4.1 Environmental Implication of Household energy consumption

Inefficient and unsustainable cooking practices can have serious implications for the environment, such as land degradation and local and regional air pollution. Biomass takes up to almost 61% for cooking *Injera* and 84% for making *Wet* in the town. As high as 19% of the surveyed households collected biomass fuels from forests to gain necessary energy.

So, from household energy consumption pattern of households in Nekemte it can be easily concluded that, the household energy consumption of the town is one of the major contributors of deforestation in East Wollega. Sources of household energy in the study area clearly shows that heavy dependency of households on biomass energy for household cooking. According to(ORSSPIP 2002), therefore, sources of household energy in the study area has been contributing for the deforestation of the nearby forests and wood lands.

About 250.44 Kg of charcoal consumed on average at household per year. The annual charcoal consumption obtained from the result of this study is slightly higher than the average consumption of urban households in Zambia, which according to (Mulenga 2002) is about 490.8kg and lower than Ogbomoso households in Nigeria, which according to (Ajao A.O 2011) is about 556.8kg. Findings from this study reveals that the average household size in the study area is approximately 5 persons, and the population of the study area is 84506, these two figures give an approximated number of the households in the study area as 14083. Using this number of household annual charcoal consumption rate given above, the total annual charcoal consumption in the area is estimated as 3527 tons. And going by (VanAsperen 2001) conversion ratio of 50,000 tons of charcoal equivalent to 16,600 hectares of forest, about 1171 hectares of living and standing forests are removed annually to fill the energy need of the HHs found in Nekemte town from charcoal alone. The production of a kg of charcoal requires about 6-12 kg of dry wood. Unless and otherwise regulated or shifting to more cleaner energy sources occurs, house hold energy consumption particularly from traditional energy sources such as firewood and charcoal is contributing to the ongoing deforestation as a deriving factor.

Furthermore, like in other developing countries in Ethiopia (Zenebe 2007) this process induces tremendous environment degradation, such as deforestation, soil erosion and desertification and some other health impact and social impact, such as time and trip to get firewood in study area.

The (ORSSPIP 2002) supports the above statement. East Wallaga Zone which has an area of 2,227,036 hectares, and of this about 72,726 hectares is woodland and forest covered, found mainly in the valleys of the Abay and Didessa. The remaining areas of Zone are covered with cultivation. According to the report 3.26% of the total area of East Wallaga was covered by forests and wood lands only 23 to 25years before. But now, according to the same report, mainly because of agricultural expansion and fuel wood consumption 52.4% of the forest was lost, the remaining forest and wood land is only about 1.71% of the total area of the East Wallaga Zone. Nekemte Town is the capital city of East Wallaga Zone with large population size therefore; the contribution of the HHs of Nekemte town toward environmental deterioration is much.

The same source clearly shows that fuel wood stocks are relatively plentiful but are being harvested well above their sustainable yield in East Wallaga. Fuel wood is becoming scarce in many parts of the area. However, little or no agricultural residues and dung are being used as fuel but huge amount of sawmill residue was used. This may be attributed to the ever increasing deforestation in East Wallaga in general(ORSSPIP 2002).

With annual per HH consumption of 719.17 kg fuel wood, and the total households of the study area is about 14083; about 10128tons of fuel wood is consumed per year in Nekemte Town.

Furthermore, to assess the deforestation situation of the study area in recent years, the researcher tried to find out time traveled to collect fire wood at the time of data. From the surveyed households who collected firewood, 11(2.7%) acquire their domestic energy through both collection and purchasing and the remaining 324(78.3%) of the households acquire their domestic energy through purchasing.

At the time study, most household members who acquired firewood through collection (52.2%) traveled about 1.16 - 2.15hours and the rest 43.3% traveled more than 2.15 hours a day to collect firewood for domestic cooking or backing. They also claimed that distances to get firewood increasing from time to time years before. Access to fuel-wood is problematic in many places, either because of its cost or because of the time and effort required to collect it as revealed by (Masera et al. 2007) using data from household energy use in Mexico. Therefore, in addition to other factors such as charcoal production, agricultural expansion the ever increasing deforestation of the study area has been contributing a lot for additional time to collect fuel wood and other biomass sources of energy. The scarcity of firewood in study area was eminent from the average distance travelled by collectors in search of firewood. Moreover, this indicates that either accessibility of forests is poor or households are switching to lower-grade fuel sources viz., sawmill residue, crop residue. The result showed that about 24.1% of the total weight of biomass fuels consumed was saw-mill residue in the study area. The higher amount of consumption of saw-mill residue in the Nekemte town signifies the fuel wood crisis in the area, with the depleted forest resources in and around the town.

Therefore, currently inefficient household energy use in Nekemte town puts great pressure on the resources and environment.

The products of incomplete combustion(PICs) emitted from the cooking stove share the larger portion of energy-related emissions in terms of total GWP (in CO_2 equivalents) comprising 31% over a 100 years-time frame(IPCC 2006). The study showed that currently about 25483 tons of CO_2 equivalent is released to the atmosphere. The largest emission rate of CO_2 equivalent was from households using TSF with 10661tons, followed by kerosene stove 6351tons and the least emission was from charcoal and crop residue with 1760 tons and 620 tons respectively. This is consistent with previous findings(Bhattacharya & Salam 2002). This implies that the inefficient TSF was contributed to not only higher consumption of biomass fuels but also emission of

GHGs. The reason for this counterintuitive outcome is that household stoves generally burn biomass fuel very poorly. Solid biomass fuels burned in small scale combustion devices do not adequately mix with air, thus they give off many products of incomplete combustion (PICs) (Kammen et al. 2001; Smith et al. 2000).Though kerosene stove is more efficient, still kerosene stove was highly contributing to the emission of GHGs and health damaging pollutants. Emission of pollutants from the use of biomass fuels depends on the quantities of the fuels consumed. Also, TSFs being small and simple devices cause much higher pollution per kg of biomass fuel used compared to other energy devices. Evidences from studies assumed that large quantities of carbon dioxide (CO_2) are emitted from these stoves(IPCC 2006; WHO 2006). Due to the increased population growth and repeated fragmentation of forests, biomass fuel cycle in developing countries is unsustainable (Smith et al. 2000) which leads to increased collection of fuel wood from village forests and consequent deforestation.

6.4.2 Socio-economic Implication of Household energy consumption

The pattern of household energy consumption also have impacts on social aspects of human beings in developing countries (Bruce et al. 2002; Smith et al. 2000). Nekemte town is not exceptional. Adoption of the improved wood *mitad* and charcoal stoves, as well as the electric *mitad* and kerosene stove all contribute to a reduction in the burning of biomass fuels as well as to reduce health risks from smoke inhalation(WBISPP 2005). According to the results from the survey in Nekemte, approximately 61% of the cooking stoves are biomass stoves(three stone fires and modified TSF) without chimney that are used by the HHs in order to burn biomass for cooking food items. As a result high concentrations of CO, NO_2, and other toxic gases are released to the ambient environment, which can cause chronic discomfort, respiratory problems, allergies, and skin and eyes diseases (Smith et al. 2000). TSF alone contributed about 47 % of CO_2-e emitted from the HHs. On aggregate, about 75% of the total CO_2-e emitted from the combustion of biomass fuels (firewood, charcoal, sawmill residue and crop residue) implying that households who used dominantly TSF and biomass stoves are at the most vicinity to the effect of emission of GHGs particularly from the indoor air and health damaging pollutants.

The current dominant pattern of household fuel-wood use presents several problems. As shown, households depend mostly on open fires, leading to very high indoor air pollution (IAP) levels.

Particularly, women and children suffer most from indoor air pollution because they are traditionally responsible for cooking and other household chores, which involve spending hours by the cooking fire exposed to smoke(IEA 2006). The finding revealed that among the members of the house hold about 47% children were much closer to the stoves and fire locations. Based on the interviews with the households and filling answers of the questionnaires, the average time that the biomass energy or the time spent in kitchen used is about 3hrs per day, especially in the morning and in the evening for food preparation which was in line with a study done (Kebede 2002). In his study in the rural communities of Jimma, (Kebede 2002) showed that women and children are exposed to particulate matter and harmful gases in the home whenever a fire is lit for cooking or brewing where the common domestic energy sources used for cooking and heating in all houses surveyed were biomass fuels such as wood, cow dung, leaves, corncobs, etc.

The study showed that energy use in households, especially for cooking, comprises a large proportion of the total energy use in Nekemte town and also contributes significantly to problems of environmental pollution. Many households relied on solid biomass fuels such as fire-wood, charcoal, sawmill residue, crop residue, as their source of cooking energy. In particular, the burning of biomass energy, such as wood and dung, in polluting and inefficient stoves, results in indoor air pollution and is a major health hazard (Bruce et al. 2002; Pachauri 2007; Smith et al. 2000) in developing countries like India. The households found in the study area are not exceptional.

Households in the study area showed the use of multiple fuels as the socioeconomic factor like income increases as shown by (Mekonnen & Köhlin 2008) in major cities of Ethiopia households have limited options for fuel, as well as stoves to bake *Injera* and in Mexico (Masera et al. 2000) households generally used more fuel types as their incomes increased, instead of completely switching to another fuel type. Such behavior is associated with the fact that while households were more likely to afford to buy additional cooking stoves if new fuel types required them, there were also various other reasons to do so, including preferences for a particular fuel type used for a particular type of food, for a particular time or occasion, for convenience, or due to uncertainty about the supply of a fuel type.

UNIT 7: CONCLUSION and RECOMMENDATION

7.1 Conclusion

Households require energy for cooking, lighting, heating and cooling different items. Most households in Ethiopia largely depend on biomass energy sources for household energy consumption.

Household energy consumption in Nekemte town primarily depended on biomass energy (especially firewood), which is unsustainable due to environmental effects and energy supply constraints. Almost 61 % of the households use biomass energy. In addition, low-efficiency traditional biomass energy was used for cooking, and firewood was often burned directly or indirectly in the fields. These practices wasted resources and polluted both indoor and outdoor environments.

The household energy consumption pattern of Nekemte town presented in this study has demonstrated the significant link between day-to-day household energy consumption and household energy driving factors such as socio-economic and demographic characteristics (including family size, occupation, education level of household head, house ownership, income of house hold, having own electric meter) of the households, availability of firewood, cost of firewood and their implication on the environment.

Analysis of questionnaire data and interviews revealed that the income of house hold, family size, having own electric meter are some of the variables highly influence fuel and stove choices. Further, more emphasize could be put on the forces that drive fuel choices and stove choices of the household for a better understanding of its implication.

Quantification of the factors that affect the pattern of household energy consumption would allow for a better understanding of its implication.

The heavy dependence and inefficient utilization of biomass resources for household energy consumption have resulted significant depletion of the forest resources in the study area though regarded as one of the forested areas of the country in the past.

7.2 Recommendation

The results of this study have important policy implications because they suggest the need to focus on such factors in policy design. Perhaps, factor like having own electric meter should be get more attention while policy making. For example, these results are important for implementation of the United Nations Millennium Project, which recommends halving the number of households that use traditional biomass for cooking by 2015.

It is also important to consider cleaner cooking stoves and alternative energy sources utilization.

Finally, the importance of understanding the determinants of fuel choice and cooking stoves can provide the information that policy makers can use to reduce the pressure on biomass resources and reduce the human health effects of household energy consumption.

Further studies have to be conducted to examine these issues to find out how important they are for similar smaller towns in Ethiopia.

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Annexes

Calorific values (Energy Contents) of Domestic Fuels types (MJ/Kg)

Fuel Type	Calorific Value/Energy content
Wood	16MJ/Kg
Crop Residue	15 MJ/Kg
Sawmill Residue	14.5MJ/Kg
Charcoal	30 MJ/Kg
Kerosene	43 MJ/Kg
Weight	
1 Kwh	3.6 MJ
1 Kwh	1000Watthours

The annual estimated amount of fuel type consumed at household level

Type of energy source	**Minimum**	**Maximum**	**Mean**	**Std. Dev.**
Firewood (Kg)	288	1260	719.17	190.32
Charcoal (Kg)	84	432	250.44	81.84
Crop Residue(Kg)	58.89	80.27	69.58	5.38
Sawdust(Kg)	288	396	330.84	33.12
Kerosene (L)	24	48	30	10.44
Candle (Kg)	0.12	0.84	0.324	0.144
Electric Power (KWh)	172.8	3984	1363.8	1237.58

Questionnaire

Jimma University College of Public Health and Medical Sciences, School of Graduate Studies, Department of Environmental Health Science & Technology

Questionnaire for assessing the implication of house hold energy consumption patterns on the socio-economy and the environment in Nekemte town, 2013

Dear Householders, My name is Girma Guluma; I am here on behalf of Jimma University. You have been selected to participate in the study designed to collect information on Household energy consumption and its implication on socio-economic and environment in Nekemte town. As a result, I kindly ask you to share me your opinion and experiences. Your genuine cooperation is very important, because you represent many other householders who have similar experiences. The genuine response you provide is highly valuable and determines the effectiveness of this investigation. I hope that the outcomes of the research contribute a lot.

Thank you for your co-operation!

Name of data collector ___________________________signature ___________date _________

Part I- Demographic and Socio-economic Information

S. No Questions

101. Name of household head (optional) ___________

102. Age of the household head (years) ________

103. Sex A. Male B. Female

104. House ownership A. Private B. Rented

105. Household family size

A. 1 B. 2 C. 3 D. 4 E. 5 F. 6 G. 7 I. 8 H.9

106. Household family composition : Number of male ______ Number of female______

107. Level of education of household head

A. Never to schooling B. Primary School C. Secondary school

D. College Diploma E. First degree F. others, specify______

108. Occupation A. Unemployed B. Daily laborer C. Employed

D. Merchant E. Others, specify_____

109. Estimated monthly income of the HH in birr____________

110. Religion: A. Orthodox B. Protestants C. Muslim D. others, _____

Part II- Questions on Energy used for cooking

201. What is the type of food you usually cook? A. Injera & Wet B. others (please specify),

202. How many times do you cook Injera per week? A. 3 times B.4 times C. 5 times

203. Please specify your reason for question no.202 above

A. fuel is expensive C. due to the size of your family

B. fuel has scarcity of supply D. Income E. nature and time of my job

204. At what time do you cook Injera? A. morning B. afternoon C. evening

205. Please specify the reason_____________________________

206. What type of energy source do you use for baking injera?

A. Fire wood B. Agricultural residue C. Electricity D. cow dung E. Sawdust

207. How many times do you cook wet per day? A. 1 B. 2 C. 3 D. do not cook

208. Please specify the reason for question no.207 above. _____________

A. Fuel is expensive C. due to the size of your family

B. Scarcity of Fuel D. In come E. habit of my job and time

209. At what time do you cook wet? A. morning B. afternoon C. evening

210. Please specify the reason______________________

211. What type energy source do you use for making *Wet*?
A. Fire wood C. Agricultural residue E. biogas G. LPG
B. Charcoal D. Kerosene F. Electricity
212. Do you make coffee and tea? A. Yes B. No
213. How many times do you make coffee per day?
A.1 B. 3 C. more than 3 D. do not make
214. Please specify the reason for question no.213
A. Fuel is expensive C. due to the size of your family
B. scarcity of Fuel D. Income E. nature of my job and time
215. At what time do you prepare tea or coffee? A. morning B. afternoon C. evening
216. Please specify the reason_________________________
217. What types of energy sources do you use for making Coffee and tea?
A. Fire wood C. Agricultural residue E. Biogas
B. Charcoal D. Kerosene F. Electricity
218. Do you buy or collect fire wood? A. buy B. collect C. Both
219. How much a bundle of firewood costs if you buy it? ________
220. How much a bundle weighs? ________
221. If you collect the firewood, from where?
A. from forest B. from own farm land C. others (specify), _______
222. The fire wood is collected by
A. Mother B. Sister C. Servant (female) D. Father
223. How much does it take to get the firewood? A. In Kilometer______ B. In Hours____
224. What do you think about the trips to get the firewood from the forest?
A. It is the same as in the past B. It is increasing from year to year
225. Do you have a separate kitchen? A. Yes B. No
226. Are the family member stays with you during cooking? A. Yes B. No
227. If you choose 'Yes', who are they?
A. Small children B. the whole family C. Elders D. other females
228. How long do you stay in kitchen per day? A. 1-3 hrs B. 5-6 hrs C. others, __
229. How ventilate is it in square meter? A. Less than 5 B. 6-10 C. 10-15 D. Above 15
230. What kinds of stoves do you use for firewood? A. Open TSF B. Improved stoves
231. How much bundle of firewood do you use with your stove per day?
232. Do you have an electric meter (Qoxari)? A. Yes B. No
233. If you choose 'No', please specify the reason____________________
234. Do you use electricity for cooking? A. Yes B. No
235. If you choose 'yes', for making what?
A. cooking wet B. Cooking Injera C. re-heating cooked wet D. Preparing coffee
236. If you choose 'No' for question no. 244, why?
A. not convenient B. not reliable C. do not have electric stove
237. Do you use agricultural waste for cooking? A. Yes B. No
238. If you choose 'yes', what are they? A. Maize straw B. Sorghum straw C. others,
239. How much bundle of the agricultural waste do you use to cook the food per day?
A. 1- 3 B. 4 - 7
240. How much a bundle weighs, in kilogram? ____
241. From where do you get the agricultural wastes? A. buy B. collect
242. How much a bundle of agricultural wastes costs if you buy it? _____

243. Does the agricultural waste convenient to use? A. Yes B. No
244. If you choose 'Yes', for what kind of food? _____________
245. If you choose 'No', please specify the reason
A. Not available B. Bulk to collect C. Others, _____
246. What other options do you use for cooking? A. Kerosene B. Biogas
247. If kerosene, how much per week in litre? A.1- 2L B.3- 4L C. 5-8L
248. How much a liter of kerosene costs you? _________________
249. What kind of food do you cook with kerosene? _________________
250. What kind of kerosene stoves do you use? A. Wick type B. Pressure
251. Why do you use to cook with kerosene? _____________________________
252. Do you use charcoal for cooking? A. Yes B. No
253. If you choose 'yes', from where do you get the charcoal? A. I buy it B. I prepare it
254. If you choose 'yes', how much charcoal do you buy per week in sacks?
A. 1 B. 2 and above
255. If you choose 'No' question no266, please specify the reason_________________
256. How much does it cost you for a (Kg /sack) of Charcoal? _______
257. For what purpose do you use charcoal? _____________
258. For what kind of food does using charcoal is convenient?
A. cooking wet B. making coffee and tea C. others, _____
259. What type of stoves do you use to cook with charcoal?
A. ordinary charcoal stoves B. improved charcoal stoves
260. What is the other use of kerosene? A. lighting B. to ignite fire C. others, _____
Part-III: Questions on Energy for Lighting
301. What do you use for lighting?
A. Fire wood B. Kerosene C. Electricity D. Candle
302 Do you have wick lamp? A. Yes B. No
303. How many wick lamps (Fanos, Kuraz) do you have? A. 1 B. 2 C. 3
304. For how long per day (in hour) do you use) wick lamps? A. 1- 3 hours B. 4-5 hours
305. For what purpose do you use wick lamps (Fanos, Kuraz)?
A. As of electricity failure B. to start the fire to cook C. Others (specify) __
306. If you choose electricity for no.301, how many bulbs do you have?
A. 2 B. 3 C. 4 D. 5
307. Which type of an electric bulb you have? A. compact fluorescent B. incandescent
308. Please specify the reason for your choice ______________________
309. How long do you use per day (in hours)?
310. What type of fuel do you use when there is failure of electricity?
A. Candle B. Kerosene C. Firewood
311. Please specify the reason for your choice ______________________
312. How much do you pay per month for electric energy? In KW_____, In Birr______
313. Do you have a refrigerator? A. Yes B. No
Part IV- The types of cooking stoves and appliances they use
401. Which type of appliances you are using for cooking Injera?
A. Three stones open fire B. MirtMitad/Midija C. Electric stoves/mitad
402. Please specify the reason for your choice ________________________
403. If you failed to choose Mirt Mitad/Midija& Electric stoves/mitad, why?
A. I can't afford B. not friendly and not easily utilized C. Not recognized well

404. Which type of utensils you are using for making wet? A. Shekla Dist B. Biret Dist
405. Please specify the reason for your choice ___________
406. Which type of stoves you are using for making *Wet*?
A. Three stones open fire C. Kerosene stove (Buta gas
B. Charcoal stove (Keselmandeja) D. Electric stove
407. Please specify the reason for your choice ________________________

Gaaffiiwwan Afaan Oromootiin (Afaan Oromo Version)

Gaaffii waa'ee miidhaan itti fayyadama annisaa mana-jireeynaa haariiroo naannoo fi haalaa jireenyaa dhuunfa magalaa Naqamteee irratti qabu adda baasuuf qophaa'e dha

Maqaankoo _______________________ kanan jedhamu Yuunversiittii Jimmaatti Kolleejjii Saayinsii Fayyaa Hawaasaa fi Medikaalaatti dippaartimentii(kutaa) Saayinsii Naannoo bakka bu'uudhaan. Kaayyoon qorannaa kanaa haalli itti fayyadama annisaa mana-jireeynaa magalaa Naqamtee maal akka fakkatu hubchuuf dha .Gaaffii kana keessatti hirmaachuun keessan bu'aa qabatamaa jiru kan nu agarsiisuu fi rakkoo jiru foyyeessuuf baayee nu gargaara. Gaaffii kana keessatti hirmaachuun guutummaa guutuutti fedhii irratti kan hundaa'eedha.Gaaffii deebisuu hin barbaadne irra darbuu ni dandeessu garuu, hirmaannaa keessaniif isin dinqisifanna,Gaaffiin isiniif hin galle yoo jiraate na gaafachuu dandeessu. Kanaafuu, akka hirmaattaniif kabajaan isin gaafanna.

Maqaa nama odeeffannoo funaanuu________________Mallattoo_________Guyyaa________
Maqaa Nama to'atuu________________mallattoo________________guyya

Kutaa- I Gaaffiwaan Haala hawaasummaa

101. Maqaa Abba/hadha warraa_____________________________
102. Umurii_______________
103. Saala A. Dhiira B. Dhalaa
104. Abbummaa mana jireenyaa A. Dhunfaa B. kiraayii
105. Baay'ina maatii A. 1 B. 2 C. 3 D. 4 E. 5 F. 6 G. 7 H.8 I. 9
106. Haala baay'ina miseensa maatii : Baay'ina dhiiraa _____ Baay'ina dhaltuu_____
107 .Sadarkaa barnoota
A. Kan dubbisuuf barreessuu hin dandeenye C. Kan barate/baratte yoo ta'eef, kutaa meeqa____________
B. Kan dubbisuu fi barreessuu danda'u
108 Hojii A. kan hojjii hin qabne C.hojjaataadha E. soorama kan ba'e
B. hojjataa guyyaa D. daldalaadha F. kan biraa yoo ta'e ibsi___________
109. Galiin keessan ji'a giddu galeessan hagam ta'a? (qarshiidhaan)_____________
110. Amantii A. Ortodooksii B. Protestantii C. Musliima D. Kan biroo

Kutaa- II Madda annisaa for nyaata qopheessuuf

201. Nyaata kamiin yeroo baay'ee qophessitu? A. Buddenaa fi Ittoo B. Kan biroo(ibsi_______
202. Torbanitti buddeen ala meeqa toshitu? A. 3 B. 4 C. 5
203.Sababaa deebii gaaffii 202 ibsi
A. Boba'an qaalii dha C. Baay'ina maatii koo E. Haala hojii kiyya
B. Hir'ina dhiyeessi boba'a D. Xiqqachu galii koo
204. Yeroo kam buddeen toshita? A. Ganama B. Waree booda C. Gara galgalaa
205. Sababaa deebii 204f ibsi_______________________________
206. Buddeen toshuuf madda humna kamiin fayyadamtu? A. qoraan B. Hoffaa C. Humna ibsa D.Dikee loonii
207. Guyyaatti, ittoo ala meeqaa tolchitu? A. 1 B. 2 C. 3 D. Hin tolchu
208. Maaliif, gaaffii 207f?
A. Boba'an qaalii dha C. Baay'ina maatii koo E. Haala hojii kiyya
B. Hir'ina dhiyeessi boba'a D. Xiqqachu galii koo
209. Yeroo kam ittoo tolchita? A. Ganama B. Waree booda C. Gara galgalaa
210. Sababaa deebii 209f ibsi_______________________________
211. Ittoo toshuuf madda humna kamiin fayyadamtu?
A. qoraan C. Hoffaa E. Biogas G. LPG
B. kasala D. Gaazii adii F. Humna ibsa

212. Buna fi shaayii ni daffistu? A. Eyyee B. Lakii
213. Guyyaatti ala meeqa danfistu? A. 1 B. 3 C. 3 ol D. Hin danfisu
214. Sababaa deebii 213f ibsi________________________________
A. Boba'an qaalii dha C. Baay'ina maatii koo E. Haala hojii kiyya
B. Hir'ina dhiyeessi boba'a D. Xiqqachu galii koo
215. Yeroo kam buna danfistu? A. Ganama B. Waree booda C. Gara galgalaa
216. Sababaa deebii 215f ibsi________________________________
217. Buna danfis uuf madda humna kamiin fayyadamtu?
A. qoraan C. Hoffaa E. Biogas
B. kasala D. Gaazii adii F. Humna ibsa
218. Qoraan eessaa argatta? A. Nan bita B. Nan funaana
219. Yoo ni bitta ta'e, ba'a 1 meeqaan bitta?
220. Ba'an 1 hangam ulfaata?
221. Yoo ni funaanta ta'e, eessa argatta? A. Bosona B. Oyiruu koo irra C. Kan biroo,_________
222. Eenyutu funaana? A. Harmee B. Obboileetti C. Hojjeettuu D. Abbaa
223. Qoraan argachuuf hangam deemtuu? A. KM dhaan _______ B. Sa'aatii dhaan______
224. Haala fageenya qoraan argachuuf, maal fakkata? A. akkuma durii dha B. Yeroodha yerootti dabalaa jira
225. Marbeetii Mana irraa addaan qofatti qabdu? A. Eyyee B. Lakkii
226. Miseensi maatii biroo si waliinMarbeetii turuu yeroo nyaatni bilchaatu? A. Eyyee B. Lakkii
227. Yoo turuu ta'e , eenyuufa dha? A. Da'imman B. Maatii hunda C. Manguddoo D. Kan biroo
228. Sa'a meeqaaf Marbeetii keessa turtu? A. 1 – 3 B. 5 - 6 C.kan biroo
229. Qilleensi hangam mana keessa naanna'a KM^2? A. 5 gadi B. 6 -10 C. 10 – 15 D. 15 ol
230. Qoraan bobeessuuf Geemmii kamiin fayyadamtu? A. Geemmii 3 B. Geemmii ammayyaa
231. Qoraan ba'a meeqa fayyadamta, Geemmii keetiin?
232. Qoxaarii Elektrikii qabdu? A. Eyyee B. Lakkii
233. Maaliif hin qabdu?______________________________
234. Humna Elektrikiidhaan nyaata ni bisheesita? A. Eyyee B. Lakkii
235. Yoo fayyadamte, maal tolchuuf?
A. Ittoo B. Buddeen C. Ittoo ho'isuuf D. Buna danfisuuf
236. Yoo gaaffii 244f "lakkii" jette, maaliif? ____________________
A. hin mijatu B. Hin amansiisuu/badu ni danda'a C. Eelee Elektirikii hin qabu
237. Balfa bu'a qonnaa(hoffaa...) nyaata bisheessuuf itti fayyadamta? A. Eyyee B. Lakkii
238. Yoo gaaffii 237f " Eyyee" jette, kami dha? A. Kan boqqolloo B. Kan bisingaa C. Kan biroo
239. Kaasuu meeqa fayyadamta nyaata tolchuuf? A. 1 – 3 B. 4 – 7
240. Kaasuun 1 hangaam ulfaata?
241. Balfa bu'a qonnaa eessaa argatta? A. Nan bita B. Nan funaana
242. Yoo ni bittu ta'e, Balfa bu'a qonnaa meeqaan bittuu?
243. Balfa bu'a qonnaa itti fayyadamuf ni mijata? A. Eyyee B. Lakkii
244. Nyaata kam bisheessuuf mijata?_______________
245. Yoo Lakkii jette gaafii 245, maaliif______
A. Hin jiru B. Funaanuf hin rakkisa C. Kan biroo______
246. Kan biroo maalitti fayaadamta? A. Gaazii adii B. Biogas
247. Yoo Gaazii adii ta'e, torbanitti litirii meeqa? A. 1- 2 B. 3-4 C. 5-8
248. Gaazii adii 1L meeqaan bitta?
249. Gaazii adiitiin nyaata gosa kamiin tolchita?
250. Buttaa Gaazii kamiin fayyadamta? A. Isa fo'a qabu B. Isa dhiibbaa qabu
251. Maaliif Gaazii adiitiin nyaata tolchita?
252. Kasala nyaata bilcheessuuf ni fayyadmta? A. Eyyeen B. Lakkii
253. Eessati argatta? A. Nan bita B. Nan qopheessa
254. Yoo nan bita jette,torbanitti madabaraa meeqa bitta? A.1 B. 2 fi ol
255. Gaafii 256f lakki yoo jette maaliif?
256. Madabaraa /Qumxee1 meeqaan bitta?
257. Kasala sababa maaliif fayyadamta?
258. Kasalli nyaata kamiin tolchuuf mijata? A. Ittoo B. Bunaa fi shayii C. Kan biroo_______
259. Kasal mandejaa kamiin fayyadamta? A. Isa durii B. Ammayyaa(Laqech,...