IHS
Making cities work

IHS is the international institute of urban management
of Erasmus University Rotterdam

MSc Programme in Urban Management and Development

Rotterdam, The Netherlands

September 2014

Thesis

Title: Factors Influencing Household Cooking Energy Choice and Transition: Empirical Evidence from Mekelle City, Ethiopia

Name Gebray Berhe Truneh

Supervisor: Julia Skinner

Specialization: Urban Environmental Management

UMD 10

MASTER'S PROGRAMME IN URBAN MANAGEMENT AND DEVELOPMENT

(October 2013 – September 2014)

Factors Influencing Household Cooking Energy Choice and Transition: Empirical Evidence from Mekelle City, Ethiopia

Gebray Berhe Truneh

Ethiopia

Supervisor: Julia Skinner

UMD 10 Report number: 679

Rotterdam, September 2014

Summary

It is an alarming fact that more than 92% of the Ethiopian population still depend on traditional energy sources such as firewood, charcoal, animal dung and plant residues for cooking activities. As a consequence, associated environmental problems such as deforestation and soil erosion coupled with social and economic impacts on households have contributed to the country's overall poor development performance. Cognizant of the severe nature of this challenge, the Ethiopian government has been working to improve access to modern energy services such as electricity in most of the big cities and rural towns all over the country. However, though considerable changes have been observed in utilizing this improved access of electricity supply for lighting end-uses, this has not been the case for cooking activities. Yet, in most urban areas, it is common to see households cooking with firewood and charcoal despite the availability of alternative cooking fuels such as electricity, LPG and kerosene. Therefore, a better understanding of the major factors that determine urban households' cooking energy choice is crucial for informing policy makers thereby promote sustainable development.

It was against this background that this research was conducted- with an objective to identify and explain the different factors influencing household cooking energy choice and transition in Mekelle city, Ethiopia. Thus, in its methodology, this study followed a mix of survey and case study research approaches with quantitative and qualitative research techniques. To collect the necessary data, survey questionnaire, interview and field observation data collection methods were employed. Moreover, 110 surveys and 10 interview samples were taken and using multi-stage cluster random sampling and purposeful non-random sampling techniques households were indentifies to fill the survey questionnaire and make the interviews respectively. After this, quantitative data were analysed using both descriptive and inferential statistical analysis methods and the qualitative data were analysed through narrations and direct quotations to support propositions found from the quantitative results and most importantly, to explain variables that are qualitative in nature. Particularly, in the descriptive analysis, mean scores, standard deviation was calculated and the data found was displayed in charts, graphs and tables and for the inferential statistics, Chi-Square test of independence was administered to test relationship between variables.

Accordingly, the major interesting finding of this study was that, most households combine fuels rather than relying on a single cooking fuel and a complete shift from use of those traditional fuels was rarely observed. The main explanation for this is the existence of multidimensional factors influencing household cooking energy choice and transition. Of these, in the socio-economic dimension, household income, level of education and age of the household head were found as influential factors and in the socio-cultural dimension, household taste preferences, cooking norms and practices have also a significant influence in household cooking energy choice and transition. Similarly, cooking energy supply related factors such as limited access to electricity services, erratic supply of the fuels particularly observed in electricity and kerosene, and high upfront costs of modern stove prices for LPG and electricity influenced household cooking energy choice and transition in Mekelle city.

Overall, according to the survey results, apart from the socio-economic determining factors of household cooking fuel choice, the role of socio-cultural and energy supply related factors in influencing household cooking fuel choice and transition was more evident than expected.

Keywords

Household cooking energy; energy choice; energy transition; Mekelle city; Ethiopia

Acknowledgements

I am deeply grateful and indebted to Julia Skinner, my supervisor, for her encouragement, suggestions, guidance and overall assistance. Successful accomplishment of this research would not have been easy without her unreserved, scholarly and precise advises. Hence, my sincere thank goes to her next to Almighty GOD.

This piece of work is dedicated for my mother Kibra Gebre'zgi, my leader and role model, who she has been working hard since my childhood to make my entire life better. I cannot imagine what I was up to if God has not given me such a wonderful mother. She is the source of all my strength and the driving force for my achievements.

I am also extremely grateful to The Netherlands government, Nuffic program, for providing me full sponsorship to follow my masters' education in such amazing country and university. It was my childhood dream to learn abroad. Thank you for opening my eyes!

Similarly, I would like to express my gratitude to all my people: friends, brothers and sisters for all the love and encouragements. Particularly, my appreciation goes to all the people that helped me during the data collection period specially Haben Girmay, Kinfe Gebremedhin, Rahel Kahsay and Fishatsion Kebede. Thank you all for what you have done for me. At this time, I have not mentioned others since they are many to be presented here but this is not to mean that their support is not significant compared to the once mentioned above, so I thank you all for helping me to make it up.

Last but not least, I want to thank all my instructors for sharing their knowledge and experiences during the master's program and all the IHS-Erasmus University staff, for all their unreserved efforts to make the master's program so pleasant and unforgettable. Thank you!

Foreword

Access and use of modern energy services such as clean and efficient fuels is a basic means for attaining the daily basic needs of cooking in a sustainable way. Unfortunately, in most developing countries, it is still common to see a significant number of households cooking with firewood, charcoal, animal dung and other plant residuals using archaic cooking stoves. However, when frequently used, such fuels inevitably have health and environmental consequences- affecting the general living conditions of households as a result of indoor air pollution and high rate of deforestation. Though this is a massive challenge that requires special attention, nonetheless, governments of most developing countries do not pay due attention to the household energy sector in their development discourse and policy agenda.

It is partly because, in most developing countries, adequate and cohesive studies, which inform and convince policy makers and decision makers with up-to-date and empirically oriented data, are hardly available. It was therefore against this dire need that the researcher decided to write his thesis on this multi-disciplinary and interesting subject matter.

Therefore, with an overall aim to create a deep understanding on household cooking energy choice and decision-making, based on empirical data collected from household surveys and interviews, this research tries to identify the major factors that influence household cooking energy choice and transition. In addition to identifying the major barriers and influencing factors, it is also believed that, this study will provide insights how urban households' cooking fuel transitions unfold in developing countries like Ethiopia.

Abbreviations

ACS	Advanced Cook Stoves
CSA	Central Statistical Authority of Ethiopia
GoE	Government of Ethiopia
HHs	Households
IAP	Indoor Air Pollution
ICS	Improved Cook Stoves
IEA	International Energy Agency
KoTE	Kilogram of ton equivalent
LPG	Liquefied Petroleum Gas
MCS	Modern Cook Stoves
MoFED	Ministry of Finance and Economic Development of Ethiopia
NGOs	Non-Governmental Organizations
TREMA	Tigray Region Energy and Mining Agency
UNDP	United Nations Development Program
WB	World Bank
WHO	World Health Organization

Table of Contents

List of Boxes

List of Tables

List of Figures

Chapter 1: Introduction

1.1. Background/Rational

The role of energy in enhancing human life is widely stated. For instance, at macro level, energy is highly regarded as a contributing factor for national socio-economic development. Equally, at micro level, energy is fundamental to sustain household livelihoods: prepare food, accomplish income generating activities and supplement comfortable living environment. For these reasons, energy use is always liable to household consumption expenditure decision making- where households make choices on which type of fuel[1] to use and how much amount of energy to consume- to satisfy their daily basic needs such as cooking. However, it is also true that, households have to make such choices under various constraints, which in turn, force them to utilize either 'traditional fuels'[2] or 'modern fuels', and for some others, a mix of both.

Nonetheless, it is apparent that excessive utilization of traditional fuels has negative environmental, social and economic impacts- in cases where frequent use of firewood and charcoal aggravates the rate of deforestation and distorts ecological biodiversity, and increased use of plant residues and animal dung reduces soil nutrients that otherwise would have been used as organic fertilizers for crop and plant cultivation (Malla & Timilsina, 2014). Moreover, the smoke produced from traditional fuels combustion creates dire health consequences such as respiratory and eye related infections (World Health Organization, 2014). Hence, ensuring access and use of modern energy services like efficient and clean fuels for cooking would be indispensable to households not only maintain sustainable livelihoods but also promote clean and productive environment.

Yet, in most developing countries, access and use of modern energy services specially for cooking activities is limited. For instance, the International Energy Agency energy use data shows that, worldwide, more than 1.3 billion people do not have access to electricity and a staggering 2.6 billion people (which accounts nearly to 38% of world population), lack access to modern cooking facilities such as clean, efficient and affordable cooking fuels and improved cook stoves[3](IEA, 2014). Of these, more than 95% of them are only from Sub-Saharan Africa and Southeast Asia (IEA, 2014). Besides, data fact sheet from the World Health Organization(WHO) indicate that, as a consequence of indoor air pollution(IAP) generated from using these unclean traditional cooking fuels, more than 3.8 million premature deaths occur every year all over the globe (WHO, 2014).

On the other hand, those households who use traditional cooking fuels spend a substantial portion of their cash incomes - often as much as 15% to 22% on energy- decreasing their

[1] In this paper, the term 'fuel' is sometimes used interchangeably with 'energy' when referring to any material used to produce heat or power for cooking.

[2] In this paper, 'traditional fuels' also termed as 'solid fuels' refers to firewood, charcoal and other animal dung and plant residuals whereas 'modern fuels' which is also used interchangeably with the term 'non-solid fuels' mainly refers to kerosene, LPG (liquefied petroleum gas) and electricity. Though charcoal and kerosene in some papers are considered as transitional fuels, in this paper, for simplicity purpose, these are considered as traditional and modern fuels respectively.

[3] An improved cook stove is a stove that consumes less biomass energy to cook the same amount of food with less smoke than a traditional one. However, there is no clear threshold of fuel saving and emission reduction level that indicate a stove is improved cook stove (Barnes et al., 2004).

disposable income for other basic expenses of food and housing (Karekezi et al., 2012). This is mainly the result of both the poor heat content of the traditional fuels and the energy conversion inefficiencies of the cook stove technologies used to produce 'useful energy'. Thus, utilization of traditional cooking fuels coupled with the use of inefficient cook stoves exacerbates households' vulnerability to other poverty dimensions of social and economic deprivations.

This challenge is nowhere more severe than in Ethiopia, where for centuries, its people have been experiencing heavy reliance on traditional energy sources with all the negative consequences associated with it. Looking at the Ethiopian Ministry of Finance and Economic Development household yearly welfare monitoring report, one can recognise the magnitude of the challenge- as more than 92% of Ethiopian population still rely on traditional energy sources mainly for cooking services (MoFED, 2013). This has clear implication for its current low level of development and 'poor country' status.

Also, it is worth noting that, in most developing countries, household energy use takes the loins' share of the total national energy consumption, of which more than 90% is for cooking services (Takama et al., 2011). Thus, in such countries, improving both access to and use of modern cooking fuels and efficient cooking energy conversion technologies is essential. In short, the combined importance of minimizing the health, environmental and welfare impacts associated with the mass usage of unsustainable traditional cooking fuels and inefficient cook stoves creates a greater impetus to develop comprehensive policies and strategies that improve access and use of modern cooking fuels in most developing countries like Ethiopia.

1.2. Statement of the Problem

Most theoretical literatures on household energy use reiterate the notion that through the evolution of modern fuel markets and changes in life styles, urbanization derives household energy transition: from use of traditional fuels towards those modern ones (Barnes, et al., 2004). However, in many developing countries, especially in cities of Sub-Saharan Africa, the rate at which households shift towards modern cooking energy uses has been stalled (Barnes et al., 2004; Mekonnen & Kohlin, 2008). For instance, in the last decade or so, though African cities have experienced remarkable urbanization processes with some level of socio-economic growth, yet, more than half of urban residents throughout the continent rely only on traditional fuels primarily for cooking services (IEA, 2010). It is also predicted that, unless effective measures are taken, the proportion of households who depend on traditional cooking fuels will continue to grow by at least 14% till the year 2015 (Takama et al., 2011).

As previously mentioned, the challenges of household energy transition is nowhere more pressing than in Ethiopia, as more than 92% of its people still depend on traditional energy sources mainly for cooking activities (MoFED, 2013). Cognizant of the severe nature of the problem and the relative importance of modern energy supply to the country's overall development, the Government of Ethiopia (GoE) has been working to scale up electricity access to most of the big cities and rural towns all over the country. However, though ample changes have been observed in utilizing this improved access of electricity supply for lighting end-uses, this has not been the case for cooking activities (Gamtessa, 2003; Abebaw, 2007; Gebre'egziabher, et al., 2012). Even these days, in most of urban Ethiopia, it is still common to see households cooking with firewood and charcoal despite the availability of electricity and other alternative cooking fuels such as kerosene and LPG. Consequently, this high demand for and utilization of traditional cooking fuels has intensified the rate of deforestation which eventually has caused these traditional fuels (mainly firewood and charcoal) to be more scarce and costly in most urban areas (Gebreegziabher, et al., 2012). This high price increase of traditional cooking fuels, according to most empirical literatures, is also believed

to prompt household energy use shift towards other alternative cooking fuels such as kerosene, LPG and electricity (see for example Barnes et al., 2004).

Nevertheless, in most Ethiopian urban areas, even under such circumstances where there is a trend in which access to modern energy sources like electricity is improving on one hand, and those traditional cooking fuels mainly firewood and charcoal are becoming more scarce and costly on the other, a fast transition towards the use of modern cooking fuels has not been materialized. Showing this fact is a household welfare monitoring survey report[4] from the Ethiopian Ministry of Finance and Economic Development, in which all over the country, the percentage of urban households who use electricity primarily for cooking services only increased from 2.4% in 2004 to only 7.2% in the year 2011(MoFED, 2013). This shows the slow process of household cooking energy transition in most urban areas of the country. Such phenomenon is more pronounced in Mekelle city- where more than (65%)[5] of its residents still use traditional cooking fuels- even though the city has been connected to the national electricity grid for more than a decade (Tigray Region Mining and Energy Agency, 2010).

As a result, this has put immense pressure on cities' surrounding environment- escalating the rate and scale of deforestation and soil degradation. On top of this, though there are no clear figures that show the extent and coverage of the problem for Ethiopia in general and Mekelle city in particular, the smoke produced from the combustion of traditional fuels that impose health hazards mainly on women and children is enormous. However, despite the fact that this intensified utilization of traditional cooking fuels has been causing multifaceted impacts all over the country, adequate and scientific studies pertinent to the depth and scale of the problem especially at urban household is few. Even the available studies are based on national estimates and lack empirical ground. For such possible reasons, the household energy sector has been overlooked and no special focus has been paid to improve this slow transition of household cooking energy use at all governmental levels.

Needless to say, there is a need for bringing this issue to the policy scene and introducing sound policy intervention mechanisms that embrace sustainable solutions for this slow process of household energy transition prevailing all over the country is crucial. However, to introduce policies with plausible solutions, it is essential for policy makers to first develop their understanding on the dynamics of urban households' cooking energy choice and decision-making, the existing household cooking energy consumption patterns and most importantly, the major factors that influence households' cooking energy choices.

Therefore, with an overall aim to create deep understanding on the importance of devising sound policy mechanisms that address the household cooking energy transition challenge prevailing in most parts of urban Ethiopia in general and in Mekelle city in particular, investigating why do a vast proportion of urban households in Mekelle city still heavily depend on traditional fuels for cooking services and what are the different factors underpinning such phenomenon is the concern of this paper.

[4] This is an extended welfare monitoring report by the Ethiopian Government to observe the effectiveness of the different previous policies and strategies pursued on poverty eradication in the country (MoFED, 2013).

[5] This figure is based on unofficial report from the local governmental office. Data from Ethiopian Central Statistical Authority responsible for official and authorized household survey reports could not be found.

1.3. Research Objectives

The overall objective of the research is:

- To identify and explain the different factors influencing household cooking energy choice and transition in Mekelle city

Under this broad objective, this study also has the following specific objectives:

1. To analyse household cooking energy choice and consumption pattern in Mekelle city.
2. To investigate the different socio-economic and socio-cultural factors influencing household cooking energy choice in Mekelle city.
3. To assess and examine the existing household cooking energy supply condition in Mekelle city and how it influences households' choice of energy for cooking services.

1.4. Research Questions

While undertaking this research, the main research question considered is:

- What factors influence household cooking energy choice and transition in Mekelle city?

Also, to answer the main research question, the sub-research questions examined include:

1. What are the existing household cooking energy choice and consumption pattern in Mekelle city?
2. What are the specific socio-economic and socio-cultural factors influencing household cooking energy choice in Mekelle city?
3. What is the existing household cooking energy supply condition in Mekelle city and how does it affect households' choice of energy for cooking services?

1.5. Significance of the Study

As previously mentioned, this study aims to create a deep understanding on the importance of introducing comprehensive policy mechanisms that address the slow household energy transition problem prevailing in most of urban Ethiopia in general and in Mekelle city in particular. It also aims to build knowledge upon the existing literature through its empirical findings and fresh insights by identifying the different factors that influence household cooking energy choice from its own local contexts. Since locally determined cooking practices are significantly related with cooking energy choice, it is expected that this study findings will instil new lessons that can be viewed in connection with other literature findings conducted in different settings.

Most importantly, for its policy relevance, it is believed that, this study will trigger the local and national governments, nongovernmental organizations and policy makers to adopt appropriate policy measures and intervention programs that promote household modern cooking energy use. Regarding this, it is assumed that any policy intervention that intends to influence the existing household cooking energy choice and consumption pattern needs to first identify the main factors that are considerably causative to the existing situation. Knowing these factors therefore would help to suggest corresponding solutions. Specifically, it is believed that conducting this study in Mekelle city will help to inform different stakeholders such as the regional government, the Tigray Region Mining and Energy Agency, Tigray Rural Development and Agriculture Office and other donors and local NGO's interested to work on improving access and use of modern and clean energy to urban households. This will in turn, enable to attain the envisioned transition of households cooking energy uses in the city. Consequently, when this household cooking energy transition is vastly promoted, this will ultimately make households better off in terms of health, income

and other social and economic welfare aspects thereby contribute to minimize the incidence of urban poverty in Mekelle city.

Likewise, at national level, knowledge about the various factors underlying the existing household cooking fuel choice and consumption pattern helps policy makers to set measures that will strengthen the conditions that induce households' use of modern cooking energy sources on one hand and to stick with measures that weaken households' heavy dependence on traditional fuels on the other. Equally, it will also acquaint practitioners that are involved in the implementation of initiatives that work on sustainable development- as household cooking energy is a cross-cutting issue that has policy implications on social, economic and environmental aspects of any country's development.

1.6. Scope and Limitations

The focus of this study is on household cooking energy uses for domestic consumption and does not address other domestic uses such as heating and cooling, lighting, mechanical and communication uses and/or energy use for business or income generating activities. Moreover, its unit of analysis is also limited to urban households in Mekelle city, Ethiopia. Therefore, it should be known that since the study is location specific with unique cultural contexts, it may not lead to generalization for other cities with distinct socio-economic, socio-cultural and/or geographical profile. Furthermore, this study has the following limitations:

- Limited financial resources to undertake the research
- Time constraints for data collection and analysis
- Inadequate availability of documented secondary data particularly for the study area

Thus, under such limitations, though the researcher has put much effort for the quality of the research not to be compromised, the above restrictions mentioned, which would be beyond the researcher's efforts may influence the level of detail and comprehensiveness of the research.

1.7. Organization of the Paper

This paper has five main chapters and each chapter is organized as follows: chapter one briefly provides information about the rational of the study, statement of the problem, objective of the study, research questions, scope and limitations and significance of the study. Chapter two describes the theoretical and conceptual insights of household energy use related literatures. Chapter three also provides a description of the research methodology followed to conduct the study- including operationalization of the research concepts and variables which was used as a contextual setting of the study and the detail description of the sample selection process and data analysis methods employed. Moreover, in chapter four, short description of study area and socio-economic and demographic profile of the sample respondents' are presented. Furthermore, it presents the main data findings and research results. Consequently, this chapter gives a brief discussion points based on the explanations of the analytical results presented earlier. And finally, chapter five outlines the main conclusions of the study.

Chapter 2: Literature Review

2.1. Introduction

In this chapter, relevant theoretical and empirical literatures on household cooking energy use are briefly reviewed and discussed. But, before reviewing some of the available literatures, it gives an overview on how household energy is related to other poverty dimensions- especially issues stated in the Millennium Development Goals- which helps to highlight the importance of improving access and use of modern energy services at household level. In relation to this, it continues to identify and conceptualize the main household energy services and the different types of energy sources used primarily for domestic cooking activities. After that, to specify the key variables and concepts of the study, it analyses some relevant theoretical and empirical literatures that explain what determines household cooking energy choice and consumption pattern. Ultimately, it presents a conceptual research framework based on the main research question set and the concepts and variables discussed in the literature.

2.2. Household Energy and Poverty

2.2.1. What is Energy Poverty?

Unlike to most traditional literatures that consider poverty only as 'a shortfall in income', most recent empirical literatures argue that poverty is beyond lack of sufficient income, encompassing other social and economic deprivations such as inadequate access to basic infrastructure services: education, health and a minimum level of energy services (Akindola, 2010). From this conception of poverty, we can understand that, the multidimensional nature of poverty can partly be explained in terms of lack of basic energy services that enable to meet the basic needs of cooking, heating and other domestic benefits. In this case, it is intended to stress the fact that energy is fundamental for supplementing households with the necessary needs of life such as cooking food, accomplish income generating activities or maintaining a comfortable living environment. This on the other hand explains the condition that, each dimension of poverty has a connection (to a greater or lesser extent) to the use of energy and energy services since access to adequate energy or lack it influences households living conditions and their poverty status (Clancy et al., 2006; Clancy, 2008). Hence, it is possible to look at the energy dimension of poverty which is termed in most literatures as 'energy poverty'.

So, what is energy poverty? As has been tried to show the connection between energy and poverty above, defining energy poverty is not straightforward. For instance, the International Energy Agency conception of energy poverty defines 'energy poverty' as a condition in which there is *"lack of access to modern energy services. These services are [also] defined as household access to electricity and clean cooking facilities (e.g. fuels and stoves that do not cause air pollution in houses)"* (IEA, 2010; p: 8). By the same token, similar work by the IEA World Energy Outlook (OECD/IEA, 2010, p.8) exemplifies this definition further stating that energy poverty is, *"…the inability to cook with modern cooking fuels and the lack of a bare minimum of electric lighting for reading or for other household and productive activities at sunset."* Hence, from both definitions one can understand that, the major aspect of energy poverty is the heavy reliance on those less clean and inefficient energy sources such as firewood, charcoal, animal dung and plant residuals to undertake domestic activities such as cooking.

In line with this, equally important is also mentioning energy poverty has an equity dimension. As study made for the Asian Development Bank by Sovacool (2013) indicates,

the connection between energy and poverty is evident in such a way that, poor households who utilize traditional energy sources spend much of their share of total income mainly on energy expenses than rich households. According to this study, this reaches up to 30% of their total annual income. This is mainly because, since the 'energy poor' use those traditional energy sources like firewood and charcoal with inefficient cooking technologies, the loss of energy usage is much higher than those that use more efficient energy sources and cooking instruments. As a result, it is believed that these households pay on average eight times more for the same unit of energy than households who use modern cooking energy sources such as electricity which eventually trap them in the poverty cycle (Sovacool, 2013).

Therefore, it is possible to deduce that, ensuring access to modern cooking energy sources for the 'energy poor' enables them to develop the financial capacity to meet their basic needs and fight poverty. To elaborate this more clearly, the various positive influences that access to and use of modern energy services can have on maintaining sustainable household livelihoods can be understood by looking at the linkage between household energy with each of the Millennium Development Goals discussed here under.

2.2.2. Modern Energy Services and the Millennium Development Goals (MDGs)

> *"To implement the goal accepted by the international community to halve the proportion of people living on less than one dollar per day by 2015, access to affordable modern energy services is a prerequisite."*

This was a short but strong statement made in the 2002 World Summit on Sustainable Development (WSSD) in Johannesburg. This summit underscored the significance of universal access to modern energy services which governments of developing countries should use as a platform to achieve the Millennium Development Goals by 2015. Since that time, it was widely appreciated that not only household modern energy use is strongly related with the 7th goal of the MDG agenda which is 'environmental sustainability', it was also stressed that access to modern energy services for cooking, productive activities and lighting are the prerequisite for all the achievement of Millennium Development Goals within the needed timeframe. As stated in the International Energy Outlook (IEA, 2010) here is a general summary of the different roles that access to and use of modern energy services have to achieve each MDGs and target objectives:

Box 1: Household energy and millennium development goals (MDGs)

• Goal 1: 'Eradicate Extreme Poverty and Hunger'. Access to modern energy services such as modern cooking fuels(electricity and LPG) which are clean and efficient and improved cook stoves and electric power lighting services accelerates economic growth by enabling households to accomplish tasks in more productive and efficient ways; opens the opportunity to extend long working hours and improves access to technologies respectively.

• Goal 2: 'Achieve Universal Primary Education' It is widely known that women from poor families particularly young girls from rural areas are forced to spend their school times while collecting firewood, charcoal, animal dung and plant residuals and on cooking and other household activities. This reduces the time left for schooling and study hours; consequently, affecting their school performance. Access to improved cooking fuels or technologies therefore has a paramount importance in solving all these obstacles and improves their school attendance. Most importantly, electricity is vital for education because it facilitates communication and helps to meet basic needs of lighting services which are vital for teaching learning process.

• Goal 3: 'Promote Gender Equality and Empower Women.' In most non-western cultures women and girls are solely responsible for cooking and collecting the required fuels. Hence, access to modern fuels reduces the drudgery on collecting fire-wood and charcoal and gives them more free time which also increases their employment opportunities and empowers them to have a say in household decision-making.

• Goals 4, 5, and 6: 'Reduce Child Mortality; Improve Maternal Health; and Combat HIV/AIDS, Malaria and other Diseases.' Similarly, eating properly cooked foods with clean energy sources boosts nutrition value for children and HIV infected people. Improved access to energy on the other hand, allows households to boil water which is also good way to prevent contagious diseases.

• Goal 7: 'Ensure Environmental Sustainability.' Modern cooking fuels and more efficient cook stoves avoid the rate of deforestation and soil degradation by reducing the incidence of tree cutting and forest clearing for firewood and charcoal fuel production and consumption.

• Goal 8: 'Develop a Global Partnership for Development.' Though it is not directly related with cooking, power from electricity is important to extend and transmit information and foster communications technology to remote areas and create networks among regions. This on the hand indirectly helps households by facilitating easy access to fuel market for cooking.

All in all, as mentioned above, modern energy services are essential to households to undertake productive activities that raise their incomes; to meet the minimum social welfare of basic health and educational needs; for supplying water and sanitation services that are all indicated in the Millennium Development Goals. Therefore, to achieve the MDGs, universal modern energy access to accomplish at least three types of energy services: cooking, lighting and mechanical power to accomplish productive activities should be secured and maintained (for further reviews on this issue see Modi et al., (2006)).

2.2.3. Household Energy and Gender

As partly discussed in the previous section, access to and use of modern energy services has an overriding importance for fighting energy poverty and other poverty manifestations such as gender inequality and child mortality. In this respect, global studies on different poverty issues indicate that, women take the larger proportion of poor people around the world. It is also obvious that women often face poverty differently to men, as women are more exposed to many social segregation and economic deprivations. One aspect of these deprivations can be partly demonstrated by lack of access to modern energy services (Clancy, 2008; Karekazi et al., 2012).

This poverty dimension, as termed previously 'energy poverty' is inherently attached to the livelihoods of women because the gender role in many households living in most developing countries is biased towards women. Some to mention, in the developing world, unlike to men, women are solely responsible for cooking activities and other household chores. This takes their time that otherwise would have been spent in other productive activities or as leisure and entertainment (Clancy, 2008). With a similar argument, Karekazi et al (2012, p. 181) demonstrate this stating, *"wider access to cleaner and affordable energy options improves gender parity and school enrolment of girls…as cleaner energy options (electricity for lighting services in schools and cleaner cooking fuels at home such as LPG) can extend studying hours for girls by reducing the time*[6] *they spent collecting fuel and cooking."* This shows how ensuring modern energy access is important not only to promote the immediate benefits it generates for household welfare but also how it can be used as key instrument to tackle complex poverty dimensions of gender equity within the household.

On the other hand, Clancy (2008) looks at the poverty-energy-gender nexus and suggests that energy should be viewed as a 'strategic issue' in any poverty alleviation programs- which have been mentioned in the above statements relating with each Millennium Development Goals. Adding, Clancy (2008, p. 11) argues claiming that *"…women and men have different access to resources and decision-making. Women's access to decision-making within the household and community is restricted, limiting their ability to influence processes and resource allocation on many issues including energy."* This means, in most developing countries, the gendered division of labour generally disfavours women in such a way that though this 'household gender role' gives women the responsibility for household activities mainly that of cooking and other monotonous domestic activities including child caring, when energy has to be purchased, men take the centre stage of decision-making such as on which type of fuel or cook stove should be purchased for the household (Clancy, 2008). Thus, under such circumstances, it is rare for men to be so keen on purchasing clean fuels and adopting convenient efficient cook stoves that provide direct benefits to women and children's health and general wellbeing.

In a nutshell, the impact of lack of access to and use of modern energy services especially that of clean cooking fuels and improved cook stoves on women's livelihoods should not be overlooked while formulating any development policies and poverty alleviation programs. Thus, all the potential benefits related to access and use of modern energy services would be fruitful if and only if energy policy intervention programs target women.

[6] However, there is also a controversial view that the time saved from having access to and use of modern energy sources do not actually benefit women because, time savings in one area of drudgery can result in increased workload in another area (Karekazi et al., (2012))

2.2.4. Household Energy and the Environment

In the previous section, the relationship between household energy and other poverty dimensions by which lack of access to modern cooking energy sources could affect the welfare condition of households was discussed. Besides, it is interesting mentioning that intensified use of traditional biomass fuels has also a significant impact on the environment. This is evident because unsustainable tree harvesting for different human energy needs could aggravate deforestation and soil erosion. Moreover, from the combustion of such biomass related fuels such as firewood, animal dung and plant residuals, massive amount of smoke is emitted. This smoke also has toxic air compounds like carbon mono oxide (CO) and carbon dioxide (CO2) and other contaminates like ashes and dust particles. These particles cause indoor air pollution and contribute to global warming thereby affecting health conditions of people all over the globe in general and users of such fuels in particular (Malla & Timilsina, 2014).

Recently, this challenge has been increasing as a result of fast urbanisation and population growth in most developing countries. For instance, since urban fuel transition to energy efficient and sustainable fuels has been stalled in most developing countries, biomass related fuels demand from the growing population in the urban areas added an extra pressure on rural areas and urban hinterlands. Therefore, in such circumstances, it is not uncommon to find barren lands around cities and towns, and the coverage has been increasing year after year. What makes this challenge more perplexing is also the fact that solid fuels are mostly used in complementary with archaic stoves such as the open three stone fires. Hence, it is believed that since such cook stoves are inefficient at converting energy input into 'useful energy' for cooking, it more than doubles the amount of biomass cooking fuel required to meet an individual household cooking needs (IEA, 2010). This in turn, increases the rate of tree cutting for firewood and charcoal harvesting leading to unsustainable utilization of natural resources. On the other hand, in urban areas, the unsustainable use of firewood and charcoal which results in deforestation pushes the price of such fuels upward. In such cases, households start to use other less inferior fuels like animal dung, twigs, and other plant residuals. However, the use of animal dung and plant and crop residues as fuels for cooking activities diminishes soil fertility.

Overall, the linkage between household energy and the environment is explained in such a way that heavily reliance on biomass related fuels which results in demand and supply of imbalance distorts the natural re-growth process of forest resources. This ultimately distracts the local environment putting at risk all the ecosystem services that are so essential for humans and other living things existence. In many developing countries, it is believed that because of unsustainable use of cooking fuels such as firewood and charcoal, agricultural land, forest areas and their benefits are under severe threat of extinction. Therefore, access and use of modern fuels is crucial to minimize if not alleviate such kind of environmental impacts.

2.3. Conceptualizing Household Energy Services and Energy Carriers

For a household, energy is a means rather than an end which is useful to perform specific domestic tasks to meet those ends. For instance, electricity power produces heat which provides cooked food, thermal comfort, hot water and a range of other benefits. Therefore, electricity can be considered as a means for providing those end-use benefits the so-called 'energy services'. These services are the benefits that energy carriers[7] (electricity, liquid fuels and solid biomass) provide for human wellbeing.

As stated in many literatures, some of the energy services include heat for cooking, illumination for home lighting, mechanical power for grinding or pumping and telecommunication and other entertainment needs. Moreover, energy carriers that supply benefits mentioned above are derived from different primary energy sources: electricity from hydro power, wind or solar-panel; liquid fuel energy carriers like kerosene from fossil fuel ruminants and solid biomass energy carriers (e.g. firewood and charcoal) from biomass etc. Thus, as Modi et al. (2006, p. 9), demonstrate *"what matters to the user is the energy service not the source [meaning] the reliability, affordability and accessibility of the energy services''*. This is true as demand for energy is a derived demand from households need for cooked food, boiled water or other household needs.

Thus, it is important to understand that, it is the need for cooking services or other productive activities that are collectively stated as 'energy services' that derives the household demand for energy. Hence, it is necessary to differentiate energy carriers and the types of services each carrier provides in understanding household energy use patterns and decision making. To illustrate this, a schematic representation of the inter-linkage among the different components of energy sources, energy carriers and their related energy services such as illumination, cooking, refrigeration and other mechanical and communication service benefits are shown in the figure below.

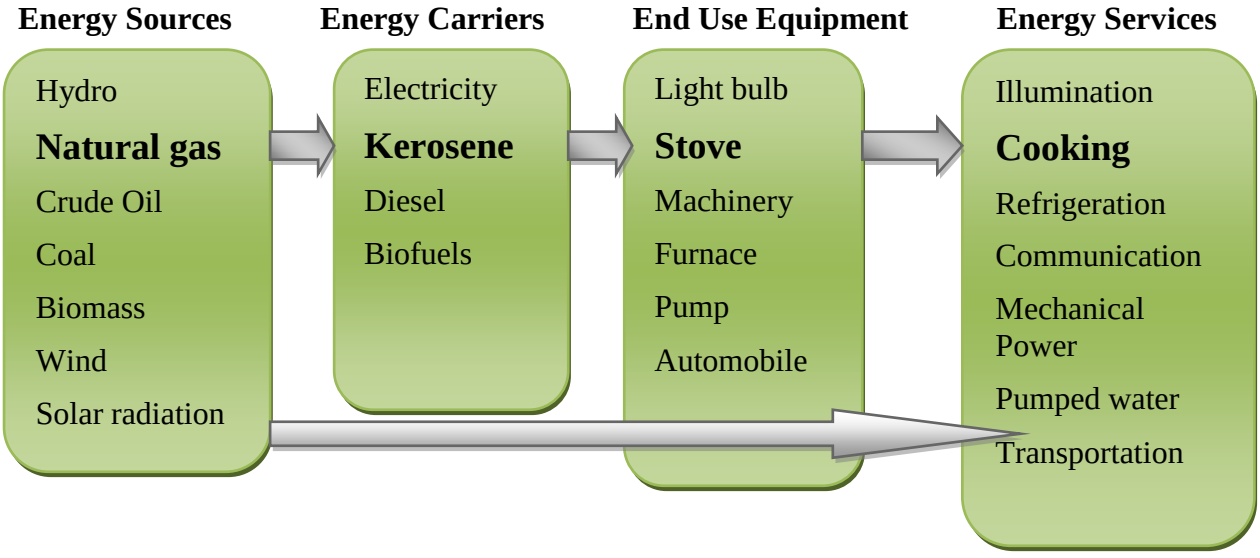


Figure 1: Schematic representation of energy source, energy carrier and energy services

Source: UNDP, 2004

[7] Energy carrier is the form in which energy is delivered to the end user which among others includes: fuels (biomass and fossil fuels) and electricity grid.

2.3.1. Household Cooking Energy Uses

It is true that most of the food that humans consume is cooked primarily to free it from contamination, for easy digestion and/or to make it more appealing for consumption. Whatever the purpose be, it is obvious that, some amount of energy is needed to meet these cooking purposes. However, it should also be understood that the quantity of energy needed for cooking activities depends on the food amount and type of food to be cooked, with the type of fuels and cook stoves available, and the individual cooking practices and cultural norms of individuals. For example, in the former cases, not less than 80% of the heat energy produced while cooking with firewood on a traditional three-stone fire stove is wasted and contrarily, for kerosene and LPG, the cooking energy efficiency improves by twice (Modi et al., 2006). In addition, Modi et al., (2006, p: 12) highlights household energy use of traditional coking fuels for cooking in such ways, "*in most of the poorest households, [the amount of energy need] is primarily met by burning roughly one up to half ton per person per year of firewood (the same applies to crop residues and dung) in open fire depending upon the kind of firewood, its moisture content, and the type of cook stoves used. A family of six thus uses about three tons of biomass each year*".

The type of food to be cooked is also a factor in households energy needs. A good example that helps to understand this is by looking at people who live in coastal areas, where fish is a popular cuisine, use much less cooking energy than people who has the tradition of consuming staple crops and potatoes or other meat products.

On the other hand, they type of fuel chosen to undertake any cooking activity is important. For example, if the household uses only either LPG or kerosene, and with the performance of energy efficiency of such type of fuels and typical stoves, the amount of energy needed would be about 40 kg of LPG/kerosene per person per year (Modi et al., 2006). Beyond their time and energy saving behaviour, for cooking activities, gaseous and liquid fuels are advantageous and are the most preferred because of their easiness to use and convenience for storage. Therefore, it is believed that, as households' income increases, these are much preferred to traditional fuels (for further reviews see Modi et al., (2006). To elaborate the difference in energy efficiency of the different cooking fuels, the following table summarizes this below.

Table 1: Cooking fuels and their efficiency factors

Fuel Type	Energy content			Efficiency for cooking
	Megajoules	KgOE	Kilo-calories	Percent
LPG (kg)	45.0	1.059	10,800	60
Electricity (kWh)	3.6	0.085	860	75
Kerosene (liter)	35.0	0.824	8,400	35
Charcoal (kg), 5% Moist. C. 4% Ash	30.0	0.706	7,200	22
Wood (kg), 15% Moist. C. 1% Ash	16.0	0.376	3,840	15
Coal (kg) can vary significantly	23.0	0.541	5,520	NA
Dung (kg) 15% Moist. C. 20% Ash	14.5	0.341	3,480	NA
Straw (kg) 5% Moist. C. 4% Ash	13.5	0.318	3,240	NA

Source: Barnes et al., 2004

2.3.2. Types of Cook Stoves

It is necessary to make clear that this paper only focuses on household cooking fuel choice and the related factors that determine household cooking energy choice and decision-making. However, it is also important to take into account those fuels have their own complementary cook stoves that are necessary for undertaking different cooking activities. Therefore, of their complementary nature, it is difficult to differentiate them as a concept (Risseeuw, 2012). Though more inclusive study would have been important, this study only focuses on household cooking fuel choice. Hence, in this study, a mention to traditional cooking fuels complements with those traditional stoves and a mention to modern cooking fuels also indicates modern cooking stoves. However, for clarity purpose, it is neccessary to give overview information on the different types of cook stoves that are used in complementary with each cooking fuels. As such, as mentioned in a rigorous study by Risseeuw (2012)[8] the following list of cook stoves are identified and their related function and features is discussed. Based on the division of each cook stove type, it has also been tried to relate the different types of cook stoves mentioned with on the ground information of the local cook stoves predominantly used in the study area (Mekelle City).

Box 2: Types of cook stoves

1. Traditional Cook Stoves (TCS): these are probably the most archaic stoves which are considered as the most inefficient and dirty stoves. This is because; these produce a lot of smoke and consume massive amount of energy. Mostly, these use firewood and charcoal fuels as a source of energy. Of their inefficient nature, it is believed that these cook stoves utilize only the 10% of the energy available (Barnes et al., 2004).To mention some examples used by the local residents, the three-stone open fire stove called *'Eton'* and the metallic charcoal burner which is called *'Fernelo'* are the most common traditional stoves produced and used by local residents of Mekelle City.

2. Improved Cook Stoves (ICS): These kinds of cook stoves are considered as improved version of the traditional stoves. Relatively speaking, these emit low level of smoke and have some degree of energy efficiency. Most of them are locally developed and are available in the local market of Mekelle City. Some to mention that are used and available in the city, '*Lakech'* and '*Mirt*' are among the dominant ones.

3. Advanced Cook stoves (ACS): These types of stoves use modern technologies. These are not common in the city and even in most developing countries.

4. Modern Cook Stoves (MCS): a stove related with modern cooking fuels like LPG and electricity carriers fall under the category of advanced stoves. An 'Electric Mitad' is one example of a modern cook stove available and used by some of Mekelle city residents. There are many other types of modern cook stoves imported from other developed countries that are available in the local market.

[8] This study focuses on the determinants of household cook stove adoption and fuel transition in Mozambique. It gives due emphasis on household improved cook stove adoption and willingness to pay. The category of cook stoves used in this paper is adopted from this study.

2.4. Theoretical Literature

2.4.1. Introduction

As stated in many literatures, there are two principal models that explain the dynamics and pattern of households' energy choice and consumption pattern. Therefore, as background information, it is important to get an overview of these two prominent models to have a full understanding on household energy use and decision-making. This section therefore tries to shade light on the theoretical basis underpinning the different empirical literature findings reviewed under section 2.5 of this chapter.

2.4.2. The Energy Ladder Model

Beginning from the early 1980's, the 'energy ladder hypothesis' has been the most dominant model used by researchers and policy makers to critically analyse household energy choice and decision-making. An array of empirical literatures confirm that the energy ladder model describes household consumption patterns of fuel substitution- a condition in which household respond to changes in their socio-economic status by totally shifting from the use of one fuel towards another. Moreover, to this model, the most dominant factor that derives household energy transition across the 'energy ladder' is hypothesized to be income. Thus, as household income increases, this models states that, households abandon the use of traditional fuels (firewood, animal dung and plant residuals) and start to use those modern ones like LPG and electricity.

In such circumstances, this model assumes that the more efficient and clean energy sources like electricity and LPG are 'superior goods' because of their convenience for energy storage, efficiency and cleanness whereas the traditional energy sources (firewood, charcoal, and animal dung and plant residuals) are considered as 'inferior goods' as such kind of fuels are less efficient and produce a lot of smokes. Therefore, borrowing a 'utility theory'[9] from microeconomics, it states that when households' income increases, demand for those 'inferior' fuels decreases and conversely, the demand for those 'superior' ones go up. In light of this, the ladder puts those modern cooking fuels which are considered as 'superior' in the upper part of the 'ladder' and those traditional ones in the lower part. Therefore, when household income improves, this model states that households decide to go up the energy ladder- a total shift from the utilization of traditional cooking fuels such as firewood towards electricity or LPG (for simplistic representation see figure 2).

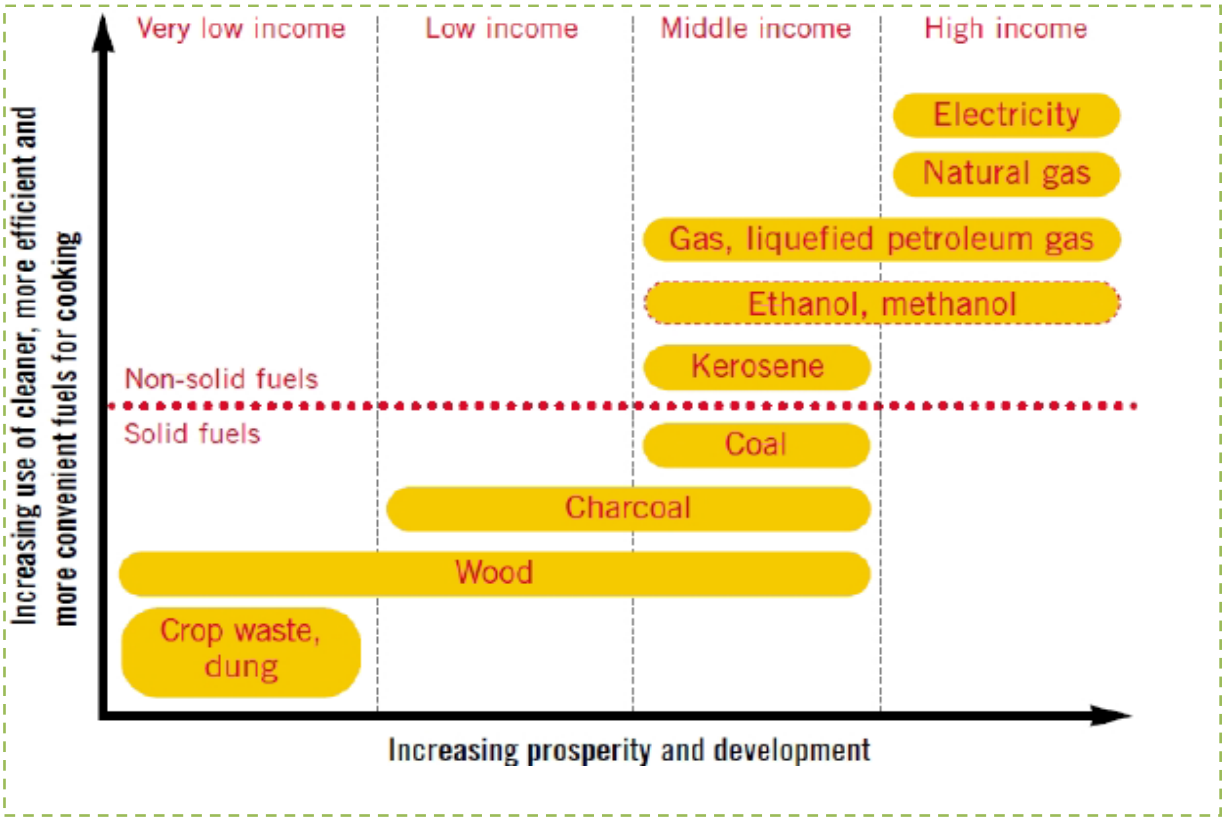
The strong proposition by the 'energy ladder model' acknowledged by many empirical findings is the existence of close correlation between income and household cooking energy choice and consumption pattern. In support of this proposition, Heltberg (2004) state that households with relatively higher income and education status tend to go up the higher part of the energy ladder and use more efficient and time saving fuels and the related cook stoves. For such households, using efficient and time saving fuels and cook stoves lowers time and budget losses. Heltberg (2004) further argue that, since households with higher education are aware of the health impacts inherent with using those traditional fuels like firewood and charcoal, such households have the tendency to switch onto other efficient and clean modern fuels. Similar findings are also stated in Mokennen and Kohlin, (2008) where the woman (housewife) in the household is educated and has good paying job outside the household

[9] Shows how the quantity demand for a good changes with changes in consumer income levels. Thus for normal goods, the quantity demand increases with income increments whereas for inferior goods it reduces in the opposite direction

chores, the household becomes more motivated to adopting those efficient and modern cooking fuels that are found high in the energy ladder.

Putting it more precisely, as it can be seen from the schematic representation of the energy ladder hypothesis in (figure 2) the energy ladder model is composed of a three-stage household fuel transition process. The first stage is demonstrated by reliance on solid biomass fuels such as animal dung, plant residuals, and firewood whereas the second stage represents a condition where households switch to charcoal and kerosene when their socio-economic status improves. In the third stage, households decide to use LPG and/or electricity. As mentioned in the above paragraphs, this model assumes that throughout the whole process of fuel transition, the main driver for households' the movement up the energy ladder is income.

However, though this model provides some basic insights on the role of income in household fuel choice which is widely recognized by many empirical findings, it is far from many critics and pitfalls (Takama, et al., 2011). For instance, research findings from different places and time have criticized the energy ladder hypothesis labelling it as idealistic and ambitious in explaining the complex household energy decision-making. This is mainly because; household fuel use decisions are found to be influenced by several exogenous and endogenous factors to the household (Heltberg, 2004; Abebaw, 2007; Schlag and Zuzarte, 2008; Mokennen and Kohlin, 2008; Kowsari and Zerriffi, 2011; Takama, et al., 2011; Alem et al., 2012). Unlike to the household energy ladder which assumes households totally shift from one type of fuel towards another as their socio-economic status changes(predominantly assumed to be income), a new thinking of households' multi fuel use behaviour which most literatures call it households' 'energy stacking model' has dominated the recent empirical literatures on household cooking energy choice and technology adoption. Some of the selected literatures that are critical of the energy ladder model are discussed as follows.



Source: UNDP, 2004

Figure 2: Schematic representation of the household energy ladder

2.4.3. The Energy Stacking Model

As mentioned before, it is understood that recent empirical studies on household energy consumption have been critical to the energy ladder model. Such studies claim that fuel switching is not a linear process where households directly switch the energy ladder as their socio-economic status improves. Rather, contradicting results reveal that households always use traditional fuels even after they have started using modern cooking fuels (Masera, et al., 2000; Abebaw, 2007; Kowsari and Zerriffi, 2011; Takama, et al., 2011). One of the reasons stated by Kowsari and Zerriffi, (2011) is that household energy sources are imperfect substitutes among each other for the fact that most of the time, specific fuels are preferred for specific cooking tasks. Therefore, as can be seen from figure 3 (b), instead of simply switching between different cooking fuels, most of the time, households choose to use one or more combination of fuels and adopt the related cook stoves depending on different circumstances.

In support of this argument, a pioneer empirical study by Masera et al., (2000) in Mexican households asserts that the change in energy use can be characterized as an "accumulation of energy options'' rather than as a direct shift along the 'energy ladder' which is termed by most literatures as ''fuel stacking behaviour''. Critical of the energy ladder hypothesis that claims one fuel is better than the other and so, a pioneer study by Masera et al., (2000; p: 2084) emphasized saying *"…households do not switch fuels, but more generally follow a multiple fuel or 'fuel stacking' strategy by which new cooking technologies and fuels are added, but even the most traditional systems are rarely abandoned."* This means, households do not always follow the energy ladder as there are conditions where those traditional fuels are preferred to the modern ones in specific cooking tasks. Therefore, this household fuel transition behaviour should be looked from within a specific historic and cultural context of household cooking practices and household energy decision making (Masera et al., 2000). A study by Takama, et al. (2011) is also in support of this claim stating that, household multiple fuel use is determined by the unique features of the fuels and end-use cooking devices and other conditions like fuel availability and the socio-cultural aspects that shape household cooking norms and behaviour (see also Masera et al., 2000).

To elaborate this, Figure 3 (b) clearly shows how households use multiple fuels. Thus, from figure 3 (b), one can easily recognize that, households do not completely switch from one cooking fuel use towards another even though their socio-economic status improves. This on the other hand tells us the fact that, there are many other factors that influence household cooking energy choice and transition other than the income of the household- as widely assumed by the energy ladder model discussed above. The different factors that determine household cooking fuel choice are discussed in detail under the following section of this chapter by reviewing different empirical studies from different countries.

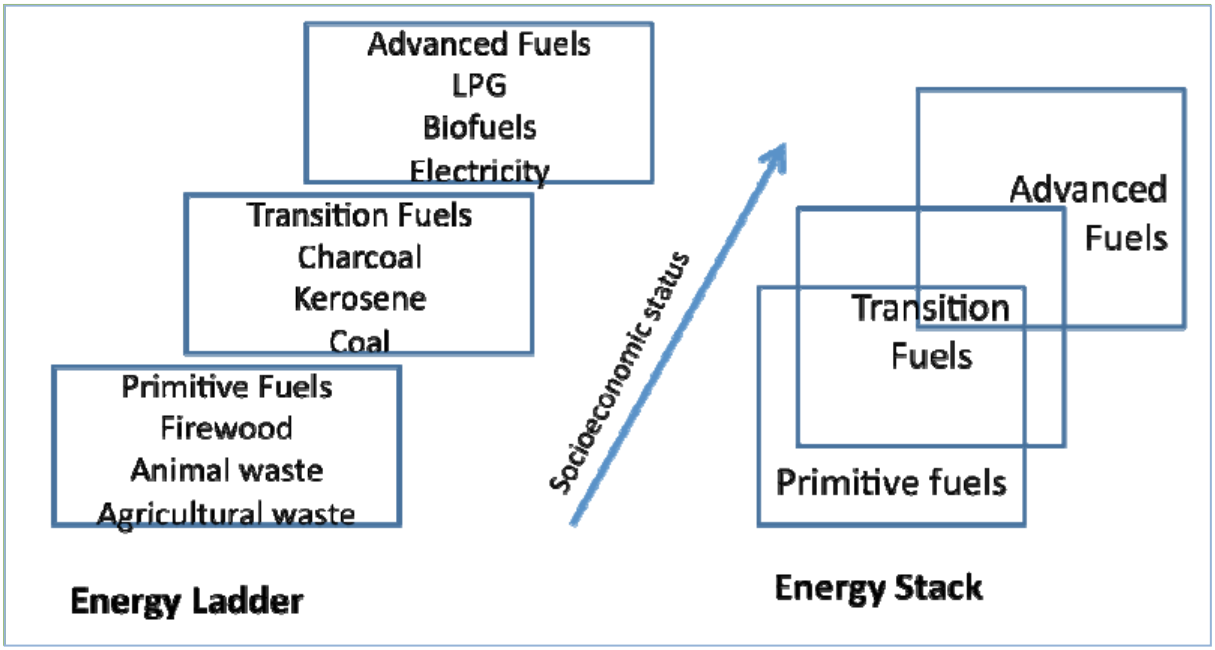


Figure 3 (a) **Figure 3 (b)**

Figure 3: Simplistic representation of energy ladder model (a) and energy stacking model (b)

Source: Schlag and Zuzarte, 2008

2.5. Empirical Literature

2.5.1. Determinants of Household Cooking Energy Choice

As stated previously, in the earlier times, most researchers used to understand households energy use through the lens of the energy ladder model- the general belief that households completely shift from use of traditional fuels to modern fuels as their socio-economic status improves. In view of that, income is considered as the dominant factor for households' energy use decision making.

However, recent empirical findings have criticized this traditional thinking of the energy ladder model, because households' energy use decisions are subject to other factors related to social, economic and cultural preferences (Masera et al., 2000). A rigorous study in some Ethiopian cities by Mekonnen and Kohlin, (2008) shows that, household income is not the sole factor in household energy use decision-making. This empirical study shows that modern cooking fuels are often used in combination with other traditional solid fuels by a large number of urban households with different levels of income. Though their study was focused on the socio-economic dimension of domestic energy use, in its conclusion, this study speculated that the factors behind this households multiple fuel use phenomenon go beyond household income, education, and family size, to include factors such as taste preferences, availability and reliability of fuel supply, cost, cooking and food consumption habits (Mokennen and Kohlin, 2008).

Household energy use assessment made by the International Energy Agency, (IEA, 2010) on the other hand stated that fuel availability and affordability are main constraints that affect households' transition from use of traditional cooking fuels like firewood, animal dung and plant residuals towards those modern and efficient fuels like LPG and electricity. Likewise, a study by Schlag and Zuzarte (2008) found that high modern cooking fuel prices force households to use traditional cooking fuels. In addition, similar study by Kowsari and Zerriffi (2011) stated that availability, affordability, accessibility and reliability of the different

cooking fuels also have a great influence in household cooking energy choice. According to this study, irregular supply of fuels may force households to diversify different fuels to cope with such shocks like price fluctuations, seasonality of fuel availabilities and other energy policy effects. In such cases, price of traditional cooking fuels compared to modern fuels is considered an important driving force for household fuel switching (Mekonnen & Kohlin, 2008; Schlag & Zuzarte, 2008). According to these studies, fuel cost variation can encourage or discourage households to use that particular fuel and/or promote a shift towards other possible fuel substitutes. But, it is important to understand that, price of fuels and cook stoves complement with income to become an affordability issue in determining households' fuel choice (Malla & Timilsina, 2014) which one effect overlaps with the other.

On the other hand, findings from Schlag & Zuzarte (2008) suggested that, some households' continuous use of traditional cooking fuels is related to lack of awareness on the negative consequences associated with those types of fuels. For Such households, Schlag & Zuzarte proclaim that, though they have started to use modern cooking fuels, they do not completely abandon using those traditional fuels. This is because, households might not be aware of the negative impacts associated with frequent use of firewood and charcoal that is believed to have negative health consequences and environmental problems. Similar studies from Mozambique by Risseeuw (2012) also claim that awareness can be considered as one of the main factors in household fuel choice. Adding, this study suggest that, in such cases, different campaigns and public education can play a decisive role in stimulating households to completely switch to alternative cooking energy sources like LPG and electricity.

The common findings among all the reviewed empirical literature on household energy use show that socio-economic profiles of households has a significant effect on the type of cooking fuels that households adopt. These empirical studies confirm that, income, age, education, household size (except Mokennen and Kohlin, 2008) and gender of the household-head are the major determinants that influence household cooking energy choice (see for example Masera et al., 2000; Barnes et al., 2004; Pachauri, 2011; Taylor et al., 2011). Most of these empirical findings further state that, income, education and family size have positive influence for households to use modern cooking fuels such as electricity and LPG and contrarily age and male headedness have negative influences. However, there are also other findings that look into the determinants of household cooking energy choice in other dimensions such as factors related to household cooking practices that are culturally determined and are very essential to consider in understanding the dynamics of household cooking energy choice and decision-making.
However, in this case, in most empirical literatures, the socio-cultural dimension of household cooking energy choice is underrepresented (see also Risseeuw, 2012). Literatures that acknowledge such factors in household cooking energy choice are very few. Most of these studies reiterate that cultural factors such as cooking practices and traditional customs in food preparation play a central role for households' continuous use of traditional cooking energy sources. For example, empirical findings by Taylor et al. (2011) in Guatemala households revealed that households usually use traditional cooking fuels even though LPG is available and affordable. This is evident because; for some households, some foods retain their flavor when cooked with firewood or charcoal than with electricity or Liquefied Petroleum Gas. In this respect, a rigorous study by Masera et al. (2000) in Mexican households, stated that a popular dish called 'Tortillas', when cooked with traditional fuels either by firewood or charcoal is much better in taste than when cooked with kerosene or LPG. Consistent recent findings have also been found by Risseeuw (2012) and Atannasov (2010) - both undertaken in Mozambique- which both claimed that socio-cultural factors have

significant influence on household cooking fuel choice and transition. Thus, though few studies indicate such circumstances where socio-cultural factors like the role of women in household decision-making, culturally determined cooking practices and individual taste preferences as main determinants of household cooking energy choice, yet the available literature on household cooking energy use has focused only on analyzing the socio-economic related factors. Specially, in urban Ethiopia, all studies made on household energy choice did not address the socio-cultural dimensions of household energy decision-making (see for example Abebaw, 2007; Mokennen & Kohlin, 2008; Alem et al, 2012; Gebreegzabher et al. 2012). In point of fact, little is understood why many urban households continue to use traditional fuels even though they have access to modern cooking fuels such as LPG and electricity. Supporting of this literature gap available in the Ethiopian household case is a study by Mokennen & Kohlin, 2008. This study recommended in its conclusion that further studies should be made to find out what factors other than income of the household(as suggested by the energy ladder model) determine household cooking fuel choice in emerging Ethiopian cities. New studies on household cooking energy choice that give equal emphasis to socio-cultural and energy supply related dimensions, therefore, would add greatly to the myriad of studies done on household cooking energy transitions. Similar proclamations were also found in a study by Risseeuw (2012), whom for such reasons; decided to combine the different dimensions in investigating the different factors the influence household energy choice and transition in Mozambique households.

Generally speaking, as it has been observed in most of the literatures discussed before, socio-cultural aspects of households' energy use and preferences and other external contexts were not studied in parallel with other socio-economic dimensions. Most studies focus only on the socio-economic dimensions of households cooking energy choice. This consequently has led to incomplete understanding about the complex situation of household energy decision-making especially in Ethiopian urban households. Therefore, from this literature review, it has been understood that, though there are growing number of research done on household energy use, yet more studies that target the different dimensions in determining household energy choice are required. Understanding this, in this paper, it has been decided to bring both the socio-economic, socio-cultural and the household energy supply related factors into the spot of investigation to have a vivid picture of household cooking energy condition in Mekelle city. Thus, it is believed that, this will ultimately help to better understand why a significant number of households still depend on traditional cooking energy sources despite the availability of modern cooking fuels such as electricity, LPG and kerosene around the city.

2.6. Research Conceptual Framework

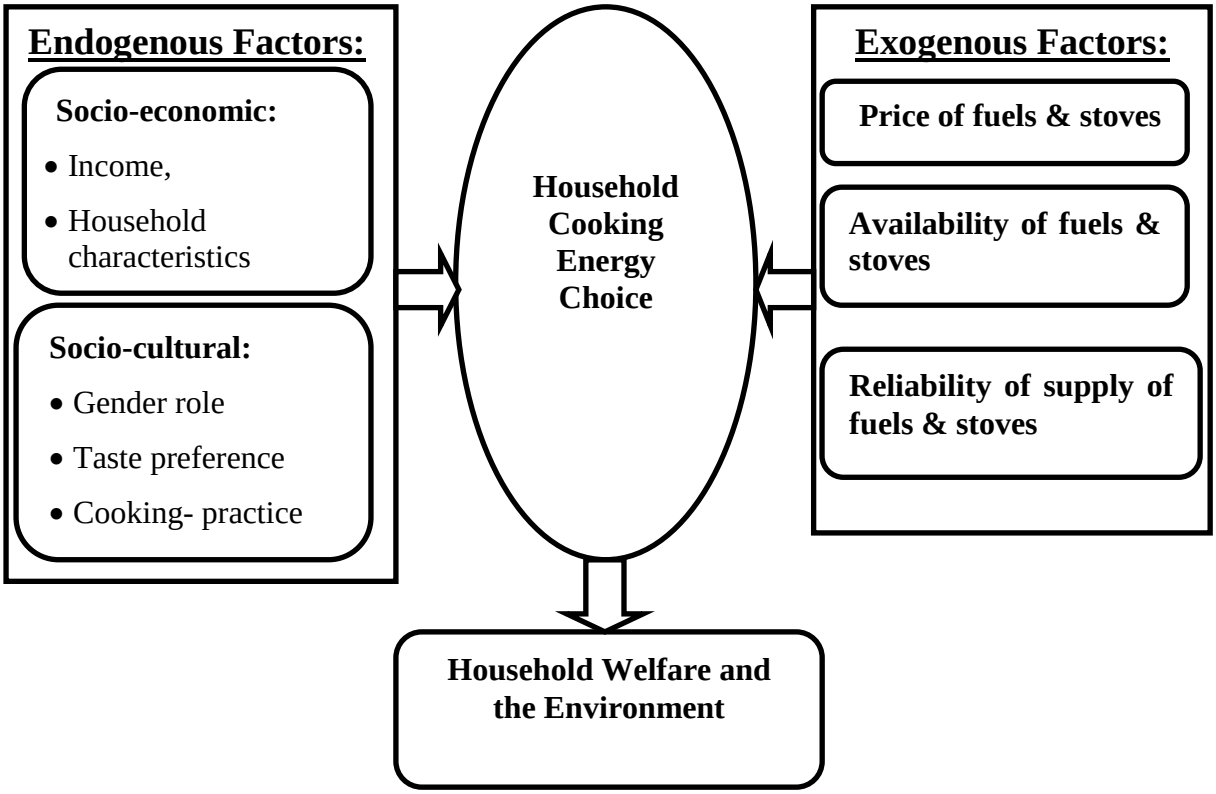


Figure 4: Research conceptual framework

Source: Author, 2014

As can been seen from figure 4, based on the theoretical and empirical literature review, the different factors that are believed to influence household cooking energy choice have been identified. These different factors, based on their similarity are generally grouped into two broad categories: endogenous and exogenous factors. By endogenous factors, it is to mean that those factors that are inherent to the household which among others include: socio-economic and socio cultural factors. These are also further sub-divided into the different variables, income; household demographic characteristics like age of the household head, household size, and gender of the household head; and socio-cultural variables like the role of gender within the household decision making process, and other individually determined taste preferences and cooking practices of the household.

On the flip side, by exogenous factors it is to mean that those factors that are external to the household decision-making which influence from the outside. These include: price of the different fuels and cook stoves (upfront costs); the physical availability of the fuels which mainly determines households' access to those fuels; the reliability of the supply of fuels and the different unique characteristics of those fuels.

All combined, these different variables are hypothesized as influential factors of household cooking energy choice and will be investigated based on the empirical findings of the study. Note! Analysing the impact that household cooking energy choice could bring to household welfare and the environment is beyond the scope of this paper. It is shown here to only indicate the rational and implication of the research.

Chapter 3: Research Design and Methods

3.1. Introduction

After reviewing several empirical literatures relevant to this study, different variables that help to investigate which factors influence urban households cooking energy choice in Mekelle city have been identified. Therefore, to comply with the research conceptual framework, the research questions have been revised for further operationalization as follows.

3.1.1. Research Questions

The main research question that this study seeks to answer is:

- What are the different factors that influence household cooking energy choice and transition in Mekelle city?

Moreover, to answer the main research question, the following sub-research questions were considered:

1. What are the existing household cooking energy choice and consumption pattern in Mekelle city?
2. What are the different socio-economic and socio-cultural factors that influence household cooking energy choices in Mekelle city?
3. What is the existing household cooking energy supply condition in Mekelle city and how does it affect households' choice of energy for cooking services?

3.1.2. Operationalization: Variables and indicators

As part of the research process, concepts and variables identified in the literature review are here translated into indicators for actual field-work of data collection. Household cooking energy choice is a dependent variable which is supposed to be influenced by many independent variables that are broadly categorized into socio-economic, socio-cultural and cooking energy supply related factors. As such, under each of the broad categories, specific variables were identified and for each variable, depending on the context of the concept or variable used, a minimum of one indicator was assigned which all the indicators combined enable to answer the research questions. Furthermore, indicators were cascaded into questions that became part of the survey questionnaire or semi-structured interview guide to collect the necessary data and information from sample respondents and the interviewees selected. Used as a roadmap during the field work for data collection, the following table portrays the detail breakdown of each variable into corresponding indicators and sample questions with each method of data collection assigned.

Table 2: Research operationalization: variables and indicators

S. No	Research Question	Variable		Indicators	Sample Questions	Type of Data	Data Collection Method
1	**What are the existing household cooking energy choice and consumption pattern in Mekelle city?**	Households' Cooking energy choice and consumption pattern		type of cooking fuel choice now and before	• What type of fuel does your household use now for baking *injera*[10]? • What type of fuel did your household use for baking *injera* five years before?	Quantitative	Survey Questionnaire & Semi-structured Interview
				amount of fuel consumption in kg/liter/Kwh per month	• How much fuel does your household consume per month?	Quantitative	Survey Questionnaire
				monthly fuel consumption expenditure in *Birr*[11]	• What is your household monthly fuel expenditure in Birr?		
2	**What are the different socio-economic and socio-cultural factors influencing household cooking energy choice in Mekelle city**	Socio-economic Factors	Income	ability to pay (proxy measures of income was estimated)	• Over the past 12 months, what was your households' average monthly income in Birr..? • Do you live in (rented or own room); housing condition (modern, medium or precarious) • Does your household own any of these durable goods (TV, refrigerator, etc…)?	Quantitative	Survey Questionnaire & Observation
			Household characteristics	Level of education , Type of occupation, Gender, Age, Household size	• What is the highest level of education of the HH head? • What is the main occupation of the housewife in the HH?	Quantitative	Survey Questionnaire
		Socio-cultural Factors	Gender role	Women's role in household decision making	• Who does what in your household? • Who decides on fuel and cook stove purchases in your household?	Qualitative & Quantitative	Survey Questionnaire & Semi-structured interview

[10] *Injera* is a sponge like flat bread consumed by most of the local people usually with different sauces

[11] *Birr* is the Ethiopian currency and as of March 20, 2014, one Birr is equivalent to 0.0511195 US dollars

			Cooking practice	Household's cooking frequency	• How many hot meals does your household consume per day? • How much time does the cooker in your household spend cooking per day?	Quantitative	Survey Questionnaire & Observation
				Type of commonly cooked meals within the household	• What are the most frequently cooked foods in your household? • Which meal you prepare does consume fuel most? • Does your household use different fuels to cook different foods?	Qualitative & Quantitative	Survey Questionnaire & Semi-structured interview & Observation
			Taste Preference	Household's perception on taste difference of foods cooked by different fuels	• Is there a difference in taste when a food is cooked using different fuels?		
3	**What is the existing household cooking energy supply condition in Mekelle city and how does it affect households' choice of energy for cooking?**	Supply related factors	Price	Per unit usage fees of a fuel	• What is the unit price of fuel X?	Quantitative	Survey Questionnaire & Observation
				Unit price of a cook stove and maintenance cost	• What is the unit price of a cook stove X? • What is the unit maintenance cost needed for a cook stove X? • How frequent does cook stove X dis-function per year?		
			Availability	The possibility to purchase fuels in different quantities	• Do you get fuel X in any quantity you want in the market?	Quantitative & Qualitative	A mix of Semi-structured Interview & Observation & Survey Questionnaire
				Physical presence of fuels and stoves in the market	• Which fuels and stoves are permanently supplied in the city? • Are there spare parts and/or maintenance service available in the market for cook stoves X?		
			Reliability	Frequency of interruption in supply of fuels per day/month	• Is there any supply interruption in fuel X? • How often does it interrupt per day/month? • What does your household do when there is interruption?		Survey Questionnaire & Semi-structured interviews & Observation

3.2. Research Type, Approach and Data Collection Method

3.2.1. Research Type

Generally speaking, the expected answers to the research questions require more than describing the different factors that determine household cooking energy choice. Therefore, it can be said that, the type of research design followed in this study was both descriptive and explanatory. Moreover, from the review of empirical literatures, it was found that the factors that potentially influence household cooking energy choice include not only variables that are easily quantifiable like prices of fuels and household income but also variables that are difficult to measure and quantify such as culture specific factors of gender roles, taste preferences and household perceptions. Hence, both quantitative and qualitative research design was important to collect the necessary data that help answer the research questions.

3.2.2. Research Strategy

In this study, a mix of cross-sectional survey and case study research strategy was followed to allow a variety of data-collection instruments. However, of the very nature of the research questions and the research phenomenon under investigation, survey research strategy was the main research strategy as it enables to analyse households' cooking energy choice in one point in time and compared to each other. Taking sample survey, it was used to collect a breadth of data that enables to generalize the results of the data analysis for the whole city population. On the other hand, the case study approach was adopted in investigating the socio-cultural and household energy supply related factors and Mekelle city households were the case under observation. The main reason for adding this approach is that, household perceptions and cooking energy use behaviours are always influenced by culture and social norms which is complex in nature and difficult to separate from the context under investigation. Therefore, in such instances, the case study research strategy is helpful (Yin, 2009). At both ends, incorporating survey strategy with the case study approach helps the researcher to utilize a variety of data collection methods that could not have been captured by only using a cross-sectional survey (Gable, 1994). However, it should also be noted that the emphasis of the study was put on the survey questionnaire and the interviews and field observations were employed to reinforce and possibly extend the survey findings.

3.2.3. Data Type and Data Collection Methods

For this study, primary data sources were predominantly used by employing different data collection methods. The main data collection methods employed include: semi-structured observation which was mainly used to capture information about the local cooking practices, household cooking energy use behaviours and the availability of cooking energy supplies around the city; household door-to-door survey questionnaire which was administered to collect data on household cooking energy choices; and the semi-structured interviews were held to probe some questions that enable to extract in-depth information on how the different factors identified could interact and impact upon household cooking energy decision-making. However, some secondary data were used for describing the background information of the study. Hence, under the mix of research strategy, to keep the flow of information, the different research methods were undertaken in sequential ways- first it was started by exploring the household cooking energy supply condition of the city, followed by the household survey questionnaire and ending with the semi-structured interviews. While collecting the necessary data, a notebook and pencil research materials were used. Moreover, electronic instruments such as voice recording and picture taking were used when appropriate and based on the will of the respondents.

3.2.4. Sample Design: Sampling Method and Sample Size

According to Mekelle City Health Office survey report, (2011), the study area (Mekelle City) has a total population of 237,922 and a total household number of 54,073 across seven administrative units. These administrative units are further sub-divided into 74 'ketenas' (plural form of ketena[12]) all around the city. Since the unit of analysis of the paper is at household level, the research population is the total number of households in Mekelle City. Considering the fixed time and budget limitation of the research, it was decided that the confidence level of the study to be at 95% with a confidence interval of ±9. Based on scientific sample size calculator[13], at this level of confidence and confidence interval, the computed representative sample size is 118 households. In this case, it is important to note that, as discussed in the literature review, 'household income' is expected to be the dominant variable in household cooking energy choice. Thus, it is imperative to draw a representative sample of the city population while taking care that the sample closely mimics the income distribution of the city as a whole. Therefore, since the living standard (e.g. housing condition) of the city residents is not evenly distributed across the city, to avoid data bias, the investigator decided to include all administrative units of the city in the sampling process. Hence, using Multi-stage sampling method, two 'ketenas' from each of the seven administrative units were randomly selected. After that, to maintain equal probability of selection of households in the different 14 'ketenas' with different population size, the probability proportionate sampling technique was followed to determine the sample household number for each 'ketena'. Further, at the field work, to identify individual households for the survey from each of the randomly selected 'ketenas', a systematic random sampling was used. The following table summarizes the household sample selection process.

Table 3: Number and distribution of sample population in Mekelle city

No	Name of city Administration unit	Number of ketena in each Administration unit*	Name of Sampled ketena**	Number of HHs in each ketena*	Number of sampled HHs per each ketena**	Total Number of HHs Sampled per Administrative Unit**
1	Adi-haki	7	ketena 1	1850	13	27
			ketena 7	2025	14	
2	Ayder	14	ketena 6	576	4	9
			ketena 7	742	5	
3	Hadnet	9	ketena 9	984	7	15
			Industry	1123	8	
4	Hawelti	10	ketena 9	2001	14	23
			ketena 4	1213	9	
5	Kedemay weyane	11	ketena 9	1638	11	23
			Mai-degene	1650	12	
6	Quiha	7	Awash	293	2	7
			Camp	650	5	
7	Semein	16	ketena 1	1179	8	14
			ketena 2	900	6	
	Total	**74**		**16,824**	**118**	**118**

Source: *Mekelle City Health Office Survey, 2011 **Computed from the given data

[12] *Ketena* is the smallest administrative unit in the city

[13] http://www.surveysystem.com/sscalc.htm

On the other hand, to triangulate data collected from the household survey, semi-structured interviews to a total of 10 interviewees were administered. Based on purposive non-random sampling method, 5 interviewees were selected from households who use exclusively traditional cooking fuels and 5 from those households who have fully or partially switched to modern cooking fuels. These interviewees were purposefully selected to enable the researcher identify those who can give detail information about the specific context under-study. On the other hand, the researcher explored and observed the cooking energy supply condition using a transect walk to different firewood and charcoal vendors, kerosene and Liquefied Petroleum Gas(LPG) retail stations(shops) and the Electricity Supply Office of the city. At that time, availability of the cooking fuels was checked and the current market price of the different cooking fuels was collected. And during the field work, since the time available for data collection was short; two additional research assistants were involved in the data collection, by giving prior short training on how to handle the overall data collection process.

3.2.5. Survey Questionnaire Design

The questionnaire used in this study was designed carefully so that respondents can answer each question with ease and clarity. For this purpose, it was translated into the local *Tigrigna* language to make it more understandable. Moreover, only questions that go in harmony with the research objectives were included which enabled to answer the research questions posed by the study. To keep the flow of information and as a way to make more convenient for the respondents, the questions were divided into four major parts. The first part contains information about household cooking energy choice and different questions on types of fuels used, amount of fuel consumed and monthly fuel expenditure spent and the types of cook stove adopted by households were asked. With some limitations, this section of the questionnaire also tried to collect information about household fuel transition process by asking households cooking fuel choices now and before 5 years. The second part of the questionnaire tried to collect data about households cooking practices- to know about the local cultural practices and cooking norms of the city residents. As such, it posed questions that comprise households' cooking frequencies, time spent on cooking, types of foods that are commonly cooked. The third part of the questionnaire covered questions appropriate to inquire about cooking energy supply situation in Mekelle city. In this part, different questions were asked to extract information about cooking fuels availability and the reliability of the different fuels supply condition. Lastly, questions that allow drawing information about households' socio-economic characteristics were included at the end of the questionnaire. Generally speaking, easy questions were deliberately put at the end and those relatively difficult questions at the front in order to increase the response rate of the questionnaire.

3.3. Validity and Reliability

According to Black (1994) validity refers to the ability of the research data collection tool (in this case the survey questionnaire and/ or semi-structured interview guide) to measure what it is purports to measure. The main challenge in using one research strategy is widely mentioned that it is difficult to collect adequate and relevant data that are sufficient to answer the different research questions under investigation. Understanding this, this paper employed a survey and case study research approaches to allow using different data collection instruments. This data triangulation therefore helps to ensure internal validity of the research (Black, 1994). In addition to this, to ensure content validity of the research instruments, for each variable, a thoroughly thought indicators were set by cross-checking with other 'similar

empirical literatures'[14]. Moreover, representative sample survey did help to extract a breadth of data that enable to generalize about the whole city population's cooking energy use condition and even to other similar cities. Understanding this, in the sample selection process, a clear and scientific method was adopted. This fosters the external validity of the research (Black, 1994). On the other hand, according to Black (1994) to attain maximum reliability of the study (the degree of consistency between two measures of the same thing) test, re-test of the survey questionnaire is important. Thus, before undertaking the practical field-work, the researcher used test, retest of the questionnaire as a main tool to ensure maximum reliability. In line with this, for the interviewees, contact lists were registered and attention were paid to data storage techniques to minimize data missing risks during and after the data collection process.

3.4. Data Analysis Methods

Quantitative data collected from the survey questionnaire was first stored and catalogued using excels software. After that, for further rigorous analyses it was put into Statistical Package for Social Sciences (SPSS version 20) software, then after, using descriptive and inferential statistical tests, it was analysed to the level that answer the research questions posed by the study. In the process of data analysis, different data analysis techniques were employed: ranging from simple descriptive statistics such as mean, variance, percentages, frequencies and crosstabulations presented in the form of charts, tables and figures to inferential statistical tests mainly Chi-Square test of independence based on the data type and the analysis outcome required. Similarly, side by side, the qualitative data which was collected through the semi-structured interview guide and observations was also analysed qualitatively in the form of story-lines, narrations and direct quotations. The depth and rigorousness of the analysis was monitored by taking each variable and respective indicator into the spot of analysis.

3.5. Research Limitations and Pitfalls

It is true that any research has its own limitations and pitfalls. Thus, the following are some of this study's pitfalls and limitations that the reader should take into account. One major pitfall of this research is associated with the data collection method. In this case, detail ethnographic data collection strategy would have been so important in collecting data related with the socio-cultural dimensions of household cooking energy choice. Because of time limitations, the researcher did not able to spend much time observing households cooking practices and fuel use behaviour during the field work. Another major pitfall of this research is related with data analysis. Though this study has its own strengths of data analysis that through data and methodological triangulation, it tried to come up with robust results, for the quantitative data, more analytical and predictive inferential statistical data analysis techniques like multinomial logistic regression would have been much better in estimating the parameters of each independent variable. The descriptive analysis and Chi-Square test employed by this study could not give more beyond indicating the existence of relationships between variables. Regarding the third imitation, had the research include other household energy services such as lighting and household cook stove technology adoption, more holistic and complete understanding would have been created on how households make energy choices and adopt advanced household cooking technologies which is an intriguing subject matter in the field of household energy.

[14] For example, previously used similar questionnaires was partially adopted notably from (Risseeuw, 2012)

Chapter 4: Research Findings and Analysis

4.1. Introduction

Divided into three main sections, this chapter is organized in such ways: the first section gives snapshot background information of the study area (Mekelle City) and some of the descriptive analysis of respondents' demographic characteristics. And the second section is devoted to answer the research questions and provides deep analysis on household cooking fuel choice and consumption pattern and the factors that determine household cooking fuel choice and transition. Consequently, the final section of this chapter discusses the key findings of the study to draw some relevant conclusions.

4.1.1. Description of the Study Area

4.1.1.1. Location and Climatic Conditions

Mekelle, the capital city of the National Regional State of Tigray, is found in the Northern most part of Ethiopia. It is found 783 kilometers far from Addis Ababa, the capital city of Ethiopia. It has total area coverage of 20,599.7 square kilometers (Mekelle Municipality, 2011). Its astronomical location is found at a longitude and latitude of 13°29′N and 39°28′E respectively. Moreover, situated on the flat plateau of the central high lands of the region, its topography has an elevation ranging between 2,150 and 2,270 meters above sea level. According to data found from Mekelle City municipality (2011), the climatic condition of Mekelle city and its immediate environs is categorized under the '*Weyna Dega'* meaning sub-tropical climatic zone. The annual rainfall amount of the city in the past nine years varied from 579 to 650 mm. Much of the rainfall rains in the summer season mainly in the months of July and August. On the other hand, from the month of September to May the city has dry season. Likewise, its mean temperature for the past nine years was 24 ^{0}c, and the hottest months in the year are May and June whereas the coldest months are December and January.

4.1.1.2. Demographic and Socio-Economic Conditions

Mekelle city is the most populated city in the Tigray Region of Ethiopia. Data from the Central Statistical Authority (CSA, 2007) shows that, the projected total population of the city for the year 2014 is about 281,177 of which 49 % are male and female account for the remaining 51%. The same data also show that due to the natural growth and massive rural-urban migration to the city, the growth rate of population of the city is tremendously high which is estimated to be 5.5% per year. The average household size is 4, when extrapolated, matches to around 65,390 households. In addition, the age distribution of the city reveals that 41% of the total population is below 15 years of age and 55 % is between ages 15 – 49 years. And the remaining 4% of the population is aged 65 and above. Consequently, as mentioned above, as the city is experiencing unprecedented population growth, the number of poor residents who live below one dollar a day is also increasing. Though there are no recent data that indicate the poverty condition of the city, the number of female-headed households are significant which in turn, increases urban poverty condition of the city. However, the city is also registering fast socio-economic growth- becoming a hub for manufacturing, research and development, trade and investment. This has attracted rural migration to the city pushing residents demand for basic public amenities such as education, health, water and energy services.

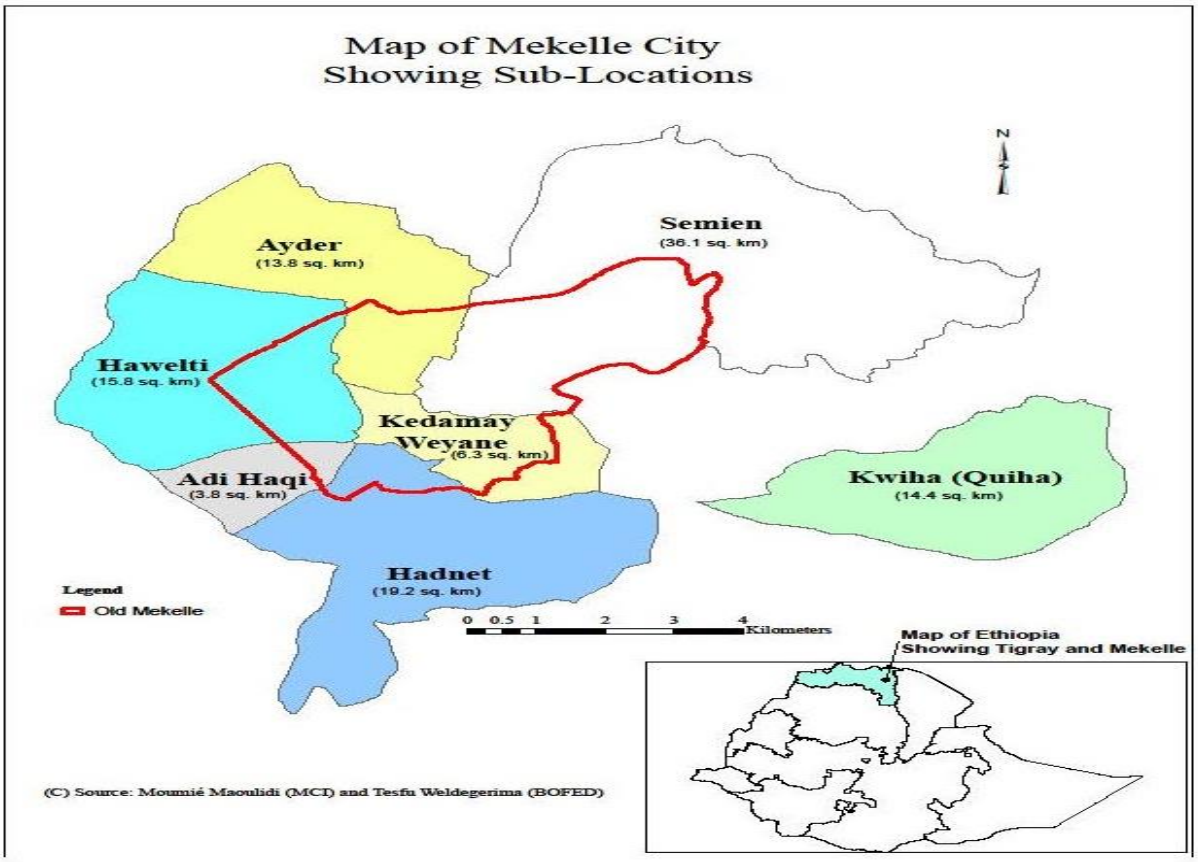


Figure 5: Geographical location map of Mekelle city

Source: Millennium City Initiative (MCI), 2010

4.2. Survey Results

4.2.1. Characteristics of Respondents

It is a requisite for any survey based study to first present demographic and socio-economic profile of sample respondents as it helps one to have a good understanding on how the sample taken represents the whole research population. Thus, in this section, main socio-economic characteristics of the sample population which among others include age, gender, level of education and income of the households surveyed are presented. But, before that, it is to be noted that out of the 118 representative sample calculated (see chapter three), because of different reasons[15], only 110 households' were successfully surveyed, putting the response rate at 93%.

Table 4: Socio-economic characteristics of respondents

Stratum	***Sub-stratum***	***Households N=110***	***Percentage***
Gender of the respondent	Male	35	32%
	Female	75	68%
Relationship of the respondent to the HH	Husband	35	32%
	Wife	57	52%
	Daughter	16	14%
	Servant	2	2%
Gender of the HH head	Male	77	70%
	Female	33	30%
Age of the HH head	Mean	44	-
	Maximum	85	-
	Minimum	23	-
Level of education of the HH head	No formal education	17	15%
	Primary education	19	17%
	Secondary education	21	20%
	Diploma & above	53	48%
Average monthly income of the HH	<500 Birr	8	7%
	501-1,000 Birr	23	21%
	1,001-2,000 Birr	31	28%
	2,001-3,000 Birr	24	22%
	>3,000 Birr	24	22%
Household size	Mean	4	-
	Highest	11	-
	Lowest	1	-
Quality of Housing	Precarious	17	16%
	Modest	54	49%
	Modern	39	36%

[15] Few incomplete and inconsistent questionnaires were excluded. However, it is believed that, this will not significantly affect the research results.

Thus, as could be seen from table 4, women take the lion's share of the total sample population surveyed constituting 68% whereas men take the remaining 32%. This gender imbalance was made deliberately because, in the context of the study area, women are responsible for domestic tasks, which cooking is the main household activity given to the female gender. It was understood that, within this cultural environment, a man to cook, while he has a wife or mature daughter, is not socially acceptable. However, it should also be noted that if the man is living alone or is single, there is no wrong in it to cook himself. Hence, in a randomly selected household, the wife (women) was targeted to fill the questionnaires or make the interviews, as it is believed that women could give better information about cooking fuel choice of the household than their men counterparts. But in some cases, if the wife was not available, the husband was selected as an option. Table 4 shows this in detail about who were the main respondents and their relationship to the household. Accordingly, out of the total respondents, 52% of them were Wives, 32% Husbands, 14% Daughters and the rest 2% Servants within the randomly selected household. As previously mentioned above, in situations where all are available during the survey, the housewife was selected to fill the survey questionnaire. Therefore, in the absence of the main housewife, husbands were selected and in rare cases if both the housewife and the husband were absent, a mature daughter or servant for the household was selected. Likewise, of the total households surveyed, 70% were male-headed and the rest 30% were found to be female-headed households.

Moreover, socio-economic profile of the sample households, as it was indicated in the literature review, is considered as determinant factor for household cooking energy choice. Therefore, data related to main socio-economic variables like age, household size, level of education and income of the households were collected.

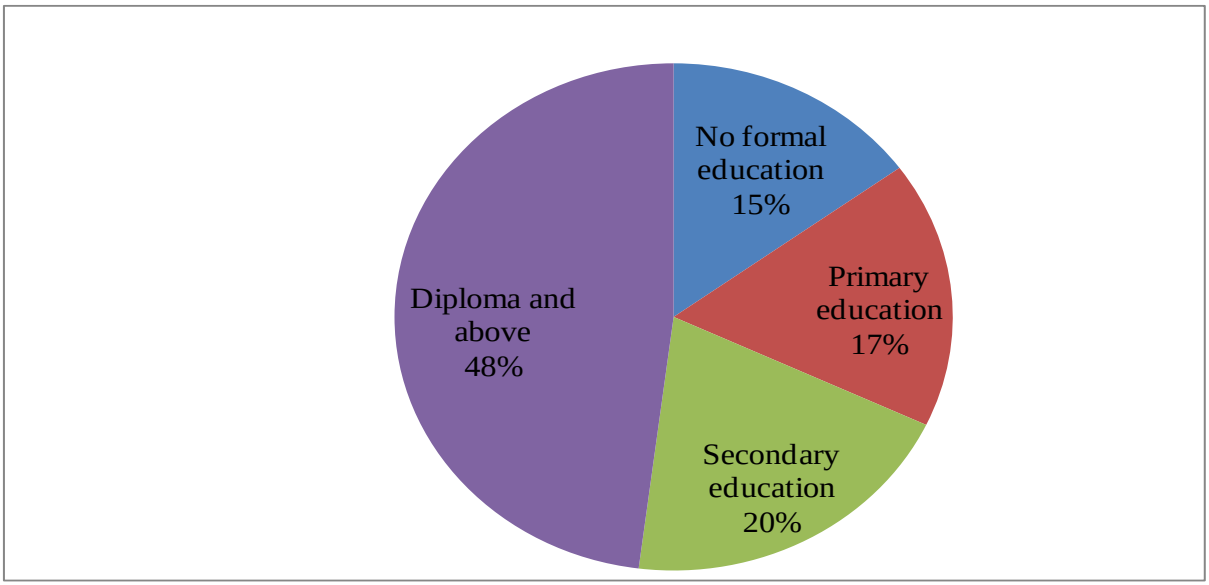


Figure 6: Respondents by level of education

As shown in table 4, regarding socio-economic profiles of sample households, the survey results indicated that the mean age of the sample respondents is (X= 44.1 years, SD=18.9) and with maximum and minimum age of 85 and 23 years respectively. The mean household size as well, was found to be 4 members (X=4.0, SD=2.1). And the highest number of people living within a household was 11 and the lowest was 1 which is typical of a single household.

This is consistent with data found from the Mekelle city municipality mentioned in the introduction section of this chapter. In addition to this, based on their level of education[16] and income, the socio-economic profile of sample respondents is presented in table 4. For quick reference, these are further exemplified in figure 6 and 7 respectively. Thus, as shown in both the summary table and respective figures, the percentage share of sample respondents with diploma and above is much higher than those with no formal education, primary education or secondary education, accounting for 48% of the total and the rest correspond to 15%, 17% and 20% respectively. This was expected as the study site is an urban area with high literacy rate.

Correspondingly, respondents were asked to state their average monthly 'income category.'[17] And so, the survey result showed that about 28% of the sample respondents reported that their monthly income falls between 1,001 to 2,000 Birr, the same percentage of respondents (22%) reported they earn an average monthly income between 2,001 to 3,000 Birr and above 3,000 Birr. Similarly, some 21% of the respondents stated their average monthly income between falls between 501 to 1,000 Birr and the remaining few (7%) reported they earn an average monthly income of less than 500 Birr. In line with this, it should be noted that, as the income variable is a 'stated income' by the respondents themselves, there might be some underestimations. However, the stated income of the respondents was also verified by asking them whether they possess expensive appliances like television, fridges, sofa and mobile phones. This helped to crosscheck their stated income.

Accordingly, survey results showed that almost all sample respondents (99%) own a mobile phone, more than half of the respondents (68%) have television sets and some 30% of them possess a home sofa furniture and a relatively few of them 25% have fridges. In view of that, during data entry, no significant inconsistency or mismatch with the stated income was observed. Also, to ascertain the sated income, based on site observation and personal judgements of respondents, data that indicate households' quality of housing,[18] which is a good indicator for wealth status of households, was also collected. Hence, survey results showed that a slightly high number of respondents (49%) dwell in moderate houses while some respondents (36%) reside in modern houses and a relatively few (16%) respondents live in precarious houses. This also helped to cross-validate their stated income which as a result, confirmed the stated income of households surveyed was not overly underestimated as suspected.

[16] Based on the Ethiopian education system, primary education runs from grade 1 – 8; secondary education runs from grade 9 – 12, 12 grades +2 is diploma and a minimum 3 years education in recognized higher institution is BA/BSc degree (CSA, 2011).

[17] The reference income category was set based on government employee's monthly salary scale distribution in Tigray region.

[18] The main criteria assumed in determining the quality of housing of sample respondents were, whether houses have connection to electricity and water pipes within the compound, are with concrete roof tops, brick walls and the location around the city.

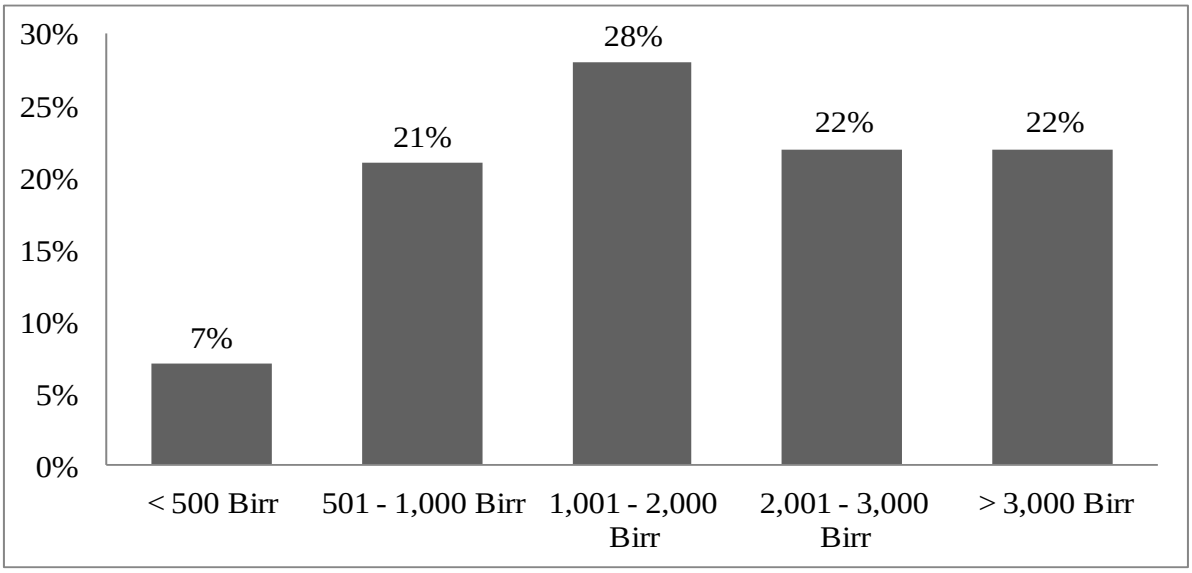


Figure 7: Average monthly income of sample respondents

4.2.2. Findings on Research Question 1: Households' Cooking Energy Choice and Consumption Pattern

As expected, survey results regarding household cooking energy choice indicated that the number of households who still depend on traditional energy sources such as firewood and charcoal is significantly large. Hence, as data findings indicate, the most popular fuel type is charcoal followed by electricity and firewood (see table 5 below). Hence, a great proportion of the total households surveyed (77%) utilize charcoal, and almost half of them (53%) and (49%) utilize electricity and firewood respectively. Relatively speaking, LPG and fuels such as animal dung and plant residuals noted under 'Others' are among the less frequently utilized fuels by only 10% and 5% of the total respondents respectively.

Table 5: Household cooking fuel choice (percentage of households choosing)

		Frequency (N=110)	Percent
Valid	Firewood	54	49%
	Charcoal	85	77%
	Kerosene	47	43%
	LPG	11	10%
	Electricity	58	53%
	Other	5	5%
Total		**	**

**Total for each column cannot be executed as one household uses more than one fuel

As shown in table 5, one of the most important findings of the survey is that households rarely depend on a single fuel rather utilize a combination of different fuels. This confirms the 'households multi-fuel use behaviour' which was thoroughly discussed in the literature review. In connection to this, Figure 8 demonstrates household multi fuel use behaviour more clearly. Thus, by having a quick look at figure 8, one can easily understand that the number of households who utilize only a single fuel type is very few. For example, only 8% of households exclusively use electricity and a few 5% use kerosene and the same 5% use LPG exclusively. In contrast to the rest of households who use a combination of fuels, this is insignificant proportion. And looking at the percentage of households who use a multitude of fuel combinations, Firewood and Charcoal with 32% and Electricity and Charcoal with 13% takes the large share of households who utilize a combination of fuels. This also reveals how traditional fuels like firewood and charcoal are predominantly used either exclusively or in combination with those modern fuels. From this, it would be interesting to ask why households combine different fuel types and what makes this such a common phenomenon in the city. Data that possibly answer such questions are discussed in detail in the forthcoming paragraphs (see figure 9 below).

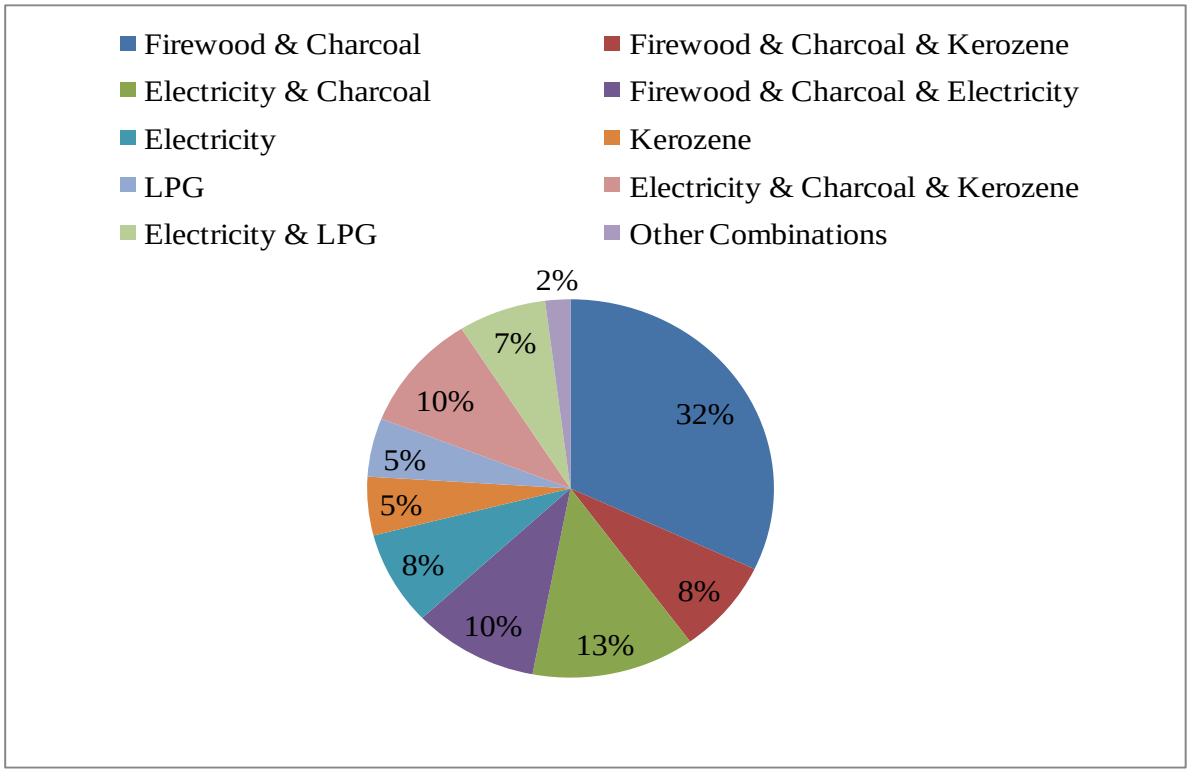


Figure 8: Household multiple cooking fuel choice

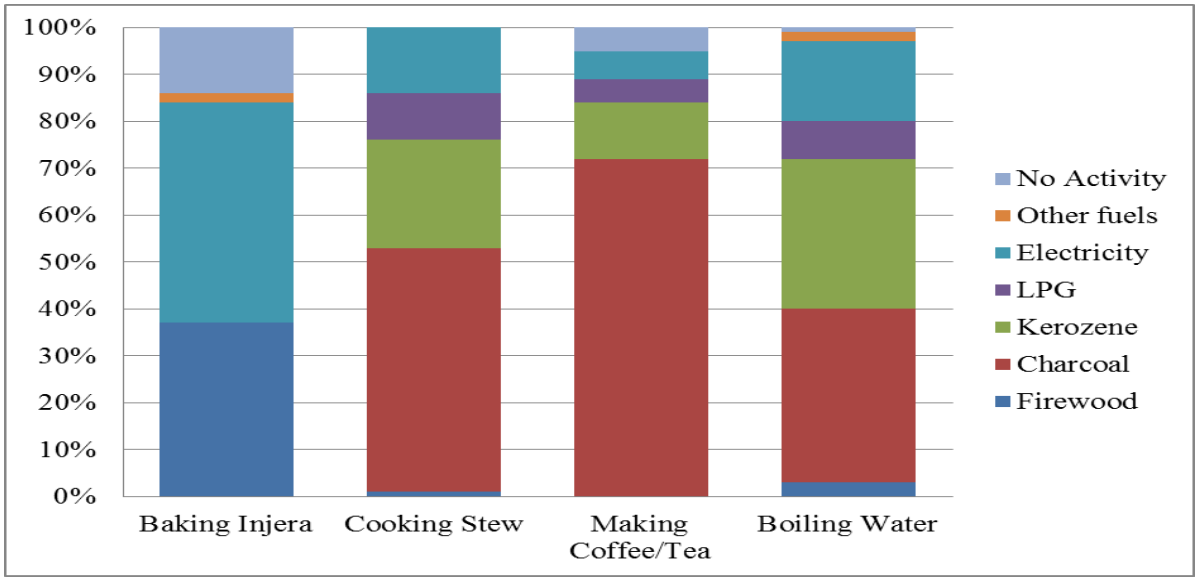


Figure 9: Household cooking fuel choice by cooking tasks

The major justification why households use multiple fuels is partly related to the fact that some fuels are only convenient for undertaking specific cooking activities. For instance, as shown in figure 9, electricity and firewood are predominantly used for baking *injera* [19]whereas charcoal is widely used for making coffee and to some extent for cooking stew (different kinds of sauces eaten with *injera*) and boiling water. In this case, it is worth mentioning that, as it has been observed during the data collection process, it is not possible to bake *injera* using charcoal, LPG or kerosene as the stoves used for baking *injera* are not suitable for such fuels. Only firewood or electricity is convenient for such cooking activity. Particularly, firewood is almost solely used for baking *injera*. This therefore can be considered as a possible reason for household multiple fuel use behaviour. On the other hand, for preparing coffee, charcoal is the most popular fuel unlike to other fuels. On top of this, figure 9 shows that the use of LPG and kerosene is only limited to boiling water, cooking stew and somehow to making coffee. Overall, it can be understood that households use different fuels for different cooking activities which in turn, indicates that, the different fuels has their own unique importance in accomplishing specific cooking tasks. This appears to be the main reason for household multi fuel use behaviour which was mentioned before.

In the above paragraphs, it was stated that most of the households surveyed utilize a combinations of fuels based on their choices and individual cooking preferences. Since the variety of fuel combinations used by households is too many, it is not to easy to analyse how households make fuel choices and what factors influence their choices. Therefore, to better understand the household multi fuel use behaviour and explain the factors that determine household fuel choice (to be discussed in the forthcoming section) in a more sensible way, the different household fuel choices are adjusted and put into three relevant fuel choice categories[20]: solid fuels, non-solid fuels and a mix of solid and non-solid fuels. This category

[19] It is pancake-like flat bread usually made out of fermented *teff* (a tiny grain unique for Ethiopia) flour and is eaten by placing a stew and different spices on top of it. It is the most common food of the Ethiopian people.

[20] Solid fuels include firewood, charcoal, animal dung and other plant residuals and fuels categorized under non-solid fuels are kerosene, LPG and electricity which are found in the form of liquid, gas or electrical power. These are more clean and efficient than their solid counterparts. Thus, categorically, in this paper, a mention to solid fuels refers to traditional fuels and a mention to non-solid fuels also refers to modern fuels.

is sensible in such a way that it simplifies the complex nature of the fuel combinations utilized by the sample respondents. Therefore, households who utilize fuels with similar attributes are grouped under one category to accommodate the diversified nature of household fuel choice combinations. Since the study's interest is also to analyse households' cooking fuel choices and how households make a transition from those traditional (solid fuels) to those modern ones (non-solid fuels) under the influence of different factors, regrouping the different combinations is crucial. The different combinations of households' fuels choices are regrouped and illustrated in Figure 10 below.

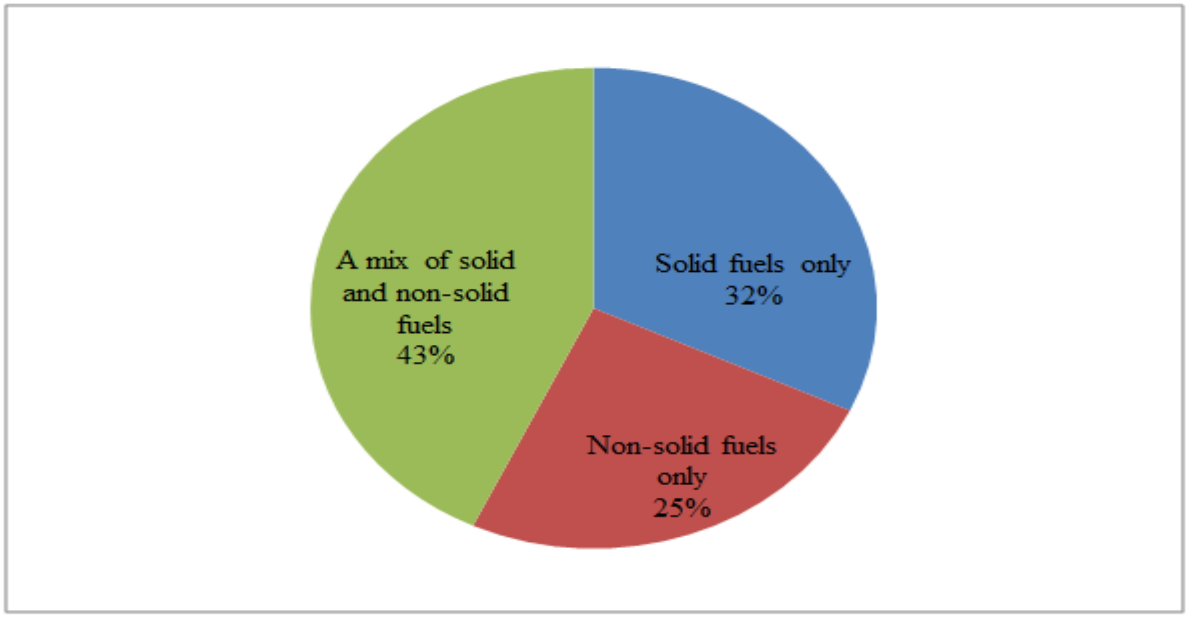


Figure 10: Household multiple cooking fuel choice (regrouped)

As seen above, a significantly high proportion of the total households surveyed (43%) utilize 'a mix of solid and non-solid fuels' while 32% of them use 'solid fuel only' and the remaining 25% exclusively use 'non-solid fuels'. This reinforces the notion that households do not completely switch from the use of traditional fuels towards those modern ones which is against the 'energy ladder model' that assumes households complete fuel switching across the ladder. This model also considers the household energy transition as a unidirectional process where households completely stop utilizing traditional fuels- which are assumed to be found at the lower part of the 'energy ladder'- to those modern ones found up the 'energy ladder' (this was discussed in detail in chapter two). However, the survey result showed that for most of the sample respondents (43%) even though they had started to utilize non-solid fuels like LPG and electricity, they did not completely abandon the use of traditional fuels such as firewood and charcoal. This shows the bidirectional process of the household energy transition confirming households' multi fuel use behaviour or as it was termed in many literatures as 'energy stacking' model. This disproves the existence of an 'energy ladder' rather it is 'a portfolio of fuel choices', where households combine different types of fuels.

On the other hand, though with some limitations[21], this study also attempted to capture some information about the temporal side of household cooking energy choice and transition. This helps to give some insight how households shift from one fuel type towards another across

[21] A longitudinal study would have been better to examine household cooking fuel transition across time

time. The following figure portrays the pattern of household cooking energy choice by comparing the situation between 'now' and 'before five years'[22].

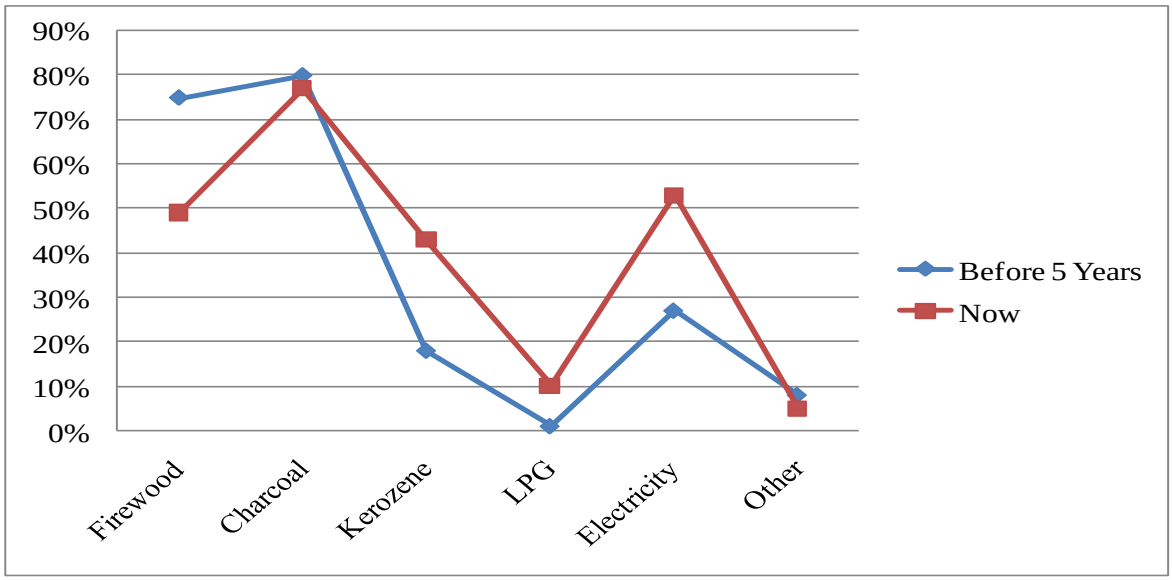


Figure 11: Household cooking fuel choice and transition

The above figure describes how households' choice of cooking fuels changes overtime. Accordingly, while the percentage of households who utilize firewood dropped by 26% (from 75% to 49%) throughout this five years' time period, the proportion of households utilizing charcoal remained almost unchanged, showing only a slight drop from 80% to 77% over the same period of time. The same trend was observed in the 'Other' fuel category falling from 8% to 5% across time. On the other hand, in all the other non-solid fuels (kerosene, LPG and electricity) the proportion of households utilizing such type of fuels increased significantly across time. Specifically, utilization of LPG has increased by 100%, from none to 10% yet, it is still utilized by a very small proportion of the total sample households. Utilization of kerosene and electricity also registered a remarkable increase by 25% (from 18% to 43%) and 26% (from 27% to 53%) over this five years' time period respectively.

By and large, this household cooking fuel transition shows the condition that, through time, there is a tendency for households to shift from utilizing those inefficient and unclean fuels such as firewood, animal dung and plant residuals towards those efficient and clean ones like LPG and electricity. One possible explanation for this phenomenon might be the conventional thinking that, through changes in life style and evolution of modern fuel markets, urbanization derives household cooking energy transition. However, it should also be noted that this inter-fuel substitution that was revealed over time is not a complete shift as it was observed that households who utilize charcoal fuel sought negligible change over the course of five years. Perhaps, this might be because of some socio-cultural factors inherent with each household cooking norms and practices. This will be critically analysed under section 4.2.3 of this chapter.

[22] This reference year was selected based on two basic assumptions: one is that, this five year period is enough time for households to make fuel transition. Second, households could easily remember and tell their previous fuel choices.

Similarly, to have a full picture of household cooking energy consumption pattern, the sample respondents were asked to state their monthly average fuel consumption expenditures.

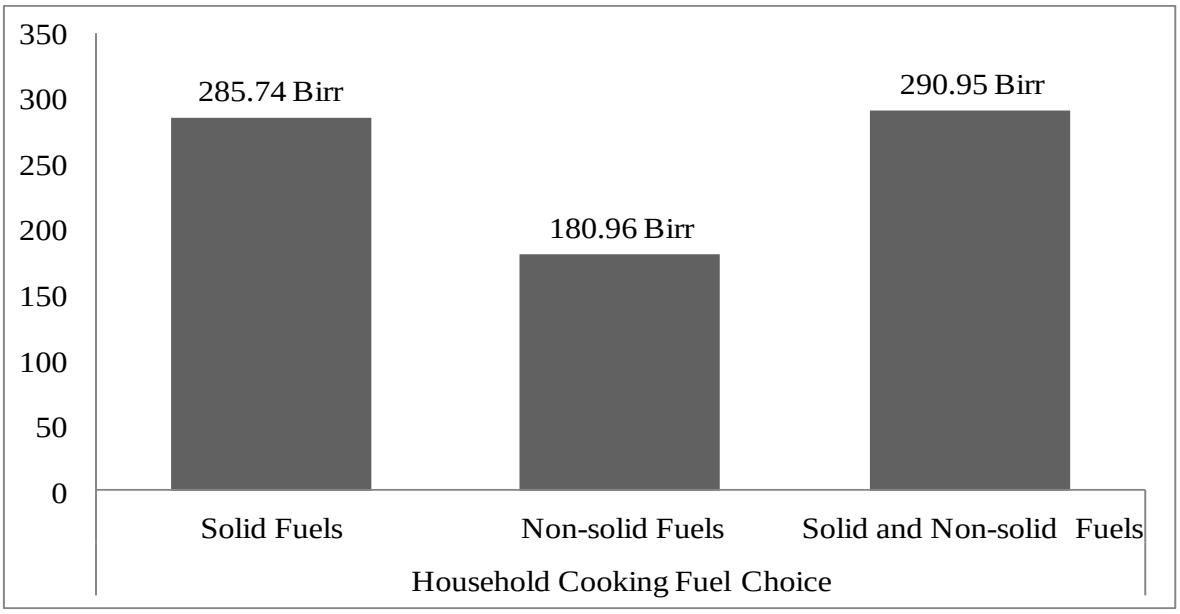


Figure 12: Household mean monthly cooking fuel consumption expenditure

As such, figure 12 presents the mean fuel consumption expenditure of the sample respondents grouped based on their fuel choices. In this case, it is important to make clear that this mean fuel consumption expenditure does not take into account of household size and individual household energy use behaviour which are two key elements that could alter the amount of fuel consumption expenditure. Moreover, of those households who utilize electricity, since there is no separate metering system of electricity power consumption, for most of them, it was difficult to differentiate the specific electricity use charge used for cooking from other use charges such as lighting. And so, for such households the fuel expenditure stated may also include usage fees for lighting services. This may limit the robustness of the data to represent households' real fuel expenditures.

However, to some extent, it can display the pattern how fuel expenditure differs among households who utilize different combination of fuels: solid fuels, non-solid fuels and a mix of both. Thus, the above figure suggests that the mean expenditure for households who only use non solid fuels like LPG, electricity and kerosene is much less than other households who utilize either solid fuels only or a mix of solid and non-solid fuels.

Perhaps, this is partly because, in the study area, solid fuels such as firewood and charcoal are purchased unlike in other small towns and rural areas, where it is possible to collect freely from nearby bushes and forests (see figure 13). In this respect, it was discovered that, regarding firewood users(N=54), almost all of them (93%) reported they purchase it from the market while the rest few 2% stated they collect it freely and 6% reported it is a gift from relatives living in remote rural areas. Similarly, of those charcoal users (N=85) most of them 85% reported they purchase it from the market, 11% reported they self-produce it and the remaining 5% acquire it as gift from relatives.

All in all, the above findings where the mean expenditure of households who use non-solid fuels only, to be far less than those who use either solid fuels only or a variety of solid and non-solid fuels is against the perceived belief among the general public that firewood and charcoal are cheap fuels. This will also be further discussed under section 4.2.3 of this chapter.

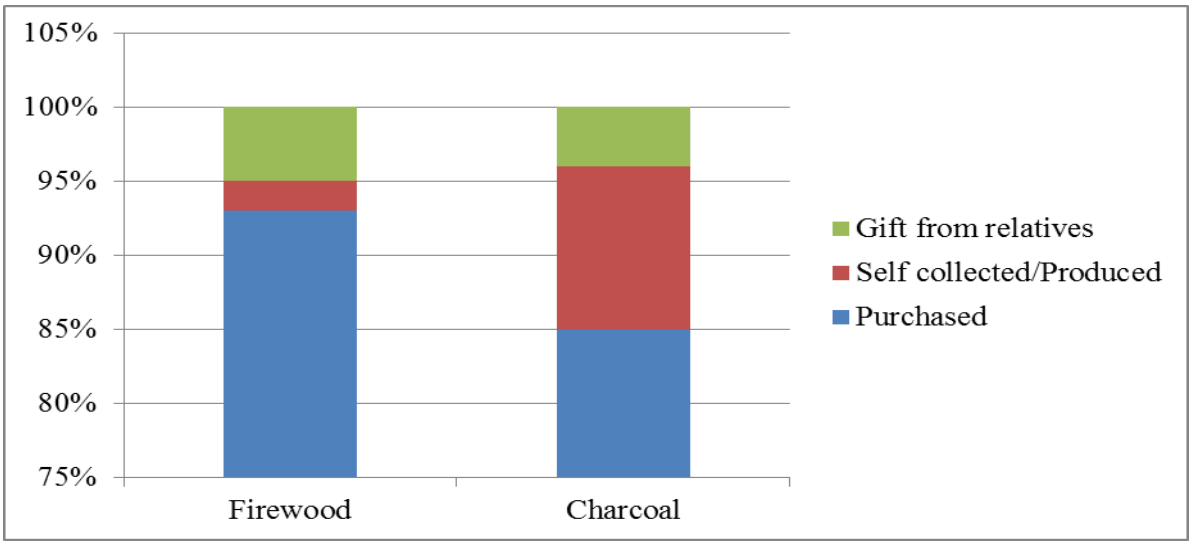


Figure 13: Mode of acquisition of firewood and charcoal fuels

4.2.3. Determinants of Household Cooking Energy Choice

4.2.3.1. Overview on Answering Research Question 2 and 3

It is assumed that household cooking energy choice discussed under 4.2.2 is the dependent variable influenced by the socio-economic, socio-cultural and household cooking energy supply related factors which also are assumed as independent variables. Thus, within the general framework set, this section tries to find out how household cooking energy choice is influenced by analysing data collected on each identified variable.

Hence, to analyse the relationship between the dependent and independents variables (which in this case are the socio-economic, socio-cultural and cooking energy supply related factors) a two-step process was followed. First, the observed data was described by looking at the data patterns and distributions put in each respective figures and tables and in the second step, using the Chi-Square test of independence, the relationship revealed by the descriptive analysis is verified whether it is statistically significant relationship or not. Moreover, further statistical tests particularly Cramer's V are employed to determine the magnitude of the relationships results found from the Chi-Square test.

It should also be known that, before conducting the Chi-Square test, it was checked if basic assumptions were met to make the Chi-square test which among others include: the two variables are categorical in nature, random sampling technique was employed to draw the sample population, the number of responses in each cell are at least five and the sample is representative enough which in this case is 110. As a result, all assumptions are met by this study to make the Chi-square test. On the other hand, for those variables which are qualitative in nature, data collected from the interviews as narrations, direct quotations is used to support and possibly extend ideas so that results are credible and reliable. Based on this, survey results that enable to answer research question two and three are analysed here under.

4.2.3.2. Findings on Research Question 2: Socio-economic Factors Influencing Household Cooking Energy Choice

As previously mentioned, survey data related to age, gender and level of education of the household head, household size and income were presented and partially described. In this section, how these variables influence household cooking fuel choice is also explained by analysing the distribution of household cooking fuel choices with changes in each variable.

i. Household Income and Cooking Energy Choice

Most classical literatures on household energy confirm that income is one of the most dominant determinant factors in household energy choice. One notable example is the energy ladder model- that assumes when household income improves, households go up the energy ladder- where each step in the energy ladder represents more efficient and clean fuels. According to the survey results, it was observed that as household income increases, there is a tendency for households to utilize either 'non-solid fuels' or a 'mix of solid and non-solid fuels'. In other words, this means that for any household with high income earning, there is high chance to find this household utilizing non-solid fuels such as LPG and electricity rather than solid fuels like firewood and charcoal (see figure 14 below). Hence, it was found that, of the total households with average monthly income below Birr 500 (N=8), most of them (N=6, (75%)) utilize solid fuels only (mainly firewood & charcoal) whereas of those total households with an average monthly income between Birr 501 - 1,000 (N=23), only (N=9, (39%)) of them utilize solid fuels only. Thus, a sharp fall in the proportion of households that utilize 'solid fuels only' from 75% to 39% when household average monthly income increases clearly indicates that there a trend where households shift from utilizing 'solid fuels' to other 'non-solid fuels'. Decreasing at an increasing rate, this trend continues up to the last income category (households with higher average monthly income of more than Birr 3,000) where only (N=2, 8%)) of the total households in this income group (N=24) were found to utilize 'solid fuels only'. Conversely, no household with average monthly income of less than Birr 500 utilizes 'non-solid fuels only'. And looking at the other income groups, of the total households with average monthly income of 501 - 1,000, (N=23) only 25% (N=2) of them utilize 'non-solid fuels only' but the proportion of households who use 'non-solid fuels' increased dramatically in the income groups with 1,001 - 2,000 Birr (N=31) to (39% (N=12)). Consequently, though it decreased in the higher income groups, it never goes below those with low average monthly incomes. Similarly, more steady and linear increment was observed for those households with a combination of 'solid and non-solid fuels' confirming the general belief that when household income improves, household shift towards using those fuels with relative efficiency and cleanness advantage such as LPG and electricity. The possible explanation for the existence of high proportion of households who utilize 'a mix of solid and non-solid fuels' in the higher income groups (mainly in > 3,000 income group) may lie in the fact that income is not the only dominant factor that influence household cooking fuel choice. This leads us to anticipate that other factors such as socio-cultural and supply related factors might have a role to play. If such factors do have a role will be discussed under the forthcoming sections of this chapter.

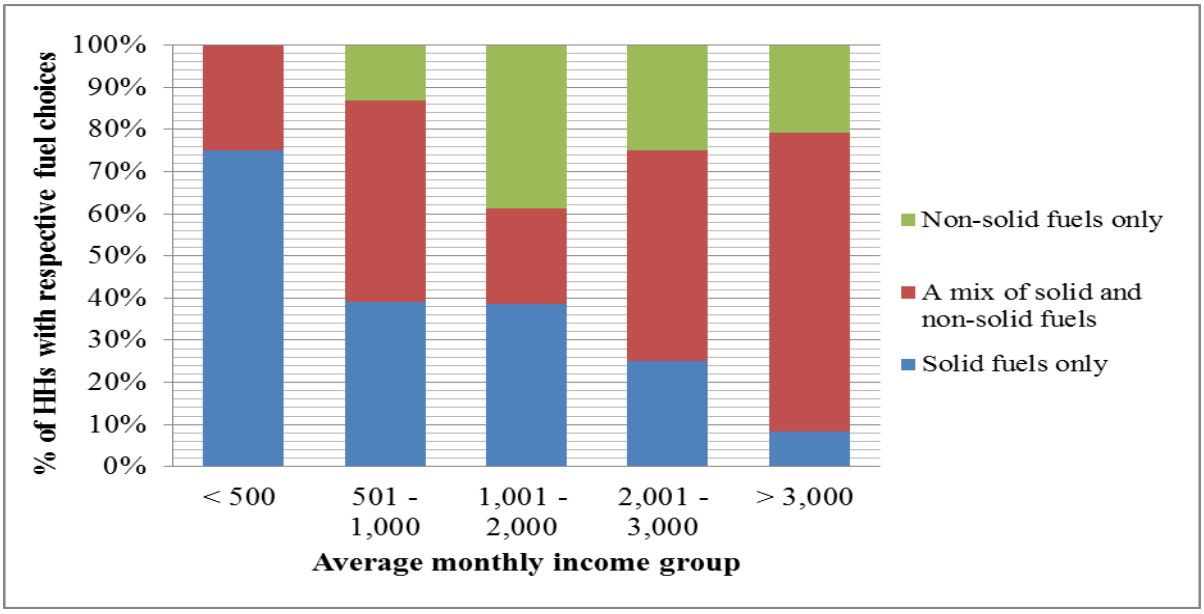


Figure 14: Distribution of household cooking fuel choice by household income

Putting it simply, the above findings indicated that there is a smooth pattern in household cooking fuel transition across the different household income categories showing the existence of an association between income and household cooking fuel choice. However, it is also worth noting that, whether this potential relationship observed was happened by chance or not should be tested. Thus, to verify this, Chi-Square statistical independence test was applied (see table 6 below).

Table 6: Chi-Square Tests result on household cooking fuel choice and income

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	25.021[a]	8	.002
Likelihood Ratio	28.733	8	.000
Linear-by-Linear Association	14.709	1	.000
N of Valid Cases	110		

a. 3 cells (20.0%)[23] have expected count less than 5. The minimum expected count is 2.04.

Table 7: Effect size measure result of Chi-Square Test on household cooking fuel choice and income

		Value	Approx. Sig.
Nominal by Nominal	Phi	.477	.002
	Cramer's V[24]	.337	.002
N of Valid Cases		110	

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

According to these results there is statistically significant relationship between households' cooking fuel choice and income $X^2(8, N=110) = 25.021$, $p = .002$), $V = .337$.

[23] According to Cochran's rule (1954), in Chi-Square test, up to 20% of expected counts less than 5 is tolerated

[24] measures the magnitude of the relationship between the variables tested in more than 2x2 Chi-Square test

Moreover, the value of Cramer's V denoted as 'V' = .337 showed the observed relationship between household cooking fuel choice and household income is between moderate to large.

ii. Level of Education of the Household Head and Cooking Energy Choice

In addition to income, education status of the household head is considered as determinant factor in household cooking fuel choice by many empirical literatures. In view of that, one critical presumption that is widely discussed by most empirical findings is that households with good level of education develop the knowhow about the health and environmental advantages and disadvantages of cooking with each type of fuel. This is because when household members are with good education level, it is easy for them to get informed about the merits and demerits of each fuel character and function. Possibly, it is highly probable that, educated households are familiar with how to use cooking technologies related with more advanced fuels and cook stoves used in complement with non-solid fuels such as LPG and electricity. Acquainted with such premises, in this study, data was collected to investigate if the level of education of the household head has any relationship with the type of cooking fuel chosen (see figure 15 below).

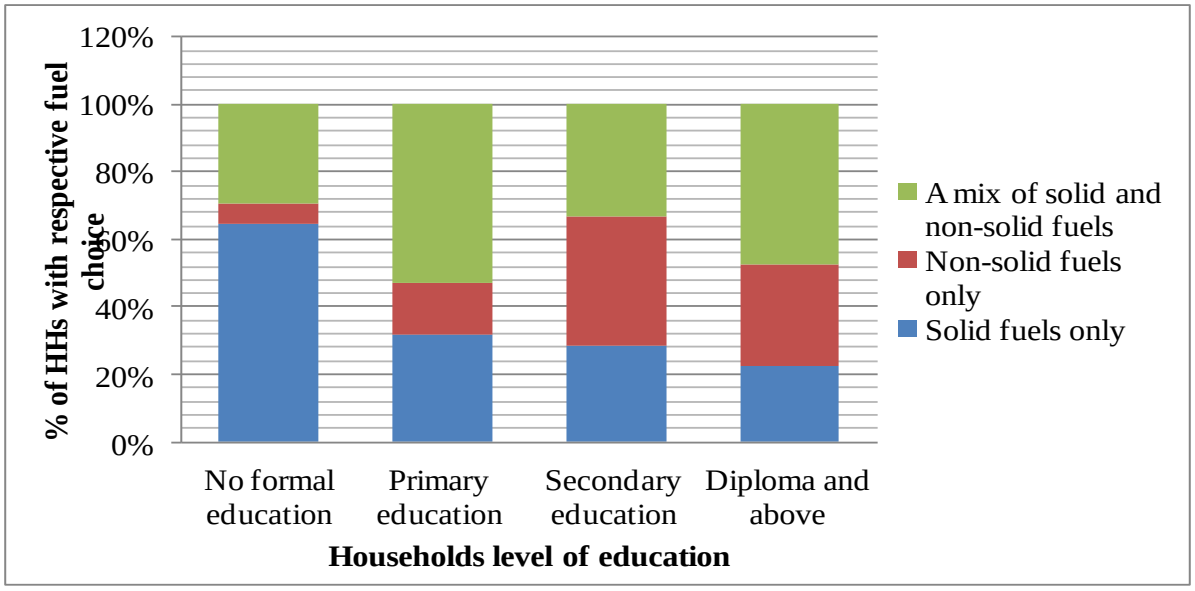


Figure 15: Distribution of cooking fuel choice by level of education of the household head

Hence, data collected showed the existence of a direct relationship between level of education of the household head and household fuel choice- explained in terms of households' energy use transition from reliance on 'solid fuels only' towards use of 'non-solid fuels'. This relationship is illustrated in figure 15 in more understandable way. From this figure, one can infer that, households with more education levels are more inclined to adopt 'non-solid fuels' either exclusively or in combination with 'solid fuels'. To put it more clearly, of the total households whose their head has no formal education (N=17), the survey result showed that, a great proportion of them (65%) use 'solid fuels only' whereas of the total households whose their head is with primary and secondary education (N=19 & N=21), only 32% and 29% of them were found utilizing 'solid fuels only' respectively. This trend also continued to decrease further in those households whom their head is with higher education to 23%. On the other hand, a very opposite trend was observed for the proportion of households who utilize non-solid fuels though slight fluctuation is observed in between. To look at this, it was found that, of total households with no formal education (N=17), the percentage of households who utilize a 'mix of solid and non-solid fuels' is 6% (N=5) but for those

households with primary education, the percentage of households who utilize the same fuel category increased swiftly to 53%. Surprisingly, it was also observed that this percentage decreased back to 33% and 47% for those households whose their head is with secondary and higher education respectively. This trend was also observed for the 'income variable' mentioned previously. In both cases, it is an interesting finding because such scenarios might be indications of the existence of other factors that influence household cooking fuel choice other than socio-economic factors such as income and education level.

Therefore, even though a little non-linearity was observed in the distribution of household cooking fuel choice with changes in level of education of the head of the households surveyed, the existence of an overall relationship between these two variables was found. However, it is also imperative to confirm whether this relationship is statistically significant. Hence, with a similar approach, Chi-Square test of independence was applied to test the statistical significance of the observed relationship. Hence, according to these results, there is statistically significant relationship between households' cooking fuel choice and level of education of the household head $X^2(6, N=110) = 14.112$, $p = .028$), $V = .337$. Additionally, the value of Cramer's V denoted as 'V' = .253 showed that the magnitude of the observed relationship between household cooking fuel choice and level of education of the household head is moderate.

Table 8: Chi-Square Test result for household cooking fuel choice and level of education of the household head

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	14.112[a]	6	.028
Likelihood Ratio	14.087	6	.029
Linear-by-Linear Association	4.255	1	.039
N of Valid Cases	110		

a. 2 cells (16.7%) have expected count less than 5. The minimum expected count is 4.33.

Table 9: *Effect size result on Chi-Square Test on household cooking fuel choice and level of education of the household head*

		Value	Approx. Sig.
Nominal by Nominal	Phi	.358	.028
	Cramer's V	.253	.028
N of Valid Cases		110	

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

In line with this, some literature also suggest that the main occupation of the wife in the household which is mostly responsible for cooking activities in the household is an important determining factor in household cooking fuel choice. This is because, when the wife of the household is educated, it is highly probable to engage with high paying jobs in non-domestic activities. The big assumption of this proposition is cooking with non- time-efficient fuels such as firewood and charcoal brings high 'opportunity cost'[25]of time. Thus, it is believed that when the wife in the household is busy in outside jobs, this motivates the household to adopt time and energy saving fuels such as LPG and electricity. Understanding this, data concerning both the level of education of the household head and the main occupational status of the wife in the household were collected. Following same steps, whether occupational type of the wife in the household has a relationship with household cooking fuel choice is also presented under (see figure 16 below).

Figure 16: Distribution of HH cooking fuel choice by main occupation of the wife in the HH

Subsequently, the data found showed that unlike to when the wife in the household is either unemployed or engaged in housework activities, there is high tendency for households to adopt 'non-solid fuels' when the wife is engaged in full-time wage employment or business activities.

Table 10: Chi-Square Tests result on household cooking fuel choice and occupation of the wife within household

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	29.315[a]	8	.000
Likelihood Ratio	27.653	8	.001
Linear-by-Linear Association	4.908	1	.027
N of Valid Cases	110		

a. 3 cells (20.0%) have expected count less than 5. The minimum expected count is 1.78.

[25] Is an economic term which refers to the value of forgone alternative when others are chosen

Table 11: Effects size measure result for Chi-Square test on household cooking fuel choice and main occupation of the wife in the household

		Value	Approx. Sig.
Nominal by Nominal	Phi	.516	.000
	Cramer's V	.365	.000
N of Valid Cases		110	

a. Not assuming the null hypothesis.
b. Using the asymptotic standard error assuming the null hypothesis.

As hypothesized, the Chi-Square test for the household cooking fuel choice and main occupation of the wife of the household showed the existence of significant relationship between these two variables. Therefore, to these results there is statistically significant relationship between households' cooking fuel choice and main occupation of the wife in the household $X^2(8, N=110) = 29.315$, p = .000), V= .365. Also, the value of Cramer's V denoted as 'V' = .365 showed, the magnitude of the observed relationship between household cooking fuel choice and main occupation of the wife in the household is between moderate to strong.

iii. Gender of the Household Head and Cooking Energy Choice

Survey results about the relationship between these two variables which is shown in figure 17 indicate that there is no uniform distribution in the household fuel choice across gender of the household head. For instance, the proportion of female headed households that use 'non-solid fuels only' (30%) is higher than the proportion of male headed households with the same fuel choice (23%). Therefore, this may support the idea that female headed households are more inclined to adopt non-solid fuels than the male headed ones. This seems true that since the women in the household are direct victims of the side effects associated with cooking with solid fuels like firewood and charcoal, one can expect more women to adopt non-solid fuels than their men counterparts. On the other end of the spectrum, the survey results showed that the proportion of female headed households in the utilization of 'solid fuels only' showed little difference to male headed households, which is against the previous argument. At the same time, Chi-Square Test was also applied to find out if these two variables have statistically significant relationship (see table 12). However, the Chi-Square test result revealed that there is no statistically significant relationship between households' cooking fuel choice and gender of the head of the household $X^2(2, N=110) = .916$, p = .632).

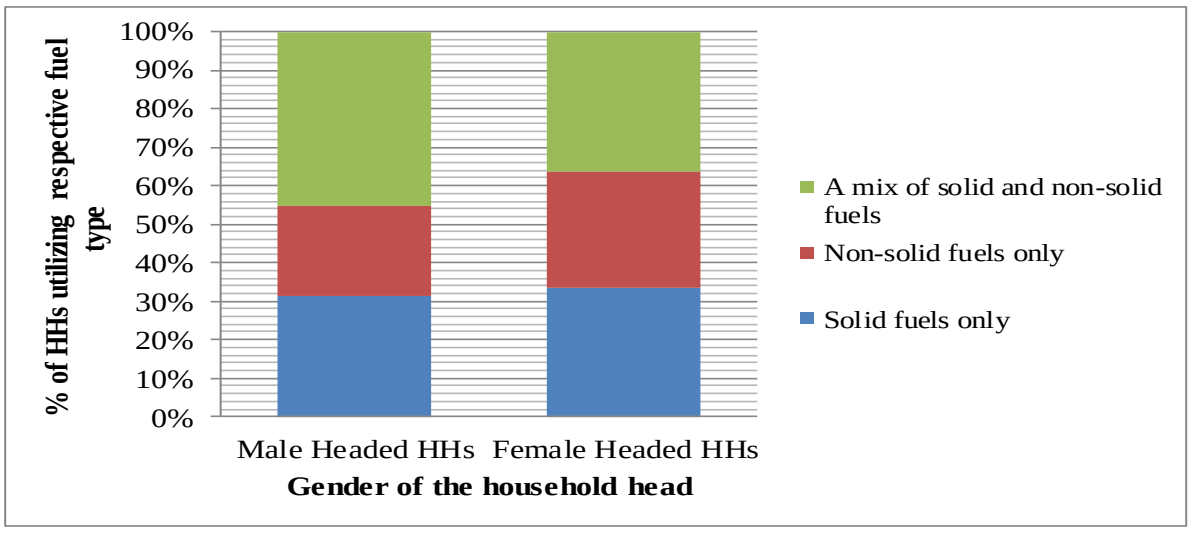


Figure 17: Distribution of household cooking fuel choice by gender of the household head

Table 12: Chi-Square Test result on HH cooking fuel choice and gender of the HH head

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	.916[a]	2	.632
Likelihood Ratio	.916	2	.633
Linear-by-Linear Association	.395	1	.530
N of Valid Cases	110		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 8.40.

iv. Age of the Household Head and Cooking Energy Choice

Among the different socio-economic variables that are considered as potential influencing factors on household cooking fuel choice, equally important is analysing the age of the household. In this respect, it is expected that age of household head is inversely related with household cooking fuel transition. The major assumption against such assertion is, aged households are more comfortable with familiar technologies and are keener to preserve norms and traditions which consequently discourage against household cooking fuel transition. Therefore, to analyse if there is any potential association between household cooking fuel choice and age[26] of the household head, the same procedure was followed (See figure 18).

Based on this, data findings indicated that there is less chance for a given household to utilize either 'non-solid fuels only' or in combination with solid fuels, with households headed by aged person. For instance, as one can see from figure 18, of the total households with 18 - 30 years old household head (N=23), most of them (N=12, 52%) use 'non-solid fuels only' while the rest very few percent (N=3, 13%) use 'solid fuels only'. Contrarily, the percentage of households who utilize 'non-solid fuels only' decreased in households with household head aged between 31-45 years to 23%, in households with a household head aged between 46-65 years to 11% and increased slightly back to 25% in households with household heads aged above 66 years. However, in this age group, still the percentage of households who use 'solid fuels only' did not decreased.

Overall, this finding tell us that, it is highly probable that household with old household heads to utilize 'solid fuels only' than households with young household heads. Data collected regarding both variables was tested using Chi-Square test to ascertain if it is statistically significant relationship or not.

[26] In the first place, age of the household head was collected as a continuous variable but in order to make the Chi-Square test, it was changed into a categorical variable.

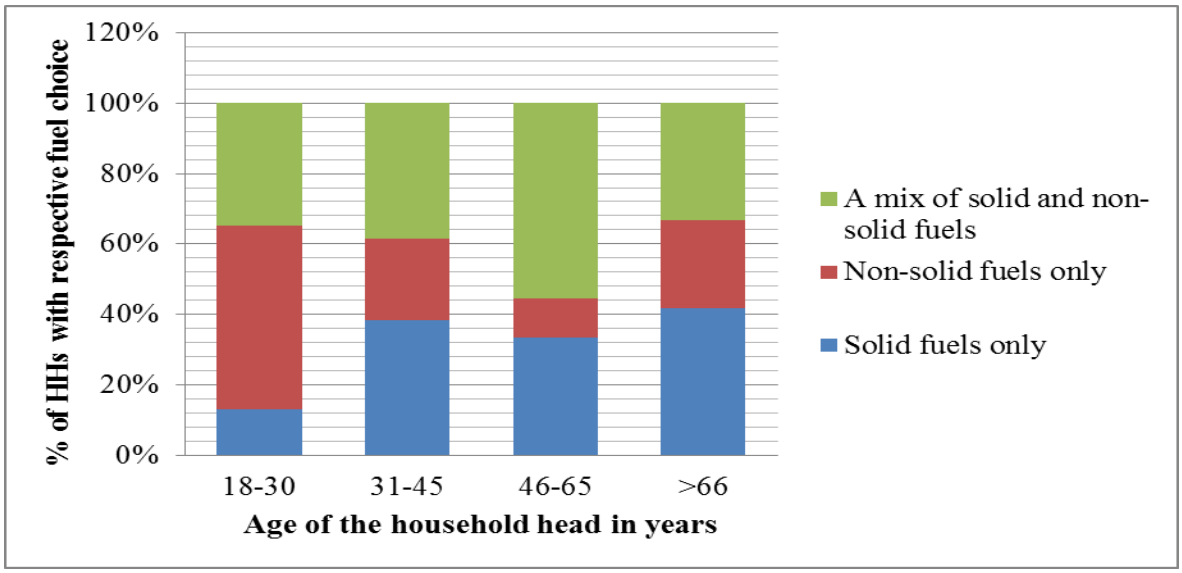


Figure 18: Distribution of household cooking fuel choice by age of the household head

Table 13: Chi-Square Test result on HH cooking fuel choice on age of the HH head

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	15.069[a]	6	.020
Likelihood Ratio	14.940	6	.021
Linear-by-Linear Association	.132	1	.717
N of Valid Cases	110		

a. 2 cells (16.7%) have expected count less than 5. The minimum expected count is 3.05.

Table 14: *Effect size measure result on Chi-square test on HH cooking fuel choice and age of the HH head*

		Value	Approx. Sig.
Nominal by Nominal	Phi	.370	.020
	Cramer's V	.262	.020
N of Valid Cases		110	

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

Therefore, the Chi-Square test result revealed that there is statistically significant relationship between households' cooking fuel choice and age of the household head $X^2(6, N=110) = 15.069$, $p = .020$). And, to determine the magnitude of this relationship, Cramer's' V was calculated at 0.262 which revealed the existence of moderate relationship between these two variables.

v. Household Size and Cooking Energy Choice

As one of the socio-economic variables, household size was also hypothesized as a determinant factor in household cooking fuel choice in some of the relevant literatures reviewed in chapter two. Nonetheless, survey results indicated that, even though there was a reduction in the number of households who utilize 'non-solid fuels only' as household size of sample households increased, for households who utilize a combination of 'solid and non-solid fuels' it changed in the opposite direction. Therefore, it is difficult to interpret it logically based on the notion of household transition. Moreover, the same non-uniform pattern was revealed for users of 'solid fuels only' where little change was observed across the different groups of households with different household size. To make sure that this did not happen by chance, it was also tested using the Chi-Square test which revealed that there is no statistically significant relationship between household cooking fuel choice and household size $X^2(4, N=110) = 8.534$, p = .074, (see table 15 below)).

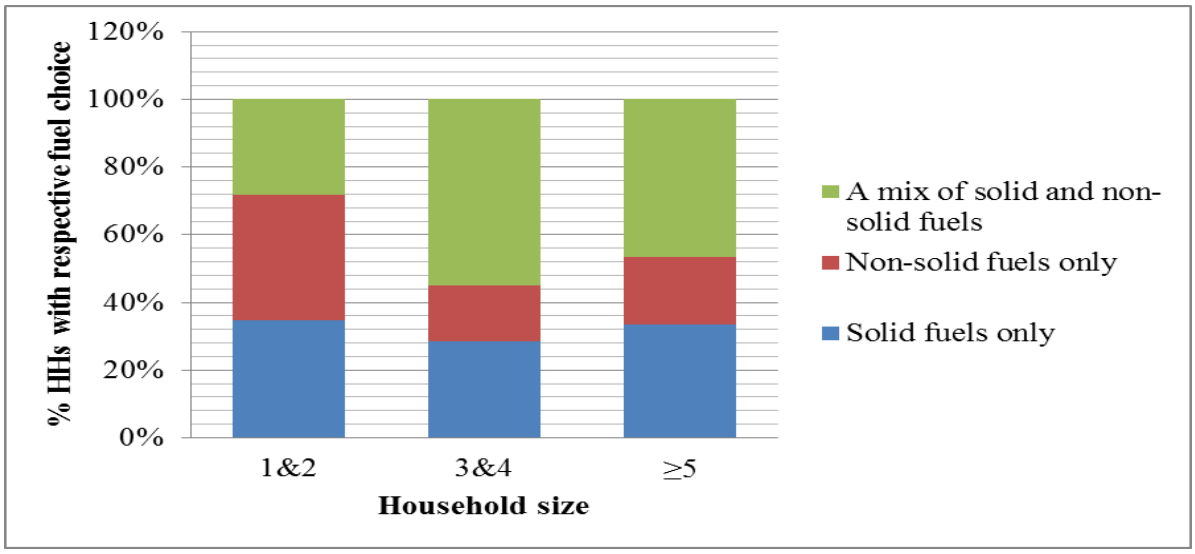


Figure 19: Distribution of household cooking fuel choice by household size

Table 15: Chi-Square Tests result on household cooking fuel choice and household size

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	8.534[a]	4	.074
Likelihood Ratio	8.649	4	.071
Linear-by-Linear Association	1.816	1	.178
N of Valid Cases	110		

a. 2 cells (20.2%) have expected count less than 5. The minimum expected count is 3.82.

4.2.3.3. Findings on Research Question 2: Socio-cultural Factors Influencing Household Cooking Energy Choice

As previously mentioned, the socio-cultural dimension of household cooking energy choice is not as widely discussed in current literature as socio-economic factors. As a consequence of this, little has been known how and to what extent factors related to culturally-determined cooking norms, practices and household social structure influence household energy choice and demand. In need of this, data related to socio-cultural factors were also collected to examine if such factors influenced on household cooking fuel choice. Therefore, this section presents the main findings related to the socio-cultural dimensions of household cooking fuel choice as follows.

i. Gender Role in Household Decision-making and Cooking Energy Choice

It is widely known that the gendered division of labour differs with traditional norms and societal culture. For instance, in most non-western societies, the gender role of women is closely associated with domestic activities. As a result, unlike to men who are considered as breadwinners outside the house, women are mostly responsible for undertaking domestic chores such as preparing food and taking care of family members in the household. In such circumstances, it is obvious that women are more prone to the consequences of cooking with unclean and inefficient fuels. Hence, common-sense can lead one to believe that their role in household decision-making can influence households' decision to adopt modern cooking fuels such as LPG and electricity. Thus, to understand if the role of gender in household decision-making influences the household cooking fuel choice and transition, respondents were asked to state who does in their household decide on which type of fuel to use and the results are illustrated in figure 20 below.

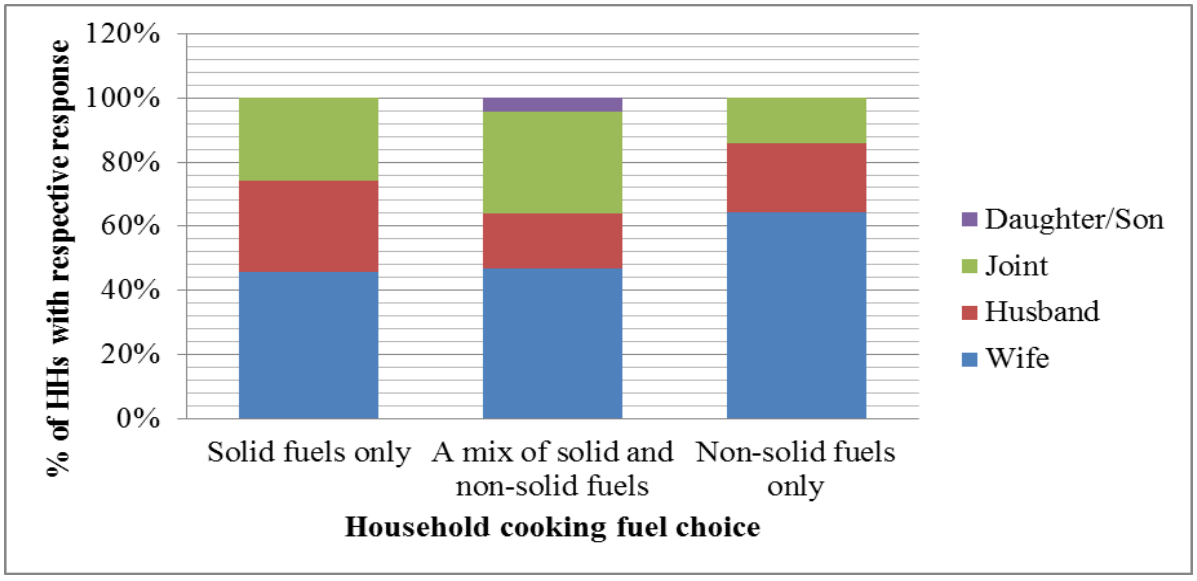


Figure 20: Distribution of HH fuel choice by gender role in HH fuel choice decision-making

Figure 20 shows that the role of the wife(mama) as main decider on what type of fuel to use for the household is more pronounced in those households who utilize 'non-solid fuels only' than for 'solid fuel only' users. However, there seems no significant difference between households who utilize 'solid fuels only' and those who use 'a mix of solid and non-solid fuels' though, the role of the husband declined slightly for the later. By looking at the above figure, one can support the idea that when women are more involved in household decision making, it is more probable for the household to adopt modern cooking fuels.

Table 16: Chi-Square Test results on Household cooking fuel choice and gender role in household decision-making

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	10.469[a]	6	.106
Likelihood Ratio	11.297	6	.080
Linear-by-Linear Association	1.575	1	.210
N of Valid Cases	110		

a. 0cells (0 %) have expected count less than 5. The minimum expected count is .51.

However, to make sure that this did not happen by chance, it was tested using the Chi-Square test which revealed that there is no statistically significant relationship between household cooking fuel choice and gender role in household decision-making $X^2(6, N=110) = 10.469$, $p = .106$).

ii. Household Cooking Practices and Cooking Energy Choice

Most of the time, culture and cooking practices are closely intertwined things where it is very common to find at least one unique food in every culture. Such distinct foods on the other hand require typical cooking practices. Besides, each typical cooking practice demands a specific fuel and cook stove. For this reason, it can be assumed that such culturally determined cooking practices have an influence on household cooking fuel choice. Therefore, to understand how cooking practises determine household cooking fuel choices, it is interesting to have an overview on the different cooking practices: cooking tasks, cooking frequency, time taken for cooking etc…of the households surveyed.

Table 17: Household cooking practices: cooking time and frequency by each cooking tasks

		Hot meals per day	Cooking time hours/day	Frequency of *injera* cooking per week	Frequency of cooking stew per day	Frequency of boiling water per day	frequency of making coffee per day
N	Valid	110	110	91	108	88	99
	Missing[27]	0	0	19	2	22	11
Mean		2.44	2.59	1.92	2.26	1.56	1.85
Std. Deviation		.893	1.15466	.687	.836	.993	.761
Minimum		1	1.00	1	1	1	1
Maximum		5	5.00	4	7	7	4

Table 17 shows the mean number of hot meals consumed by sample households is more than twice a day (X= 2.4, SD=0.89). Therefore, from this, one can understand that eating hot meals is a popular food consumption habit in the context of the local society of the study area. Moreover, the mean hours spent while cooking per day ranges between 1 up to 5 hours with a mean hour of (X=2.59, SD=1.5). The more than two mean hours spent on cooking

[27] Some of the missing figures indicate the case where households report they do not practice such cooking tasks at home. But, this does not necessarily mean they do not consume such kind of foods.

shows, how far cooking is a monotonous activity in the study area. Also, the more than one hour standard deviation in cooking time can be considered as an explanation for how cooking with different fuels results in a substantial amount of time loss/saving. Therefore, it is interesting to note that use of modern cooking fuels that are time efficient minimizes drudgery and opens an opportunity to use the time saved in other productive activities. In addition to this, table 17 reveals households frequency of cooking by each cooking task: households bake *injera* almost twice per week (X=1.92, SD=.687), cook stew more than twice a day (X=2.26, SD=.836), boil water at least once a day (X=1.56, SD=.993) and make coffee almost twice a day (X=1.85, SD=.761). These are among the most important and frequently practiced cooking activities[28] in the study area.

Besides, households were asked which cooking tasks in their respective household consume fuel most. And the responses are presented in figure 21 below. Hence, the survey results showed that, of the different cooking tasks, a significantly high number of respondents (70%) reported that, in respect to their cooking habit, baking *injera* consume more fuel than other cooking tasks and some of the respondents (24%) on the other hand reported, cooking stew consumes more fuel than other cooking tasks. The rest cooking activities were reported as fuel consuming cooking activities by insignificant number of the total households surveyed.

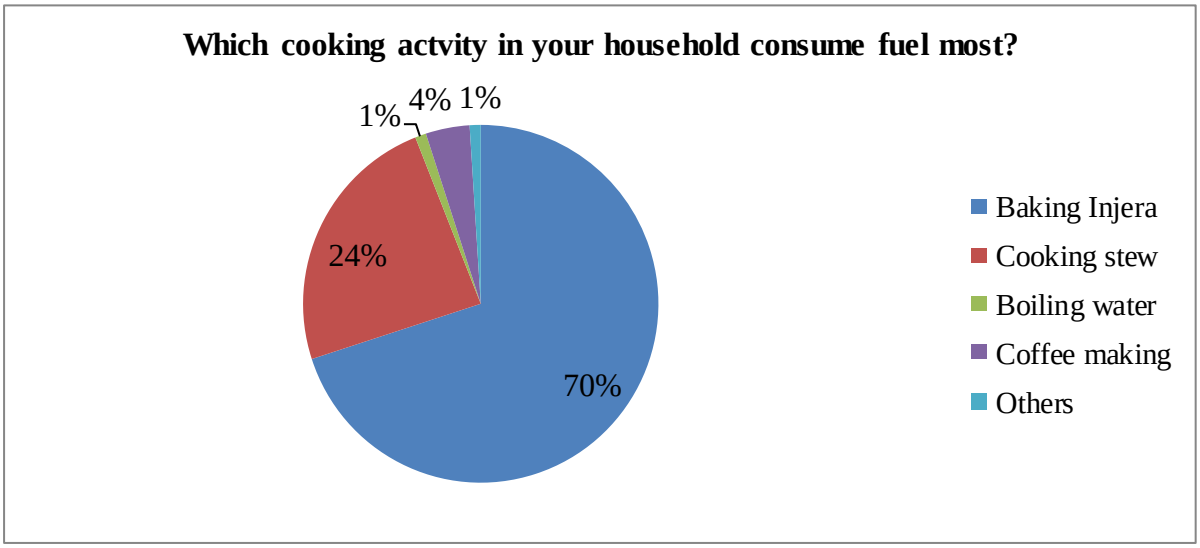


Figure 21: Comparison of household cooking tasks by fuel consumption

In line with this, from the field observation and the interviews, one of the striking findings found is that fuels such as LPG, kerosene are not convenient for baking *injera* as no suitable cook stove that works with LPG or kerosene is available in the market. This limits the portfolio of fuels available for households to make their choices to undertake the task of baking *injera* which on the other hand is the most principal cooking activity. Figure 22 also supports this finding showing that for baking *injera* only firewood, electricity and in rare cases animal dung are used by the survey households. Fuels like LPG and kerosene are quite popular for cooking stew, making coffee and boiling water. Most importantly, it was observed that charcoal is almost exclusively used for making coffee and for other casual

[28] This list of cooking tasks is only the most common cooking activities practiced by most households in the study area. However, one should understand that the list is not exhaustive and other cooking tasks might be left out.

cooking tasks such as for cooking chicken sauce in special ceremonial days. In this regard, an interviewee response summarizes this idea more succinctly as follows: when asked if there are any cultural reasons that prompt her cooking with charcoal, a 45 years old female interviewee responded: *"Though I have the opportunity to cook with electricity, I prefer to make coffee using charcoal because it saves you energy as it burns slowly and retains so much heat to complete the long process of coffee-making*[29]*".* As such, the interviewee response indicated that charcoal is much popular for undertaking coffee making than other modern fuels like electricity highlighting the fact that households make fuel choices depending on the convenience of the different fuels to undertake the cooking tasks needed. This on the other hand, disproves the critical assumption of the household energy ladder model that considers those traditional fuels as 'inferior' fuels- in which households stop using them when their socio-economic status changes.

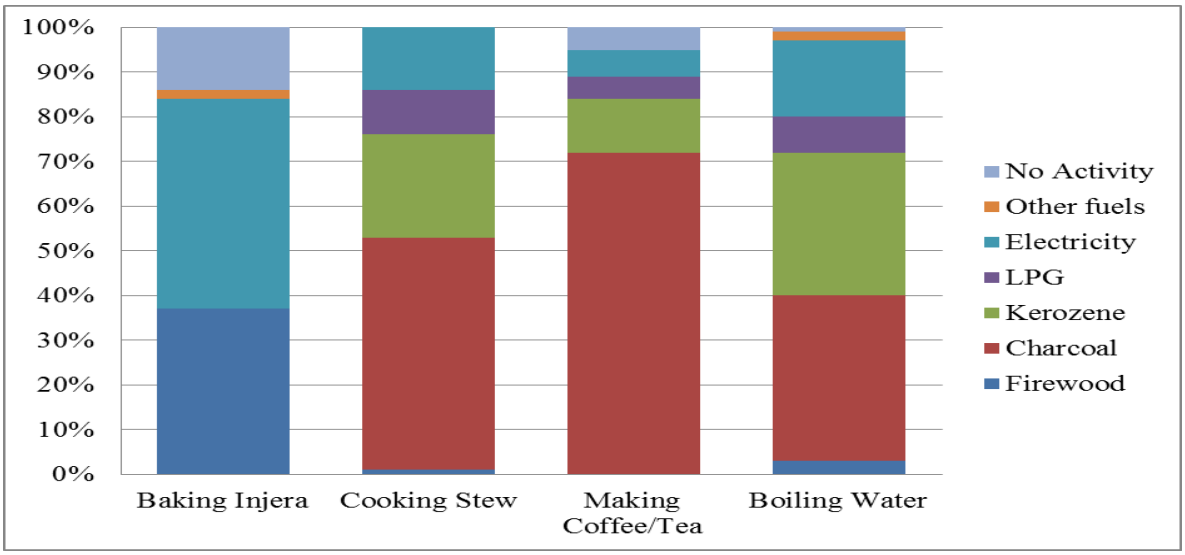


Figure 22: Household cooking fuel choice by household cooking tasks

iii. Taste Preference and Cooking Energy Choice

Similarly, one of the most important components of socio-cultural aspects in household cooking energy choice is individual households' perception towards taste preferences among foods cooked with different fuels. These taste preferences are more or less related to how the attributes of the different cooking fuels and cook stoves make foods more superior in tastes than others which in turn depend upon the intended type of food to be cooked. To find out whether those households who still use those unclean and inefficient fuels (mainly firewood and charcoal) have reasons related with taste preferences, they were asked to report the main reasons for their reliance on such kinds of fuels by indicating if each reason is 'major, 'minor, or 'not at all' a reason from a list of potential reasons provided. The responses are summarized in the following table.

[29] In this case, it is interesting to make clear that coffee making, in most Ethiopian households is a ritualized process that takes an hour or more to complete with three or more steps. This process involves washing and roasting the beans usually in charcoal stove, mortaring the roasted beans and putting the bean flour into boiling water over a charcoal stove, putting incense into a flame container to create fabulous aroma inside the house. Then the process of boiling the coffee is repeated three times.

Table 18: Main reasons for continuous use of firewood & charcoal (as stated by respondents)

Possible reasons	Firewood(N=54)			Charcoal(N=85)		
	Major	Minor	Not a reason	Major	Minor	Not a reason
It is cheap	22%	28%	50%	27%	15%	58%
It's convenient for specific cooking tasks	22%	24%	54%	51%	26%	24%
It is always available in the market	65%	20%	15%	52%	35%	13%
It has taste superiority	17%	9%	74%	65%	21%	14%
Other	2%	-	-	1%	-	-

As expected, table 18 signifies the continuous use of firewood and charcoal goes beyond money issues to include others factors such as their convenience for specific cooking tasks (as observed in charcoal), easiness to get in the market (as observed in both fuels) and to some extent having a superiority in taste of foods cooked with such fuels (mainly observed in charcoal). Under the 'other' category, a few proportion of households (2%) mentioned that they use firewood because they could not access electricity services, and a negligible 1% of the households indicated they use charcoal because they self produce charcoal. Moreover, to curious about if there are any cultural reasons behind this, for those households who reported they use charcoal fuel because of cheapness, they were probed further asking 'if money were not an issue, would you completely stop using charcoal and use other modern fuels like LPG and/or electricity?' and consequently, more than half of them (60%) responded 'they would not have stopped'.

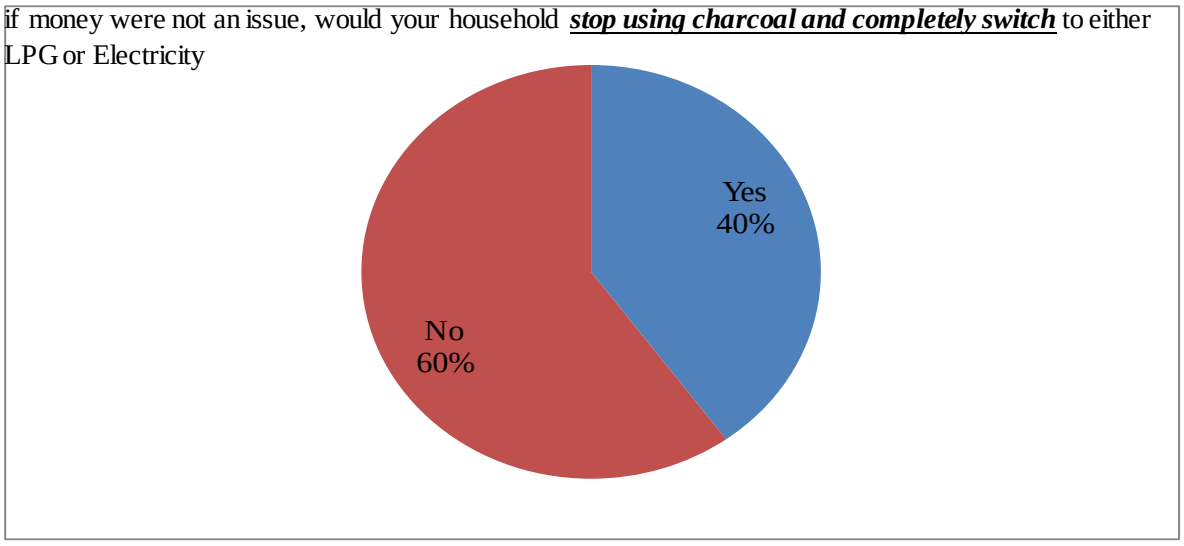


Figure 23: Households' opinion on complete fuel switching

To sum up, the above analytical statements indicated that apart from socio-economic factors like income and household demographic characteristics, socio-cultural related factors such as cooking practices, individual household taste preferences determine household cooking fuel choice and transition. Thus, the above data findings can enable us to conclude that such factors play a significant role in hindering the household energy transition process- from reliance on those unclean and inefficient fuels (mainly firewood and charcoal) towards those fuels which have non-pollutant and time and energy efficient attributes such as LPG and electricity.

4.2.3.4. Findings on Research Question 3: Household Cooking Energy Supply and its Influence on Household Cooking Energy Choice

As part of the field observation, efforts were made to collect relevant data on household cooking energy supply condition around the city both from the suppliers and users. The supply side data collected include: the main source of the different fuels, since when suppliers started selling their respective fuels, the consistency of supply of each fuel, from which section of the local society are their regular customers and the specific retail prices of the different fuels and cook stoves. Such data were collected from firewood and charcoal vendors, LPG and kerosene retailers and the electricity supply office. On the other hand, from the demand side, data collected include: users' opinion on which fuel types show frequent interruption of supply in the city, frequencies of interruptions of such fuels and what strategic measures do households' take when faced with such fuel shortages were among others. Based on this, the main findings are presented as follows.

i. Price of Fuels and Cook Stoves in Mekelle City

Table 19: Current market price of cooking fuels and cook stoves (collected from retailers)

Fuel Information		
Fuel Type	**Measurement**	**Unit price in Birr**
Firewood	Quintal	220 - 350**
Charcoal	Quintal	250 - 300**
Kerosene	Liter	21
LPG*	Kg	12 ½ kg= 700
		15 kg= 850
		22 kg= 1,650
		52 kg= 4,350
Electricity	Kwh	0.75 cent

*The refill price for 12 ½ & 15 kg= 700 Birr, for 22 & 52 kg= 1,500 Birr

**Price differs based on type of wood

Stove information			
Stove Type	**Price in Birr**	**Type**	**Cooking Task**
Traditional-*Megego*	120	partially self-made	baking *injera*
Charcoal stove-	75-200*	Locally made	making coffee, boiling water, cooking stew
Kerosene stove	200-250*	Imported	Making tea, boiling water cooking stew
Cylinder gas	350-500*	Imported	Making tea, boiling water cooking stew
Electric stove	350-500*	Imported	Making tea, boiling water cooking stew
Electric stove-*Mitad*	750-1,500*	Locally made	Baking *injera*

*price differs based on size and quality

Since these different fuels have their own unique attributes, it is difficult to compare them based on price. Moreover, it is also worth mentioning that price of fuels and cook stoves interact with income of households in determining household cooking fuel choice as it affects households' ability to pay for using such fuels. Therefore, analysing the influence of price of

fuels and cook stoves may have an overlap with the previous analysis made on the relationship between income and household cooking fuel choice. However, based on respondents' perception survey, it is possible to infer how households' react to the different fuel prices and stove costs and affect their cooking fuel choice. Accordingly, it is to be recalled that (see section 4.2.3.3, table 19) those households who utilize firewood and charcoal were asked to indicate whether 'cheapness' of such fuels is the main reason behind their choice of such fuels. However, unexpectedly, more than 50% of them were with the opinion that, the perceived cheapness of such fuels (for both firewood and charcoal users) is not 'a reason at all" for their continuous use of such fuels. Similarly, during the market assessment, this was proved by the firewood and charcoal fuel retailers who reported that the price of firewood and charcoal have been skyrocketing year after year and these kinds of fuels can no longer be regarded as low-cost fuels. Strengthening this proposition, when asked about her opinion, from which section of the society are her regular customers, one firewood selling woman replied carefully saying *"though it is difficult to say that they are poor or rich I can tell of those people whom I am close and know very well that they are people from all sections of the society: business persons, civil servants, daily labourers etc...*." This is also against the common understanding that low grade fuel users such as firewood and charcoal are 'people with low incomes'. Surprisingly, most interviewees' stated that the using firewood and charcoal fuel is much costly than using electricity but not LPG. This can be confirmed by looking at the monthly cooking energy expenditure of the households surveyed. As discussed in the introduction part under section 4.1 those households who utilize 'solid fuels only' (mainly firewood and charcoal) have higher monthly fuel expenditure than those households who use 'non-solid fuels only'.

However, it was also found that the different fuels have unparalleled differences in terms of the price of stoves used in complementary with each type of cooking fuel. As data indicate, the cost of stoves used in complementary with modern fuels such as LPG and electricity is much higher than their traditional counterparts (see table 19). This becomes a barrier for some households to access the services of modern fuels. In support of this statement, during the interviews, when asked what her 'ideal' fuel is, a 45 years old firewood fuel user was quoted saying: *"My ideal fuel was electricity which is fast, clean, cheap and easy for storage. But, since I could not afford the price of electricity mitad [stove name] which is equivalent to my two months' salary, I still bake injera using the traditional megego [stove name]."* Hence, this echoes the fact that households should have a minimum threshold of income that enable them afford the upfront cost required to start utilizing modern cooking fuels such as LPG and electricity. Thus, from this, one can understand that it is not the usage fees (price of fuels) rather the price of the cook stoves as upfront costs that prohibit some households from making the energy transition to modern fuels such as LPG and electricity. In other words, for some households who can afford the initial cost of modern cook stoves particularly the electric *mitad*, the high price of firewood might persuade them to make the energy transition to modern fuels like electricity.

Overall, it is logical to state that, even though the price of cook stoves used with modern fuels as upfront costs have an influence in accessing modern cooking fuels, the usage fees (unit price of fuels) between traditional and modern fuels can no longer be considered as a barrier. This is because, in the city, traditional fuels are purchased and for many reasons their price is increasing making them much more costly. Logically speaking, this is expected to push households to make the fuel transition.

ii. Availability of Cooking Fuels and Stoves in Mekelle City

Availability, in this research is measured into ways: whether the fuels and the related stoves are physically present in the market within the vicinity of the city and how these different fuels are available. Therefore, as field data showed among the traditional cooking fuels firewood, charcoal, different animal dung and plant residuals (even though they are hardly used by the city residents) are available in the market. On the other hand, modern fuels such as kerosene and LPG are also supplied and sold around the city. Electricity power service is also provided 24 hours per day all over the city. Thus, it can be said that the physical availability of the cooking fuels has nothing to with determining the existing household cooking fuel choice in the city. However, in the second indicator which is how these different fuels are supplied in the city and whether these different fuels are available in different quantities based on the need of households is worth investigating.

In connection with this, evidence found from the interviews and fuel market assessment suggested that the electricity metering system, the criteria requirement for getting electric connection in Mekelle city is discouraging most households from using electricity for cooking activities. This is particularly major obstacle for those households who do not own private homes. For instance, some of the households contacted during the field work were with the opinion that they could not use electricity for cooking because they live in a rent house. This was proved during a visit to the local electricity utility office in which they insisted that households who live in rent houses are not allowed to have their own private electricity metres. For such households, their access to use electricity depends on the willingness of the land lord (renter). Such circumstances prove that availability does not always guarantee accessibility. This accessibility issue can be demonstrated by the information found from one interviewee. During the interview, when asked what was the main reason for her continuous use of firewood and charcoal, a 28 years old female respondent gave her response straightforward saying that *"my land lord did not allow me to use electricity power for cooking services, though we had an agreement I would use it for both lighting and cooking, now, he changed his mind and told me so…and I am thinking to leave this house sooner than later."* Thus, this reality suggests that the physical availability of fuels is not always a guarantee to have a portfolio of fuel choices for any household to make a decision which fuel to use and/or make the needed cooking energy transition.

In relation with the accessibility challenge, one interesting finding that most respondents indicated is how the different fuels are available in the market have a great influence on household cooking fuel choice. This is to mean that some fuels by nature are difficult to access them in different quantities that meet each household's preference and ability to pay. Concerning this, charcoal, kerosene and firewood are available in different and small quantities whereas LPG and electricity are always available in large amounts. This also was found to have an influence on household cooking fuel choice mainly on those households with low income. Therefore, the way the different fuels are available in the market, their reliability of supply and other affordability issues manifested in terms of high stove costs determine households' cooking fuel choice. Under such conditions are only that households could make a fast transition towards use of modern fuels.

iii. Reliability of Cooking Fuel Supply in Mekelle City

Taking note of such possible influences beyond physical availability of fuels on household cooking fuel choice, data was also gathered regarding the reliability of household cooking energy supply condition in Mekelle city. As such, transect walk around the city's main cooking fuel supply centres was very helpful to discover which cooking fuels/stoves are available, which are intermittent and which are consistent in their supplies around the city.

Also, questions related with household cooking energy supply related issues were included in the questionnaire. Hence, the information gathered from the different fuel suppliers (retailers) showed that there has not been any supply problem on traditional fuels mainly firewood and charcoal and with modern fuels like LPG. However, the supply of cooking fuels such as kerosene and electricity was found to be so unreliable. This was confirmed by findings from the questionnaire survey and interviewees that revealed that electricity and kerosene are the most intermittent fuels in the city (see table 20 and figure 24).

Table 20: Households' opinion on which are the most frequently interrupted (unreliable) fuels in Mekelle city?

Fuel type	Frequency(N=110)	Percent
Firewood	15	14%
Charcoal	8	7%
Kerosene	50	45%
LPG	20	18%
Electricity	90	82%

Note! Percetages cannot be added to 100% as some respondents indicated morethan one fuel

As could be seen in table 20 above, most of the respondents (82%) were with the opinion that electricity supply have frequent interruption in the city and some of them (45%) also reported that kerosene is not reliable and a relatively few of them (14%) reported firewood has also interruption in its supply. On the other hand, according to respondents opinion, charcoal and LPG supply are among the least frequently interrupted fuels in the city. Adding, to understand the depth of the problem, for those respondents who reported electricity supply is frequently interrupted, they were asked how frequent they have been facing this problem over the previous month or so. The frequency of interruption reported by most of the respondents was astoundingly high as half of them (50%) claimed that they had faced 30 minutes or more electricity service failure more than three times over the previous month. This respondents' (users) opinion about the reliability of supply of the different cooking fuels around the city is almost similar with the information gathered from the suppliers which reported that electricity supply is quiet erratic while the supply of firewood, charcoal and LPG is consistent throughout the year.

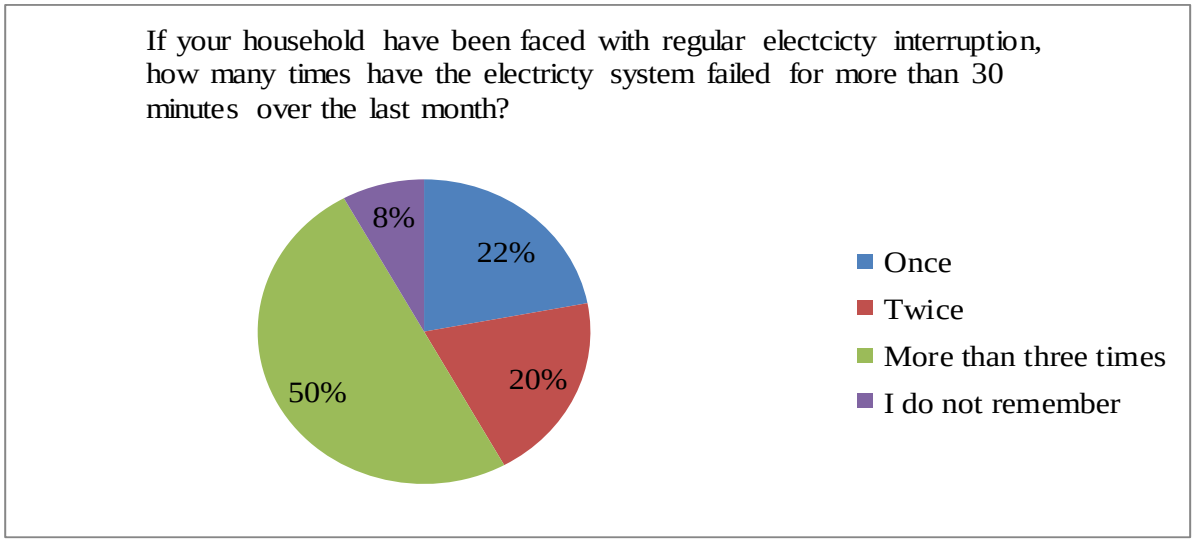


Figure 24: Respondents opinion on frequency of electricity service supply interruption around Mekelle city

Similarly, to find out how households react to fuel shortages either in times of price hikes or supply shortages, they were asked to indicate what strategies they employ in such situations. This is summarized in table 21 below.

Table 21: Coping strategies adopted by households in times of fuel shortage in Mekelle city

Strategies adopted in times of fuel shortage	**Frequency(N=110)**	**Percent**
Eat uncooked foods	30	27%
use fuels more economically	50	45%
Collect firewood freely instead of buying	3	3%
Obtain supplies in large quantities	60	55%
Shift to inexpensive but less desirable fuels	90	82%
Invest in energy efficient cook stoves	30	27%
Others*	20	18%

Note! Percentages cannot be added to 100% as some households adopt more one strategy

Table 21 illustrated above indicates that the three most common coping strategies used by households in times of cooking fuel shortages are shift to inexpensive but less desirable fuels used by 82% of the total households surveyed; obtain supplies in large quantities used by 55% of them; and use fuels more sparingly and economically adopted practiced by 45% of the total respondents. On the other hand, the least popular strategies as reported by households are collect firewood instead of buying, buy commercial cooked foods indicated under 'others' and invest in more efficient stoves which account for 3%, 18% and 27% of total respondents respectively. This indicates that, when fuels are unavailable temporarily (as indicated for electricity and kerosene before) there is tendency for most of the households to shift to other fuels with consistent supply condition (as reported before firewood and charcoal are always available) in the market. This supports the previous assertion that reliability of supply of fuels determines household cooking fuel choice and transition which in turn, can be considered as one possible answer for the question why households in Mekelle city still utilize traditional fuels such as firewood and charcoal. As mentioned above, even those households who started to utilize modern cooking fuels do not fully stop using to traditional cooking fuels which is evident in times of cooking fuel shortage and price hikes for modern cooking fuels.

All in all, from the aforementioned data findings, it is possible to deduce that, household cooking energy supply related factors mainly cook stove prices for modern fuels such as LPG and electricity negatively influenced some households from utilizing modern fuels. Moreover, the possibility to obtain fuels in different quantities which is applicable only to traditional fuels like firewood and charcoal and to some extent for kerosene encourage continuous use of such fuels and conversely, discourage household fuel transition to modern fuels like LPG and electricity. Most importantly, limited access to electricity services explained in terms of households living in rent houses inability to fulfil the criteria required to owning private electricity metres, and the intermittent nature of electricity supply service in the city influenced household cooking fuel choice and transition tremendously.

4.3. Survey Results Discussion and Analysis

As expected, the number of households who still depend on traditional cooking fuels mainly charcoal and firewood was remarkably high. Survey results revealed that more than three fourth of households surveyed utilize traditional cooking fuels either exclusively or in combination with modern cooking fuels such as LPG and electricity demonstrating 'household multi fuel use behaviour'. Almost all households surveyed use a combination of fuels. The possible explanation for this finding lies on the fact that households allocate different fuels for undertaking different cooking tasks. In this case, from the findings, it was unusual to learn that households attitude towards some traditional cooking fuels mainly charcoal- which is the most popular fuel of all cooking energy sources available around the city- remains positive. Most households believe that such traditional fuels are more suitable and better in undertaking some cooking practices. For instance, charcoal is almost exclusively used for coffee making by most households. In relation to this, it was very rare to see households use other cooking fuels (either modern or traditional) for making coffee other than charcoal and most of the other fuels were considered as inconvenient and uneconomical to make coffee by most households. This finding is in support of Kowsari & Zerriffi (2011) study, in which their findings stated that cooking fuels are not perfect substitutes of each other and in essence, one fuel can outdo another in some specific cooking tasks. This therefore influences households' multi fuel use behaviour confirming the 'energy stacking model'.

The other possible explanation for households multi fuel behaviour in the study area is the condition that only firewood or electricity is used for baking *injera*- the most popular and regular cuisine of the local people- as for other fuels other than firewood or electricity, there are no appropriate stoves for purchase in the local market that enable to carry out the '*injera* baking' cooking activity. Therefore, such realities would trigger household multi fuel use behaviour which in turn, can slow household cooking energy transition from use of traditional fuels towards those modern ones. And so, households were found utilizing traditional fuels such as firewood and charcoal even though they had already started utilizing modern cooking fuels such as LPG and electricity. This finding is against the notion of 'energy ladder theory' that assumes households switch fuels across the ladder. As discussed in chapter two before, the main presumption of this model is that those traditional fuels are supposed to be found in the lower part of the ladder and are 'inferior' in quality and function to those modern ones and anticipates complete abandonment of such fuels with changes in households socio-economic status such as income. However, as previously mentioned, survey results that observed household fuel choice proved this theory as unrealistic as most households were observed to combine multiple fuels than switching fuels.

Similarly, concerning the temporal side of household fuel choice and transition, it was understood that, over time, there is a tendency for households to shift across the energy ladder. In light of this, data that compared household fuel choice between 'now' and 'five years before' showed that the number of households who utilize firewood decreased significantly over the course of five years. Contrarily, the number of households who utilize modern fuels such as LPG and electricity increased. However, charcoal utilization remained unchanged over time. This in turn, indicates the non-linear process of household cooking energy transition which is also against the household energy ladder model that considers a unidirectional process of the household energy transition up the energy ladder. This finding is consistent with a longitudinal study on household energy transition made by Gebre'egzabher et al. (2012).

Moreover, survey results on determinants of household cooking fuel choice revealed that a number of elements influence the dynamics and pattern of household cooking fuel choices. Regarding this, the most important discussion point identified by this study is the multidimensional nature of the influencing factors. As such, all data results showed the significant influence that apart from income, other dimensions such as socio-cultural and energy supply related factors have on household cooking energy choice and transition. Under the socio-economic factors, as hypothesized, it was found that, income influences household cooking energy choice. As shown in figure 14, with higher household income, there is a high chance to find more households who utilize 'non solid fuels' (e.g. LPG and electricity) either exclusively or in combination with solid fuels than those households who utilize 'solid fuels only' such as firewood and charcoal. This is consistent with findings from most empirical literatures such as Masera et al. (2000); Heltberg et al. (2004); Mokennen & Kohlin (2008) which have found similar findings on the smooth relationship between income and household cooking fuel choice. Within these socio-economic factors, level of education of the household head was also found to have an influence on cooking fuel choice. In view of that, survey results shown in figure 15 clearly establish that with higher level of education, households were more inclined to adopt 'non-solid fuels' than those with no formal education. Such similar findings are studies done by Schlag & Zuzarte (2008) which emphasized the connection between households continuous use of solid biomass based fuels with lack of awareness either on the side effects of such fuels or the positive benefits associated with shifting to clean and efficient ones. This finding further indicated that, those households with low educational status are less likely to be familiar with the advantages of making the energy transition than those households with good education status. Therefore, it is safe to say that level of education of household head influences household cooking fuel choice. Similar results on age of the household head- in which norms and familiarity of traditional fuels are associated with aged people- and main occupation of the wife in the household- explained in terms of opportunity cost of time- were found as determinants of household cooking fuel choice. Contrarily, survey results on the relationship between household demographics like gender of the household head and household size with household cooking fuel choice were found insignificant. These results are against findings from Abebaw, (2007) and Gebre'egzabher et al., (2012). This inconsistency might be created partly because of the difference in socio-economic and demographic profile of the study areas under investigation in which the other studies had included small towns and rural areas in their sample population. In regard to the socio-economic dimension of household cooking fuel choice, one interesting finding of this study is that on both income and level of education, even though the proportion of households who utilize 'only solid fuels' decreases with increases in income and level of education of the household head, even at higher stages of income and education level, there are many households who utilize 'solid fuels' either exclusively or in combination with 'non-solid fuels'. Hence, the possible explanation for this might be the case that apart from such socio-economic factors, other influences such as socio-cultural and supply dimensions do play significant role in determining household cooking fuel choice and transition. As anticipated this was found to be true as further analytical findings on such dimensions indicated the possible relationship between some of the indicators for variables interrelated with socio-cultural and energy supply with household cooking fuel choice.

Hence, data analysis on socio-cultural dimension of household cooking fuel choice revealed that household taste preferences and cooking practices have a close relationship with household cooking fuel choice. In this case, one notable example is the condition that most households prefer to use charcoal for making coffee and cook chicken sauce for convenience and taste preference reasons respectively. In line with this finding, supportive evidence found from the interviews conducted indicated that, familiarity in cooking with some of the

traditional fuels encourages households' continuous use of such fuels even though they have the opportunity to use other alternative fuels. For instance, from those households who use both solid and non-solid fuels, a 32 years old female interviewee was quoted saying that *''though I have both charcoal and LPG fuels available at home, when I am not in rush, I prefer to use charcoal because I am accustomed to cooking with it for a long time…it is also good as it does not need constant check-ups and attendances while cooking".* Though it seems bold, this somehow tells us the influence of familiarity with traditional cooking practices on household cooking fuel choice. Very few studies such as one study made in Mexico by Masera et al. (2000) and recent studies by Atannasov (2010) and Risseeuw (2012) both conducted in Mozambique had similar findings on the role of taste preferences in determining cooking fuel choices. For instance, the very finding of Masera et al. (2000) in Mexican households confirm that households use firewood to cook *Tortillas* since households believe the taste is much better when cooked with firewood than LPG or electricity. Having such findings, this paper therefore argues that socio-cultural factors such as individual taste preferences and other cooking norms and practices have major impact on household cooking fuel choice and transition in Mekelle city households.

With equal measure, the household cooking energy supply condition of the city and how such external factors to the household affect household cooking fuel choice and transition was also investigated. As expected, price of cook stoves explained in terms of upfront costs, access and reliability of supply of fuels were found as dominant barriers of household cooking energy transition in Mekelle city. In connection to this, data findings revealed that supply of cooking energy sources such as firewood and charcoal in the city are consistent throughout the year whereas electricity and kerosene cooking fuels were singled out by both retailers and users as the most intermittent fuels in the city. Adding, most households who diversify fuels were with the opinion that because of frequent interruptions in electricity supply they were forced to use firewood for baking *injera* in times of electricity blackouts. Affecting the dynamics of household cooking fuel choice, this also highlights the explanation for households' multi fuel use behaviour and slow energy transition observed in the study area. This finding on the other hand is consistent with empirical literatures by Kowsari and Zerriffi (2011) and the International Energy Agency (IEA, 2010) which both reiterate that fuel availability and reliability of supply have major impacts on household cooking fuel choice and transition.

Simply put, according to the survey results and analytical findings of the interviews and field observations made, apart from the socio-economic determining factors of household cooking fuel choice, the role of socio-cultural and energy supply related factors in influencing household cooking fuel choice and transition was more pronounced. Having said this, based on the key discussion points raised, relevant conclusions that address each research question are drawn in the following chapter.

Chapter 5: Conclusions

This paper investigates factors that influence household cooking energy choice and transition in urban households of Mekelle city, using data collected from household survey questionnaire, interviews and field observation. Unlike to most literatures in household energy use, in this paper, both quantitative and qualitative research techniques were employed. The qualitative research technique was added partly to fill some gaps that are more pronounced in quantitative methods. As a result, the quantitative data collected were analysed using both descriptive and inferential statistics and the qualitative data using narrations and direct quotations, which combined, have enabled to answer the research questions of the study.

Hence, data findings revealed that there are a significant number of households in Mekelle city who still depend on traditional fuels such as firewood and charcoal. Of the different fuels used by households, charcoal is the most popular cooking fuels followed by electricity and firewood. Contrarily, fuels such as LPG and animal dung and plant residues are rarely used. Similarly, it was observed that, most households use a combination of fuels confirming the household multi fuel use behaviour widely discussed in most recent empirical literatures. One possible explanation for household multi fuel use behaviour is the fact that households use different fuels for undertaking different cooking tasks. The other possible explanation is related with the condition that households are faced with unreliable cooking energy supplies- which is evident in electricity and kerosene fuels- forcing households to diversify fuels.

Moreover, further analysis on the determinants of household cooking energy choice demonstrated the existence of multidimensional factors influencing household cooking energy choice and transition. In terms of the socio-economic dimension, as hypothesized in most empirical literatures, household income, level of education and age of the household head and main occupation of the wife in the household are among the most important factors that influence household cooking energy choice and transition whereas, gender of the household head and household size were found as insignificant factors. Similarly, it was observed that in the socio-cultural dimension, household taste preferences and cooking norms and practices have a significant influence on household cooking energy choice and transition. However, though it was hypothesised that the gender role in household decision-making influences household cooking fuel choice, this could not be confirmed with empirical data findings. On the other hand, as empirical data revealed, the household cooking energy supply condition of the city in influencing household cooking energy choice and transition is also notable. In this regard, it was witnessed that the supply of electricity and kerosene is unreliable forcing households to still depend on firewood and charcoal in times of shortage of such fuels. This affects the dynamics of household cooking fuel choice and pulls the household cooking energy transition process backwards.

All in all, the influence of the socio-economic factors like income cannot be underestimated, based on the empirical findings, this study argues that the role of socio-cultural and energy supply related factors in influencing household cooking fuel choice and transition is more comprehensible. In view of this, the argument of this study fits well with the assertion of Masera et al. (2000, p: 2084) that highlights the importance of socio-cultural and energy supply factors in household cooking energy choice and transition as follows *"…households do not switch fuels, but more generally follow a multiple fuel or 'fuel stacking' strategy by which new cooking technologies and fuels are added, but even the most traditional systems are rarely abandoned."* Thus, it can be said that such factors underpin the unique phenomenon where a vast proportion of urban households in Mekelle city still use traditional energy sources making the household energy transition so slow.

Bibliography

Abebaw, D., 2007. Household determinants of fuelwood choice in urban Ethiopia: A case study of Jimma town. *The Journal of Developing Areas*, 41 (1), pp. 117-126.

Atanassov, B., 2010. Socio-cultural dimensions in households energy choice: Implications for energy transition in Catembe, Mozambique. A master's thesis paper. Stockholm University, Sweden.

Akindola, R., 2010. Towards a definition of poverty: poor people's perspectives and implications for poverty reduction. Journal of Developing Societies 2009 25: 121. Melbourne, Australia. Available at: http://jds.sagepub.com/content/25/2/121

Barnes, D.F., Krutilla, K., Hyde, W.F., 2004. *The Urban household energy transition – social and environmental impacts in the developing world*, resources of the future, USA

Black, T. R., 1994. Evaluating social science research: An introduction. SAGE. Publications Limited.

Central Statistical Authority, 2011. Population and housing census of Ethiopia. Administrative report. Addis ababa, Ethiopia. Available at: http://unstats.un.org/unsd/censuskb20/Attachment489.aspx [accessed in 20/02/2014]

Clancy, et al., 2006. Finding the energy to address gender concerns in development. DFID project paper. Halcrow Ltd. UK.

Clancy, J., 2008. Sustainable energy systems and the urban poor: Nigeria, Brazil, and the Philippines. urban energy transition. pp:533-562

Gable, G., 1994. Integrating case study and survey research methods: An example in Information Systems. European Journal of Information Systems, Vol 3, No 2, pp.112-126.

Gamtessa, S. F., 2003. Household's consumption pattern and demand for energy in urban Ethiopia. project paper Addis ababa University, Ethiopia

Gebre'egziabher, Z., Mekonnen, A., Kassie, M. and Köhlin, G., 2012. Urban energy transition and technology adoption: The case of Tigrai, northern Ethiopia. *Energy Economics*, 34 (2), pp. 410-418. Available at: http://www.sciencedirect.com/science/article/pii/S0140988311001472.[Accessed 20/05/2014]

Heltberg, R., 2004. Fuel switching: evidence from eight developing countries. Energy Economics 26 (5), pp. 869 - 887

International Energy Agency (IEA), 2006. World Energy Outlook. Paris France. Available at:

International Energy Agency (IEA), 2010. World Energy Outlook. Paris, France. Available at: http://www.worldenergyoutlook.org/media/weo2010.pdf [Accessed 29-04-2014].

International Energy Agency, 2014. International Energy Agency Home Page. Available at: http://www.iea.org/topics/energypoverty/ [Accessed 28-4-2014].

Karekezi, S., et al., 2012: Energy, poverty and development. In global energy assessment - toward a sustainable future, Cambridge University Press, Cambridge, UK and New York, NY, USA and the International Institute for Applied Systems Analysis, Laxenburg, Austria, Chapter 2 -pp. 151-190.

Kowsari, R. and Zerriffi, H., 2011. Three dimensional energy profile: A conceptual framework for assessing household energy use. *Energy Policy*, 39 (12), pp. 7505-7517. Available at: http://www.sciencedirect.com/science/article/pii/S0301421511004861. [Accessed 10/05/2014]

Malla S. and Timilsina G., 2014. Household cooking fuel choice and adoption of improved cook stoves in developing countries: a review. Policy Research Working Paper 6903. World Bank.

Masera, O. R., Saatkamp, B. D. and Kammen, D. M. 2000. From linear fuel switching to multiple cooking strategies: A critique and alternative to the energy ladder model. *World Development,* 28 (12), pp. 2083-2103. Available at: http://www.sciencedirect.com/science/article/pii/S0305750X00000760. [Accessed 17/03/2014]

Mekelle City Health Office, 2011. Household Survey report. Unpublished. Mekelle, Ethiopia

Millennium City Initiative, 2010. Webpage. Available at: http://mci.ei.columbia.edu/millennium-cities/mekelle-ethiopia/mekelle-maps-and-population-data/ [Accessed in 29/06/2014]

Ministry of Finance and Economic Development (MoFED), 2013. Development and poverty in Ethiopia. a household welfare monitoring report, 1995/96-2010/11, Addis Ababa, Ethiopia. Available at: http://www.mofed.gov.et/English/Resources/Documents/Development%20and%20Poverty%20in%20Ethiopia(1995-96)(2010-11).pdf. [Accessed 19/02/2014]

Modi, J., 2006. Energy service for the poor. Commissioned paper for the Millennium Project Task Force 1. Columbia University.

Mokennen A., Kohlin, G., 2008. Determinants of household fuel choice in major cities of Ethiopia.

Pachauri, S., 2011. The energy poverty dimension of energy security, The Routledge Handbook of Energy Security, B. K. Sovacool. London, Routledge.Oreg 2003Working paper.Goteborg, Sweden

Rehfuess, E. A., Briggs, D. J., Joffe, M., & Best, N., 2010. Bayesian modelling of household solid fuel use: Insights towards designing effective interventions to promote fuel switching in Africa. Environmental Research, 110: P: 725-732.

Risseeuw, N., 2012. Household energy in Mozambique: A study on the socioeconomic and cultural determinants of stove and fuel transitions. Research Project (468017) Faculteit der Aard- en Levenswetenschappen, Vrije Universiteit, Amsterdam.

Schlag, N., Zuzarte, F., 2008. Market barriers to clean cooking fuels in Sub-Saharan Africa: A review of literature, SEI working paper, Stockholm Environment Institute.

Sovacool, B., 2013. Energy access and energy security in Asia and the Pacific. Asian Development Bank Economics Working Paper Series No. 383. New York, USA Available at: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2479159 [Accessed in 12/03/2014]

Takama, T., Tsephel, S. and Johnson, F. X. 2012. Evaluating the relative strength of product-specific factors in fuel switching and stove choice decisions in Ethiopia. A discrete choice model of household preferences for clean cooking alternatives. *Energy Economics*, 34 (6), pp. 1763-1773. Available at: http://www.sciencedirect.com/science/article/pii/S0140988312001375.

Tigray Region Mining and Energy Agency, 2010. Household cooking energy use assessment report. Unpublished.

Taylor, Matthew J., Michelle J. Moran-Taylor, Edwin J. Castellanos, and Silvel Elías., 2011. "Burning for sustainability: biomass energy, international migration, and the move to cleaner fuels and cook stoves in Guatemala." *Annals of the Association of American Geographers* 101 (4):918-928.

UNDP., 2004. *World energy assessment: overview 2004 Update*. New York, United Nations Development Program.

UNDP. , 2010. Gender and Energy for Sustainable Development: A toolkit and resource guide. New York:

World Bank, 2010. Urban poverty: an overview. Available at: http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTURBANDEVELOPMENT/EXTURBANPOVERTY/0,,contentMDK:20227679~menuPK:7173704~pagePK:148956~piPK:216618~theSitePK:341325,00.html [Accessed 15/05/2014].

World Bank, 2011. Household cook stoves, environment, health and climate change: A new look at an old problem. Washington: World Bank.

World Health Organization, 2014. Household air pollution and health. Available at: http://www.who.int/mediacentre/factsheets/fs292/en/ [Accessed 01-08-2014]

Yin, R., 2009. Case study research: Design and methods (Vol. 5). sage.

Yue, T., Long, R. and Chen, H. 2013. Factors influencing energy-saving behavior of urban households in Jiangsu Province. *Energy Policy*, 62 pp. 665-675.

Annex 1: Chi-Square test result table (sample)

*Households' average monthly income * Household cooking fuel choice Crosstabulation*

			Household cooking fuel choice			Total
			Solid fuels only	A mix of both solid & non-slid fuels	Non-solid fuels only	
Households' average monthly income	< 500 Birr	Count	6	2	0	8
		Expected Count	2.5	2.0	3.4	8.0
		% within Households' average monthly income	75.0%	25.0%	0.0%	100.0%
	501 – 1000 Birr	Count	9	3	11	23
		Expected Count	7.3	5.9	9.8	23.0
		% within Households' average monthly income	39.1%	13.0%	47.8%	100.0%
	1001 - 2000 Birr	Count	12	12	7	31
		Expected Count	9.9	7.9	13.2	31.0
		% within Households' average monthly income	38.7%	38.7%	22.6%	100.0%
	2001 - 3000 Birr	Count	6	6	12	24
		Expected Count	7.6	6.1	10.3	24.0
		% within Households' average monthly income	25.0%	25.0%	50.0%	100.0%
	> 3000 Birr	Count	2	5	17	24
		Expected Count	7.6	6.1	10.3	24.0
		% within Households' average monthly income	8.3%	20.8%	70.8%	100.0%
Total		Count	35	28	47	110
		Expected Count	35.0	28.0	47.0	110.0
		% within Households' average monthly income	31.8%	25.5%	42.7%	100.0%

Annex 2: Interviewee's profile

S.N	Age	Gender	Occupation	Sub-city	Remark
Res#1	40	Female	Petty trade	Hadnet	Traditional fuel user
Res#2	36	Female	Civil servant	Hawelti	""
Res#3	58	Female	Unemployed	Ayder	""
Res#4	30	Male	Business owner	K/woyane	""
Res#5	50	Female	Civil servant	Adihaki	""
Res#6	28	Female	Business owner	K/woyane	Traditional & Modern fuels user
Res#7	45	Female	Physician	Qiuha	""
Res#8	32	Female	Housemaid	Hadnet	""
Res#9	34	Female	Housework	Hawelti	Modern fuels user
Res#10	68	Male	Pensioner	Adihaki	Traditional & Modern fuels user

Annex 3: Survey Questionnaire

Interviewer‘s full name: _____ Date of interview: __ _____

Time: _____ Name of sub city/Ketena: _____

Questionnaire Number: _____

Introduction:

I am studying my Master’s Degree in the Institute for Housing and Development (HIS), Erasmus University Rotterdam, The Netherlands. As part of my studies, now, I am doing research on Household Cooking Energy Choice in Mekelle City, and this questionnaire is an instrument to my research and your responses are necessary for providing me with better understanding on the household energy situation in Mekelle City. This will take about 20 minutes. Your responses will be kept strictly confidential and will only be used for the purpose of this study. Your cooperation is highly appreciated!

Part I. Fuel Information (Please thick √ for each question as appropriate)

Fuel type	1. Which type of fuel does your household use **at this time** for different cooking activities? [Please rank in order of frequency of use] 1= most frequent…5= less frequent]	2. How much fuel does your household consume monthly? (please put in Kg, Liter or Kwh for each fuel you use as appropriate)	3. How much money does your household spend for each type of fuel you use monthly? (please put for each fuel you use in Birr)	4. Which type of fuel did your household use **before five years** for different cooking activities**?** [Please rank in order of frequency of use,1=most frequent…5=less frequent]
Firewood				
Charcoal				
Kerosene				
Cylinder gas(LPG)				
Electricity				
If other, Specify				

5. Does your household use ***different fuels for cooking different foods***?

(1) Yes (2) No

6. If your response for Question number 6 is ***Yes***, please fill the following table in the space provided

Type of fuel	**6. What type of fuel does your household use for :** (please select more than one if appropriate by ticking √)				
	Baking *Injera*	Cooking Stew	Making Coffee or tea	Boiling Water	If other, specify _____
Firewood					
Charcoal					
Kerosene					
Cylinder Gas(LPG)					
Electricity					
If other, _____					

7. Does your household use ***different fuels in different seasons*** (e.g. summer Vs. Winter) of the year for any cooking activities? (1) Yes (2) No

8. If your response for Question number 7 is ***Yes***, please answer the following question in the table

Type of fuel	**8. What type of fuel does your household use for cooking activities during:** (please select more than one if appropriate by ticking √)	
	Winter season (dry season)	Summer (wet season)
Firewood		
Charcoal		
Kerosene		
Cylinder Gas(LPG)		
Electricity		
If other, specify_____		

9. If you mention in the previous Questions your household uses ***Firewood and Charcoal*** what is ***the mode of acquisition*** of these fuels?

9.1 Firewood is: (1) purchased (2) Self collected (3) Gift from relatives (4) Other_____

9.2. Charcoal is: (1) Purchased (2) Self-produced (3) Gift from relatives (4) Other_____

9.3. Please indicate whether the following are ***major, minor, or not reasons*** for your household to ***use firewood and charcoal*** for cooking activities

(please thick √ more than one if appropriate)

Possible reasons	**Firewood**			**Charcoal**		
	Major	Minor	Not a reason	Major	Minor	Not a reason
Because it is cheap						
Because it is convenient for some specific cooking practices						
Because it is always available in the market						
Because foods cooked with it are superior in their taste						
If Other, specify_____						

10. If your response to Question number 9.3 is ***only 'because it is cheap'*** if money were not an issue, would your household ***stop using charcoal and completely switch*** to either LPG or Electricity?

(1) Yes (2) No

16. Please indicate if the following ***characteristics of a fuel*** influence your household decision which fuel to use? ***[Please put 1 for 'yes, 2 for 'No']***

a. Time Saving _____ c. Safety_____

b. Smokiness/cleanness_____ d. Price _____

e. Easiness of storage _____ f. Energy efficiency_____

g. Taste difference _____ h. Reliability _____

Part II: Cooking Practices

17. Who ***cooks*** in your household?

(1) Wife (2) Husband (3) Housemaid (4) Daughter (5) Other, specify_____

18. In average, how many ***hot meals*** does your household consume within a day? ……

19. How much time does the main cooker in your household spend cooking per day? .....

20. Which of the following cooking activities in your household consume fuel most?

(1) Baking injera (2) Cooking stews (3) Boiling water (4) Making coffee/tea (5) Other

22. How many times does your household cook the following cooking tasks?

(1) Baking injera……per week (2) Cooking stew….per day (3) Making coffee/tea…. per day

(4) Boiling water…..per day (5) if any other please mention……

23. Please indicate your kitchen type? (1) Private (2) Shared (3) I do not have kitchen

Part III. <u>Household Cooking Energy Supply</u>

24. In your opinion, which of the following cooking fuels have ***<u>frequent interruption of supply</u>*** in Mekelle city? (Please select more than one if appropriate)

(1) Firewood (2) Charcoal (3) Kerosene (4) LPG (5) Electricity (6) I do not know

25. If you mention in Question number 22, ***<u>(5) Electricity</u>***, over the past month, ***<u>how many times</u>*** has electricity services failed for more than 30 minutes?

(1) Once (2) Twice (3) Three and above (4) Never (5) I do not now

26. If your household has been adversely affected by ***<u>scarcity of fuel supplies</u>*** in recent years, please indicate ***<u>what strategies you have adopted</u>*** to cope with the situation. (Thick √ more than once if appropriate)

(1) Reduce cooking /_____/

(2) Use fuels more sparingly/economically /_____/

(3) Collect wood freely instead of buying /_____/

(4) Obtain supplies in large quantities /_____/

(5) Shift to inexpensive but less desirable fuels /_____/

(6) Invest in energy-efficient cooking devices /_____

(7) Other (Specify) _____

Part IV: <u>Household Characteristics</u>

27. Relationship of the respondent to the household_____

28. [Observe] Gender (1) Male (2) Female

29. Gender of the head of the household? (1) Male (2) Female

31. Age of the household head? ……in years

32. Family size of the household …….

33. What is ***<u>education status of the household head</u>***?

(1) No formal schooling (2) 1 - 8 grade (3) 9 - 12 grade (4) Higher education

34. What is the ***main occupation of the wife in the household***?

(1) Full time salary employment (2) Own business /petty trade (3) Unemployed (4) Housework (5) if other specify……

35. Over the past 12 months, what was the household's ***average monthly income***?

(1) < 500 Birr (2) 500 to 1000 Birr (3) 1000 to 2000 Birr (4)2000 to 3000 Birr (5) > 3000 Birr

36. Does your household ***own*** any of these appliances? [Tick √ more than one if appropriate]

(1) Television (2) Fridge (3) Sofa (4) Car (5) Mobile phone (6) not any

37. Who in your household makes decisions on? (Please put the given code in the space provided): 1= Wife 2= Husband 3= Joint 4 = Daughter/Son 5 = other)

i. on buying food items: …… ii. on buying the type of fuels to be used for cooking: ……

iii. on buying expensive house equipment (TV, fridge): ……

iv. On type of stove to be used for cooking …… v.. Education and health expenses: ……

38. Does your household live in? (1) Rent house (2) own house (3) if other, specify_____

39. [Observe] quality of housing: (1) Traditional (2) Modest (3) Modern

Thank you again for participating in my survey!

Annex 4: Interview Guides

Semi-structured Interview Guideline 1 (for solid fuel only users)

1. What is 'best fuel' for you? _____
2. What are your main reasons for choosing Firewood as your primary fuel? _____
3. What are your main reasons for choosing Charcoal as your primary fuel? _____
4. (If the interviewee mention reasons about money issues) probe by asking if money were not an issue, would you completely stop using firewood and charcoal?
4.1. If yes, why? _____
4.2. If not, why not? _____
5. Are there any other reasons that influenced your choice to cook with firewood? What type of foods do you always cook using firewood? Why? Are there any foods that cannot be cooked using Electricity in your household? _____
6. What are some of the things you like about cooking with firewood? What about cooking with charcoal?
   6.1. Firewood _____
   6.2. Charcoal _____

7. What are some of the things you do not like about cooking with firewood? What about cooking with charcoal?

   7.1. Firewood_____
   7.2. Charcoal _____
8. What is your opinion about the side effects of cooking with firewood?
   8.1. For example about health? _____
   8.2. About the environment? _____

9. Who always decides on the type and amount of cooking fuel purchase in your household? _____
10. If your household has been adversely affected by scarcity of fuel supplies in recent years, can you tell me what strategies you have adopted to cope with the situation?
    _____
    _____
    _____

Thank You!

Semi-structured Interview Guideline 2: for both solid and non-solid fuel users

1. Why does your household use more than one cooking fuel? Why does your household still use firewood and charcoal? _____

2. Are there any other reasons that influence your choice to cook with firewood? What type of foods do you always cook using firewood? Why? Are there any foods that cannot be cooked using Electricity in your household?

_____

3. What are some of the things you like about cooking with firewood? What about cooking with charcoal?

3.1. Firewood _____

3.2. Charcoal _____

4. What are some of the things you do not like about cooking with firewood? What about cooking with charcoal?

4.1. Firewood _____

4.2. Charcoal _____

5. What are some of the things you like about cooking with Electricity? What about cooking with LPG

5.1. Electricity_____

5.2. LPG_____

6. What are some of the things you do not like about cooking with electricity? What about cooking with LPG?

6.1. Electricity_____

6.2. LPG_____

7. What is your opinion about the side effects of cooking with charcoal? What about with firewood

7.1. For example on health? _____

7.2. On the environment? _____

8. Who always decides on the type and amount of cooking fuel purchase in your household?_____

9. Is there any shortage of supply in electricity around the city? If yes, how frequent does it interrupt per day? _____

10. If your household has been adversely affected by scarcity of fuel supplies in recent years, can you tell me what strategies you have adopted to cope with the situation?

_____

_____

Thank You!

Annex 5: Fuel Market Assessment Checklists

1. Price of fuels

Type of fuel	Measurement*	Price in Birr	Site/vendor	Remark
Firewood				
Charcoal				
Kerosene				
Cylinder Gas				
Electricity				

*The most common mode of buying a fuel

2. Price of stoves

	Type of stove	Selling price	Maintenance cost	Durability	Remark
1.	**Traditional 'Megego'**				
2.	**Charcoal Stoves**				
2.1.					
2.2.					
2.3.					
3.	**Kerosene stoves**				
3.1.					
3.2.					
3.3.					
4.	**Cylinder Gas stove**				
4.1.					
4.2.					
4.3.					
5.	**Electric Stoves**				
5.1.					
5.2.					
5.3.					

Some Questions to Fuel or Stove Vendors (Firewood, Charcoal, Kerosene or LPG)

1. Since when did you start selling this fuel/stove around the city? _____
2. Have you faced any shortfall or increase in demand for your fuel/ stove in the last 1-2 years? If so, what do you think the reason behind? _____
3. Does the supply of your fuel/stove consistent throughout the year? _____
4. Where is the source of the fuel/stove you sell? _____
5. In your opinion, from which social strata do you think are your regular customers? For instance, high income groups, lower income groups, the elite?

   _____

   _____

   _____

Annex 6: Field Observation Photos

Photo 1: Firewood sale centre in Mekelle city

Photo 2: Charcoal sale centre in Mekelle city

Photo 3: Small quantities of charcoal for sale in Mekelle city

Photo 4: Cylinder gas (LPG) in different quantities in a retail shop in Mekelle city

Photo 5: *Injera*, the popular Ethiopian food

Photo 6: Roasting Coffee beans in a charcoal stove, (the 1st step of the coffee ceremony)