# Socio-economic determinants of Household Cooking Fuel Choices: Evidences from Kailali, District Nepal

**A Thesis**

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***Submitted By***

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April 11, 2022

# LETTER OF RECOMMENDATION

This thesis entitled **SOCIO-ECONOMIC DETERMINANTS OF HOUSEHOLD COOKING FUEL CHOICES: EVIDENCES FROM KAILALI, DISTRICT NEPAL** has been prepared by Ms Himani Ojha under my supervision. I, hereby, recommend this thesis for examination by the thesis committee as a partial fulfillment of the requirements for the Degree of MASTER OF ARTS in ECONOMICS for final examination.

**Thesis Supervisor**
**Naveen Adhikari**
**Assistant Professor**
**Date: APRIL 11, 2022**

# APPROVAL SHEET

We certify that this thesis entitled **SOCIO-ECONOMIC DETERMINANTS OF HOUSEHOLD COOKING FUEL CHOICES: EVIDENCES FROM KAILALI, DISTRICT NEPAL** submitted by HIMANI OJHA to the Central Department of Economics, Faculty of Humanities and Social Sciences, Tribhuvan University, in partial fulfillment of the requirements for the Degree of MASTER OF ARTS in ECONOMICS has been found satisfactory in scope and quality. Therefore, we accept this thesis as a part of the said degree.

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# DECLARATION

I, Himani Ojha, declare that this thesis entitled SOCIO-ECONOMIC DETERMINANTS OF HOUSEHOLD COOKING FUEL CHOICES: EVIDENCES FROM KAILALI, DISTRICT NEPAL submitted to Central Department of Economics is my own original work unless otherwise indicated or acknowledged in the thesis. The thesis does not contain materials which has been accepted or submitted for any other degree at the University or other institution. All sources of information have been specifically acknowledged by reference to the author(s) or institution(s).

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This thesis **SOCIO-ECONOMIC DETERMINANTS OF HOUSEHOLD COOKING FUEL CHOICES: EVIDENCES FROM KAILALI, DISTRICT NEPAL** has been prepared for partial fulfillment of the requirements for the Master Degree of Arts in Economics.

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Himani Ojha

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# ABSTRACT

Cooking with effective, renewable, and healthy fuels is critical for both health and environmental benefits, but nearly half of the world's population lacks access to reliable, affordable, and clean cooking facilities. Despite efforts to disseminate improved cooking facilities, a large number of Kailali District households continue to use traditional fuel, especially firewood. Households' failure to embrace modern fuel appears to be due to socioeconomic and product-related factors. The objective of this research is to identify the key factor influencing household fuel choice. Based on the questionnaire applied to 190 households, this study explored the energy choice behavior. Similarly, the required data are obtained from secondary sources such as Central Bureau of Statistics, International Energy Agency, Water and Energy Commission Secretariat 2010 and 2014, journals, and articles. The multinomial regression is used to identify the household fuel choice. This model describes the behavior of consumer, when they are provided with variety of alternatives with the common consumption objectives. According to the study, household income has a major impact on the decision to move from traditional to modern fuel. Household size, age, education, marital status, and ethnicity have minor effect on household fuel choice behavior. Firewood is the predominate indigenous source of energy, providing 85.91 percent of the district's energy needs. In Kailari Gaupalika as well, firewood has remained the major source of household energy. It meets 67.37 percent of the energy requirement for cooking in Kailari Gaupalika households and 45.27 percent of the energy requirement for cooking in Dhangadhi SMPC households. In comparison to Kailari Gauplaika, Dhangadhi SMPC used the least bio gas and the most LPG. The findings indicate that policies and interventions that increase household income and improve household education contribute in the adoption of modern energy sources in the Kailali District.

**Key words: Energy Ladder Hypothesis, Socio-economic determinants, Adoption, Kailali District**

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# ABBREVIATIONS/ACRONYMS

ANOVA Analysis of Variance

CBS Central Bureau of Statistics Authority

CO Carbon Monoxide

FAO Food and Agricultural Organization

GACC Global Alliance for Clean Cookstove

GHG Greenhouse Gas

HHD House Hold Head

ICS Improved Cook Stove

IEA International Energy Agency

LPG Liquid Petroleum Gas

MN Multinomial

MWTP Marginal Willingness TO Pay

OECD Organization for Economic Co-operation and Development

PM Particular Matter

UNDP United Nations Development Program

WHO World Health Organization

HHs Households

ESMAP Energy Sector Management Assistance Program

GDP Gross Domestic Product

GJ Giga Joule

GoN Government of Nepal

GOs Government Organization

MDGs Millennium Development Goals

NEA Nepal Electricity Authority

NGOs Non-Governmental Organization

REDP Rural Energy Development Program

TPES Total Primary Energy Supply

# CHAPTER 1 INTRODUCTION

## 1.1 Background

Energy consumption is the determinant of the socio-economic status of many citizens across the globe. Majority of households especially in the rural parts are highly dependent on traditional fuels, such as firewood, crop wastes, coal and dung (Dipti Paudel, March 2021). While earlier understanding relies on Energy Ladder Hypothesis that considers energy choices being unidirectional and perfect substitute from dirty to cleaner one (A Bhide, 2011), there is growing evidence that households make choices on the consumption of different energy sources by selecting a mix of different energy sources due to differences in socio-economic conditions and availability of resources (Alternative Energy Promotion Centre, 2018).For example, a household may use either traditional fuel such as firewood or modern energy sources such as LPG, electricity, for cooking purposes. Similarly, electricity, kerosene, either alone or in combination with both alternatives, can be chosen for lightening. The choice and inter-fuel switching and substitution behavior of different energy sources depends on the availability of different energy sources and the affordability of households.

Nepal has abundant natural resources in areas such as agriculture, forestry and hydropower. Economic growth came from large part of population growth, industrialization and urbanization, leading to the increasing demand of energy. In response to the growth of the energy sector, the establishment of secure, reliable and cost-emphasized energy has been established. The need now is to use energy effectively to diversify energy sources and ensure the minimization of waste.

As of 2011, the population of Nepal is 26.5 million and the number of households is around 5427,000(Statistics, 2011). Nepal's energy resources are generally divided into three categories: conventional, commercial, and alternative. Biomass (such as fuel wood, agricultural residues, and animal dung) is a traditional source, while fossil fuels and energy are industrial sources, and new and renewables are alternative sources. Nepal has no significant fossil-fuel reserves. All petroleum products and over 75% of coal are imported from India (Secretariat, Government of Nepal, 2018). Natural gas is not used in the country. Nepal, on the other hand, has immense hydropower capacity and is well-equipped with modern and renewable energy sources such as biogas, solar, wind, and geothermal energy. Owing to rising revenue and urbanization, biomass fuels are being replaced by more productive fuels such as liquefied petroleum gas (LPG), biogas, and electricity, primarily for cooking and lighting. However, biomass, especially fuel wood, is expected to remain the primary source of energy for households in the near future. The per capita electricity consumption of Nepal is the lowest among the South Asia Association for Regional Co-operation (SAARC) member countries (Dhungel, 2009). Household energy use habits are closely related to levels of energy access and poverty. These issues have recently gotten a lot of attention around the world, particularly in developing countries. This is evident from the United Nations' initiative to declare 2012 to be the year of renewable energy for all. In this regard, Nepal has made significant progress in recent years in improving access to energy services. For example, from 37 percent in 2004 to 70 percent in 2010, the country's total number of households with access to electricity nearly doubled (Statistics, 2011). Furthermore, by the end of 2011, the government had distributed more than 258 thousand biogas plants and 620 thousand ICS primarily to rural households across the country through various government programs.(Alternative Energy Promotion Centre, 2018). Despite these promising figures, Nepal's energy poverty rate remains among the highest in the world. For comparison, the country's EDI of 0.091 is at the bottom of the rankings as compared to other developing countries in Asia and other parts of the world, suggesting low household electrification rates and a high proportion of biomass used for cooking.

Nepal is an agriculturally dominant economy, with about 74 percent of households relying on agriculture for subsistence. Nepal's total primary energy supply (TPES) per capita is 0.4 million tons of oil equivalent (Mote), much less than the global TPES of 2 Mote (IEA, 2015). Despite having abundant energy resources, Nepal has been unable to use its resources to achieve its development goals due to a number of constraints, including widespread poverty, a lack of initial capital (high upfront costs of such projects necessitate abundant investment capacity), and a lack of high-tech marketplace(BK Sovacool, 2011). Due to the inadequate availability of energy coupled with low wages, for lighting purposes only, households with access to electricity frequently consume it. The production of other renewable energy sources such as wind and solar is also being significantly promoted. Traditional fuels (such as firewood, animal dung, and plant residue), intermediate fuels (such as kerosene and biogas), and modern fuels are the main cooking fuel sources available in Nepal (such as LPG).Although there is domestic access to conventional fuels, transitional and new fuels are imported from foreign countries. More than 70% of Nepalese households rely primarily on conventional cooking fuels (Statistics, 2011). About 80% of the households are located in rural areas, and about 90% of rural households use traditional fuel as a primary cooking fuel (Statistics, 2011). Various studies(e.g.(Pokharel, 2007); (Malla, 2013) illustrate Nepal's energy use and access to energy are well below the level of basic human needs, and firewood is expected to continue to be the dominant source of fuel in the near future. In Nepal, a household spends about four hours to collect a bundle of firewood (Statistics, 2011). Urban households spend an average of 3 h collecting a bundle of firewood, versus 3.32 h for rural households (Statistics, 2011). Since urban households are likely to consume comparatively less firewood, these households need to drive less than rural households to collect a bundle of firewood. It is less likely that urban households would use as much firewood as their rural counterparts. Urban households, thus, spend less time gathering bundles of firewood. In addition, exposure to indoor air pollution caused by heavy dependency on conventional cooking fuels raises the risk of different diseases, such as chronic pulmonary and respiratory disorders and infant mortality. More than 4 million people die due to household air pollution worldwide, according to the World Health Organization, which is mainly caused by the intensive dependency on conventional cooking fuels. Owing to both exposure to indoor air pollution (e.g. health deterioration) and time-consuming firewood collecting activities, firewood reliance often decreases labor productivity. In developing countries, women and children are primarily vulnerable to the risk of health decline, decreased productivity and premature deaths;(J Barron, 2011).Thus, from an economic, environmental, public health and welfare standpoint, reliance on traditional fuels is undesirable (Rehfuess, 2006). Although modern fuels are beneficial for economic well-being and environmental sustainability, disincentives for such fuels may be created by high economic costs (A Bhide, 2011)(Kaygusuz, 2012). The internalization, through policy initiatives, of the external costs of conventional fuels (e.g. resource scarcity, emissions and fuel inefficiency) will help to minimize modern fuel costs. Understanding the preferences of households for different cooking fuels, which are subject to changes in the economic and non-economic characteristics of those households, helps inform policies in developing countries to direct the energy transition to modern fuels. A growing number of studies investigate the impacts of various factor such as household income, and education status that would influence household cooking fuel choice and then inform the policies to promote fuel switching to the modern sources.

Strong dependence on traditional fuels has a negative impact on public health and the environment, which ultimately exacerbates energy poverty and hinders the socio-economic development of the developing nation. Most developing countries have limited access to modern cooking fuels. Over 2.5 billion people in developing countries rely heavily on traditional fuel, such as firewood, plant residues and animal dung, as the primary source of daily household chores (Agency, 2015).

Energy consumption in Nepal ranges from conventional energy sources such as firewood, animal dung to modern energy sources such as LPG and electricity. In Nepal, about 70 per cent of households at national level and 90 per cent of families in rural areas depend on conventional cooking fuels(Statistics, 2011).

Households' energy consumption accounts for approximately 87% of Nepal's total final energy consumption. Nepal's total final energy consumption includes energy derived from a variety of sources, including firewood, gasses, fossil oil, and electricity, among others. Despite this, Nepalese have very limited access to basic energy resources, including access to electricity and clean kitchen facilities. As of 2010, for example, more than 30% of the total households in our country (approximately 8 million people) lack access to electricity and 78% of the total households rely on conventional fuel for cooking purposes(Statistics, 2011). This clearly demonstrates that household energy, which primarily uses traditional fuels, plays a significant role in the energy system of Nepal. As per(Van der Hoeven, 2013),Usually, Nepal's energy is classified into three groups of conventional fuels, commercial fuels and alternative fuels, with an 87% share of traditional fuels compared to a 12% share of commercial fuels and 1% of alternative fuels (indigenous renewable energy like solar energy). The share of conventional energy was reduced from 91% in 1995/1996 to 87% in 2008/2009. However, due to 3 A's, that is, accessibility, affordability and availability, individuals still rely on conventional fuel for regular household chores.

The emphasis of this study is on the pattern of energy consumption for cooking in the district of Kailali. The main energy sources available in the district include firewood, coal, kerosene, LPG gas and electronic appliances. The research also describes the socio-economic factors that affect the choice of energy.

## 1.2 Statement of Problems

Despite large potential and a long history of hydro generation the total hydropower generation of Nepal stands only 1329 MW as of April 2021. As per the 2019/20 economic survey consulted by Ministry of Finance, Government of Nepal about 90% of the population has access to electricity with 80% being connected to the national grid and remaining 10% benefiting from other renewable sources such as off grid small & micro hydropower and other solar systems. However, a large portion is still accounted for by traditional sources such as firewood, i.e., 80% Traditional, 19% commercial and 1% by renewable sources. The underdevelopment of the energy generation infrastructure has led the population to heavily rely upon traditional sources of energy leaving them vulnerable to the associated health hazards. NEA 2020, the demand of the country during peak hour is 1200 MW before the lockdown, however energy barely covers supply. The energy supplied is often barely enough for basic uses such as lightening, making it impossible for many households to the appliances which use more electricity due to resulting power outages.

However, the government of Nepal has put a priority on meeting the MSDG and has been investing sizeable resources to promote the use of renewable energy across the country. The government of Nepal has prioritized the hydropower sector for foreign and domestic investment. As a result, the hydropower sector has received 46% of total foreign direct investment in Nepal. Similarly, Nepal Climate Change Policy (2011) has envisaged protection of environment and sustainable human development by promoting the use of clean energy, reducing GHG emission. Enhancing the climate adaptation and resilience capacity of local communities.

Despite of the acceptance of the fact that the energy is critical for development, energy has not received significant attendance in policy debate. The government is directly or indirectly providing subsidy to import the fossil fuel that has favored the increased use of imported fuels compared to pricy hydroelectricity. Similarly, lack of awareness about the benefits of the use of renewable energy and the adverse impact of existing practices in health, economy and environment create hindrance in achieving the renewable energy goals. Although, rural communities have access to renewable energy technology, they lack understanding of these technology and people tend to use traditional fuel for meeting their daily household chores. Likewise, development of large-scale hydropower requires massive capital investment. The government do not have enough financial resources for investing on such projects. Renewable energy targets like solar and biogas is equally expensive especially the rural people and local institution cannot afford the capital cost of these technology without adequate financial support from other organization but due to immature business models, market insecurity and implement and usage risks, the financial institution are not readily motivated to invest in such project. Thus, these issues have created hindrance in the development of the clean energy in Nepal.

Kailali one of the five district of Seti zone of Nepal is located in South Western Part of Terai in the Sudurpaschim Province of Nepal. In Kailali district, majority of population i.e., 85.91% use firewood and about 7% use LPG gas. Other household families use bio gas, Kerosene, homemade dung fuel, electricity and other alternative energy. Out of total household of 142,480 in the district, around 35 percent are use some kind of alternative energy. Solar domestic system and small solar household systems are used from solar energy. Solar drinking water system and institutional solar system have not been used until now.

Abundant sources of renewable energy all over Nepal are hydropower and solar energy. It is important to switch to renewable energy which is not only cost effective but also reduces pollution. Although many research studies regarding the determinants of fuel choice at the household level has been conducted, most of them have their own limitation. This study analyzes the consumption pattern of types of energy sources for cooking in households of Dhangadhi Sub-Metropolitan City & Kailari VDC of Kailali District in relation to the socio-economic condition of the household to fill the research gap in the area. Firstly, conducting the household interviews and observation, this study aims to understand the economic conditions of the respondents by enquiring about their income, housing conditions, and education levels. The study also focuses on the energy sources used in the household by inquiring about its purpose, duration and cost. Focusing on the aspects listed above, the study aims to find the reasons behind the continuous use of traditional fuel in Kailali District and come up with recommendations for the government and non-government agencies to decrease the reliance on traditional sources of energy and work towards the promotion of sustainable energy sources. The switching of cooking fuel is essential for the sustainable future of Nepal. As there has been less research done on substituting traditional cooking fuel with model cooking fuels, this study has raised the following research questions:

i) What is the current fuel consumption pattern of the households in Dhangadhi Sub-Metropolitan City & Kailari VDC?
ii) What socio-economic factors determine the choice of particular type of cooking fuel source?

## 1.3 Objectives

The primary objective of this study is to analyze the household fuel choice for cooking. The specific objectives of the study are:

i) To analyze household fuel choice pattern for cooking in Dhangadhi Sub-Metropolitan City and Kailari VDC.
ii) To explore the socio-economic determinants of different cooking fuel choices by the households in the study area.

## 1.4 Significance of the Study

Analyzing the change in energy consumption pattern is important as such study have vital policy implication. Although, there are some literatures existing in the subject, people still lack knowledge about the possibility of up gradation of traditional fuel into modern fuel sources that could yield larger benefits. This study focuses on the awareness in the community and the government on the negative aspects of traditional biomass energy. This research helps to recognize the socio-economic factors that lead people to make energy choices. Furthermore, this study has helped in exploring the relationship between household fuel choice behavior, their income level and socio-economic factors like household education, geographical location of house, family size that generally explain about the variation in energy preference. Lastly, this research aims to add on to pool of minimal research done on the subject of use of modern energy and its effects. Increased research and study on the current sources of energy and their impacts on the socio-economic condition, way of living and overall development of society could also help in gathering the attention of the government which could ultimately create an impact on its policy making process. Thus, this research could be a stepping stone for future research on the topic and its recommendation and findings could also guide the provincial level government in making positive changes in the existing energy policies.

## 1.5 Limitations

The study is completely based on Primary data. Firstly, the primary limitation of this study is the time and budget that led to the smaller sample size for the interviews, Furthermore, as the respondent of the survey live within the city of Kailali District, the finding of this research does not present the opinion of entire population of Kailali District.

The consumption pattern of energy might be different in different region within the country. In particular, as Nepal is a country with extreme geographical variation, the same study is likely to lead to different findings if conducted in some other regions. Also, this study does not provide enough evidence or statistical data from various sources as minimal studies have been done on this issue targeting the exact same research group (Households of Dhangadhi SMPC and Kailari VDC) and energy sources (traditional fuel). Therefore, additional and continuous study on the subject matter needs to be done in a larger scale to better analyze the holistic impact of excessive use of traditional biomass energy in the whole of Nepal. Lastly, lack of prior research on the topic and also lack of reliable data of Dhangadhi SMPC and Kailari VDC are the main limitations of this research.

## 1.6 Organization of study

This study attempts to examine the effect of determinant on Household Fuel choice for cooking. To achieve the objective, the study is structured into six chapters. Chapter one includes the overall introduction to energy consumption behavior and its impacts on the choice and inter-fuel switching and substitution behavior of different energy sources depends on the availability of different energy sources and the affordability of households. Chapter two includes, synopsis of previous research on energy choice behavior of households. Likewise, third chapter is the conceptual framework, tools and methods of data analysis along with econometric variables. Chapter four, deals with the presentation and analysis of the primary data regarding the fuel choice in Dhangadhi SMPC and Kailari Gaupalika. Chapter five includes summary, findings, conclusion and recommendation of the overall study.

# CHAPTER 2 LITERATURE REVIEW

This Chapter provides a synopsis of previous research on energy choice behavior of households.

## 2.1 Household Fuel Choice Theories

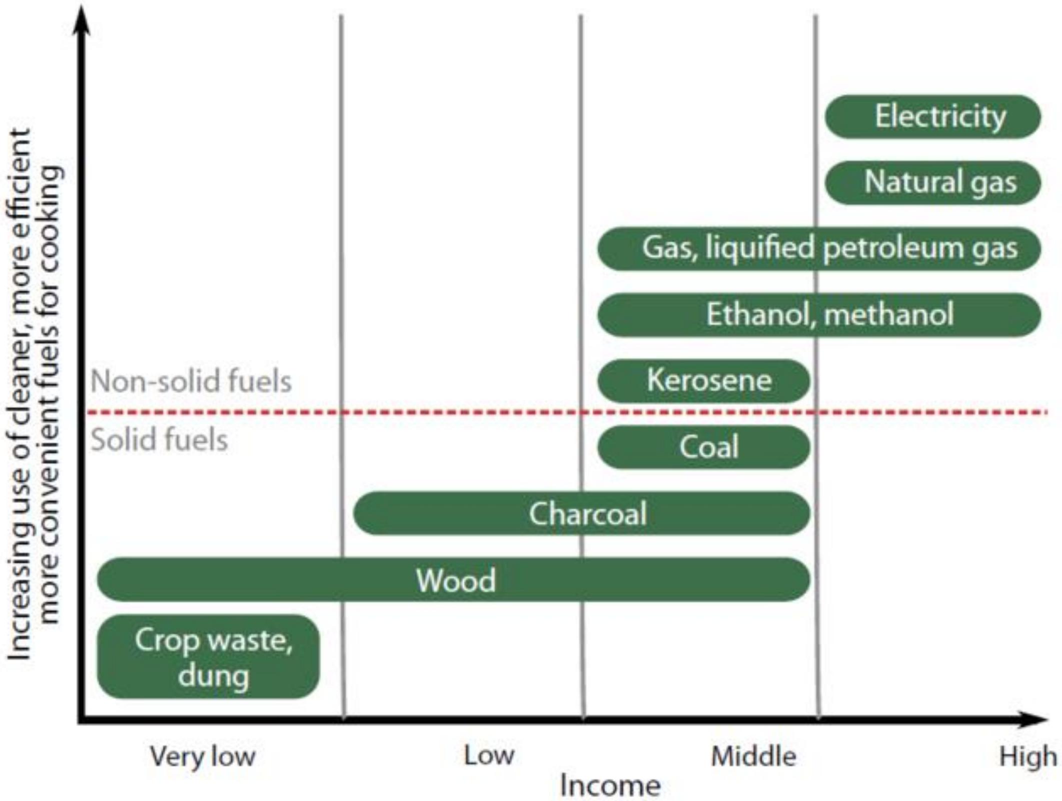
Recognizing the key determinant that affects household cooking energy use is important because it aids in the creation and implementation of effective policies to increase access to renewable energy. Energy sources are accessible and inexpensive in various locations within or around the world. Two theories related to HHs energy choice have been outlined in the literature, "The Energy Ladder Theory" and "The Fuel Stacking Theory," which guide the study of HHs fuel choice.

### 2.1.1 The “Energy ladder” theory

In the past, using the Energy Ladder Method, the choice of household fuel was evaluated in which fuel is less efficient and there is more pollutant at the bottom of the ladder and fuel is more efficient and less pollutant at the top of the ladder. Generally, the higher ladder energy sources are more costly, but they are efficient, require less labor input and generate less fuel per unit (Arias-Chalico, 2014). Energy Ladder implies that they abandon systems that are unreliable, less costly and more polluting, i.e. 'lower' like dung, fuelwood and charcoal on the energy ladder, as the family gains socio-economic status.

This model splits patterns in energy-use into three fuel selection phases. In the first point, universal reliance on biomass fuels is manifested. In the second phase, households turn to "transition" fuels such as kerosene, coal and charcoal. Households are converting to LPG, natural gas, or electricity in the third level ((Heltberg, 2005);(N Schlag, 2008);(Osiolo, 2009).

Figure 2-1: Energy ladder




Source: Adopted from (Paunio, 2018)

This energy ladder reflects the positive relationship between socio-economic level and model fuel uptakes, i.e. an increase in households' economic well-being allows them to leave traditional fuels at the bottom of the ladder and purchase stoves & duels higher on the ladder. According to (Arias-Chalico, 2014)the different fuels and stoves carry a social status as well. Therefore, on the one hand, the higher costs of new technology are offset by the higher fuel efficiency and cleanliness of the stove, but also by the targeted rise in social status. Agricultural waste and firewood are viewed as the 'energy of the poor' that is used instead of preference out of necessity and it is believed that consumers will search for the most advanced source of energy they can afford.(G Hiemstra-Van der Horst, 2008).

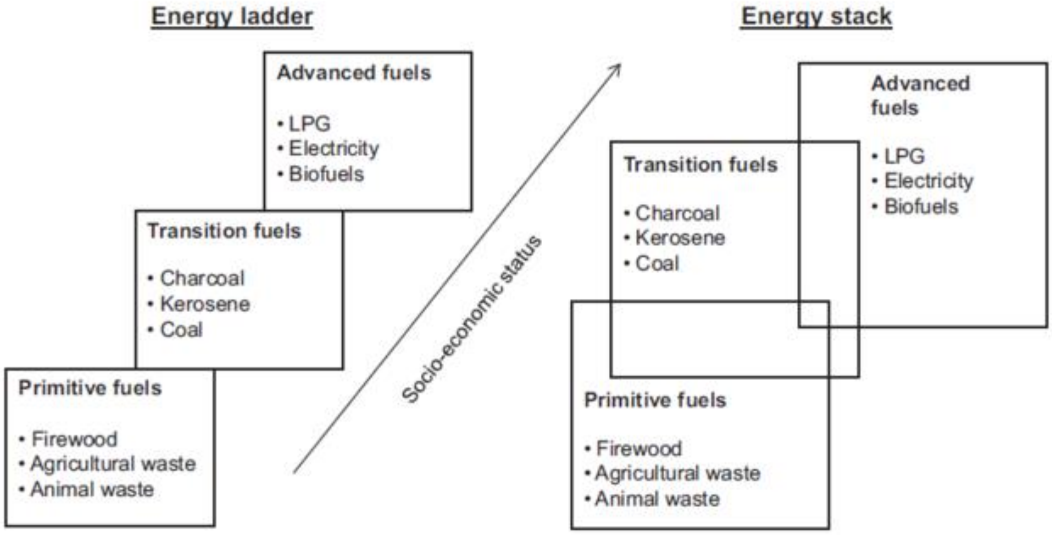
According to (RH Hosier W. K., 1993), the microeconomic theory of domestic behavior is the foundation of the transition to oil. If income rises, the demand for normal goods increases, while the demand for inferior goods decreases. The energy ladder hypothesis implies that modern fuels are normal goods and traditional fuels are inferior goods. Therefore, as household income grows, they switch from conventional fuels (inferior goods) to comparatively modern fuels (normal goods).(RH Hosier J. D., 1987) argued that the goal of stepping up the energy ladder for households is not to achieve higher fuel efficiency or lower pollution exposure, but to express an increase in socio-economic status.

However, the Energy Ladder model has been criticized because it exclusively considers income as an important determinant to explain household fuel choice behavior. It assumes once the income of the HHs increases they stops the consumption of the traditional energy sources and adopt modern fuels that they can afford with the increase income. However, a few empirical studies present evidence against energy ladder hypothesis -- households move towards modern energy sources as their income rises--. For example, (R Sehjpal, Going beyond incomes: Dimensions of cooking energy transitions in rural India, 2014)in rural India finds that household income is less significant compared to other social and cultural factors in choosing cleaner fuels. Furthermore, studies by (G Hiemstra-Van der Horst, 2008), (MR Bhagavan, 1995)in India find that fuelwood is chosen by households of all incomes, while studies by(Davis, 1998), (BM Campbell, 2003)also find the use of electricity and LPG for cooking in low income households. (A Mekonnen, 2008) argues that the higher income, particularly in urban areas, causes diversification of fuel choice rather than substituting one particular fuel with others. Apart from income, several other socio-economic factors also influence household's cooking fuel choices. One important factor is education or awareness. (MO Pundo, 2006)Find that education level of wife significantly influences the probability of switching from fuelwood to charcoal or kerosene in rural Kenya. (VL Pandey, 2011) finds that number of educated females between 10 and 50 years of age and average household's level of education had a positive and significant impact on probability of using clean cooking fuels in rural India. Another factor is fuel pricing. (U Kumar, 2010) finds that Indian households continue to depend on traditional and inefficient fuels mainly due to high price of clean and modern fuels. Factors such as household size could also influence cooking fuel decision. For example, (CE Nnaji, 2012)find that fuelwood is by far the fuel of choice for a majority of households with relatively larger size. In general, household cooking fuel choice and adoption of clean technologies are mutually inclusive.

### 2.1.2 Fuel Stack Theory

Fuel Stack Theory has been proposed as alternative to the energy ladder approach as the energy ladder approach cannot adequately describes the dynamics of households’ fuel use. Fuel stacking refers to multiple fuel use patterns-where HHs choose a combination of fuel from both lower and upper levels of the ladder. Indeed, modern fuels may serve as partial rather than perfect substitutes for traditional fuels.

Figure 2-2: Fuel stacking




Source: Adopted from (Kroon, 2013)

Multiple Fuel use arises from several reasons such as price changes, preferences, taste, and reliability of supply, cooking and consumption habits, availability of technology, education, HHs compositions and further cultural and habitual factors. Even there are more factors that could affect the fuel switching behavior of HHs such as occasional shortages of modern fuels (R Kowsari, Three dimensional energy profile:: A conceptual framework for assessing household energy use, 2011), high cost of appliances associated with using exclusively modern fuels, fluctuations of commercial fuel prices and preferences inducing households not to fully adopt modern fuels. This aspect generally leads to the concept of stack or fuel stack theory, which states that households do not simply switch to a new cooking facility as income increases, rather they continue to use a combination of fuels (solid and non-solid) and cook stoves located across the energy ladder. This helps them to maximize fuel security and to get the advantages of different fuels as fuels are imperfect substitutes for each other, and often specific fuels are preferred for specific tasks (Arias-Chalico, 2014). Fuel switching is the main response to increasing incomes in urban areas, while fuel stacking is dominant in rural areas. This is because substitution and income effects work in opposite direction. As income rises, households can afford to consume a larger variety of energy types in greater quantities, resulting in non-decreasing firewood use as known in the rural areas. On the other hand, in urban areas, when income increases, high-income households can afford modern fuel sources and switching to costlier liquid and gaseous fuels. (Alam M. S., 1998)Furthermore, it was argued that there may not be a direct transition in the energy ladder from traditional to modern fuels. Improved stove technology could serve as an intermediate step in the energy ladder model, bridging the gap between traditional biomass stoves and modern fuels in many parts of the developing world where modern fuels are currently unavailable. As a result, households will continue to use traditional fuels.

## 2.2 Empirical Review

From the results of the various empirical studies carried out in different countries, it is proved that income is not the only factor which affects households fuel choice as the energy ladder model verifies. Apart from income, product related attributes and several other socioeconomic factors also influence household's cooking fuel and stove choice. Understanding of those determinants of household cook stove and fuel choice is important for the design and implementation of effective policies that promote clean technologies. Following are the factors that affect the fuel choice.

### 2.2.1 Income

Most of the studies point out that “Income” as the major drives behind the uptake of modern fuels. Income is assumed to be the main driver of fuel choice, and rise in income will lead to switch from biomass fuel to modern fuel. The effect of income on HHs fuel choice has been investigated in most of the empirical econometrics’ studies. Most of the authors specify income as a measure of household earnings. (Dowd, 1987) conducted an empirical test on the energy ladder hypothesis by applying Multinomial logit formulation of the energy ladder to household energy-use data from Zimbabwe and found that that the household do move away from wood to kerosene and electricity as their economic status improves.(Ouedraogo B. , 2005), conducted an extensive survey on household expenditure in Ouadougou to analyze the factor determining urban households energy choice by using multinomial logit model, descriptive analyses show that the domestic demand for wood-energy is strongly related to household income i.e. higher income induces urban households to choose natural gas over kerosene. (Gautam Guptaa, 2006), investigates the demand for domestic fuels when households face four choices: Fuelwood, Coal, Kerosene and LPG by conducting a survey of 500 households in Kolkata, India and found that in urban India some evidence for an energy transition from fuelwood and kerosene to LPG (Light Petroleum Gas), is largely driven by expenditure levels. (Sylvie DÉMURGER, 2011). discusses the determinants of firewood consumption in a poor township in rural northern China, with a special focus on the relationship between households' economic wealth and firewood consumption and found that household economic wealth is a significant and negative determinant of firewood consumption and analysis also shows that the own-price effect is important in explaining firewood consumption behavior, the price effect gaining importance with rising incomes. (Jessica J. Lewis, Who Adopts Improved Fuels and Cookstoves? A Systematic Review, 2012), conducted a systematic review of the literature on the adoption of ICSs or cleaner fuels by households in developing countries by applying multivariate regression method and found that income is positively and significant factor that determine the adoption of improved cook stoves. (Jann Lay, 2013), study the determinants of households' choices of lighting fuels in Kenya including the option of using solar home systems (SHS) by testing "cross-sectional energy ladder and found that rising expenditure induces households to choose electricity and solar energy over wood and kerosene.(Puzzolo, 2013), describe and assess the importance of different enabling and/or limiting factors that have been found to influence the large-scale uptake by households of cleaner and more efficient household energy technologies and found that higher socio-economic status is positive and significant factor in determining a household's improved cook stoves adoption decision. (L.J.S. Baiyegunhi, 2014), analyzes the effect of households' socio-economic characteristics on choice of cooking fuel by multinomial logit (MNL) model which estimate the determinants of fuel choice in Giwa Local Government Area of Kaduna State, Nigeria study found that the transition from fuelwood to kerosene, natural gas and electricity occurs along to rising income i.e. the patterns of fuel usage are consistent with the 'energy stacking' theory as fuelwood are often used alongside modern fuels, and majority of the households depend largely on fuelwood as its principal cooking fuel. All these studies are based on the concept of Energy ladder, which emphasizes on income as a main determinant that generally affect the decision of HHs on fuel choice.

However, a few empirical studies present evidence against energy ladder hypothesis --households move towards modern energy sources as their income rises--. For example,(Greg Hiemstra-van der Horst, 2008), examines the practical relevance of transition theory using a recent case study, by using Linear regression analysis and found that despite the long-term link between socio-economic development and increased modern fuel consumption at the national scale, the notion of ''transition'' does not accurately reflect ongoing energy-use patterns at lower levels of aggregation i.e., the fuelwood is chosen by households of all income group in Botswana. (Ritika Sehjpal, 2014), analyzes the definition of access to include for reliability and quality going beyond conventional understanding by binary-choice logit model to assess the factors that influence a household's choice of primary cooking fuel and found that that household income is less significant compared to other social and cultural factors in choosing cleaner fuels.

### 2.2.2 Price

Price is considered as the economic factor determining the consumption of Households' energies. Price variables include the price of improved cook stoves, the price of fuel-wood, the price of kerosene and others.(Schlag, 2008), provides an overview of the social, economic, and political factors that act as market barriers to clean cooking fuels in sub-Saharan Africa by a qualitative assessment of these barriers made through a general overview of clean cooking fuels, as well as through examples of specific fuels and countries and found that high fuel prices made household more likely to use traditional fuels in SSA. (Slaski, 2009) identified that improved cookstoves' cost affordability by the poor is a positive determinant factor of adoption. Furthermore, the authors argue that low affordability of the cost improved cookstoves negatively affects cookstoves adoption likelihood by the poor.(Jingchao, 2012)estimated the energy demands of rural households by using survey data taken from Beijing's ten suburban districts, by using reduced-form approach to estimate energy demand by using observable exogenous factors as explanatory variables in the regression and found if the Chinese government were to design appropriate policies associated with renewable energy technologies and related energy prices, then coal consumption can be reduced in the near future, and the substitution to cleaner energy use will accelerate.(Zhou, 2013) assess the impact of actions taken by the Chinese government as well as planned and potential actions, and evaluate the potential for China to reduce energy demand and emission by using the bottom-up LBNL China End-Use Energy Model and found that inability of the poor to pay the cost of improved household fuel is one of important barriers of adoption decision.

There is much evidence showing significant negative own-price effects both for the quantity of fuel consumed and the probability of choosing this fuel. These previous studies generally give us a clue to expect what is the effect of price on Households' fuel purchasing decision. Therefore, it is expected the price of these fuel have a negative effect on the households' purchasing decision.

### 2.2.3 Household attributes

Most socio-economic attributes of the consumer influence household decision-making for the fuel choice. Education, Household size, Age, lifestyle all act together in determining fuel choice behavior of households.

#### 2.2.3.1 Education

The education level of the household has significant impact on fuel switching. The education level of household members may improve the ability to earn more, and it further improves the knowledge about the impact of using different fuel options, which may subsequently influence the cultural and consumer preferences.(Pundo, 2006), o investigate the factors that determine household cooking fuel choice between firewood, charcoal, and kerosene in Kisumu, Kenya by using Multinomial Logit Model and found that that level of education of wife, the level of education of husband, type of food mostly cooked, whether or not the household owns the dwelling unit, and whether or not the dwelling unit is traditional or modern type are important factors that determine household cooking fuel choice.(Abebaw D. , 2007), investigates why some urban households use more fuelwood than others by using Tobit model and reveal that he association between per capita income and per capita fuelwood consumption is non-linear and that per capita fuelwood consumption is inversely associated with family size and education of the household head (HHD).(Pandey, 2011) analysis decision making process in rural households regarding the choice of cooking fuels by using logistic regression model and found out that number of educated females between 10 and 50 years of age and average household's level of education had a positive and significant impact on probability of using clean cooking fuels in rural India.(Z Gebreegziabher, 2012), investigates urban energy transition and technology adoption conditions using a dataset of 350 urban households in Tigrai, in northern Ethiopia and found that the transition to electricity is affected by households adopting the electric cooking appliance, which in turn is influenced by the level of education and income, among other things.

(Rahut, 2017), examines the effects of dirty fuels on human health and household health expenditure by using propensity score-matching approach and found that, an increase in education level of the Household increases the probability of using modern fuels. Thus, from the study it can be expected that the education level of the household has a positive relationship with the choice of improved fuels.

#### 2.2.3.2 Household Size

The size of the household has significant impact on Household fuel switching decision. Several studies have been carried out on the impact of Households decision on fuel choice in regards with Family size. Such as family size is one of the most important aspects of family welfare that affects the decisions on fuel selection. (Heltberg, 2005), discusses on the factors guiding household choices of cooking fuels by analyzing Patterns of fuel use, energy spending, Engel curves, multiple fuels, the extent of fuel switching, and the determinants of fuel choice and found that household size encourages fuel stacking behavior rather than fuel switching. (Pattanayak1, 2012), reviewed empirical studies on ICSs and fuel choice to describe the literature, examine determinants of fuel and stove choice, and identify knowledge gaps by conducting a systematic review of the literature on the adoption of ICSs or cleaner fuels by households in developing countries. Results are synthesized through a simple vote-counting meta-analysis and found that household size is statistically significant and positively associated with the probability of adoption of improved cookstoves. (Joshi, 2017) assess the impact of various socioeconomic factors in a household's cooking fuel choice and motive for making a transition toward cleaner fuels by using household level cross-sectional data (2011) and pooled data (1996, 2004, and 2011) from the Nepal Living Standard Survey, multinomial and binomial logit models and the result suggest that along with household income, other social and ecological factors play a critical role in inter-fuel switching decisions.

As the number of family members in a household increase, the household becomes more sceptic towards switching to modern fuel types. Some authors also found that household size is statistically significant factor that determines improved cookstoves adoption decision. The study revealed statistically positive correlation between improved cookstoves adoption and large family size. Household size affects energy use based on per capita income and per capita resource availability. It is argued that larger Thus, households with larger family size consume larger fuel wood as compared to households' smaller family size that results in influencing larger family size households to economize fuel wood usage.

#### 2.2.3.3 Gender

In most of the developing countries, female members of the households take the responsibility of cooking and collecting fuelwood. Thus, it is often argued that the number and presence of female members in household decision-making position affect the fuel consumption decision. Women generally play a major role in household cooking decision-making activities. Studies have shown that households headed by women generally opt for modern fuels than those headed by men. This may be attributed to the fact that women are often responsible for household cooking and thus they are directly affected by the air pollution emitted from the burning of the dirty fuels.(Ko¨hlin, 2006), investigates the demand for domestic fuels when households face four choices: Fuelwood, Coal, Kerosene and LPG by surveying of 500 households in Kolkata, India conducting a two-stage process where the first stage investigates choice and the second the quantity used and found that the coefficient of gender of the household's head is insignificant in some contexts, For instance, women who work for monetary compensation may have higher opportunity costs of time and thus prefer time-saving fuel. (Rahut, 2017) analysis on the effects of dirty fuels on human health and household health expenditure and found that female-headed household preferred electricity over firewood for cooking. They argued that when women are in a decision-making position, they are likely to go for convenient sources of fuel because they are the one who are supposed to prepare a meal. Thus, Gender is another debated factor that generally plays a vital role in Household's fuel choice.

#### 2.2.3.4 Age

The empirical findings on the role of age in explaining household fuel use remain contradictory. Some studies find that age is positively associated with preference for traditional fuels. Mean age of household members has significant positive effect on the choice of LPG, and it has significant negative effect on the choice of kerosene. Age generally has negative impact on the probability of using electricity. (Rao, 2007)determine the factors that influence individual's decision to choose a particular energy carrier, viz., firewood, LPG, kerosene, and electricity by assessing the 1999–2000 National Sample Survey (NSS) data covering over 118,000 households and analyses the rural and urban areas separately, he applied a multinomial logit selection model for estimating the energy carrier choice decision the result shows that individuals are influenced by per capita income, household size, educational status of the head of the household, occupation of the household members, in addition to other household location characteristics. It is found that the monthly household income and household size have nonlinear relationship on the probability of choosing a fuel. (Démurger S. a., 2011), discusses the determinants of firewood consumption in a poor township in rural northern China, with a special focus on the relationship between households' economic wealth and firewood consumption and found that household average age has a positive and significant impact on firewood consumption in rural households of northern China.

(Guta, 2012) assessed biomass fuel resource potential of Ethiopia and founds that older household heads are more likely to prefer modern fuels to traditional fuels in Ethiopian rural households.(Özcan, 2013), analyzes several economic and socio-demographic factors which affect households' energy choices in Turkey by obtaining data from household Budget Surveys (HBS) conducted by the Turkish Statistics Institute (TÜİK). The multinomial logit model is used to identify households' energy choices and observes that older household heads are more likely to shift away from wood towards natural gas, liquid fuel and electricity in Turkey. (Hassan, 2014), analyzes the effect of households' socio-economic characteristics on choice of cooking fuel. A multinomial logit (MNL) model was used to estimate the determinants of fuel choice in Giwa Local Government Area of Kaduna State and found that household head's age, is statistically significant factors influencing households' choice of cooking fuel. Thus, the role of age in explaining household fuel use remains contradictory; it may have positive impact or a negative on HHs fuel decision-making.

### 2.2.4 Access/ Availability

The availability of fuel-wood is one of the factors that lead to the decision not to adopt improved fuel energies. It refers to the availability and sustainability of the fuel supply in the market. In many developing countries modern fuels (such as LPG and electricity) supply is erratic due to a number of reasons for instance the lack of dung is the main hurdle in the regular operation of biogas plants, whereas in other areas, participants refuse to use improved cooking stoves because of fuelwood adequacy. The utilization pattern of these resources is entirely dependent upon the availability of particular biomass. In general, fuelwood is considered superior, and every household tries to maximize its use, whereas the burning of crop residues and dung cakes is common in fuelwood deficient areas. The use of biogas is limited to only few households. The households located in forest-rich areas only use fuelwood, whereas households in forest-deficient areas use a mixture of biomass. As the availability of both dung and crop residues is dependent on seasons, information on the variation of those resources plays a significant role in addressing demand-based site management. Furthermore, the use of biomass during the winter is noticeably higher than in the other seasons, which should also be evaluated in order to determine the supply-demand relationship. Easy availability of fuelwood in the local environment in most of the cases, the dependence on fuelwood is mostly to be observed in poor households. (Troncoso, 2007) also investigated a positive correlation between lack of access to open forest and improved cook stoves adoption and the vice versa. Based on this empirical evidence, it is assumed that for households that get wood for free, and who have access to forest opt for fuel-wood and vice-verse. Also, the insecurity of improve fuels supply such as the route and frequency of delivery ultimately affects the adoption behavior of households with regards to cooking fuels. (Joshi, 2017), assess the impact of various socioeconomic factors in a household's cooking fuel choice and motive for making a transition toward cleaner fuels and identified that the distance between homes and forests (where households typically collect their firewood) significantly affects the choice of modern fuel types. This study also found that the access to open forest is found to be negatively correlated and statistically significant with the probability of improved cook stoves adoption decision.

### 2.2.5 Other External factors

From several studies, other factors such as physical environment, government policies, social factors are found to influence the adoption decision of improve fuels. Studies have shown that there are number of barriers associated with adoption of clean fuel and fuel choice in developing countries. Some of these barriers include costs of LPG, lack of communication between manufactures and consumers, markets and lack of supplementary financial provisions such as micro-finance programs or grants for households and entrepreneurs, inadequate local support and rigid stove design capabilities. Indonesian HHs switch from kerosene to LPG for cooking needs through the government's inter-fuel substitution program. Social and community interaction factors also influence fuel choice. For example, in rural Kenya found that the decision to purchase improved biomass stove by households is significantly influenced by observational learning and interpersonal communication through social networks from neighbors and relatives who had adopted the stove.

(Arias-Chalico, 2014) explained the rationale for stacking in terms of the roles of end uses, cooking tasks, livelihood strategies, and the main patterns of use resulting from them. It uses evidence from case studies in different countries and from a 1-year-long field study conducted in 100 homes in three villages of Central Mexico; outlining key implications for household fuel savings, energy use, and health and found that fuel stacking as a household strategy to cope with the uncertainty due to scarcity and unreliable distribution.

(Giri, 2017) identifies the determinants of energy choice for lighting in Nepal by applying a multinomial logit regression to a nationally representative set of household level data, and from his study it was found that such as seasonal variation and altitudinal variation may influence household fuel consumption. People living in colder climates consume more energy than people living in warm climates. Other external factors such as distance from major trading routes, large cities, and existence of road infrastructures, fuel distribution channel and size of the settlement associated with the accessibility of modern fuels probably have direct influence on fuel switching. Likewise, the reliability of fuel supply is also an important determinant of fuel choice. Unreliable modern fuel supply in many areas may encourage households to adopt mixed fuel use strategy. High installation costs and extra expenditure in arranging compatible utensils are often found as a barrier to fuel switching. Switching might be costly for rural families in many ways. In contrast to modern fuel, the fuelwood and kerosene can be purchased in small quantity against payment of less money, but customers are required to buy a standard weight of LPG with an amount of huge money. Thus, even the method of payment might force the poor households to rely continuously on purchased biomass or kerosene even though it might be expensive for them in the longer term.

Previous studies, generally, proved that household stove choice depends on economic variables, household characteristics, institutional factors and infrastructure related variables. Income and price of stove are found to be important economic factors which determine household stove preference. Household with high income are more likely to adopt clean and efficient cook stove, while an increase in stove price reduces the probability of using it. Education of household members in general and household head in particular has significant positive effect on the choice of modern cook stoves. Household size is also important household characteristic which has positive effect on the use of clean stoves in urban areas, but it has negative effect in rural areas. Age has inconclusive impact on the transition to modern cooking technologies. Status of cooking facilities, including ownership of kitchen and type kitchen are also important factors.

Thus, it is proved that, income alone cannot sufficiently explain household fuel choice behavior rather household characteristics, including level of education, household size, age and sex of household head, infrastructure related variables and institutional factors also determine household fuel choice.

## 2.3 Economics of Fuel Choice of Households

Several empirical studies have identified numerous economic benefits associated with household fuel choice. Modern fuels have environmental, health, and socioeconomic implications, many of which are primary targets of most Renewable Energy Initiatives. According to (Alam M. J., 1998), Sponsors' key motivations for encouraging the use of improved stoves have been to minimize strain on the natural resource base, to use resources in a cost-effective and productive manner, and to provide disadvantaged people with a way to reduce their high energy expenses. For example, from the perspective of the users' benefit, this usually involves health benefits such as reduced indoor air pollution and economic benefits such as time savings from harvesting fuels such as firewood from the forest and reduced fuel costs. It also has other advantages, such as better aesthetics and a healthy lifestyle.

Depending on the determinants, different household consumers have different viewpoints on fuel choice. The economic benefits of using improved cook stoves include reduced fuel demand, fuel expenditure, and time spent collecting and cooking fuel. To evaluate the effect of ICS on firewood use and CO2 emissions,(Khanal, 2010)) conducted a study in Nepal. The study used before and after technology intervention impact evaluation method. The outcome revealed that using improved cook stove reduces firewood demand and time allocated to wood collection. Firewood demand was reduced by about 45 per cent after the use of improved cook stove.(Malla, 2013) analyzes the patterns of household energy use and associated air pollutant emissions in Nepal based on LEAP framework for thirteen analytical regions and three end-uses and found that cooking device interventions have major economic benefits, largely due to fuel and cooking time savings. In Maharashtra and Karnataka, India, (Thurber, 2014)The highest rate of adoption of the "Oorja" ICS, which uses pelletized biomass, was found among LPG-using households, owing to lower fuel costs. However, according to their report, only 9% of households that purchased Oorja ICS used the stove due to a lack of fuel. However, time spent by women collecting fuelwood in the villages is significantly higher, in the range of 1-3 hours per day. As a result, the adoption of more efficient energy reduces the time spent gathering fuel wood, enabling the household to devote more time to income-generating activities, child care, and education, especially for women and children.(Brief, 2013)

Many studies show that switching to modern fuels and introducing ICS has health and environmental benefits, especially in terms of smoke and protection. For example, using cost benefit analysis (CBA), (Dorian, 2006) found that investing in modern fuels and ICS may be beneficial to human health as well as the local and global climate. Using similar CBA framework in Kenya, Sudan and Nepal, (Malla, 2013)found that enhanced cooking device interventions have a significant health benefit in terms of decreased medical costs and time savings due to less days spent ill or caring for a sick child.

## 2.4 Research gap

Several studies have been carried out to analyze modern energy fuel demand and potential in Nepal. However, research related to economic benefit of switching to modern energy fuel and factor affecting the Household fuel choice, especially in Dhangadhi Sub-Metropolitan City and Kailari VDC is scarce in literature. Hence, this thesis analyze the factors that influence the household's choice of cooking fuel and the benefits of switching to alternative energy.

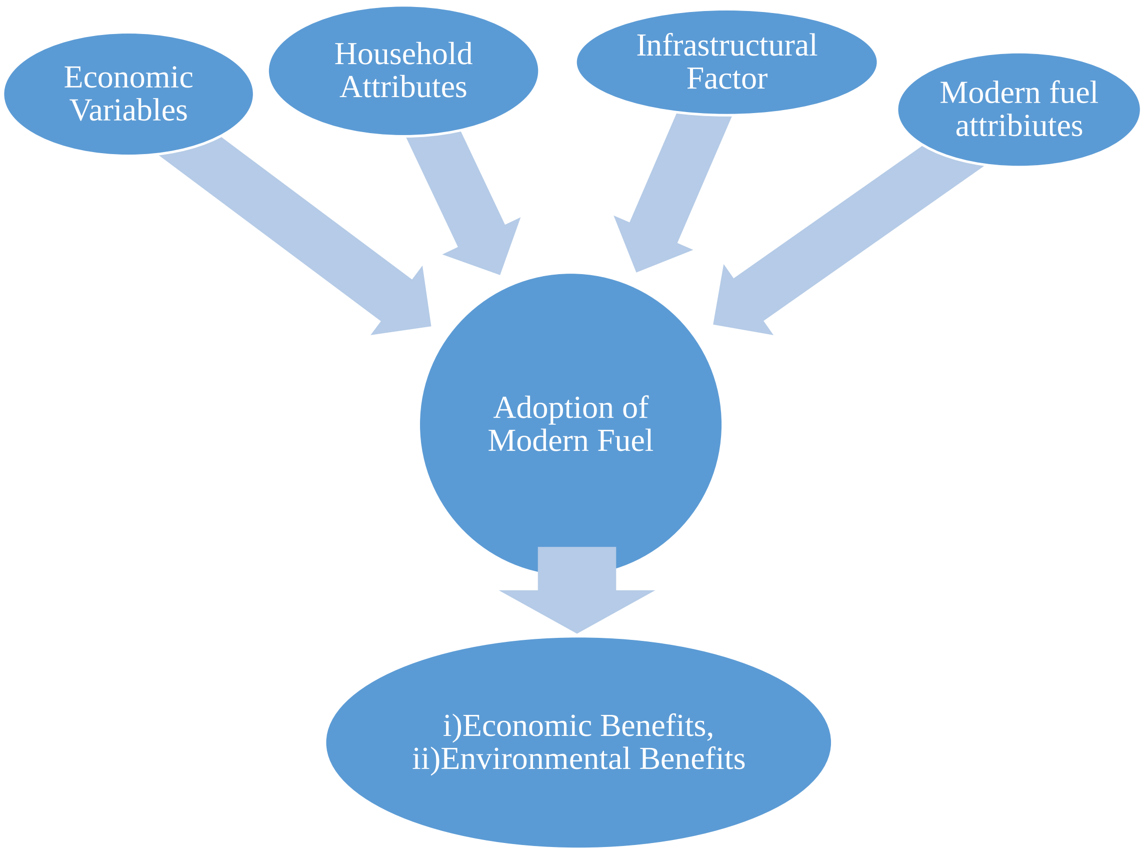
# CHAPTER 3 RESEARCH METHODOLOGY

This Chapter deals with the presentation and analysis of the primary data regarding the fuel choice in Dhangadhi SMPC and Kailari Gaupalika. The data collected were first entered on Microsoft Excel 2007 and then exported to IBM SPSS for further calculation.

## 3.1 Conceptual Framework

In literature, it is clearly shown that Household's adoption and choice of clean energy depends on many factors. These factors can be economic factor, household characteristics, infrastructure related variables and fuel specific attributes etc. Economic factor includes price and income of households. Similarly, household attributes include family size, education of household, gender, occupation etc. Likewise, infrastructure factor is related to access to modern fuel, location of the residence and modern fuel attributes includes prices of stoves, usage cost of the stove, smoke and burning risk of using the fuel. These factors directly or indirectly effect the Adoption of clean fuel energy.

Figure 3-1: Adoption of Modern Fuel



## 3.2 Description of Study area

Kailali one of the five district of Seti zone of Nepal is located in South Western Part of Terai in the Sudurpaschim Province of Nepal. In Kailali district, majority of population i.e. 85.91% use firewood and about 7% use LPG gas. Other family use gas, kerosene, homemade fuel, electricity and other alternative energy. Alternative energies such as micro hydroelectricity, solar energy, biogas and improved oven have been used in district. Out of a total household of 1,42,480 in this district, 6.59% have access to alternative energy (Kailali, 2015).

Table 3-1: Usage of Fuel Wood in Household

| S. N | Types of fuel | HH number | HH % |
|---|---|---|---|
| 1 | Wood/firewood | 122,344 | 85.91 |
| 2 | LP Gas | 9,687 | 6.80 |
| 3 | Bio gas | 8,309 | 5.83 |
| 4 | Not stated | 769 | 0.54 |
| 5 | Kerosene | 679 | 0.48 |
| 6 | Cow-Dung | 308 | 0.22 |
| 7 | Other | 272 | 0.19 |
| 8 | Electricity | 45 | 0.03 |
| 9 | Total | 142,413 | 100.00 |

Source: CBS, 2011

The study is undertaken in Dhangadhi Sub metropolitan City and Kailari Gaupalika. The study area is selected purposefully with as it has diversity in terms of social, cultural, and socio-economic means.

## 3.3 Nature and Sources of Data

This study is based on primary data. Household Survey was the main source of cross-sectional primary data. Structured questionnaire was prepared and administered to collect primary data from the households. Pre-testing of the questionnaire has been conducted before a real survey had been carried out in order to check its reliability and validity. Secondary data was obtained from various different sources. Central Bureau of Statistics, International Energy Agency, Water and Energy Commission Secretariat 2010 and 2014, journals, and articles were the main sources of secondary data. The collected data were processed and tabulated according to the need of research. Different statistical tools have been used for analysis and interpretation to draw conclusion.

## 3.4 Method of Data Collection

Questionnaires were distributed among the households of Dhangadhi SMPC and Kailari Gaupalika. A quantitative research method was applied to this study. This study involved a socio-demography survey and household energy use, questionnaire, and observation of the household energy use patterns. The data were collected from 190 households from Dhangadhi SMPC and Kailari Gaupalika. Hard copy questionnaire was distributed and collected within precise time.

## 3.5 Sample Size and Sampling Procedure

It was assumed in this sample methodology that the expected rate of occurrence was not less than 90% at the 95% confidence level with a precision level of 10% at the time of the sampling. Following the methodology of Arkin and Colton (1963), the sample size (based on a total of 36945 households) was calculated using the formula shown below.

Sample size = $\frac{N \times Z^2 \times P \times (1-P)}{N \times d^2 + Z^2 P(1-P)}$

Where,

N = Total number of households

Z = Standard normal deviation or z score or normal score. At 95% confidence interval, Z = 1.96

P = Population proportion, it is kept at 0.5, which indicates that maximum variability in population

d = Level of precision, it is kept at 10% (Error limit)

Table 3-2: Calculated Sample Size of Household of Dhangadhi Sub-Metropolitan City

Table 3-3: Sample household calculation

| **Total Number of household** | | **Total Number of Population** | **Sample size** |
|---|---|---|---|
| 29143 | | 147741 | 95 |
| Precision level | 0.1 | | |
| Confidence level | 0.95 | | |
| Proportion | 0.5 | | |

Table 3-4: Calculated Sample Size of Household of Kailari Gaupalika

| **Total Number of Household** | | **Total Number of Population** | **Sample size** |
|---|---|---|---|
| 7802 | | 47957 | 95 |
| Precision level | 0.1 | | |

| | |
|---|---|
| Confidence level | 0.95 |
| Proportion | 0.5 |

The data were collected from 190 households of Dhangadhi SMPC and Kailari Gaupalika. The houses were randomly selected which was 95 from Dhangadhi SMPC and 95 from Kailari Gaupalika in Kailali District.

After the sample size computation, the sampling interval was established by dividing the total number of households by the sample size, which is referred to as the sampling number. Beginning with household number one in the survey area, the sampling number was added to determine household number two. Subsequent households were chosen in the same way, by adding the sampling number to the prior household's number.

## 3.6 Description of Variables

### 3.6.1 Dependent Variable

The dependent variable of this study is choice of fuel for cooking in households of Dhangadhi SMPC and Kailari Gaupalika. Rather than amount of energy consumed by household, it explains the types of fuel used by household for cooking. There are different types of fuel that are used by household for cooking purpose. But this study only focuses on three major fuel types: firewood, biogas and LPG because more than 80% of household use among one of these three categories for cooking.

### 3.6.2 Independent Variable

Following are the independent variable of our study:

#### 3.6.2.1 Income of the Households

Total income of household is the sum of all income earned by family members who are involved in income generating economic activities. Negative sign in income indicates debt on household which they have to pay back. With an increase in income households prefer modern fuel rather than firewood for cooking purpose. The number of dishes that are cooked in kitchen also increases because the kerosene and LPG are costly and everybody cannot afford it for cooking. Therefore, income is also an important factor for choosing fuel for cooking and expected sign of income is also positive.

#### 3.6.2.2 Price of Alternative Fuel:

Price is considered as the economic factor determining the consumption of Households' energies. Price variables include the price of improved cook stoves, the price of fuel-wood, the price of kerosene and others. The prices of fuel make household more likely to use traditional fuels. In fact, income and price factors complement to each other. Therefore, it is expected the price of these fuel have a negative effect on the households' purchasing decision.

#### 3.6.2.3 Household size:

Household size of the household includes all the family members living together under a same roof and using same kitchen. Size of family affects the consumption of fuel for cooking. Having large family size needs to more food to be cooked and for this more energy is needed. It is difficult to collect firewood and is difficult to cook food on firewood stove. The expected sign of the family size ($\partial X/\partial FS$) is positive. Where X is the fuel consumption for cooking.

#### 3.6.2.4 Education Level of Households:

Highest level of education attained by household head will be explained by dummy variable. Total numbers of household heads will be grouped into four categories: illiterate, primary education, secondary education, university (or higher) education. Illiterate includes all households that are not educated and are up to pre-school level. Primary education includes household head have education level from nursery to class five. From class six to SLC level are grouped into secondary education. Household head whose education level are more than SLC belong to university (or higher) education. Household head with more education level have more chance to consume modern fuel because s/he could have more conscious about energy efficiency, negative impact of pollution created by combustion of firewood. Therefore, the expected sigh of education level of household is also positive.

#### 3.6.2.5 Socio-economic factor:

It includes age of the household's head, gender of the household, marital status, geographical location, ethnicity of household etc. Increasing in age of household's head increases the want to use modern fuel because getting older makes it difficult to rely on firewood. Indoor air pollution, collection firewood, difficulties for preparing food, no firewood stoves are some of problems that has to be deal by household head. The expected sign of age of household is positive.

Similarly, Female headed household are more concerned about indoor pollution and are willing to switch from kerosene to modern fuels. Modern fuel takes less time and is easier to use, which could help female head to involve in other income generating economic activities. Dummy variable will be used to define sex of household. The expected sign of sex is also positive.

Marital status of household also affects choice of fuel for cooking. This is also explained by dummy variable. Total household heads are grouped into Married, divorced, separated, widow/widower, never married. Household heads who are never married consume less fuel for cooking purpose and married household head has have large family size and to feed them more food should be cooked and it needs more fuel for cooking. Expected sign of marital status is also positive.

Ethnicity/caste of households are grouped into three categories; Brahmin/Chhettri, Others, Dalit, and Tharu Rana. Consumption of fuel for cooking depends upon ethnic group also. Tharu/rana, for instance, consume more firewood, to produce alcohol (local raksi), similarly Dalit group used firewood for cooking because they can further use of firewood for heating iron.

## 3.7 Data Processing and Analysis

In this process of data analysis, the required data from various sources were collected, classified and tabulated to fulfill the requirements of the study and data presented in percentage, tables, figure etc. Field questionnaire was carefully checked for possible errors. The collected data was classified according to its nature and characteristic. The data was carefully edited, processed and tabulated to obtain desired outcomes. Microsoft Excel 2007 and IBM SPSS V20 have been used for data processing and analysis.

## 3.8 Tools and Methods of Data Analysis

In order to examine the effect of determination of household fuel choice, the study use different tables and graph to analyze the effect of the determinant on fuel choice. In this analysis we consider, firewood, LPG and Bio gas because these fuels are commonly used in the Kailali District.

For the purpose of our analysis since households' fuel consumption decision a choice problem, we have used Multinomial Logistic Regression Model. Multinomial logistic regression is used when dependent variable has two or more categories. A multinomial logit model describes the behavior of consumers when they are provided with a variety of alternatives with the common consumption objectives. It uses one of the categories as the reference category and compares it to the other categories. It compares other categories with reference categories by taking log odds. The dependent variable in our study is the choice of fuel by households & determinants such as income, price, and household's size are the independent variable.

Assuming household's fuel consumption decision as a choice problem, we used Multinomial logit model to examine the effect of determinants on fuel substitution.

The model of the Multinomial logit is as,

$\ln odds = ln\big(p(y = j/k)\big)/p(y = j/k) = \beta 0 + \beta iXi \dots\dots\dots\dots (i)$

Where X is a set of independent variables,

$\beta iX = \beta 1lny + \beta 2A + \beta 3Hz + \beta 4G + \beta 5Edu + \beta 6Eth$

$Lny$ = monthly per capita household income

$A$ = $Household\ age$

$Hz$= $size\ of\ household$

$G = The\ Household's\ Head\ Gender$

$Edu = Household\ education\ degree 0 = illiterate, 1 = major, 2 = secondary$ & $3 = university\ (or\ higher)\ education$

$Eth = Household\ Ethnicity(ethnic/caste\ of\ household\ head)$

The parameters associated with an independent variable are $\beta 1, \beta 2, \beta 3\ and\ \beta 4$.

There are two log odds for this model, and we compared both of them with the reference category, i.e. the category of base. In general, the log odds ratio indicates how many times a given variable should be selected compared to the reference category. The independent variable of our study is choice of fuel for cooking in Dhangadi SMPC and Kailari Gaupalika. The objective of this analysis is to find out what makes people choose firewood, LPG and bio gas for cooking purposes. Let $Firewood = 1$, $LPG = 2\ and\ Biogas = 3$ be included. We have $K - 1$ for multinomial regression, $i.e. 3 - 1 = 2$ equations. The log odds relative to the baseline are determined for each model equation.Firewood was regarded as the baseline variable in our study. One is the chance of choosing LPG or bio gas compared to firewood. The formula is given as:

$$Ln\ odds = ln((p(y = 2/x)))/((p(y = 1/x))) = \beta 0 + \textstyle\sum biXi \dots\dots\dots\dots\dots\dots (ii)$$

$$Ln\ odds = ln((p(y = 3/x)))/((p(y = 1/x))) = \beta 0 + \sum biXi \ldots\ldots\ldots\ldots\ldots\ldots (iii)$$

$Equation\ (ii)\ and\ Equation\ (iii)$ demonstrate how the independent variable X affects the relative odds between firewood for LPG and firewood for bio gas. $B_0$ is an intercept and βi is the vector of the coefficient of regression. The coefficient collection inform us how the independent variable impacts relative LPG vs. Firewood chances.

For categorical independent variable there have another category of slope coefficient because each category has their own slope coefficient. For continuous variables age, Income, for instance, only $(n-1)$ estimates. For categorical independent variable there are $n-1$ categories because one is used as reference category. Therefore, total estimates for categorical independent variables are

$$(k-1) * (n-1)$$

Where, n= number of variables in independent variables.

We only give positive value to exponential β's; to get relative ratios and they give us relative odds ratios. Instead of log-odds, this model is also written in terms of original Pij probabilities. Starting with equation (1), the reference group parameter is (β1=β2=0) and can be written as

$$P[y = 1/X = 1/(1 + exp = (\beta 02 + \beta i2X) + exp = (\beta 03 + \beta 13X)), j = 1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (iv)$$

$$P[\ y = 2/X = exp(\beta 02 + \beta i2X)/(1 + exp(\beta 02 + \beta i2X) + exp(\beta 03 + \beta 13X)), j = 2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (v)$$

$$P[y = 3/X = (exp = (\beta 03 + \beta 13X))/(1 + exp(\beta 02 + \beta i2X) + exp(\beta 03 + \beta 13X)), j = 3 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (vi)$$

$$Probability\ sum - (j = 1)^{3\left[p\left(y = \frac{j}{x}\right]\right)} = 1$$

Maximum likelihood proceeds are calculated by maximizing the multinomial probability with probability interpreted as a function of $\beta 1$ and $\beta 2$ parameters in the equation (i)

# CHAPTER 4 RESULT AND DISCUSSION

This Chapter deals with the presentation and analysis of the primary data regarding the fuel choice in Dhangadhi SMPC and Kailari Gaupalika. The data collected were first entered on Microsoft Excel 2007 and then exported to IBM SPSS for further calculation.

Nepal's hydropower generation capacity, which is estimated at 43,000 MW, is Nepal's key energy resource. 87.4% of Nepal's energy needs are met by conventional fuels, and about 70% of the population has access to electricity.(Authority, 2018).Thus, commercial energy consumption per capita is very low, at just around 128 kWh in 2013. Nepal is beginning to industrialize at the same time, and the economy is projected to expand at a 7.5 percent rate. The demand for commercial energy during this time is also expected to rise at a similar pace. The challenges for Nepal at present are how to provide a higher proportion of the population with reliable access to electricity, a more efficient economy and how to handle the projected increase in energy demand.

There is great potential for harnessing solar energy in Nepal, with an average global solar radiation ranging from 3.6-6.2kWh/m2 per day, an average insulation strength of about 4.7kWh/m2 per day, and sunlight on average of 300 days per year. As the cost of installation continues to fall, solar energy is emerging as a viable and affordable solution to the problem of load shedding in the region. NEA reported that the economic potential for solar power is 1,829 megawatt-peak (MWp) with an average generation of 33.5 MWp per square kilometer of land—using 2% of the best solar irradiance area (out of the 2,729 kilometer total available). A 2008 report developed by the Alternative Energy Promotion Centre(AEPC) entitled 'Solar and Wind Energy Resource Assessment in Nepal' (SWERA Report) estimated that Nepal has a potential capacity of 2,100 MW for integrated photovoltaic (PV) grid power. Currently, roughly 8,278.8 kilowatt-peak (kWp) of photovoltaic power is used in the country's various public and private sectors.

Biomass energy technology's applicability to Nepal, a land rich in biomass, has been widely researched. There are also currently a number of additional studies underway. These are linked to issues such as better stoves for cooking, biodiesel, biogas, bioethanol and gasifiers. In addition to these studies, the Sustainable Nepal Program is currently carrying out the majority of applied research and development (R&D) studies. Since the economy of Nepal is heavily focused on agriculture, biomass technology can prove to be an important source of energy for rural and remote mountain regions of Nepal. However, in order to make this technology affordable and available, research on low-cost and cold-climate biogas plants is still needed. The scope of new projects also needs to be extended in order to use different biodegradable waste, including kitchen, municipal and industrial organic waste, as potential feed stocks. This will entail changes to existing digester designs and activities. It is still important to explore the possibility of commercial-scale investment in the field. According to the National Census 2001, Nepal has more than 4.2 million households and around 45.24% (WECS, 2011) households have potential of biogas installation but since mid-July 2011, only 365,863 biogas plants have been installed, reaching hardly 14%.

## 4.1 Types of Energy Used by Households

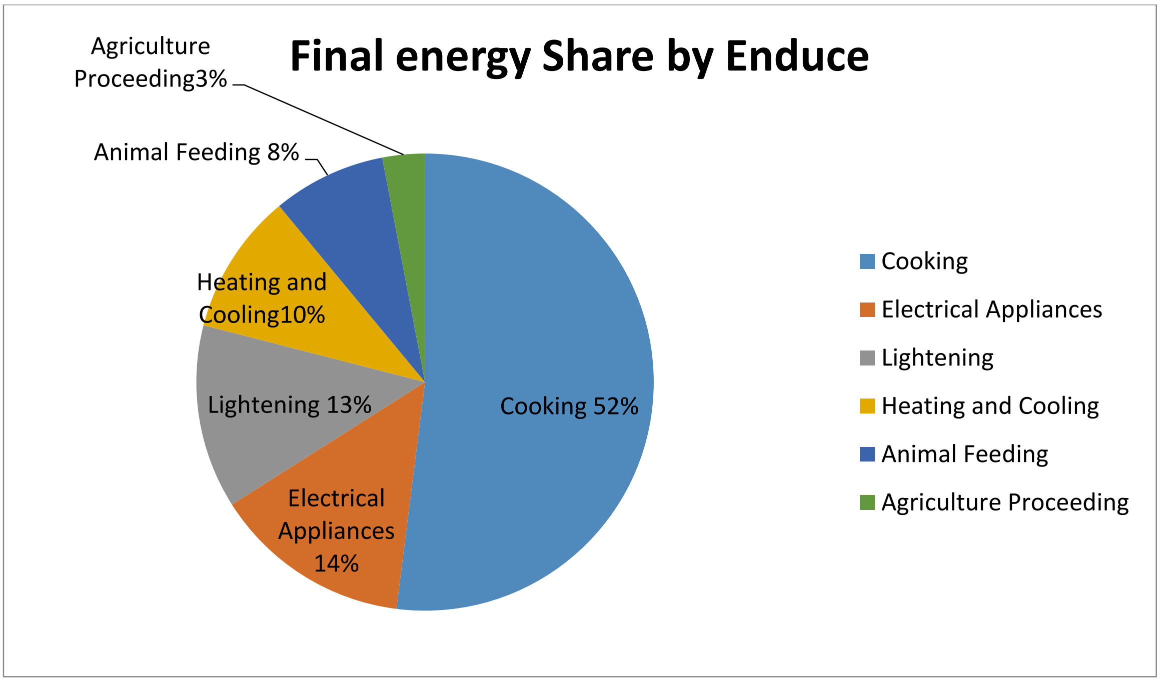
Energy is derived from various fuel resources, grouped into different categories based on the characteristics of the fuel, monetization, availability of resources, dependence, etc. Nepal's energy resources are widely divided into three categories: conventional, industrial and alternative energy, according to the World Energy Outlook (2012). Firewood, animal dung and agricultural residues are part of conventional energy. Similarly, commercial energy is energy that is used to produce electricity and is available at a specific price in the marketplace. It includes electricity, coal and advanced petroleum products and alternative energy are that energy fueled in ways that do not use up the earth's natural resources or otherwise harm the environment especially by avoiding the use of fossils fuels or nuclear power. It includes solar, wind or nuclear energy. The Nepalese household depends highly on traditional non-commercial energy such as firewood, agriculture residues and animal dung to meet their daily activities.

## 4.2 Status of Energy Consumptions by households

Firewood, coal, Kerosene, LPG, electricity, biogas and solar energy are major energy sources that are available in Nepal. From firewood to electricity there are multiple option for energy available for consumption purpose. The commercial and the alternative source of energy are highly or more consumed by urban households as compared to rural households because these resources are easily available in the market and are easy to use than the traditional energy sources.

In Nepal, about 52% of total energy consumed by household is used for cooking purpose followed by electric appliance 14%, lighting 13%, heating and cooling 10%, animal feeding 8% and agricultural proceeding 3%.

Figure 4-1: Final energy share by enduce

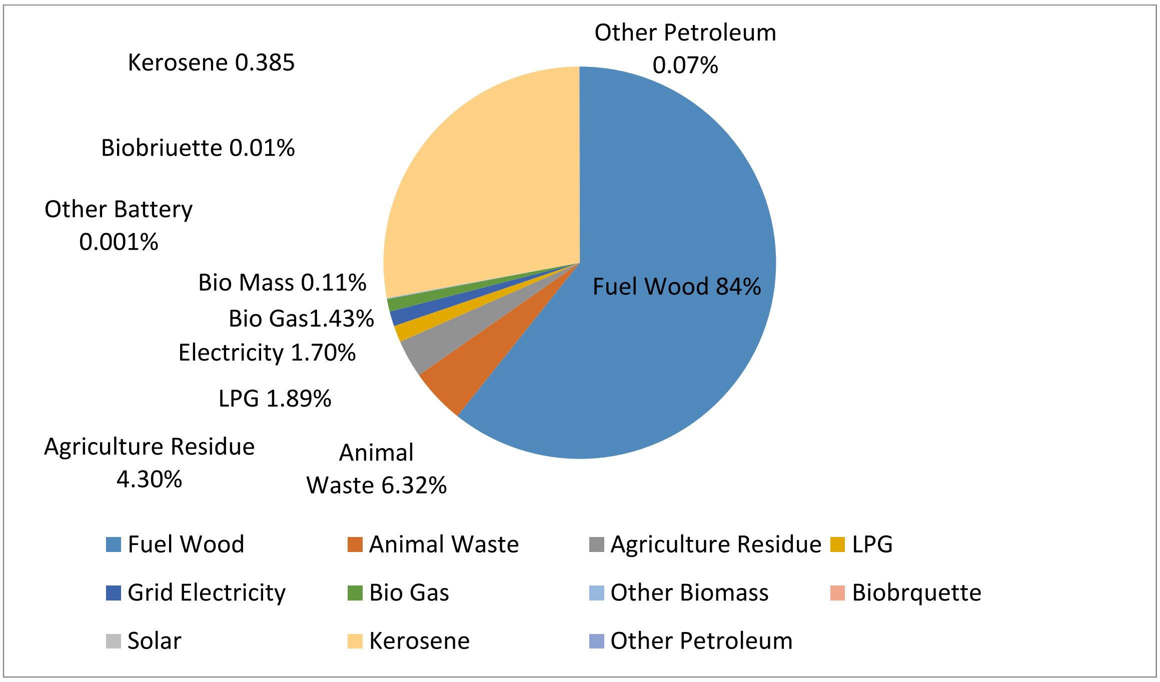



Source: Adopted from (WECS, 2014)

## 4.3 Residential Sector Energy Consumption

The residential sector consumed almost 89% of the total energy consumption of Nepal in 2008/09.Biomass resources are the major fuels used in this sector, namely fuel-wood, agricultural residue and the animal waste.

Figure 4-2: Energy Share by Fuel Types




Source: Adopted from (WECS, 2010)

Recently renewable sources like biogas and electricity from micro-hydro and solar home systems are substituting conventional fuels used mainly for cooking and lighting. The commercial sources of fuel used are nominal in amount and is mainly used in the urban centers. Fuel wood alone supplies 84% of the total energy requirement of the sector followed by animal dung, agro-residue and petroleum respectively. Share of alternative energy resources is still quite insignificant having less than 1% contribution. Residential sector energy consumption is the function of number of household and population. The population growth rates as well as the economic situation of the household are used as the main driver for the types of fuel and energy consumption in the residential sector of Nepal. In 90's the residential sector, the energy used for mainly cooking, heating, animal feed preparation, lighting etc. Residential sector is broadly divided into two categories namely the rural residential and urban residential. Urban sector energy consumption pattern is little different than the rural residential. About 52% of the urban energy is used for cooking purpose followed by electric appliance (14%), Lighting (13%), heating and cooling (10%), animal feeding (8%) and agricultural processing (3%). Unlike in the rural residential, fuel wood share in urban residential is less (29%). Contribution of fuel wood and electricity is almost equal (29%) whereas LPG contributes about 25% of the total consumption of the sub sector followed by kerosene (9%), animal residue and dung (3% each) and biogas (2%). However, there is a very high decreasing trend in the use of kerosene in the residential sector. (WECS, 2014).

The energy consumption pattern of households in Nepal has changed drastically along with the shift in their economy over time. Economic growth, the development of utilities and other energy policies are contributing to enhanced state accessibility. The choice of primary energy sources also increases with such increased accessibility, which essentially gives households the ability to select more preferred energy sources that are not only economical but also east-friendly and environmentally friendly.

Kerosene, LPG, and energy are also supplemented by the use of firewood and coal for cooking purposes. Rising per capita income raises the share of disposable income in energy consumption, so households' affordability is also higher, impacting households' patterns of energy consumption. The energy consumption pattern of households is also influenced by the easy availability of LPG at the nearby dealer, the extension of the electricity line, the decrease in the intermittent supply of electricity and petroleum products. The effect of energy accessibility, affordability and availability (3A's) is seen in the pattern of energy consumption for cooking at the household level. Two theories explain the situation of 3A at household level: the first is the energy ladder, which explains households' fuel switching actions in developed countries, and the other is fuel stacking, which explains the use of multiple fuels altogether rather than the full switch from one source to another.

## 4.4 Socio Economic Profile of the Respondent

Data was collected from 190 sample respondent in 2 different places i.e. 95 from Dhangadhi SMPC and 95 from Kailari Gaupalika. The details of the sample drawn have been presented below.

Table 4-1: Main Fuel for Cooking

| Fuel Type | Dhangadhi SMPC | | Kailari Gaupalika | |
|---|---|---|---|---|
| | Total Households | Percentage (%) | Total Households | Percentage (%) |
| Firewood | 43 | 45.27 | 64 | 67.37 |
| LPG | 40 | 42.10 | 11 | 11.57 |
| Bio Gas | 12 | 12.63 | 20 | 21.06 |
| Total | 95 | 100% | 95 | 100% |

Source: Field Survey, 2018

Table 4-1 shows distribution of households’ main fuel for cooking in two different places. It reveals that 45.27% households of Dhangadhi SMPC use Firewood as a main fuel for cooking followed by LPG and Bio Gas by 42.10% and 12.63% respectively whereas 67.37% of Households’ in Kailari Gaupalika uses firewood as a main fuel for cooking followed by LPG and Bio gas by 11.57% and 21.06% respectively. From above table, we can analyze that households’ of Kailari Gaupalika tends to use firewood for cooking than the households of Dhangadhi SMPC. This confirmed that firewood resources are still the dominant cooking fuel sources in Kailari Gaupalika. There is difference in the consumption pattern of the households of these two places. Most of the Household in Kailari Gaupalika prefer to use firewood than other fuels because its availability and ease to use than LPG and bio gas. In contrary, the households’ of Dhangadhi SMPC prefer to cook in LPG and firewood than that of bio gas because they have easy access to these two resources.

Table 4-2: Gender of the households Head

| Gender | Dhangadhi SMPC | | Kailari Gaupalika | |
|---|---|---|---|---|
| | Total Households | Percentage | Total Households | Percentage |
| Male | 55 | 57.89 | 72 | 75.78% |
| Female | 40 | 42.11 | 23 | 24.22% |
| Others | - | - | - | - |

| | | | | |
|---|---|---|---|---|
| Total | 95 | 100% | 95 | 100% |

Source: Field Survey, 2018

Table 4-2 shows the gender of the household heads. It reveals that out of 95 household in Dhangadhi SMPC 57.89% Households head were male and remaining 42.11% were female. Similarly, in Kailari Gaupalika, it reveals 75.78% of household heads were male and 24.22% were female. It shows that the role of female as household in decision making related to fuel is higher in Dhangadhi SMPC than that of Kailari Gaupalika. In Dhangadhi SMPC, the role of female as household head is more than that of Kailari Gaupalika. Increasing trend of male migrating to abroad for earning is the main reason behind the participation of female as a household head.

Table 4-3: Age of the Household Heads

| Dhangadhi SMPC | | | | Kailari Gaupalika | | | |
|---|---|---|---|---|---|---|---|
| Mean | Standard Deviation | Minimum age | Maximum Age | Mean | Standard Deviation | Minimum age | Maximum Age |
| 46.67 | 15.16 | 23 | 83 | 49.48 | 16.04 | 23 | 91 |

Source: Field Survey, 2018

Table 4-3 shows the age of the households' head in two different places. In Dhangadhi SMPC, the average age of the household head is 46.67 say 47. Household heads with minimum age of 23 years to households' head of 83 years are observed with the variation of 15.61 years from average age. Similarly, in Kailari Gaupalika the average age of the household head is 49.78 say 50. Household heads with minimum age of 23 years to households' head of 91 years are observed with the variation of 16.04 years from average age.

Table 4-4: Family size of Households

| **Dhangadhi SMPC** | | | | **Kailari Gaupalika** | | | |
|---|---|---|---|---|---|---|---|
| Mean | Standard Deviation | Minimum | Maximum | Mean | Standard Deviation | Minimum | Maximum |
| 4.25 | 1.97 | 1 | 9 | 5.53 | 2.75 | 1 | 14 |

Source: Field Survey, 2018

Table 4-4 shows the size of the household's size in two different places. In Dhangadhi SMPC, the average family size of the household is 4.25 say 4. Household heads with minimum family size of 1 member to households' family size of 9 members are observed with the variation of 1.97 family sizes from average size. Similarly, in Kailari Gaupalika the average family size of the household is 5.53 say 6. Household heads with family size of 14 members to households' family size of 1 member are observed with the variation of 2.75 years from average age.

Table 4-5: Income of the Household

| Dhangadhi SMPC | | | | Kailari Gaupalika | | | |
|---|---|---|---|---|---|---|---|
| Mean | Standard deviation | Minimum | Maximum | Mean | Standard deviation | Minimum | Maximum |
| 51709.4 | 32427.9 | 15000 | 188000 | 34842.1 | 22621.45 | 7000 | 120000 |

Source: Field Survey, 2018

Table 4-5 shows the size of the households' income in two different places. In Dhangadhi SMPC, the average income of the household is Rs. 51710. Households' income with minimum monthly income of Rs.15000 to household maximum monthly income of Rs. 1, 88,000.00 are observed with the variation of Rs. 32427.98 from average income. Similarly, in Kailari Gaupalika the average income of the household is Rs.34800. Household income with of Rs. 7000.00 to households' maximum income of Rs. 1,20,000.00 are observed with the variation of Rs. 22621.45 from average income.

Table 4-6: Marital status of Household Heads

| Dhangadhi SMPC | | | Kailari Gaupalika | |
|---|---|---|---|---|
| Marital Status | Total HHS | Percentage | Total HHS | Percentage |
| Married | 67 | 70.52 | 63 | 66.32 |
| Unmarried | 28 | 29.48 | 32 | 33.68 |
| **Total** | **95** | **100%** | **95** | **100%** |

Source: Field Survey, 2018

Table 4-6 shows the marital status of then household head. Marital Status of household is categorized into two groups. It reveals 70.52% of household head in Dhangadhi SMPC and 66.32% of household head of Kailari Gaupalika are married.

Table 4-7: Highest Level of Education attained by Household Head

| Education Level | Dhangadhi SMPC | | Kailari Gaupalika | |
|---|---|---|---|---|
| | **Household** | **Percentage** | **Household** | **Percentage** |
| Illiterate | 30 | 31.57 | 59 | 62.10% |
| Primary | 13 | 13.68 | 9 | 9.48% |
| Secondary | 18 | 18.94 | 13 | 13.68% |
| University | 34 | 35.79 | 14 | 14.74% |
| **Total** | **95** | **100%** | **95** | **100%** |

Source: Field Survey, 2018

Table 4-7 shows the education level of then household head. Its shows that 62.10% of household head in Kailari Gaupalika are illiterate in comparison to the household head of Dhangadhi SMPC which is 31.57%.Similarly, the household of Dhangadhi SMPC have attained higher education level in comparison to the household head of Kailari Gaupalika.

The higher literacy percentage in Dhangadhi is due to the fact that it is a SMPC, but Kailari is a gaupalika, which lacks basic facilities in comparison to Dhangadhi SMPC.

Table 4-8: Ethnicity of Households

| Ethnicity | Dhangadhi SMPC | | Kailari Gaupalika | |
|---|---|---|---|---|
| | Total Household | Percentage | Total Household | Percentage |
| Brahmin/Chetri/Others | 21 | 22.11% | 15 | 15.78% |
| Tharu/Rana | 54 | 56.84% | 59 | 62.11% |
| Dalit | 20 | 21.05% | 21 | 22.11% |
| **Total** | **95** | **100%** | **95** | **100%** |

Source: Field Survey, 2018

Table 4-8 shows the distribution of household hold based on caste and ethic group into two different places. Majority of people in Kailali district are Tharu/Rana. In Dhangadhi 56.84% of ethnicity of household and 62.11% of household in Kailari Gaupalika is Tharu/rana.

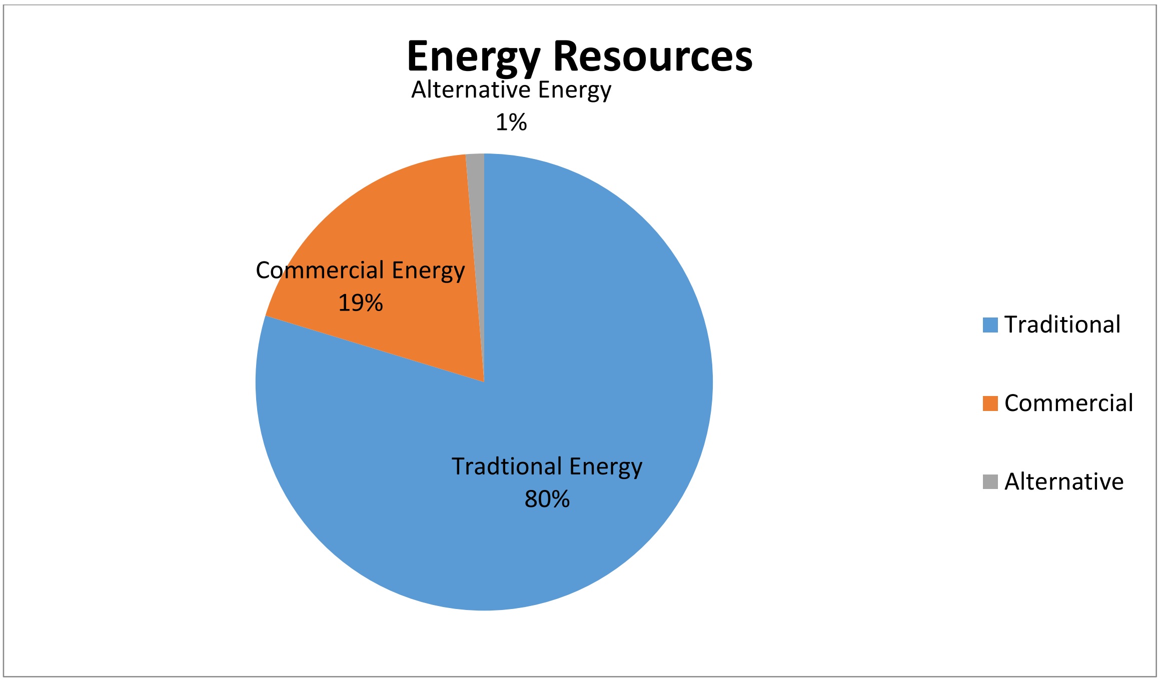
## 4.5 Energy Consumption Profile

Table 4-9: Energy Consumption by Fuel Type

| **Fuel Class** | **Fuel Types** | | **Million GJ** | **Percentage** | **GJ/per capita** |
|---|---|---|---|---|---|
| Traditional | i) | Fuel wood | 267.4 | 71.1 % | 10.1 |
| | ii) | Agri Residue | 13.2 | 3.5 % | 0.5 |
| | iii) | Dry Dung | 19.1 | 5.1 % | 0.7 |
| Commercial | i) | Electricity | 10.6 | 2.8 % | 0.4 |
| | ii) | Coal | 14.8 | 3.9 % | 0.6 |
| | iii) | Petroleum | 46.2 | 12.3 % | 1.7 |
| Alternatives | i) | Renewable | 4.6 | 1.2 % | 0.2 |
| Others | i) | Others | 0.4 | 0.1 % | 0 |
| **Totals** | | | **376.3** | **100.00 %** | **14.2** |

Source: Adopted from (WECS, 2014)

Figure 4-3: Energy resources




Source: Adopted from (WECS, 2014)

The share of traditional, commercial and alternative energy resources is 80%, 19% and 1% respectively. The share of traditional energy decreased from 87% in 2008/2009 to 80% in 2013/14. Increase in the consumption of LPG was also more than 25%, annually replacing kerosene and fire wood and electricity (WECS, 2014). Furthermore, residential sector is dominant among different sectors of an economy in Nepal. Out of total energy consumption, almost 89% of the total energy is consumed by household sector. The consumption of energy is mainly for cooking, heating, lighting and other household activities.

## 4.6 Relationship between Socio-Economic profile and energy consumption

The result first takes into account the overall relationship test. Secondly, the strength of the MLR relationship has been checked to ascertain the strength of the MLR relationship and, ultimately, to assess the utility. Multinomial Logistics Regression (MLR) describes the overall relationship between dependent and independent variables.

Table 4-10: Model fitting information

| Cities | Model | Model fitting Criteria | Likelihood ratio | | |
|---|---|---|---|---|---|
| | | -2 log Likelihood | Chi-square | Df | Sig |
| Dhangadhi | Intercept<br>Only final | 187.025<br>93.682 | 93.344 | 20 | 0.00 |
| Kailari Gaupalika | Intercept<br>Only final | 158.93<br>127.121 | 31.810 | 20 | 0.00 |

The relationship between dependent and independent variables is defined by model fitting Information. The null model hypothesis means that the final model will not have any independent variables in the model. The alternative model hypothesis is that the final model will have any independent variables in the model.

Table 4-11: Pseudo R-square

| Dhangadhi SMPC | | Kailari Gaupalika |
|---|---|---|
| Coz & Snell | 0.626 | 0.285 |
| Nagelkerke | 0.727 | 0.349 |
| Mcfadden | 0.499 | 0.198 |

Table 4-11 depicts Nagelkerke's R square value in two different places. In Dhangadhi, it is 0.727 suggesting that 72% variation in dependent variable has been explained by independent variables, Similarly, in Kailari GaupalikaNagelkerke R-square value is 0.349, suggesting that 34.90% of variability is explained by independent variable used in this model. The strength of Multinomial Logistic Regression model was stronger in Dhangadhi SMPC than that of Kailari Gaupalika.

Table 4-12: Prediction Accuracy

| Observed | Predicted Dhangadhi SMPC | | | | Predicted Kailari Gaupalika | | | |
|---|---|---|---|---|---|---|---|---|
| | Firewood | LPG | Bio Gas | Percent Correct | Firewood | LPG | Bio Gas | Percent Correct |
| Firewood | 38 | 5 | 0 | 88.4% | 61 | 1 | 2 | 95.3% |
| LPG | 5 | 35 | 0 | 87.5% | 7 | 4 | 0 | 36.4% |
| Bio Gas | 9 | 1 | 2 | 16.7% | 13 | 1 | 6 | 30.0% |
| Overall | 54.7% | 43.2% | 2.1% | 78.9% | 85.3% | 6.3% | 8.4% | 74.7% |

Table 4-12 shows the percentage of correctly made prediction of the model based on the explanatory variables. In Kailari Gaupalika, the model classifying the choice of firewood, LPG and biogas were classified as 88.4 percent, 87.5percent and 16.7percent respectively. The overall accuracy rate of the model is 78.9percent. Similarly, in Dhangadhi SMPC, the model classifying the choice of firewood, LPG and biogas were classified 95.3percent, 36.4percent and 30.00percent respectively with the overall accuracy rate 74.7 percent of the model. Result shows that Bio gas was not much common for household in Dhangadhi SMPC. Household of Dhangadhi SMPC mostly rely on firewood and LPG compared to bio gas as a main fuel for cooking. But in Kailari Gauplaika 30 percent of household use bio gas as a main fuel for cooking but firewood and LPG were dominant fuel as 95.3 percent and 36.4 percent of household heavily rely on firewood and LPG as a main fuel for cooking.

Table 4-13: Likelihood Ratio Test

| **Dhangadhi SMPC** | | | | | **Kailari Gaupalika** | | | |
|---|---|---|---|---|---|---|---|---|
| Effect | Model Fitting Criteria | | Likelihood ratio Tests | | Model Fitting Criteria | | Likelihood ratio Tests | |
| | -2 Log likelihood of reduced Model | Chi-square | Df | Sig | -2 Log likelihood of reduced Model | Chi-square | Df | Sig |
| Intercept | 93.682[a] | 0.000 | 0 | | 127.121[a] | 0.000 | 0 | |
| HHD income | 118.225 | 24.54 | 2 | 0.000 | 137.705 | 10.584 | 2 | 0.005 |
| HHD head age | 103.462 | 9.780 | 2 | 0.008 | 131.064 | 3.943 | 2 | 0.139 |
| Family size | 95.972 | 2.290 | 2 | 0.318 | 135.299 | 8.178 | 2 | 0.017 |
| HHD gender | 97.622 | 3.940 | 2 | 0.139 | 127.301 | 0.181 | 2 | 0.914 |
| HHD marital status | 93.984 | 0.302 | 2 | 0.860 | 127.623 | 0.502 | 2 | 0.778 |

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0. This reduced model is equivalent to the final model because omitting the effect does not increase the degrees of freedom.

Likelihood ratio tests the overall relationship between the dependent variables and independent variables. Table 13 shows the contribution of each variable to the model. From above table we can conclude that each of the independent variables i.e. age, family size, income, gender & marital status of household head are significant variable related to dependent variable in both the cities. Referring to Table 13, we can say that both the places independent variables like income of the household, age of the household head, family size, gender and marital of the household head are significantly and positively associated with dependent variable.

## 4.7 Parameter Estimations

The empirical outcomes of the Multinomial Regression Parameter Estimate Household fuel option model in Kailali District in two separate locations, i.e. In Table 13, the Dhangadhi SMPC and Kailari Gaupalika are shown. The result estimates the independent variable's coefficient set and its standard error. The odd ratio for interpreting the use of LPG and biogas relative to firewood is also included in Table 13. The majority of the estimation parameter on the explanatory variable used in the model is critical and has the expected sign. The results of the estimate of the parameters are summarized in the next section.

The result shows that revenue has a major and positive impact on the option between firewood and bio gas v/s firewood for LPG. As total log revenue of the household increases in Dhangadhi SMPC, the household prefers LPG 1.00 times more than firewood as a primary fuel for cooking the same case holds true for bio gas, as household income increases, they choose to use bio gas than firewood. These findings indicate that higher household income results in the preference for modern fuels in Dhangadhi SMPC for cooking purposes. There is a strong correlation between LPG and firewood revenue and consumption, as well as biogas and firewood revenue and consumption in Kailari Gaupalika. When income grows, households are 1.00 times more likely to prefer LPG and biogas than firewood. Therefore, from our research, it has been shown that household shifts to use LPG and bio gas as income increases than that of firewood in both locations. The findings of several studies do confirm this outcome. Jan (2012) has shown that high revenues encourage the adoption of improved cooking stoves in his efforts to recognize determinants of the adoption of alternative fuel. The conclusion of Alem et.al (2013) also yielded the same result.

This research considers family size as one variable that influences the choice of household fuel. The size of the family has an important and beneficial influence on the choice of LPG and firewood, biogas and firewood. As the number of families in the family is lower in Dhangadhi SMPC, the household tends to choose LPF 1.14 times over firewood. As the number of members is lower in the family, households tend to select biogas over firewood by

1.57 times. However, there is no important relationship between family size and fuel selection in Kailari Gaupalika. Thus, for households with large family size, the opportunity cost of fuel collection is lower; thus, since the number of members in the family is greater, they are more likely to use firewood in Dhangadhi SMPC than that of LPG and biogas.

Another major variable that is likely to impact alternative fuel acceptance is the age of the respondents. While there are early adopters in all age groups, older respondents are typically less likely to use alternative fuels than younger respondents. This study also explored that the age of the head of the household in both places has no significant relationship with the choice of fuel. This research, however, also investigated that the age of the household head has a major adverse impact on the choice of alternative fuel; older people prefer firewood over alternative fuels. This is because there are a range of barriers facing aged customers and it is less flexible to consider renewable energy.

The gender of the head of the household has an important and positive impact on the choice of fuel. There is no significant effect of the gender of household heads on the choice of LPG and firewood at Dhangadhi SMPC. The male, however, prefers to select bio gas over firewood 3.85 times. Similarly, in Kailari Gaupalika, the male household head prefers to choose 1.216- and 1.31-times LPG over firewood and bio gas over firewood

In Dhangadhi SMPC, marital status has no significant effect on fuel selection. However, it was found in Kailarigauplaika that married household head was significantly less likely to choose LPG and bio gas over firewood for cooking purposes compared to unmarried household. For the highest level of household education, results show that there is no significance between the achievement of household head education and fuel selection in both locations.

Household ethnicity has a major effect on the choice of fuel in Kailari Gaupalika. Particularly for cooking livestock feed and for daily household purposes, Tharu/Rana prefers less alternative fuel than firewood. There are very few Kailari Gauplaika households that use fuel other than firewood. Nevertheless, in Dhangdhi SMPC, we found that there is no significant effect of household ethnicity and fuel selection.

Our study also revealed that accessibility is one of the factors that typically affects the choice of fuel for the household. The source of primary energy for cooking is also growing with increased accessibility, giving households the ability to choose more preferred sources of energy. Therefore, LPG and bio gas can be substituted for the use of firewood and coal for cooking. Easy availability of LPG at nearby dealer influences the energy consumption pattern of households.

Table 4-14: Results of the parameter estimation

| Variables | Dhangadhi | | | | Kailari | | | |
|---|---|---|---|---|---|---|---|---|
| | LPG | | Bio gas | | LPG | | Bio gas | |
| | Coeff. | Odd ratio | Coeff. | Odd ratio | Coeff. | Odd ratio | Coeff. | Odd ratio |
| HHD income | $5\times10^{-6}$ | 1.0000 | $2.8\times10^{-7}$ | 1.0000 | $4.7\times10^{-7}$ | 1.000 | 0.000001 | 1.0000 |
| HHD age | -0.009 | 0.9915 | 0.002 | 1.0025 | -0.003 | 0.997 | 0.004367 | 0.9956 |
| Family Size | -0.016 | 0.9841 | 0.040 | 1.0408 | -0.016 | 0.985 | 0.038120 | 1.0389 |
| Gender Female | 0.091 | 1.0954 | -0.104 | 0.9008 | -0.003 | 0.997 | 0.039929 | 0.9609 |
| Primary | 0.036 | 1.0366 | 0.056 | 1.0579 | -0.019 | 0.982 | 0.162015 | 0.8504 |
| Secondary | -0.002 | 0.9977 | -0.008 | 0.9921 | 0.032 | 1.032 | 0.077706 | 0.9252 |
| University | 0.321 | 1.3786 | 0.168 | 1.1827 | 0.012 | 1.012 | 0.093001 | 1.0975 |
| Dalit | -0.151 | 0.8602 | -0.100 | 0.9044 | -0.129 | 0.879 | 0.019114 | 1.0193 |
| Tharu | 0.102 | 1.1072 | -0.008 | 0.9923 | -0.121 | 0.886 | 0.159536 | 0.8525 |
| Unmarried | 0.148 | 1.1597 | -0.007 | 0.9926 | -0.022 | 0.979 | 0.056011 | 0.9455 |
| **Constant** | **0.390** | | **-0.138** | | **0.280** | | **0.306585** | |

## 4.8 Probability Estimation

We can compute the probability that the individual choosing alternative fuel categories (i.e. categories dependent variables) in equation 4, 5 and 6 for both Dhangadhi SMPC and Kailari Gaupalika by using the expected values of coefficient of independent variables. For Dhangdhi SMPC data the predicted probability of selecting each j, for j=1, 2 and 3 are shown in the Table 4-15.

Table 4-15: Results of the probability estimation

| Variables | LPG | | Bio gas | |
|---|---|---|---|---|
| | Dhangadi SMPC | Kailari Gaupalika | Dhangadi SMPC | Kailari Gaupalika |
| | Exp(B) | Exp(B) | Exp(B) | Exp(B) |
| Age of the household Head | 0.850 | 0.945 | 0.990 | 0.963 |

| | | | | |
|---|---|---|---|---|
| Family size | 1.414 | 0.736 | 1.567 | 1.246 |
| Income of the household | 1.000 | 1.000 | 1.000 | 1.000 |
| Gender of the HHD Head=1 | 0.606 | 1.216 | 3.854 | 1.319 |
| Gender of the household Head=2 | | | | |
| Marital Status of HHD=0 | 0.538 | 1.908 | 0.544 | 1.488 |
| Marital Status of HHD=1 | | | | |
| Education attainment of HHD =0 | 0.008 | 0.774 | 0.018 | 0.560 |
| Education attainment of HHD =1 | 0.042 | 0.352 | 0.034 | 0.126 |
| Education attainment of HHD =2 | 0.008 | 0.679 | 0.005 | 0.376 |
| Education attainment of HHD =3 | | | | |
| Ethnicity of Households=0 | 0.151 | 5.861 | 0.538 | 3.988 |
| Ethnicity of Households=1 | 0.017 | 1.141 | 0.032 | 3.327 |
| Ethnicity of Households=2 | | | | |

## 4.9 Important Fuel attribute and Challenges for using Alternative fuel

In the survey, respondents who were still using conventional cooking fuel were asked to explain why they did not use alternative cooking fuel. High fuel prices were found to be the most significant factor for the majority of respondents. The lack of access to LPG is the second major factor. They also claimed that using alternative fuel is uncomfortable/difficult, which serves as yet another justification for them not to do so. The households that used alternative fuels were also asked to reflect the problems associated with the use of fuels and the fuel characteristics that need to be improved. Another important fuel attribute is the large number of users who reported that they need more price reductions and that biogas quality is also important to them.

Our research has shown that firewood has been found to be the most widely used for cooking, especially for cooking livestock feed, in both places. Households have shown little interest in firewood alternatives. Although LPG and biogas have become somewhat common in Kailari Gauplaika, because of their cost and availability, people still prefer to use firewood. The same case applies to the Dhangadhi SMPC household. It was noted in both places that LPG is mainly used to make tea, coffee and other instant food as a substitute for firewood. I bought a new LPG over a year ago that is still not finished, sometimes we use it to make tea/coffee because it is easier to use and reliable, making it faster to serve, and I will have time to talk to the guests, one Dhangadhi SMPC respondent explained. This implies that the choice of fuel depends on social status, as households explained by (Masera, 2015) seem to like modern fuel that contains some social status. Compared to those who use firewood, the use of LPG suggests a wealthier household.

The supply and economic condition of people in the household are the main reasons for the different energy sources and amounts used. In both rich and medium areas, LPG is preferred as a cooking fuel because it takes less time, is easier to use, and is more effective. It was also found that individuals in the low-income community have LPG in both regions, but they use it in the event of an emergency. Compared to an average of 3 months, it lasts more than one year if they consistently use LPG as the main cooking fuel. It could be argued that access to availability and revenue plays a critical role in contrast with other variables. As a result, sales and fuel prices have been shown to limit the option of fuel and related equipment, which are definitely a key factor in adjusting to energy usage.

# CHAPTER 5 SUMMARY CONCLUSION AND RECOMMENDATION

## 5.1 Summary

Despite the fact that using clean and efficient energy sources is critical for household welfare, about half of the world's population still uses traditional cooking facilities to meet their daily household energy needs. The majority of those without access to modern cooking facilities live in rural areas. Energy is a fundamental good. In the past, it was thought that household energy consumption adopted the concepts of the energy ladder. However, recent research, including my own, shows that individual preferences such as culture, ethnicity of household, availability, efficiency, and price, as well as household income, play a major role in determining energy fuel choice. Future research should not solely rely on the energy model, but should also take into account the household economics framework, as well as opportunity costs, cultural, and individual preferences.

Although Kailali district is endowed with a variety of clean energy sources, most households still use traditional fuels such as firewood for cooking. Firewood is the predominate indigenous source of energy, providing 85.91 percent of the district's energy needs. In the Kailali district, nearly 86 percent of households cook with firewood. In Kailari Gaupalika, firewood has remained the major source of household energy. It meets 67.37% of the energy requirement for cooking in Kailari Gaupalika households and 45.27% of the energy requirement for cooking in Dhangadhi SMPC households. The household of Kailari Gaupalika is highly reliant on firewood due to their low income and readily available firewood. In comparison to Kailari Gauplaika, Dhangadhi SMPC used the least bio gas and the most LPG.

The use of firewood for cooking was identified as a source of health, economic, and environmental issues in this study. Thus, substituting alternative fuel for traditional fuel has a number of advantages, particularly for women who spend the majority of their time in the kitchen. It has the potential to save lives, protect natural resources, and contribute to growing environmental and economic development of the overall district. Despite the various benefits associated with renewable fuels and government and non-governmental organizations' attempts to disseminate these alternative fuels, no progress has occurred. The failure of households to adopt alternative fuels on a larger scale was due to socio-economic and product-related factors. As a result, in order to encourage the adoption of alternative fuels, policymakers and governments must understand what socioeconomic factors influence household fuel choice and what product attributes make new technology appealing to households. As a result, the study's overall purpose was to explore factors that influence household cooking preferences.

The sample size was calculated using a variety of sampling methods, including the simple random sampling method and the Arkin and Colton sampling process. The key source of primary data was a household survey. A structured questionnaire was prepared and administered to collect data from 190 sample respondents, 95 from each of two locations in Kailali District. The responsiveness of fuel choice to income and other socio-economic characteristics of households was investigated using a Multinomial Logistic Regression Model.

## 5.2 Conclusion

This study uses the household survey approach to present the findings of a Multinomial Logistic Regression model to the option of cooking fuel in Kailali District in two different locations. The research is used to assess how sensitive fuel choice is to household income and socioeconomic characteristics.

According to the paper's descriptive analysis and econometric findings, firewood and biogas are more likely to be used in Kailali Gaupalika. However, in comparison to Kailari VDC, Dhangadhi SMPC uses firewood and LPG for cooking, and the use of biogas is limited. This study shows that descriptive variables such as income, family size, education, gender, marital status of the household head, and ethnicity of the household play an important role in evaluating the fuel option for cooking in Kailali district. The rise in income has increased the option of alternative fuel in both areas, according to the econometric result.

However, for selecting firewood supports, an improvement in income is statistically negligible. People want less firewood and more renewable modern fuel as their income rises on the energy ladder. Meanwhile, the findings show that, in addition to income, other factors play a role in deciding the type of cooking in the Kailali district. Older people in Dhangadhi SMPC and Kailari Gaupalika households prefer firewood to alternative fuel, and they are less likely to use alternative fuels than younger respondents because traditional fuel is simpler to use than alternative modern fuel.

With a negative coefficient, family size is also statistically important for cooking fuel choice. As the size of the family increases, households tend to cook with firewood. Gender is thought to influence fuel choice, but the findings in both places show no major variations. Unmarried household prefer LPG in Kailari Gauplaika but there is no effect in Dhangadhi SMPC analysis. In both places, there is no significant relationship between household head education and fuel selection at the highest level of household education; however, only Brahmin/Chetri/other castes prefer more modern fuel than Tharu/Rana Dalits and Tharu/Rana tend to be economically deprived groups, so those households depend on firewood as their primary source of energy.

According to our results, when a household's income grows, the household's ability to afford LPG rises as well. Increase in construction facilities, such as road LPG depots, results in the availability of LPG in various parts of the district, enabling households to replace firewood with LPG and biogas. The progress of 3 A's shows the practice of fuel stacking in Dhangdhi SMPC of Kailali District, which has resulted in a rapid increase in household reliance on LPG and biogas and a drastic reduction in firewood consumption. Although household fuel choice is influenced by income, there are other factors that influence household fuel choice. The age, education, caste, marital status, family size, and gender of the household head all affect the fuel choice. The price of fuel is also a factor in determining which fuel types to use, which is not covered in this report. The lack of reliable details about household fuel expenses was the reason for not choosing price in our report.

Finally, this study concludes that rising LPG and biogas consumption is not solely due to rising income; other socio-economic factors also affect household fuel choices. This picture depicts fuel stacking in the Kailali District. In terms of policy, an increase in household income can encourage them to use more efficient fuels. Furthermore, promotion of the advantages of using alternative fuels should be encouraged among Kailali District households. There is a need to build infrastructure to make fuel readily accessible to any household and to provide incentives for them to select more productive fuels. It is also important to involve disadvantaged groups of people so that they can afford to cook with those fuels. This effort would reduce the amount of strain on the forest and the amount of time it takes to get firewood.

Other things remaining the same, the household prefer the alternative fuel relative to traditional fuel. The find of this research indicated that all product attributes under consideration except environmental emission significantly affect household fuel choice. The research also provided insight into the perceived benefits of using clean and efficient fuel, and the result shows that using alternative fuel provides many benefits to households.

## 5.3 Recommendation

- It is clear that, fuel wood is the major source of energy, so energy efficient technology such as ICS, biogas should be widely promoted and regular monitoring is needed for reducing firewood consumption.

- Peoples are very keen to use to install biogas and other clean energy such as solar panel, ICS but they are deprived of sufficient money and resources so, financing system like subsidy should be promoted by the government.

- Adequate training, incentives and energy subsidy need to be cultivated among the consumer about the efficient usage of clean fuel energy.

- Expansion of market centers in the rural areas through public investment would offset the extra transportation cost of modern fuels, making the modern fuel more accessible and affordable.

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# CHAPTER 6 ANNEX I

## Department of Economics

## Faculty of Humanities and Social Science

## Tribhuwan University, Kritipur

This questionnaire is prepared to identify the Energy Choice Behavior of households of Kailali District of Sudurpachim Province. The information is collected only for academic purpose. All personal information will be kept confidential. Therefore, you are kindly requested to give genuine answers to all questions.

| Date of Interview | Name of Interviewer | Location Household |
|---|---|---|
| | | |

## Section 1: Household Information

1. Gender of the respondent

i) Male ii) Female iii) Others

2. Household Head

i) Male ii) Female iii) Others

3. Marital Status

i) Single ii) Married iii) Divorced

4. Total Family Size ……………………………………

5. Total Labor Force Size……………………………….

6. Age of the Household Head…………………………..

7. Education level of Household

i) Illiterate/Informal Education ii) Primary (1-8)

iii) Secondary (9-12) iv) Diploma & above

8. Occupation of the Household Head

i) Public ii) Private/foreign employment iii) Self-employed

9. How much is the household’s gross monthly income?_____________

10. Who mostly makes decision on the option of household fuel?

i. Husband ii. Wife iii. Other

## Section 2: Information on household's cooking system

11. What types of stoves are present in the household?

i. Fuel wood ii) LPG iii) Bio gas iv) Others (Specify)

12. Which of your stoves do you use for (list all the stoves present in the household?)

| Stove name | Cooking | Warming up food | Boiling water | Other (Specify) |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |

If more than one stove per task, which stove do you use as main stove for the individual tasks?

i) Cooking ………………………………
ii) Warming up ………………………………
iii) Water Boiling ………………………………

## Section 3: Characteristic of cooking stove

13. Which characteristics of the cook stove do you like more?

i. Traditional
ii. Cheaper to buy (Low price)
iii. Simple to use
iv. Consume less fuels (low usage cost)
v. Cook quickly
vi. Less risk of burn (no direct contact with the fire)
vii. Low indoor pollution
viii. Others (Mention)

14. Would you like to adapt to a modern cooking stoves?

i. Yes ii. No

15. If you are still using fuel wood for cooking food, what is the main reason for not adopting modern cook stoves? (Can choose two alternatives)

i. Lack of access to modern stoves ii. High price of modern stoves

iii. High usage cost of modern stoves    iv. Difficulty of using modern stoves

v. Lack of information about modern stoves    vi. Power interruption

16. If you are already using modern cooking stoves, what characteristics of the fuel needs improvement

i. Power supply    ii. Efficiency    iii.Time saving    iv. Risk of burn    v. Price

17. If you have modern fuel (LPG or Induction) available but not in use, why not in use?

Ans……………………………………………………………………………………

…………………………………………………………………………………………..

18. Do you think modern cooking stoves could replace your traditional woodstove? (Please explain why)

Ans……………………………………………………………………………………

……………………………………………………………………………...........................

## Section 4. Perceived benefit evaluation

Please read the statements carefully, some of the questions are phrased positively and others negatively. Don't take too long over individual questions; there are no "right" or "wrong" answers (and no trick questions). The first answer that comes into your head is probably the right one for you. If you find some of the questions difficult, please give the answer that is true for you in general or for most of the time.

| S.No | Questions | Strongly agree | Agree | Neutral | Disagree | Strongly disagree |
|---|---|---|---|---|---|---|
| 1 | The cook stove you are using is cheaper to buy (easy to produce). | ◯ | ◯ | ◯ | ◯ | ◯ |
| 2 | The cook stove you are using is simple to use | ◯ | ◯ | ◯ | ◯ | ◯ |
| 3 | The cook stove you are using consume less fuels (low usage cost) | ◯ | ◯ | ◯ | ◯ | ◯ |
| 4 | The cook stove you are using cooks | ◯ | ◯ | ◯ | ◯ | ◯ |

| | | | | | | |
|---|---|---|---|---|---|---|
| | quickly | | | | | |
| **5** | The cook stove you are using causes high risk of burn | ◯ | ◯ | ◯ | ◯ | ◯ |
| **6** | The cook stove you are using causes high indoor pollution | ◯ | ◯ | ◯ | ◯ | ◯ |
| **7** | Your monthly expenditure on household energy is low | ◯ | ◯ | ◯ | ◯ | ◯ |

## Section 5. Choice experiment questions

19. Which characteristics did you consider while making your decision? (Multiple answers possible)

i) Cost of cooking ii) Environmental impact iii) Health impact

iv) Reduction in cooking time v) Cost of purchasing the stove

vi) Consider all characteristics

20. Was there a characteristic that you considered unimportant?

i) Yes (specify)……………………………………………………………………………….

ii) No

Best Regards,

Himani Ojha

MA. Economics, TU

# Thank You

# CHAPTER 7 Annex II

Calculation procedure of the probability estimation

$$P[y = 1/X = 1/(1 + \exp(0.390 + 0.000005lny - 0.009age - 0.01672Fz + 0.091Genderf + 0.036Edu(pri) - 0.002Edu(sec) + 0.321Edu(uni) - 0.151Ethn(dalit) + 0.102Ethn(Tharu) + 0.148Unmarried)] + \exp(-0.138 - 0.0000028lny + 0.002Age + 0.04Fz - 0.104Genderf + 0.056Edu(pri) - 0.008Edu(\sec\ ) + 0.168Edu(uni) - 0.1Eth(dalit) - 0.008Eth(tharu) - 0.007Unmarried, j = 1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (vii)$$

$$P[y = 2/X = \exp(0.390 + 0.000005lny - 0.009age - 0.01672Fz + 0.091Genderf + 0.036Edu(pri) - 0.002Edu(sec) + 0.321Edu(uni) - 0.151Ethn(dalit) + 0.102Ethn(Tharu) + 0.148Unmarried)]/(1 + \exp(0.390 + 0.000005lny - 0.009age - 0.01672Fz - 0.014Genderf + 0.036Edu(pri) - 0.002Edu(sec) + 0.321Edu(uni) - 0.151Ethn(dalit) + 0.102Ethn(Tharu) + 0.148Unmarried)] + \exp(-0.138 - 0.0000028lny + 0.002Age + 0.04Fz - 0.104Genderf + 0.056Edu(pri) - 0.008Edu(\sec\ ) + 0.168Edu(uni) - 0.1Eth(dalit) - 0.008Eth(tharu) - 0.007Unmarried, j = 2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (viii)$$

$$P\left[y = \frac{3}{X}\right] = \exp(-0.138 - 0.0000028lny + 0.002Age + 0.04Fz - 0.104Genderf + 0.056Edu(pri) - 0.008Edu(\sec\ ) + 0.168Edu(uni) - 0.1Eth(dalit) - 0.008Eth(tharu) - 0.007Unmarried/(1 + \exp(0.390 + 0.000005lny - 0.009age - 0.01672Fz + 0.091Genderf + 0.036Edu(pri) - 0.002Edu(sec) + 0.321Edu(uni) - 0.151Ethn(dalit) + 0.102Ethn(Tharu) + 0.148Unmarried)] + \exp(-0.138 - 0.0000028lny + 0.002Age + 0.04Fz - 0.104Genderf + 0.056Edu(pri) - 0.008Edu(\sec\ ) + 0.168Edu(uni) - 0.1Eth(dalit) - 0.008Eth(tharu) - 0.007Unmarried, j = 3 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (ix)$$

For Kailari Gaupalika, the predicted probability of choosing each j, for j=1,2&3 are;

$$P[y = 1/X = 1/(1 + \exp(0.280 + 0.00000474 lny - 0.003 age - 0.016 Fz - 0.003 Genderf - 0.019 Edu(pri) - 0.031 Edu(sec) + 0.012 Edu(uni) - 0.129 Ethn(dalit) - 0.121 Ethn(Tharu) - 0.022 Unmarried)] + \exp(0.3065 + 0.000001 ln - 0.0043 Age + 0.038 Fz - 0.0.039 Genderf - 0.0162 Edu(pri) - 0.077 Edu(\text{sec}\quad) + 0.093 Edu(uni) + 0.019 Eth(dalit) - 0.1595 Eth(tharu) - 0.056 Unmarried, j = 1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (x)$$

$$P[y = 2/X = \exp(0.280 + 0.00000474 lny - 0.003 age - 0.016 Fz - 0.003 Genderf - 0.019 Edu(pri) - 0.031 Edu(sec) + 0.012 Edu(uni) - 0.129 Ethn(dalit) - 0.121 Ethn(Tharu) - 0.022 Unmarried) /(1 + \exp(0.280 + 0.00000474 lny - 0.003 age - 0.016 Fz - 0.003 Genderf - 0.019 Edu(pri) - 0.031 Edu(sec) + 0.012 Edu(uni) - 0.129 Ethn(dalit) - 0.121 Ethn(Tharu) - 0.022 Unmarried)] + \exp(0.3065 + 0.000001 ln - 0.0043 Age + 0.038 Fz - 0.0.039 Genderf - 0.0162 Edu(pri) - 0.077 Edu(\text{sec}\quad) + 0.093 Edu(uni) + 0.019 Eth(dalit) - 0.1595 Eth(tharu) - 0.056 Unmarried, j = 2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (xii)$$

$$P[y = 3/X = \text{xp}(0.3065 + 0.000001 ln - 0.0043 Age + 0.038 Fz - 0.0.039 Genderf - 0.0162 Edu(pri) - 0.077 Edu(\text{sec}\quad) + 0.093 Edu(uni) + 0.019 Eth(dalit) - 0.1595 Eth(tharu) - 0.056 Unmarried/(1 + \exp(0.280 + 0.00000474 lny - 0.003 age - 0.016 Fz - 0.003 Genderf - 0.019 Edu(pri) - 0.031 Edu(sec) + 0.012 Edu(uni) - 0.129 Ethn(dalit) - 0.121 Ethn(Tharu) - 0.022 Unmarried)] + \exp(0.3065 + 0.000001 ln - 0.0043 Age + 0.038 Fz - 0.0.039 Genderf - 0.0162 Edu(pri) - 0.077 Edu(\text{sec}\quad) + 0.093 Edu(uni) + 0.019 Eth(dalit) - 0.1595 Eth(tharu) - 0.056 Unmarried, j = 3 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (xiii$$

## Parameter Estimates

| Fuel Type[a] | | Dhangadi SMPC B | Std. Error | Wald | df | Sig. | Exp(B) | 95% Confidence Interval for Exp(B) Lower Bound | Upper Bound | Kailari Gaupalika B | Std. Error | Wald | df | Sig. | Exp(B) | 95% Confidence Interval for Exp(B) Lower Bound | Upper Bound |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LPG | Intercept | 7.003 | 2.161 | 10.502 | 1 | 0.001 | | | | -0.577 | 1.964 | 0.086 | 1 | 0.769 | | | |
| | Age of the household Head | -0.162 | 0.060 | 7.260 | 1 | 0.007 | 0.850 | 0.756 | 0.957 | -0.057 | 0.041 | 1.940 | 1 | 0.164 | 0.945 | 0.872 | 1.024 |
| | Family size | 0.346 | 0.357 | 0.942 | 1 | 0.332 | 1.414 | 0.703 | 2.844 | -0.307 | 0.226 | 1.848 | 1 | 0.174 | 0.736 | 0.473 | 1.145 |
| | Income of the household | 0.000 | 0.000 | 11.850 | 1 | 0.001 | 1.000 | 1.000 | 1.000 | 0.000 | 0.000 | 8.288 | 1 | 0.004 | 1.000 | 1.000 | 1.000 |
| | [Gender of the household Head=1] | -0.501 | 0.843 | 0.354 | 1 | 0.552 | 0.606 | 0.116 | 3.161 | 0.196 | 0.885 | 0.049 | 1 | 0.825 | 1.216 | 0.214 | 6.899 |
| | [Gender of the household Head=2] | 0[b] | | | 0 | | | | | 0[b] | | | 0 | | | | |
| | [Marital Status of HHS=0] | -0.620 | 1.191 | 0.271 | 1 | 0.602 | 0.538 | 0.052 | 5.549 | 0.646 | 1.098 | 0.346 | 1 | 0.556 | 1.908 | 0.222 | 16.414 |
| | [Marital Status of HHS=1] | 0[b] | | | 0 | | | | | 0[b] | | | 0 | | | | |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | [Education attainment of HHS =0] | -4.769 | 1.832 | 6.777 | 1 | 0.009 | 0.008 | 0.000 | 0.308 | -0.257 | 1.129 | 0.052 | 1 | 0.820 | 0.774 | 0.085 | 7.077 |
| | [Education attainment of HHS =1] | -3.174 | 1.808 | 3.083 | 1 | 0.079 | 0.042 | 0.001 | 1.447 | -1.045 | 1.532 | 0.465 | 1 | 0.495 | 0.352 | 0.017 | 7.079 |
| | [Education attainment of HHS =2] | -4.784 | 1.661 | 8.297 | 1 | 0.004 | 0.008 | 0.000 | 0.217 | -0.387 | 1.168 | 0.110 | 1 | 0.741 | 0.679 | 0.069 | 6.701 |
| | [Education attainment of HHS =3] | 0[b] | | | 0 | | | | | 0[b] | | | 0 | | | | |
| | [Ethnicity of Households=0] | -1.890 | 1.105 | 2.924 | 1 | 0.087 | 0.151 | 0.017 | 1.318 | 1.768 | 1.037 | 2.906 | 1 | 0.088 | 5.861 | 0.767 | 44.763 |
| | [Ethnicity of Households=1] | -4.078 | 1.529 | 7.119 | 1 | 0.008 | 0.017 | 0.001 | 0.339 | 0.132 | 1.271 | 0.011 | 1 | 0.917 | 1.141 | 0.095 | 13.767 |
| | [Ethnicity of Households=2] | 0[b] | | | 0 | | | | | 0[b] | | | 0 | | | | |
| Bio Gas | Intercept | -0.609 | 2.170 | 0.079 | 1 | 0.779 | | | | -1.691 | 1.437 | 1.384 | 1 | 0.239 | | | |
| | Age of the household Head | -0.010 | 0.037 | 0.077 | 1 | 0.782 | 0.990 | 0.921 | 1.064 | -0.038 | 0.026 | 2.216 | 1 | 0.137 | 0.963 | 0.915 | 1.012 |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Family size | 0.449 | 0.320 | 1.962 | 1 | 0.161 | 1.567 | 0.836 | 2.936 | 0.220 | 0.105 | 4.399 | 1 | 0.036 | 1.246 | 1.015 | 1.530 |
| | Income of the household | 0.000 | 0.000 | 3.216 | 1 | 0.073 | 1.000 | 1.000 | 1.000 | 0.000 | 0.000 | 1.702 | 1 | 0.192 | 1.000 | 1.000 | 1.000 |
| | [Gender of the household Head=1] | 1.349 | 0.948 | 2.027 | 1 | 0.155 | 3.854 | 0.602 | 24.693 | 0.277 | 0.699 | 0.157 | 1 | 0.692 | 1.319 | 0.335 | 5.192 |
| | [Gender of the household Head=2] | 0[b] | | | 0 | | | | | 0[b] | | | 0 | | | | |
| | [Marital Status of HHS=0] | -0.608 | 1.478 | 0.169 | 1 | 0.681 | 0.544 | 0.030 | 9.863 | 0.398 | 0.806 | 0.243 | 1 | 0.622 | 1.488 | 0.306 | 7.229 |
| | [Marital Status of HHS=1] | 0[b] | | | 0 | | | | | 0[b] | | | 0 | | | | |
| | [Education attainment of HHS =0] | -4.009 | 1.808 | 4.918 | 1 | 0.027 | 0.018 | 0.001 | 0.628 | -0.581 | 0.861 | 0.455 | 1 | 0.500 | 0.560 | 0.104 | 3.024 |
| | [Education attainment of HHS =1] | -3.372 | 1.836 | 3.372 | 1 | 0.066 | 0.034 | 0.001 | 1.255 | -2.075 | 1.400 | 2.196 | 1 | 0.138 | 0.126 | 0.008 | 1.953 |
| | [Education attainment of HHS =2] | -5.251 | 1.990 | 6.963 | 1 | 0.008 | 0.005 | 0.000 | 0.259 | -0.977 | 1.076 | 0.825 | 1 | 0.364 | 0.376 | 0.046 | 3.100 |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | [Education attainment of HHS =3] | 0[b] | | | 0 | | | | | 0[b] | | | 0 | | | | |
| | [Ethnicity of Households=0] | -0.620 | 0.985 | 0.395 | 1 | 0.529 | 0.538 | 0.078 | 3.712 | 1.383 | 0.822 | 2.830 | 1 | 0.093 | 3.988 | 0.796 | 19.982 |
| | [Ethnicity of Households=1] | -3.444 | 1.630 | 4.463 | 1 | 0.035 | 0.032 | 0.001 | 0.780 | 1.202 | 0.698 | 2.969 | 1 | 0.085 | 3.327 | 0.848 | 13.061 |
| | [Ethnicity of Households=2] | 0[b] | | | 0 | | | | | 0[b] | | | 0 | | | | |
| a. The reference category is: Firewood. | | | | | | | | | | | | | | | | | |
| b. This parameter is set to zero because it is redundant. | | | | | | | | | | | | | | | | | |