THE ENERGY–POVERTY NEXUS: VULNERABILITY OF THE URBAN AND PERI-URBAN HOUSEHOLDS TO ENERGY POVERTY IN ARBA-MINCH TOWN, SOUTHERN ETHIOPIA

AHMED MUSTEFA ALI[1], TEBAREK LIKA MEGENTO[2]

[1] Department of Geography and Environmental Studies, Mizan-Tepi University, Ethiopia
[2] Department of Geography and Environmental Studies, Addis Ababa University, Ethiopia

ABSTRACT

The study was conducted in Southern Ethiopia with the objective of investigating the linkages between domestic energy consumption and income poverty among households residing both in and surrounding parts of Arba-Minch town. The research design is mainly based on the quantitative methods and complemented with the qualitative ones. For the purpose of the study, 658 sample households have been selected from in and around the town based on random sampling design and the field data were collected using questionnaires, focus group discussions and interviews with relevant individuals. Data on the consumption of energy sources for this study were gathered in terms of expenditures (ETB) which were later converted to energy heat values measured in terms of MJ. The study examines the relevance of energy switching and fuel stacking models and the findings of this research provide insights for slow energy transition prospect in household energy use. The finding of the study indicated households do not simply substitute one fuel for another as household income increases. Regardless of their economic status, the majority of households depended on wood fuels as their primary source of cooking energy. The study reveals that commercial cooking fuels become increasingly expensive. It is becoming difficult to obtain affordable energy technologies that convert energy to useful services. A significant portion of urban and peri-urban households continue to suffer as their incomes have not kept pace with the rising prices. Therefore, for the majority of households, meeting the energy requirement in a sustainable manner continues to be a major challenge. Increasing end-use efficiency should be given greater emphasis as an important prerequisite by employing proper end-use technologies to change households' cooking practices so that household energy-related problems tackled and energy can lead to more equitable sustainable livelihoods.

Keywords: energy poverty, income poverty, energy switching, fuel stacking, Arba-Minch

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1. Introduction

Energy is one of the most essential inputs for sustaining people's livelihoods and without energy modern life would generally cease to exist (Clancy et al. 2003). According to the United Nations Development Program (UNDP) (2005) and Khandker et al. (2010) access to modern, sustainable, affordable, and reliable energy services is considered central not only to achieve the Millennium Development Goals (MDGs) but also to improve the quality of life and sustain the socio-economic conditions of the people.

Recently, the issue of energy access has been receiving more attention than ever before and it is recognized by policy makers as a significant factor in achieving sustainable livelihoods. In another major study, International Energy Agency (IEA) (2007) and World Bank (2011) stated that clean, efficient, affordable and reliable energy services are necessary to reduce poverty, promote gender equality, improve food security, health and education of the citizens, and enhance sustainable management of natural resources. The World Health Organization (WHO) (2011) report indicates that lack of access to convenient and efficient energy services is a major barrier to achieving meaningful and long-lasting solutions to poverty.

Cecelski (2004) asserted that despite many efforts, energy poverty is widespread, and gender inequality exits at every level of the energy sector. Similarly, Barnes et al. (2004) and UNDP (2009) stated that more people across the world are now subject to energy poverty or energy deficiency. Energy-poverty nexus exists at the household levels, where they use disproportionately more traditional biomass fuels. Garima Jain (2010) further indicated that the income poor face high burden of energy poverty as they tend to spend a larger share of their income on purchasing inefficient and harmful energy fuels.

Despite the fact that electricity consumption is likely to reach nearly all the households, the findings of this research provide insights for slow energy transition prospect in household energy use. There seems to be some evidence to indicate that number of urban households are unable to change their energy consumption from using woody biomass to modern energy fuels by installing improved cooking stoves thus, they consume less end-use cooking energy services. Still most urban households in the study area are the principal consumers of traditional fuel and are paying substantial portions of their incomes for energy. In spite of the significant household electrification program in the last few years, most urban and peri-urban households still appear not to be benefiting

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significantly from the availability of electricity. There are sudden and frequent blackouts and voltage drops which can make electricity a very unreliable source of energy for use domestically and the users find it hard to predict its availability. It is therefore likely that such limited use of conventional fuels and significant reliance on biomass fuels deter opportunities of most residents for economic and social advancement.

The main objective of this study was to explore the relationship between domestic energy consumption and income poverty among households in and around the town of Arba-Minch, Southern Ethiopia. This study therefore, contributes knowledge to the field of energy and it could be beneficial in order to signify how poorly a household is doing in meeting the basic energy needs. It analyses measures taken to alleviate energy poverty and recommends regulatory and policy measures as way forward.

2. Theoretical Considerations

IEA (2009) reveals that the various types of energy resources used for different purposes can be classified as traditional and modern ones. The term traditional energy source is used by Karekezi and Kithyoma (2005) to refer to readily available, low cost and unprocessed fuel. Clancy et al. (2003) used the term biomass fuel interchangeably with traditional fuel as biomass fuel is synonymous to 'traditional' fuel. Barnes et al. (2004) and Kahndker et al. (2010) used clean energy and modern energy interchangeably. According to IEA (2009) the modern energy sources (such as kerosene, electricity and LPG – Liquefied Petroleum Gas) are considered to be those that have a high energy density, high combustion efficiency and high heat-transfer efficiency so that they are less hazardous for health and save time and costs for their users.

There are two quite commonly-used measures of energy use: gross and end-use energy. The term 'gross energy' to refer to the amount of total input of energy that is burned for cooking regardless of the efficiency of the appliances that people use (Clancy et al. 2003),whereas the term end-use energy refers to the amount of energy effectively used to perform the task required by the end user (Barnes et al. 2004). A further definition is given by Kahndker et al. (2010) who describe useful or "delivered" energy as the energy that is adjusted for the efficiency of the appliance, technology and mode of use by the household.

The other frequently used term among energy and development specialists is energy poverty. Although the term is widely used in literature, one hardly comes across a clear definition. This concept has been increasingly debated and loosely defined (Heltberg 2005; IEA 2009; Barnes et al. 2010; and Getamesay et al. 2015). So far, many approach being used to define and measure energy poverty. For instance, Goldemberg (1990) measured energy poverty in terms of physical energy amount without considering economic aspects and identified 32.1 kilograms of oil equivalent (kgoe) per household per month as the minimum amount. While other studies (such as Pachauri and Spreng 2004; and WHO 2011) estimated energy poverty on the basis of economic or expenditure aspect. Energy poverty is at a level when households' energy expenditure is more than 10 percent of the disposable income, excluding other factors.

In exploring the changing patterns of energy use in the household, researchers such as Barnes et al. (2004), Reddy (2004), Farsi et al. (2005) and Nkomo (2007) have developed the notion of an energy switching hypothesis as a model to explain the shift between traditional solid fuels and modern non-solid fuels in order to meet household's energy needs as the household pass certain income thresholds. As noted by Treiber et al. (2015) the linear model predicts a positive relationship between socio-economic development and transition to more efficient, cleaner, and costly energy sources. The central idea of "energy ladder" hypothesis is to describe the patterns of energy usage associated with certain income levels. It prescribes income of the households to be the sole factor and it is a key determinant in the selection of a fuel and the movement towards other alternatives. It does not appropriately account for other factors that are likely to affect household energy services.

However, other studies by Masera et al. (2000), Heltberg (2005), Ntobeg (2007), Gundimeda and Köhlin (2008), Alemu and Köhlin (2008), and Kammen and Kirubi (2009) challenged the energy switching hypothesis and more concerned with fuel stacking hypothesis which shows the use of multiple fuels rather than completely switching from one fuel to another. Surveys (such as Masera et al. 2000; Farsi et al. 2005; Alemu and Kohlin 2008; and Treiber et al. 2015) provide important insights into the simultaneous use of different fuel regardless of income levels. The multiple fuel model gives a set of factors that together explain why energy diversification may be a rational option for households (Masera et al. 2000). The model proposed here gives guidance and a better understanding of the various influencing factors that need to be considered when implementing a development program associated with energy and technology (Treiber et al. 2015). The longitudinal survey conducted by Masera et al. (2000) in the region of Central Michoacan, Mexico, demonstrates the multiple fuel models rather than the energy switching scenario. They discovered that, rather than making concise transitions from fuel to fuel, or stove type to stove type, along the energy ladder, families in Michoacan often show the pattern of fuel stacking. According to them, fuel wood is very seldom replaced entirely when families adopt LPG, none of the family ceased using fuel wood even in the households that have been using LPG for many years. They concluded that multiple cooking fuel use patterns have been reported frequently in the households by taking the technical, socioeconomic and cultural aspects into consideration.

Heltberg (2004) analyzed the determinants of fuel switching using comparable household survey data from Brazil, Ghana, Guatemala, India, Nepal, Nicaragua, South Africa, and Vietnam. He argued that larger households are more likely to consume multiple fuels, both solid and non-solid. The study by Meikle and Bannister (2005) found that households in Tanzania, whether poor or non-poor, do not make exclusive use of one fuel, nor is only one fuel type used for only one activity. Instead for a mixture of practical and cultural reasons they use a mix of modern and traditional fuels. Similarly, Treiber et al. (2015) found that complete switching, where one fuel totally substitutes for another, is rare in Kenya. These writers evaluate and criticize energy switching hypothesis as it fails appropriately to account for other factors that are likely to affect household switches to modern energy services. Multifaceted demands of the households are an important driver of the diversification. Individual characteristics and social and cultural tradition influence the final choice. Households use various energy carriers, modern and traditional, and devices to secure a continuous energy supply and counteract potential access and availability issues.

This paper examines household energy consumption patterns in the light of energy switching hypothesis (Barnes et al. 2004; Reddy 2004; and Farsi et al. 2005) which explain the shift between traditional solid fuels and modern non-solid fuels in order to meet household's energy needs as the household pass certain income thresholds. Energy switching hypothesis shows a sequential change of fuels as income rises and it is used to describe the way in which households climb the ladder with increase in economic status (Khandker et al. 2010). It is wrong to assume that electricity substitutes biomass use in urban areas, in spite of the fact that there are substantial number of urban households with access to electricity. The most important issue is not electrification alone since the majority makes no use of electricity for cooking. Instead of moving up the ladder step by step as income rises, most households tend to consume a combination of fuels for cooking purpose depending on many more factors. Even the majority of higher incomes households do not currently substitute wood fuels for other conventional fuels for the purpose of baking and cooking.

Pachauri and Spreng (2004) noted that poor households spend less cash on energy than the more wealthy households, but the percentage of income the poor spend on energy is typically much greater. According to Barnes et al. (2004) and Garima (2010) urban poor spend a larger share of their income on purchasing inefficient and harmful fuels and face high burden of energy poverty. The World Bank (2011) has carried out a global survey of 45 cities and 20,000 households. It is found that poor urban households spend a significant portion (15 to 22 percent) of their cash incomes on energy because cooking with fuel wood is inefficient compared with cooking with modern fuels.Poor households in South Africa spend about 15–28 percent of their income on energy, and the poor in Arusha, Tanzania, spend as high as 40 percent of their incomes (Meikele and Banister 2005). The survey in Addis Ababa alone shows over 15 percent of the cash income of the lowest income group is spent on cooking fuel (Alemu and Köhlin 2008). Overall, there seems to be some evidence to indicate that the higher financial burden faced by the poorer households in meeting their energy needs.

The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) (2008) suggests that the reliable and efficient provision of modern energy services is a central part of the global fight against poverty. Lack of energy services is directly correlated with the major elements of poverty, and aggravates many social concerns, including inadequate healthcare, lack of education, unemployment and inequity as well as threatens the achievement of the Millennium Development Goals (MDGs). Urban centres have long been dependent on rural hinterlands for their fuel. The increasing dependence of the urban centres on rural hinterlands has a much more serious environmental consequence which has resulted in growing fuel scarcity and higher firewood prices in urban centres, thereby undermining the livelihoods of the urban poor (Barnes et al. 2004). As most towns in developing countries are growing rapidly, urban growth is paralleled by increasing demand for energy to meet consumption needs (World Bank 2011). Wickramasinghe (2007) and Garima (2010) stated energy poverty is a growing problem among low income groups residing in urban areas as they always have limited access to clean fuels.

According to Economic and Social Commission for Asia and the Pacific (ESCAP) (2008) billions of people worldwide are energy poor and require access at affordable prices to maintain a minimum standard of living. As Clancy et al. (2006) and Kammen and Kirubi (2009) noted the problem of energy poverty is found to be acute in sub-Saharan countries where modern fuels are difficult to procure. Sub-Saharan Africa has 9 percent of the world's population and consumes only 2.7 percent of world commercial primary energy. More than 80 percent of its population depends on traditional biomass as their primary energy source (WHO 2009). According to Organization for Economic Cooperation and Development (OECD) (2010) the number of new electricity connections in sub-Saharan Africa is outpaced by population growth. Electricity consumption per person in the region is only 0.9 percent (Barnes et al. 2010). Moreover, World Health Organization (WHO) (2009) estimated that over 70 percent of the population of sub-Saharan Africa is without electricity. Half of the population in sub-Saharan Africa is expected to remain without access to electricity even in 2030.

Like many other sub-Saharan Africa countries, Ethiopia depends heavily on traditional energy consumption with minimal use of modern energy sources (Zenebe 2007), hence the country is having difficulty in meeting the rapidly rising demand for modern energy (Nebiyu 2009). More than 67 million people are dependent on biomass energy to meet their cooking, heating, lighting and hygiene needs (UNDP 2009; IEA 2010). As Araya and Yisak (2012) noted for more than 75 percent of rural households and more than 57 percent of urban household, fuel wood is the major source of fuel for cooking. In spite of the improvement of level of access to clean fuels in the last few years, most urban and peri-urban households in the study area still appear not to be benefiting significantly from improved modern fuel supply availability. A substantial portion of the urban households continue to suffer as their incomes have not kept pace with the rising prices and face higher financial burden to meet their cooking demands. The energy-poverty nexus in urban areas of Ethiopia has been less studied than in rural areas although the body of knowledge is beginning to grow. Those urban studies are confined to the major cities of the country focusing on the consumption pattern mainly at a national level (Bereket 2002; Kebede et al. 2002; Samuel 2002; Zenebe 2007; and Yonas et al. 2013). Therefore, providing basic energy services to the urban and peri-urban poor is an important issue that requires far more attention from policy makers in order to alleviate poverty.

3. Material and Methods

The study area, Arba-Minch, is located at 505 km south of the capital, Addis Ababa and 275 km from the regional capital, Hawasa and lies astronomically between 06°05´N latitude and 37°38´E longitude.According to Arba-Minch Town Administration Office (2014), the town together with its peri-urban area, has an area of 5,557 hectares and an estimated total population of 104,107 with the population density of 13 people per hectare and average family size of 4.5 persons. Out of the total population, 51.81 percent are females and 48.19 percent are males. The area is one of the fastest growing urban areas in the country with annual population growth rate of 4.8 percent and a doubling time of 15 years. Currently the rapid population growth of the town is related to immigration of people from the surrounding highlands resulting in the development of squatter settlements in many parts of the town.

For primary data acquisition, this research used household survey method as the main methodological approach to collect information from selected households. Quantitative data were collected by using a cross-sectional survey of urban and peri-urban households that was carried out over three months from August to October, 2014. Structured, pre-tested and interviewer-administered

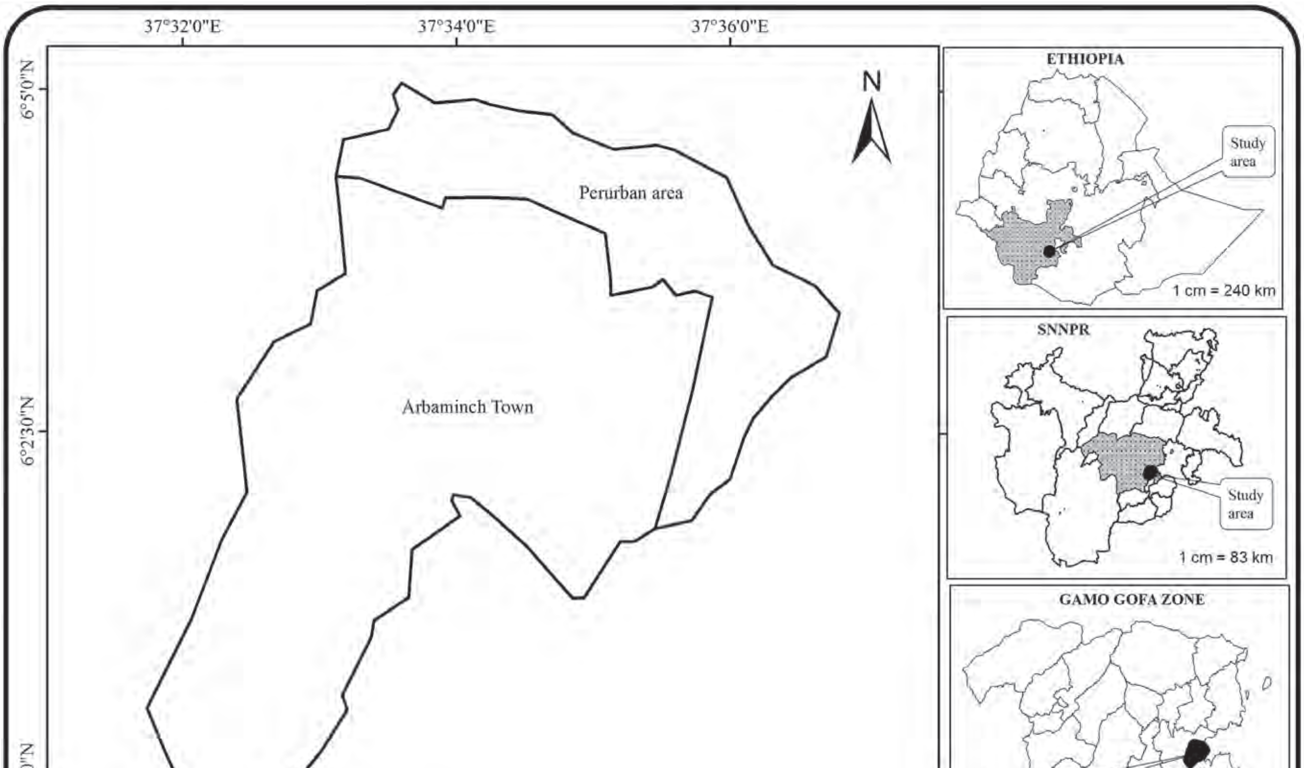

Fig. 1 Location map of the study area.
Source: Ethio-GIS, 2014.

questionnaires were used to collect such quantitative data. Qualitative data were collected using Focus Group Discussions (FGDs) and in-depth interviews.

The target population for the study was the entire urban households residing within the town and Kola-shara (peri-urban *kebele* – the smallest administrative unit under city or town administration), which was taken to be one of the sample *kebeles* with the intention to represent peri-urban area. Two-stage sampling technique was applied to select the sample households. In the first stage, sample *kebeles* (the primary sampling units) were selected purposely from the study area and then sample households (the secondary sampling units) were selected from each *kebele* randomly. For sampling purposes, the *kebele*s were categorized into two strata based on based on the dominance of the type of residential housing units. After classifying the *kebeles* into two strata, three *kebeles* from each stratum were selected. Stratum one (*kebeles* with more shanty houses) has three *kebeles*, namely, Birie, Kulfo and Kola-shara. Stratum two (*kebeles* with more of better off housing units) has also three *kebeles*, namely, Chamo, Dil-fana and Mehal-Ketema.A total of 658 sample households were selected randomly based on the list available in all *kebeles*. The number of sample households for each *kebele* is proportional to the total number of households in each sample *kebele* administration (Table 1).

4. Results and Discussion

4.1 Demographic and socio-economic characteristics of respondents

One of the most important characteristics of households that need to be considered is the size of the household and its composition. The gender composition of households reveals that MHHs (Male-headed households) are more in number (383) than their female counterparts (275). The total number of family members in the sampled households was 3,180, of which female constitutes 51.95 percent and male 48.02 percent. The majority of the sample respondents (65.96%) have reported to have between 4 and 6 family members while a few of them (21.28%) have between 1 and 3 members. On average, there are 4.83 family members in a household while the range is between 1 and 10.

Out of the total sample households, the maximum age observed from sample respondents was 68 while the minimum is 23. The majority of the respondents (41.64%) are found between 41 and 50 age range. Almost three fourth of the sample households (74.4 %) have attended formal education and are literate. Only a quarter of the total sample population (25.6%) has never attended formal education but can read and write. Regarding housing conditions, the majority of the residential units are poorly constructed and of low standard. Most of the housing units (89%) is made of mud, wood and corrugated sheets while only a small share of the residential units (11%) built using hollow blocks or concretes. With respect to dwelling ownership of the sample households, currently more than three fourth of the sample households (75.4%) live in their own houses, and 17.5 percent and 7.1 percent in rented *kebele* and private houses, respectively. Those who lacking own houses are also living in an overcrowded rooms and poor housing conditions with a serious lack of basic facilities.

4.2 Household Income and Fuel Expenditure

More than one third of the sample household heads (35.5%) are full time private and government employees and they receive much of their income from monthly salaries, whereas almost two-thirds of the participants (64.5 %) do not earn a regular income or salary. Of the total non-employed household heads, nearly a quarter of sample households (23.6%) rely on petty trade (Ethiopian Birr – One USD was equivalent to 18.75 ETB at the time of the survey) for their main source of income. Medium and higher traders occupy the next position (18.1%) followed by daily laborers (9.3%), (9.1%), farmers (7.1%), and the rest (2.5%) was pensioners. For those who engaged in farming, livestock income was quantified from sales of livestock and livestock products and crop income was quantified from the sale of all crops, including cereals, pulses, horticultural crops and other cash crops during the year. The better off households in peri-urban area continue to engage in irrigated fruit farming and normally earned their main income through the sale of fruits, particularly banana and mango. Besides fruits, some households sell a small part of their own harvest, like maize. Though a quarter of all households do not own any livestock, not even chickens, few households earned their income from the sale of livestock and livestock products, including cattle, goats and chicken.

Nearly a quarter of the households (23.25%) are earning annual per capita income of more than 8,001 ETB – Ethiopian Birr (one USD was equivalent to 18.75 ETB at

Tab.1 Household size and sample *kebeles* in the study area.

Sample *kebele*	Kolla-Shara	Kulfo	Bire	Mehal-ketema	Dilfana	Chamo	Total
Total Household size	1463	1796	1712	1346	1471	1717	9505
Sample Household size	86	132	118	98	96	128	658

Source: Arba-Minch Town Administration Office, 2014 and Field survey, 2014.

the time of the survey) a year whereas 76.74 percent of the residents earn annual per capita income of less than 8,000 ETB to support basic needs of their family members. the study revealed that almost two-thirds of the sample households (63.68%) earn mean monthly income of less than 2,000 ETB. Out of the survey households only 11.10 percent of the households were having an income greater than 3,000 ETB per month. Mean monthly income for the sample households was 2,315 ETB. The lowest monthly income for the sample households was 800 ETB, while the highest was 6,500 ETB per month. There is wide disparity in income among these groups, which can be explained by coefficient of variation of 46.48 percent.

Nearly half of the sample households (47.42%) have annual per capita income of below 5,000 ETB and belong to the low income category. About 39.36 percent were earning in between 5,001 and 10,000 ETB and belong to the middle income households, and nearly a quarter (13.22%) were having an income greater than 10,001 ETB per year and belong to high income category. Such income categorization cannot be generalized and hence is not a representation of the situation in the entire country. It may differ from region to region and from locality to locality.

As indicated in Table 2, the average monthly income for low income households was 1,517 ETB. The highest figure may go as high as 3,166 ETB and the lowest as low as 800 ETB. The average monthly income for the middle income households was 2824 ETB with the minimum income of 900 ETB and the maximum income of 5000 ETB. In the high income group, the monthly income varies from minimum income of 1,000 ETB to the maximum income of 6,500 ETB with an average monthly income of 3,570 ETB.

There are also large variations in the pattern of energy requirements across households belonging to different income classes. At the same time, as can be seen from Table 2, the average monthly expenditures of households on various types of energy differ according to income levels. The average monthly expenditure on domestic energy per household was 266 ETB for the low, 314 ETB for the middle and 302 ETB for the high income groups.

Unlike the average household monthly expenditure, per capita energy expenditures made on domestic energy significantly increases with a rise in a family income. Monthly per capita energy expenditures for all sample households was 66 ETB and it varies from 55 ETB for the low income households to as high as 105 ETB for the high income households and per capita average monthly expenditure on domestic energy was 71 ETB for medium income group. The average monthly fuel expenditure for the sample households was 290 ETB, which makes up 13 percent of the family mean monthly income. The lowest monthly expenditure for the sample households was 29 ETB, while the highest was as high as 456 ETB per month. The disparity in expenditure among sample households, which can be explained by coefficient of variation of 24.75 percent, is smaller.

For the low income households, the mean monthly expenditure on fuels was 266 ETB which constitutes 17.51 percent of the average households' monthly income. This creates a higher financial strain on the budget of households of this income group. The standard deviation of 66.89 and coefficient variation of 25.18 percent shows that disparity in the expenditure on energy for the group. For the middle income households, the average monthly expenditure on various energy resources was 314 ETB which constitute 11.13 percent of the average income of the group. The 22.12 percent coefficient of variation shows that there was low variation in expenditure made on energy among households of this income group. In the high income group, the average monthly expenditure on fuels for this group was 302 ETB which constitute 8.45 percent of the average income of the group. The coefficient variation of 22.52 percent reflects that there was low disparity in expenditure made by households of this group with less significant strain on household budget. This implies that although the lower income groups do have fewer energy expenditures they spend a great share of their incomes on biomass fuel. They pay more per unit of energy than the better off households as they have less purchasing power and failing to make shift to other alternative sources of energy (Table 3).

The average household monthly biomass fuels use was 183 ETB for low income households. The figure falls to 177 ETB for the middle income households and 136 ETB for the high income households. On the other hand, the share of both the average household expenditures on conventional fuels in households' energy budget increases as we move from low to high-income groups. The average

Tab. 2 Mean monthly incomes and expenditures by income group (in ETB).

Income Group	Annual per Capita Income Range	Household Income			Fuel Expense			
		Mean	SD	Cv	Mean	SD	Cv	As % of The Income
Low	Below 5,001	1,517.65	418.75	27.59	265.70	66.89	25.18	17.51
Middle	5,001–10,000	2,824.53	909.84	32.21	314.32	69.53	22.12	11.13
High	Over 10, 001	3,570.00	1,029.77	28.85	301.69	67.94	22.52	8.45
Average		2,315.09	1,076.08	46.48	290.15	71.82	24.75	12.53

Sd: standard deviation, CV: coefficient of variation

Tab. 3 Mean monthly expenditures on fuels by income group (in ETB).

Fuel Type	Low Income Households		Middle Income Households		High Income Households	
	Per household	Per capita	Per household	Per capita	Per household	Per capita
Biomass fuels	182.54	37.80	176.81	41.06	136.30	47.90
Conventional fuels	82.99	17.39	137.46	30.31	165.39	56.64
Total	265.53	55.19	314.27	71.37	301.69	104.54

Source: Field survey, 2014.

monthly household conventional fuels expenditure was 83 ETB for the low, 137 ETB for the medium and 165 ETB for the high income group. There is a considerable variation in expenditure patterns on household energy resources by the sample households depending up on a household's economic status. The amount of expenditure made on fuels for domestic purpose is creating more pressure on family budget as the result of increasing scarcity of fuels. The evidence presented in this section suggests that the higher financial burden faced by the poorer households in meeting their energy needs. Fuel price increase was a challenge for urban and peri-urban households and there is high strain on household's budget particularly among households of the low economic strata who often end up spending a substantial proportion of their household income on energy when compared to the share spent by high income households. It is found that poor urban households spend a significant portion of their cash incomes on energy because cooking with fuel wood is inefficient compared with cooking with modern fuels.

4.3 Data Conversion

The amount of heat energy consumed from each specific energy source can be estimated by converting its expenditure into heat value. Therefore, for conversion mechanism, total expenditure of each household on fuels is multiplied by the constant to get the heat value consumed by a household. In the field work conducted, the price of fuel wood ranged from 50 ETB per 25 kg (2 ETB per kg) in peri-urban area to 80 ETB per 25 kg (3.20 ETB per kg) in the town. Fuel wood vendors serve almost all sample households at an average price of 2.60 ETB for one kg of fuel wood. That means a household buys 0.38 kg for one ETB. One kg of fuel wood provides heat value of 15.07 MJ. Therefore, a household gets 5.73 MJ (15.07 × 0.38) gross heat value of fuel wood for one ETB (Annex 1). This constant is important to convert household expenditure on fuel wood into gross heat value (MJ). For the rest of energy sources, the constants were manipulated in the same way.

Charcoal is sold at about 70 ETB per 30 kg sack of charcoal in peri-urban area (2.33 ETB/kg) while the price of 30 kg sack of charcoal is 120 ETB in the town (4 ETB/kg). The average price of a kilogram of charcoal was 3.17 ETB. One kilogram of charcoal provides heat value of 29.73 MJ. So for one ETB a household could get 9.51 MJ (29.73 × 0.32) heat value of charcoal (Annex 1). In the case of sawdust, 5.02 percent of the sample households use this resource. Of the total users, only 1.22 percent got sawdust for free and the rest users normally buy the fuel from sawmill. The average price of sawdust was 5 ETB per kg. Thus, a household bought 0.2 kg of sawdust for one ETB. One kilogram of this fuel delivers 16.75 MJ heat value of sawdust. So a household could get 3.35 MJ (0.2 × 16.75) heat value of sawdust for the expenditure of one ETB on sawdust (Annex 1).

According to Ethiopian Electricity Utility (EEU), Arba-Minch Branch, the price of electricity was based on fixed rate of payment for electricity consumed (Annex 2). The payment rates of electricity vary in slabs of the total amount of electricity consumed. The monthly rate of payment per kWh varies from 0.27 ETB if the electric consumption was 50 kWh and less to 0.69 ETB for 501 kWh and above. That is, for example, if the total electric energy consumed is 100 kWh, the first 50 kWh is rated at about 27 cents per kWh and the second 50 kWh is rated at about 36 cents per kWh.

As Table 6 shows the average price of electricity paid by surveyed households was 0.39 ETB per kWh. Since 0.39 ETB was equivalent to one kWh, one ETB was equivalent to 2.56 kWh. Thus, a household bought 2.56 kWh of electricity for one ETB. One kWh of electricity is equivalent to 3.6 MJ of energy. Therefore, for one ETB, a household buys heat value of 9.22 MJ (2.56 × 3.6) (Annex 1). Almost all kerosene users buy a liter of kerosene by 15 ETB from petrol station. Thus, 0.07 liter of kerosene was obtained for one ETB. One liter of kerosene delivers 33.62 MJ of heat value. Therefore, 0.07 liter of kerosene delivered 2.35 MJ (0.07 × 33.62) of heat value (Annex 1). Considering the price of each energy type, expenditure made on source of fuel was converted to gross energy in terms of heat value (MJ). Accordingly, on average, fuel wood, charcoal, saw dust, electricity, and kerosene, have got a gross heat value of 5.73, 9.51, 3.35, 9.22 and 2.35, respectively. As far as dung cake and biogas are concerned, households usually procure for free from own cattle near the house throughout the year. Unlike other fuels, the study here used the amount of heat energy per their respective units of energy rather than their prices as reference to find out their gross heat values (MJ). It has been reported by UNDP (2009) cited in Ethiopian Ministry of Water & Energy (MoWE) (2011) that one kilogram of dung cake and one cubic meter of biogas can provide heat values of 14.50 MJ and 22.80 MJ, respectively. Therefore, these constants by themselves are also important to convert household consumption into gross energy heat value.

4.4 Households' Gross and End-use Energy Consumption

As shown in table 4, the mean monthly household gross energy consumption in terms of heat values delivered varies from 2,002.79 MJ for the low income group to 2,477.04 MJ for medium income group with the average monthly household gross energy consumption of 2,251.96 MJ for the sample households. On the other hand, with the rise of the household income, there is a significant proportion of increase in the mean monthly per capita consumption of energy in terms of heat value. The mean monthly per capita consumption of gross energy for the study area was 528.34 MJ. It ranges from 415.37 MJ for the low income households to 838.03 MJ for the high income households.

The average monthly domestic biomass fuels consumed varies from the lowest (1,151.29 MJ) for high income households to the highest (1,408.36 MJ) for medium income households. On the other hand, there is a proportional increase of per capita consumption of biomass fuels with income of the households. The average monthly per capita biomass fuels consumption varies from 286.33 MJ for low income households to 400.32 MJ for the high income households. Both the average household and per capita gross conventional fuels consumption proportionately increases with income of the households. The respective household and per capita gross conventional fuels consumption varies from 618.22 MJ and 129.04 MJ for low income households to 1285.04 MJ and 437.71.16 MJ for high income households.

From the previous discussion, it can be seen that the consumption of fuels was estimated in the total input household energy consumption regardless of the efficiency of fuels and appliances used. The difference is waste heat that escapes around the sides of the pan. Consumption of energy in terms of end-use energy utilized varies considerably from household to household. There is a corresponding increase for useful energy consumption with a rise in a household income. The average monthly end-use energy received by a household ranges from 674.47 MJ in the low income households to 1,160.55 MJ in the high income households.

Wood fuels (wood and charcoal) are by far the most used cooking fuels for a large majority of households in spite of the growing scarcity and price of these resources. The main reason for preferring this energy source is affordability of the fuel and the related stoves. Despite paying higher prices for useable energy, most urban and peri-urban households use less useful energy per household due to the inefficiency of traditional fuel-using cooking stoves. Households often continue to cook with biomass fuels and cannot easily make a transition to electricity in order to satisfy their cooking needs since the high costs of modern cooking fuels and stoves are major constraints for them. It is becoming increasingly difficult for most people to obtain affordable energy technologies that convert energy to useful services. The findings revealed that the provision and adoption of modern energy technologies such as LPG has not been a great success due to lack of general availability and much higher cost for household use. Although there is significant interest in the area, the cylinder is not available at affordable price. Cost of electrical cooking and LPG gas using appliances are beyond the financial reach of most households. Moreover, frequent erratic supply of electricity makes it difficult for households to access energy for the purpose of cooking.

Tab. 4 Mean monthly gross energy consumption (in MJ) by income class and fuel type.

Fuel Type	Low Income Households		Middle Income Households		High Income Households	
	Per household	Per capita	Per household	Per capita	Per household	Per capita
Biomass fuels	1,384.57	286.33	1,408.36	324.51	1,151.29	400.32
Conventional fuels	618.22	129.04	1,068.68	234.16	1,285.04	437.71
Total	2,002.79	415.37	2,477.04	558.67	2,436.33	838.03

Source: Field survey, 2014.

Tab. 5 Mean monthly end-use energy consumption (in MJ) by income class and fuel type.

Fuel Type	Low Income Households		Middle Income Households		High Income Households	
	Per household	Per capita	Per household	Per capita	Per household	Per capita
Biomass fuels	216.79	44.86	237.07	54.20	207.58	71.53
Conventional fuels	457.68	95.55	790.32	173.24	952.97	324.51
Total	674.47	140.41	1,027.39	227.44	1,160.55	396.04

Source: Field survey, 2014.

Regarding the average monthly end-use energy received, electricity has the largest share followed by charcoal and kerosene. The share of other fuels in the heat value of useful energy is not important. For the low income group, the average monthly domestic consumption of electricity was 443.21 MJ; this figure rises to 765.36 MJ for the medium and 927.71 MJ for the high income groups. Consumption of kerosene varies from 9.71 MJ for the low income group to 17.95 MJ for the medium income group and 20.01 MJ for the high income group. Low income households receive 154.24 MJ of charcoal, while the middle and high income groups receive 191.35 MJ and 184.77 MJ, respectively. Monthly per capita biogas consumption ranges from nil for high income group to 1.87 MJ for middle income households. Despite the fact that the majority of middle and higher income households combine the use of biomass fuels with other clean source of energy particularly kerosene to satisfy their cooking needs, wood fuels remain the dominant fuel among the lower income households.

Tab. 6 Share of household and per capita end-use energy out of the total input energy (MJ).

Income Group	Gross Energy (MJ)		End-use Energy (MJ)	
	Per household	Per capita	Per household	Per capita
Low	2,002.79	415.37	674.47	140.41
Middle	2,477.04	558.67	1,027.39	227.44
High	2,436.33	838.03	1,160.55	396.04

Source: Field survey, 2014.

The amount of end-use energy received by a household rises with an increase in household income. The households of the lower economic levels receive less amount of useful energy as compared to households in the high economic levels. A household in the low income group receives 33.68 percent of its gross energy input, while that of mid and high income groups receive 41.48 percent and 47.64 percent, respectively (Table 6). This indicates that with a rise in a household income, there is a tendency for households to use multiple fuels and stoves for baking and cooking. An increase in household income does not necessarily mean an overall switching, where biomass cooking fuels totally substitutes for clean cooking energy sources. It is becoming increasingly difficult for most people to obtain affordable energy technologies that convert energy to useful services. The ability to use any modern fuel is dependent on the energy-users' ability to afford not only the fuel on a regular basis but also their ability to pay for the energy-using appliances.

According to Masera et al. (2000) and Treiber et al. (2015) in many households, traditional stoves are used at the same time as improved cook-stoves, or the different stoves may be used for different foods. The study has shown that switching from biomass to conventional fuels for baking and cooking was difficult for more than half of the sample households (52.3%). Fuel switching is partial for 44.8 percent of the households while only a minority (2.9%) switches completely. The study results indicate that there is a tendency to use more wood fuels with limited conventional fuels for the purpose of baking and cooking. This means the consumption of wood fuels for baking and cooking is not declining at all income levels. Wood fuels are still the choice of most households for baking and cooking purposes regardless of household's economic status.

The use of modern fuels is always accompanied by traditional fuels and any conventional fuel does not completely substitute biomass. In an investigation into household energy consumption, Maseraet al. (2000) concluded that the specific fuel-mix choice and the relative consumption of each fuel is governed by the characteristics of the fuels and end use devices; specific aspects related to fuel availability; and the local cultural and social context that determines household preferences regarding cooking fuels and lifestyles.

4.5 Energy poverty and low income residents

As the focus of this study is on household energy spending and the differences between income groups, some of our analysis is relevant for the important issue of energy poverty. In validating Boardman's (2014) argument that raising income can lift a household out of poverty, but rarely out of energy poverty, the situation of energy poverty among urban and peri-urban households is analyzed based on the expenditure approach to identify whether households are energy poor or not. Although many researchers have similar ideas in the definition of energy-poverty, they fail to agree on what exactly is the minimum level of energy-poverty line. It can be classified as either based on measures of physical energy requirements (Goldemberg 1990) or energy expenditures (Pachauri and Spreng 2004; Boardman 2014).

Pachauri and Spreng (2004), WHO (2011) and ESCAP (2012) adopt a cutoff point of 10 percent of total expenditure because it is frequently mentioned in the literature as common level of expenditure for poor households and classified households as energy poor if more than 10 percent of their total monthly household income is devoted to energy expenditure. The energy-poverty estimation outlined in this paper is based on energy expenditures. It describes a household as energy poor or in energy-poverty if the energy-poverty ratio is greater than 0.1. Households with energy expenditure exceeding this threshold are considered to be energy poor and are consequently likely to be confronted with difficult choices between meeting energy requirements on the one hand and sacrificing other important competing spending priorities on the other.

The problems recounted by the respondents in this study show that the energy poor that spend over

10 percent of their income on energy are predominant. The majority of the sample households (72.9%) face burden of energy poverty and often end up spending a substantial proportion of their household income on energy. Out of this figure more of them (59.38%) are from low income households, about 34.79 percent are from medium income households and only a minority (5.83%) is from high income households. Households with monthly income of 2,500 ETB and less were assumed to represent less income residents and further examined in the analysis as they have a high probability of being affected by energy poverty in terms of availability of energy, safe and reliable supply, and affordability.

It was found that the problem of energy poverty is acute among the poor households as people with less income have limited access to clean fuels. This implies that low income families clearly suffer from energy poverty because they do not have the minimum amount of energy for their basic necessities of living. Fuel crisis affects families of the lower economic status adversely as opposed to the high income groups. Income poor faces high burden of energy poverty as they tend to spend a larger share of their income on purchasing inefficient and harmful energy fuels. A family in this lower economic status on an average has an income of ETB 1,640.80 and spends up to 17.5 percent of its income on domestic energy. This becomes a large economic burden on their budget. For this reason, of the total 423 low income residents, the majority (92.2%) are energy poor while only the rest (7.8%) are non-energy poor.

Biomass fuel prices in urban markets often rise rapidly as wood resources are seriously depleted in the study area, thus the poor are still inadequately served by energy supplies and they face higher financial burden to meet their basic energy needs. Among the major problems encountered by inhabitants of the town, escalating price of traditional fuels and growing strains on household's budget particularly among households of the low economic strata emerged as the main threats. Traditional fuels particularly fuel wood and charcoal have become scarce and expensive thereby forcing households to expend significant portion their limited income on energy. The fact that cash income is so low that even modest changes in energy expenditures can be a real hardship for them. They are unable to use modern energy for cooking, as they have limited access to modern end use technologies and large dependence on least efficient traditional fuels. Thus, they consume less end-use cooking energy services.

The end-use energy consumption level of energy poor households lowers as they are unable to use modern energy for cooking and they tend to stick to consumption of wood fuels. The fuel poor tend to live in energy inefficient properties as a result of insufficient capital expenditure and, therefore, they have fewer opportunities to engage in educational and income-generating activities. Meeting the energy requirement in a sustainable manner continues to be a major challenge for the majority of urban households. Therefore, The heavy dependence together with inefficient utilization of biomass resources for energy have resulted in high depletion of the forest resources and serious adverse consequences for health, environment and economic development which hinder households' efforts to improve their living situations. Most households in income poverty were in energy poverty as they find it difficult to acquire high priced cleaner fuels. Such limited use of clean energy and reliance on traditional biomass deter opportunities for economic and social advancement. Therefore, reducing energy poverty helps to reduce income poverty.

As can be seen from Table 7, energy poor households predominantly depend on biomass fuels (242.32 MJ) which is more than the biomass consumption by energy non-poor households (174.08 MJ). While energy non-poor households, on an average, consume 845.42 MJ of conventional energy much more than the conventional consumption by energy poor households (587.32 MJ). The prevalence of solid fuel use in this study was 26.9 percent; it was higher in the energy poor households (35.2%) than in the energy non-poor households (21.7%). This implies that the end-use energy consumption level of energy poor households lowers as they tend to stick to consumption of biomass fuels. This indicates the growing level of energy poverty in the area which needs to be addressed at the earliest. Such limited use of conventional fuels and significant reliance on biomass fuels deter opportunities of most residents for economic and social advancement. This is indeed a problem of the vicious cycle of energy poverty: lack of energy affects the economic activities of households and in turn limits their ability to make use of energy services. Access to energy alone is not enough to combat poverty, says UNDP report (2011), the poor need support to generate income so that

Tab. 7 Mean monthly gross and end-use energy consumption patterns of energy-poor and energy non-poor households (in MJ).

Consumption Type	Energy Poor Households		Energy Non-poor Households	
	Gross Energy (MJ)	End-use Energy (MJ)	Gross Energy (MJ)	End-use Energy (MJ)
Biomass fuels	1,503.48	242.32	988.35	174.08
Convectional fuels	793.28	587.32	1,142.79	845.42
Total	2,296.76	829.64	2,131.15	1,019.51

Source: Field survey, 2014.

energy becomes affordable, which in turn will improve household living standards.

5. Conclusion

The study reveals that electricity consumption is likely to reach nearly all the households in urban areas while no considerable switching from wood to electricity had occurred in household energy use. Despite the fact that a majority of sample households used electricity at home, wood fuels (wood and charcoal) remain to be dominant sources of energy for baking and cooking purposes regardless of household's economic status. A rise in household incomes does not necessarily mean a departure from the use of biomass. The problem of energy poverty is acute among the income poor households as people with less income have limited access to clean fuels. This implies that low income families clearly suffer from energy poverty because they do not have the minimum amount of energy for their basic necessities of living. It is common the income poor are more likely to be energy poor; however the energy poor are not all income poor. Thus, reducing energy poverty helps to reduce income poverty.

An increase in household energy demand has led to massive deforestation on the outskirts of the town. This has resulted in serious shortage of wood fuels and higher prices. One great concern, however, is the local authority does little to control access to the hinterland forests of the town from where wood fuel is extracted and supplied. The local government should give attention to the amount of depleted natural resources and rate of rapid deforestation to lessen the environmental impact from overexploitation of these resources. A key policy priority should therefore be to plan for the long-term care of endangered forests. There is a need to develop sustainable energy sources and practicing afforestation and forest management programs to overcome the problem of deforestation of natural forest.

A reasonable approach to tackle this issue could be to review the energy development strategies and search for mechanisms that minimize dependence on biomass fuel. This study suggests that increasing end-use efficiency should be given greater emphasis as an important prerequisite and cost effective solution to tackle household level energy problem. It is important to change households cooking practices by employing proper end-use technologies so that the pressure on surrounding forests and soil resources could be alleviated and household energy-related problems tackled. To generate achievable policy strategies and development targets with regards to energy poverty, there is a need for more studies at the local level to allow further assessment of local dimensions of the subject. A further study could assess the long-term and wider range effect of energy poverty at household levels. Such studies could help in the design of better strategies and policy instruments in the energy sector.

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