Fuel Wood Consumption, Health and Rural Livelihood:
A Case Study from Abbottabad

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CERTIFICATE

This is to certify that this thesis entitled: **"Fuel Wood Consumption, Health and Rural Livelihood: A Case Study from Abbottabad".** submitted by Muhammad Tanvir is accepted in its present form by the Department of Environmental Economics, Pakistan Institute of Development Economics (PIDE), Islamabad as satisfying the requirements for partial fulfillment of the degree in **Master of Philosophy in Environmental Economics**.

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ACKNOWLEDGMENTS

I want to express my appreciation to my advisor and chairperson, Dr. Abedullah, who guided me through the process in a professional manner and encouraged me each step of the way. Dr. Abedullah is my teacher, mentor, and friend.

I wish to thank my parents for their patience and encouragement during this study. Their support kept me going.

I wish to acknowledge Dr. Rehna Sidiqui, who served as a critical component of this research and a source of constant encouragement.

I wish to acknowledge my internal reviewer, Dr. Muhammad Nasir, for his provided valuable comments and suggestion.

I wish to acknowledge my external reviewer, Dr. Abdus Saboor, for his valuable comments and suggestion

Dedication

My success is not but through Allah, upon Him I have relied,

and to Him I return. (Quran 11:88)

Every challenging work need self-efforts as well as guidance of

elders especially those who are very close to our heart

This humble efforts I dedicate to my sweet and loving

Parents

Whose affection, love, encouragement and prays of day and

night make me able to get such success and honor,

Along with all hard working and respected

Teachers

DECLARATION

I, Muhammad Tanvir, hereby declare that this thesis entitled "**Fuel wood consumption, health and rural livelihood, A case study from Abbottabad** submitted by me for the partial fulfillment of **Master of Philosophy** in Environmental Economics is my own tough work under the full supervision of Dr. Abedullah. Furthermore, this thesis has not been submitted simultaneously to any other university for any other degree.

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List of Abbreviation

FAO	Food and Agriculture Organization
RWEDP	Regional wood energy development program in Asia
WHO	World health organization
DALYs	Disability-adjusted life years
ARI	Acute respiratory infection
GOP	Government of Pakistan
HESS	Household energy strategy study
AJK	Azad Jammu and Kashmir
LPG	Liquid petroleum gas
OLS	Ordinary least square method
2SLS	two stage least square method
COPD	Chronic bronchitis in adults
PM	particular matter
KPK	Khyber Pakhtunkhwa
MWTP	Marginal willingness to pay
IRR	Incident rate ratio

Abstract

Fuel wood is an important source of energy for cooking and heating in the rural area of district Abbottabad. The study was based on primary data, data were collected through well-developed questioner and interview method. The main objective of this study was, A) Quantify the sources of energy for cooking and heating. B) To explore the factors effecting the fuel wood consumption. C)To study the role of fuel wood collection in rural livelihood. D)To study the impact of fuel wood consumption on human health. Initially, we observed that 81% of the total household in the study area used fuel wood for cooking and heating, and only 19% of them used both fuel wood and LPG. This study revealed that annually about 2064 ton of valuable wood is used for heating and cooking. During summer season, pressure on forest for fuel wood is comparatively higher because 73% of the total household collect fuel wood in summer season. we analyzed that, "number of wood collector, family size and LPG price" was positively affecting the fuel wood consumption. On the other hand, "education of household head and distance from home to collection point" was negatively affecting the fuel wood consumption. We also observed that fuel wood is not only used for cooking and heating, but it was also used for subsistence need. Current study revealed that fuel wood contributes RS.6793/month to each household, which is 17% of the total income. Finally, we observed that wood users are getting sick more frequently because the wood users have traditional and poor cook stove in kitchen.

Keyword: Fuel wood use, rural livelihood, and human health

CHAPTER 1

INTRODUCTION

1.1 Introduction

Energy is one of the most important part of life, which plays a pivotal role in socio-economic development by making the quality of life (Kamakshi et al., 2004). Different stages of development people use the different type of energy sources such as wood, coal, oil, and petroleum to nuclear energy. Now a day's people and the politics are sensitive from global climate change and every state want to find the renewable energy source. Fuel wood is one of the oldest source of renewable energy with great potential, especially for developing countries where it is the main source of domestic energy (Chang et al., 2003). Fuel wood comes from both forest and non-forest land. Forest land includes natural forest, wood scrublands, timber, and woodlots. Non-forest land includes wasteland, agriculture land, home gardens, and agro-forestry system. Secondary sources of fuel wood energy are wood processing industries, recycled wood from construction activities, driftwood, pallets, packing crates and residues from logging (FAO, 1997). According to Regional wood energy development program in Asia (RWEDP), forest land contributes 1/3 of the fuel wood, while non-forest land contributes 2/3 in total consumption.

However, fuel wood is one of the most important part of renewable energy for developing countries. All around the world almost 2 billion people relying on fuel wood for cooking and heating (FAO, 2017). According to the study of WHO (2006), 52% of the total population in developing world use fuel wood for cooking and heating while 30% of these live in China, Indonesia and India. Basically, fuel wood energy use for heating and cooking with inefficient stove and traditional practice which produce high level of indoor air pollution. Exposure to indoor air from the combustion of fuel wood. Fuel wood smoke contains many pollutants such as carbon monoxide, particulate matter, sulfur oxide and nitrogen dioxide (Smith, K. R et al., 2000). These pollutants have been tested, with varying degree of evidence as a causal agent of several diseases in developing countries such as lung cancer, asthma, cataract, low birth weight and respiratory infection (Ezzati M, Kammen DM, 2001). Particulate pollution range between (PM10 and PM 2.5), PM10 is a small particle that can reach deep part of the lungs and PM 2.5 is the smallest particles that appear to have the greatest health-damaging potential (WHO 2009). Carbon monoxide affect the blood circulation, because it displaces oxygen in the blood and deprives the brain, heart and other vital organs of oxygen which cause the loss of consciousness and suffocate (WHO, 2005). Hydrocarbon emission comes from dung which affects the women and children. Children are living in household exposed to fuel wood have three times greater risk of acute respiratory infection compared to those who use cleaner fuel (smith et al., 2000).

Epidemiological studies show that exposure particles have negative impact on human health, especially for women and children because they spend most of the time at home (WHO 2009). Due to indoor pollution, more than 1.6 million people die every year, 52 percent of them are children whose ages under five years. The study also estimated that 85% of these deaths are due to solid fuel, and 15% due to coal. World Bank (2006b), estimated the annual health impact in term of annual cases and (DALYs)[1] disability-adjusted life years. They found that due to indoor air pollution 1.37 million DALYs are lost every year, which is 18% from morbidity and 86% from morality. Acute respiratory infection (ARI)[2] is the most common cause of illness in children and women and it is a major cause of death in the world. Due to acute respiratory tract infection, more than 2 million children die every year (Rudan et al., 2004). According to Stansfield, (1993), there are 4 million deaths annually have been attributed to ARI, and 75% of them are pneumonia. Smith, (2004), estimated that fuel wood consumption is also responsible for 2.4 million premature deaths each year. It has emerged as one of the ten most important threats to public health, in 2000 indoor pollution was responsible for more than 1.5 million deaths, and it is accounted for 3.7% of the burden of disease (WHO, 2007).

Pakistan is the forest poor country in the world, it has only 5% area covered by forest, but the desired level is 25%. In Pakistan Forest ownership can be divided into three categories, communal owned forest, privately owned forest, and state-owned forest. Communal and privately-owned forests cover 3.1 million hectares while state forest covers 1.29 million hectares (GOP 2008). Forest provide multiple products, one of them is fuel wood. In

[1] DALYs: Basically, a count of how many life years someone lost to sickness or illness. It was developed in the 1990s as a way of comparing the overall health and life expectancy of different countries.

[2] ARI: Acute lower respiratory infections include pneumonia (infection of the lung alveoli), as well as infections affecting the airways such as acute bronchitis and bronchiolitis, influenza and whooping cough.

Pakistan, rural areas have an limited source of energy for cooking and heating, but they use fuel wood as energy. Fuel wood comes from both community and public forest land. People in rural area collect fuel wood almost freely from surrounding forest land that may be community or public forest (Bhutto, et al., 2011). According to WHO (2005), 69% of their fuel wood consumption is collected freely. The collection of fuel wood in rural households by women and children. People may collect fuel wood and other biomass from the community and public forest land under some traditional and recorded rights. Under these rights, local people can remove the fallen and dead trees for their domestic needs and not for sale (Waheed et al., 2011). Pakistan Household Energy Strategy Study (HESS, 1992), estimated that 13% of households in Pakistan collect fuel wood from state forest land, 40% from private land and 32% from own land. Economic survey of Pakistan (2009-2010), estimated that 263 thousand cubic meters of fuel wood has provided by forest. Fuel wood is one of the main source of domestic energy[3] in Pakistan which contribute 53% of the total annual energy (Government of Pakistan 1997). The use of fuel wood is different in rural and urban areas. Rural areas use 90% for cooking and heating while in urban areas only 10% (GOP 2005). According to the government of Pakistan (2005), 75% of the rural household use fuel wood for cooking and 11% use for room heating and 14% for water heating.

When we look fuel wood consumption at the provincial level, Balochistan mostly consumed fuel wood because of non-availability of an alternative source. Crop residues are mostly used in Punjab because of large farm area. Sindh has well-developed and high level of urbanization that’s why the use of fuel wood is too low. KPK, FATA, Gilgit-Baltistan, and AJK have large forest resources and lack of natural gas in the rural area, people use fuel wood for their domestic energy (Zaman, & Ahmad, 2012). Fuel wood is the dominant source for cooking and heating in Azad Jammu and Kashmir, where domestic energy contribution is about 94% (Shaheen et al., 2011). Himalayan mountains contribute 90% wood energy to the rural households in Kashmir (Joshi et al., 2001). According to Hamayun (2016), fuel wood is the main source for cooking and heating in Kashmir, where average household’s consumption is about 16.2 megagram (Mg) per year. In the study of Utror and Gabral Kashmeer valleys annually 4800 tons of fuel wood use for cooking and heating in

[3]Domestic energy consumption is the total amount of energy used in a house for household work.

winter season while in summer season the consumption decreases because fuel wood is not used for heating (Muhammad et al., 2013). According to Anon (1998), about 94% of the total households use fuelwood for cooking and heating in district Bagh. Hamayun (2011), estimated that fuel wood consumption in AJK is about 3kg/capita/day for cooking and heating. According to study in Pakistan, fewer family members have 3 times less consumption as compare to high income and large family size. The study shows that urban households who are using wood, purchase 86% of their fuel wood needs (WHO 2005). The study of Peshawar (1992) show that high income family purchase fuel wood for their need and poor household collect it freely.

This is strong and authentic evidence that millions of poor people in Pakistan depends on traditional fuel wood for cooking and heating. Due to the exposure of indoor smoke, these people face high burden of health illness (WHO 2005). Around the world sources of indoor air pollutions are improper maintenance of ventilation, tobacco smoking, emission of construction material and solid fuel (WHO 2006a). This pollution emitted includes nitrogen dioxide, transition metals, polycyclic aromatic hydrocarbons, particulate matter, and carbon monoxide. Due to traditional and poor stove use in a close kitchen, the level of indoor air pollution is greater and incomplete combustion of wood is a serious threat to human health (Fullerton et al., 2009). In Pakistan, rural households use three stone stoves (made of clay and husk), which produce enormous quantities of smoke. An average 38% of the total sampled households have single room with close kitchen (Archar 1993). Due to an inefficient stove and close kitchen household face different type of diseases such as acute respiratory infection, pneumonia, lung cancer, stroke, and cataract. Acute respiratory infection is dominant in child mortality rate in Pakistan (Nishtar 2007). According to the World Bank (2006b), 34% of children had developed by the symptoms of ARI and diarrhea. Due to indoor air pollution, Pakistan faces 28,000 deaths every year while 40 million people suffer from ARI and diarrhea. The burden of indoor air pollution is significant, and its annual cost is about 1% of the GDP in Pakistan. WHO (2007a) estimated that Pakistan faces 51,760 death every year due to acute respiratory infection and pneumonia while 18,980 deaths due to chronic obstructive pulmonary disease. Another study of WHO (2007b) estimate that due to fuel wood consumption in Pakistan causes 70,700 deaths every year and 4.6% increase the burden of disease nationally.

The above citation gives us overall pattern of fuel wood consumption and its impact on rural livelihood at the international and national level. On the behalf of above discussion, we can say that fuel wood consumption has both positive and negative impact on rural livelihood. Positive impacts are, people use fuel wood for cooking, heating and subsistence need. In the study of India smith (2004), investigated that household does not substitute one fuel for others when their income increases, but they may add some other source of energy such as LPG. The study also shows that household does not sift totally toward LPG because fuel wood supply is cheaper and easy to collect. People in rural area are still using fuel wood for cooking and heating because they want to remember traditional technologies and taste, even if they have purchasing power to afford LPG. In best of my knowledge, this is only studied, which conducted in India but not for Pakistan. In this study, we try to fill this gap with finding the source of energy in the rural area of Abbottabad. On the other hand, fuel wood has negative impact which affects human health. Mainly fuel wood use for cooking and heating at the household level. The sources of this energy are fuel wood, charcoal, crop residues, and animal dung and are often collected by children and women on daily basis. In some rural area are not only use for cooking and heating but some of them traded among villages, within villages, and with nearer townships. Another characteristic of fuel wood traditional energy is using with three stone stoves (made by clay and husk), due to open burning, poor design stove leads to serious health damages.

1.2 Problem statement

According to FAO, (2017) 2 billion people in the world relaying on fuel wood. Fuel wood is an important part of cooking in developing countries. According to WHO, (2006), 52% of the total population in developing countries use fuel wood for cooking and heating. Basically, fuel wood is being used for heating and cooking with inefficient stove and traditional practice which produce a high level of indoor air pollution.

However, people living in rural area, use fuel wood for cooking and heating because they do not have any alternative source of energy. In case, LPG is available as an alternative source then it is beyond the purchasing power for the majority of household due to low per capita income. It is a well-established fact that, fuel wood comes from the forest. Excessive harvesting of fuel wood is one of the main cause of deforestation in the study area.

Moreover, the use of fuel wood as a source of energy is injuries to human health because incomplete wood combustion emits various gases, which affect the human health.

1.3 Research questions

2. Does fuel wood contribute a notable share in total energy consumption in the study area?
3. How socio-economics factor affect the fuel wood consumption?
4. Does education plays an important role in the selection of energy source and improve livelihood in the study area?
5. What is the role of fuel wood income in rural livelihood?
6. Is fuel wood consumption has adverse affect the human health?

1.4 Objective of the study

Considering these problems, the objective of the study are to:

1. Quantify the sources of energy for cooking and heating.
2. Explore factors affecting the fuel wood consumption.
3. Investigate the impact of fuel wood collection on rural livelihood.
4. To study the impact of fuel wood consumption on human health.

1.5 Hypothesis of the study

The following hypothesis have been formulated which will be tested in the study

H_0= LPG is the dominant source of energy for cooking and heating in study area.

H_1= Fuel wood is the dominant source of energy for cooking and heating in study area

H_0= Increase in family size leads to decrease in fuel wood consumption.

H_1= Increase in family size leads to increase in fuel wood consumption.

H_0= LPG price has no effect on fuel wood consumption

H_1= LPG price has significant effect on fuel wood consumption

H_0= Number of wood collector has negative impact on fuel wood consumption

H_1= Number wood collector has positive impact on fuel wood consumption

H_0= Education of the household has positive impact on fuel wood consumption

H_1= Education of the household has negative impact on fuel wood consumption

H_0=Average distance from home to collection point has positive impact on fuel wood consumption

H_1=Average distance from home to coalition point has negative impact on fuel wood consumption.

H_0= Total income has negative impact positive impact on fuel wood consumption

H_1= Total income has negative impact on fuel wood consumption

H_0= Fuel wood income has no impact on rural livelihood.

H_1= Fuel wood income has significant contribution in rural livelihood.

H_0= Fuel wood collection is the exogenous variable.

H_1= Fuel wood collection is endogenous variable.

H_0= Natural gas users are getting sick more frequently.

H_1= Fuel wood users are getting sick more frequently.

H_0= Error does not exhibit over dispersion.

H_1= Error does exhibit over dispersion.

1.6 Significance of the study

The study will contribute to the improvement of cooking style in rural areas because traditional cook stove and greater demand for fuel wood is serious depletion of forest and injuries to human health. The desired results of the current study will be fruitful for the society and government because based on authentic figure, communities and administration make plane to improve cooking style. I hope that current study will encourage the rural communities and government to implement the recommended policies, which are totally based on authentic facts and figure. Thus, the government that applies the recommended approaches derived from the results will be able to reduce fuel wood consumption, health problems, and forest depletion. Society will be guided on what should be emphasized by the government to improve the forest condition and cooking style. For the researcher, the study will help them to uncover critical areas in the forest depletion process that many researchers were not able to explore.

The outcomes to be considered consist of the following:

The improvement of the cooking stove, improve health, conservation of forest resource, improvement of education, use of clean energy source for cooking and heating, improve job opportunities and improve reforestation program on cultivable wasteland.

CHAPTER 2

LITERATURE REVIEW

2.1 Literature review

According to World Bank (2015) more than three billion people of the world live in rural area which has inadequate supply of energy for cooking, heating and lighting. According to IEA report (2010) 2.7 billion people depends on fuel wood, it is one of the oldest form of energy in the world. Now a day it is still important for cooking and heating in rural area. Miah (2008), determined the characteristics of traditional cooking stoves in Bangladesh. They use primary data with simple random sampling. The study shows that 43% of the household use fuel wood, 53% of them use kerosene and only 5% use LPG.

Study of Ethiopia Guta (2014), estimated the contribution of fuel wood consumption in rural households. The study used primary data and regress it with the help of OLS. They also use Tobit model for estimating the agricultural fuel and charcoal consumption. The study concluded that 90% of the rural households use fuel wood for cooking and heating, 5% of them use charcoal and 4% use agriculture fuel. The study of Tibet investigated the sources of energy for rural households and its impact on socio-economics environment. Primary data were collected through simple random sampling and descriptive statistics were used to identify the mean value of fuel wood consumption. The study concluded that fuel wood is the main source of energy in rural area which contribute 70% of their share in domestic energy (Liu et al., 2007).

Study of district Tingyi estimated the per capita fuel wood consumption and found the alternative way of energy source in study area. They used primary data with spearman correlation method to achieve these objectives. Study reported that 60% of the household use fuel wood and 4% of them use agriculture waste to fulfill their domestic need (Sein et al., 2015). Study of Lithuania Kairukstis (2004), estimated the demand and supply of fuel wood and it's assess the ecological and economic effects of substituting conventional fuel. Secondary data were collected from publish article. They calculated the burning product with the help of formula. They concluded that 3.5 million m^3 wood burned for cooking and heating in the study area.

Study of rural India Heltberg (2015), determined the fuel wood demand and supply and also found the link between forest scarcity and household fuel wood collection. Primary data were used to examine demand and supply of fuel wood in study area. Study use maximum Entropy regression for fuel wood collection, labor time and private energy. They found that with scarce resource of forest household decrease their fuel wood collection. Study concluded that 10% increase in time to collect fuel wood leads to 1.1% decrease in amount of fuel wood.

The study of India estimates the consumption of fuel wood for different tribal communities, it also collects information about the tree species prefer for consumption. Primary data were collected through preliminary survey. They concluded that fuel wood is the main source for cooking and heating which contribute 90% domestic energy. Study concluded that Pinus, kesiya, Mesua ferrea, Macaranga denticulate, are suitable for fuel wood consumption in study area (Batt et al., 2004). Kenya's study determined the fuel wood consumption and factor that influence the consumption. Primary data were used through systematic random sampling and regress it with the help of simple descriptive statistics. On the bases of these data they concluded that 95% of the domestic energy come from fuel wood and mainly it is use for cooking and heating.

Study of India Rawat (2009), investigated the utilization and distribution of fuel wood consumption. Primary data were collected through field survey. The study concluded that fuel wood is the major source for cooking and heating in study area, which contribute 22kg/household/day. Study of Maria (2014), described the overall pattern of fuel wood consumption. Primary data were collected through survey method. Descriptive statistics and G test were used to identify the fuel wood consumption. The study concluded that 76% of the household use fuel wood as a main source for cooking and heating.

Coutere (2012), used econometric approach to find the demand of fuel wood consumption in France. Primary data were collected through questioner and interview method. They used maximum likelihood method for fuel wood energy and mix energy contribution. Study concluded that price of the wood decreases leads to increase in wood consumption and household use more wood as compare to mix energy (LPG, electricity). The study of Bhutan Mokton (2014), estimated the availability of fuel wood consumption and substitution for rural and urban area. Primary data were used to find the percentage and frequencies of urban and rural fuel wood consumption. For two independent samples they used nonparametric Mann Whitney U test between harvested and unharvest stands. The study concluded that when the price of fuel wood increase people of urban area sifts toward clean energy. In case of rural area households still use fuel wood because they live near the forest and take fuel wood freely. Study of Nigeria estimate the pattern of fuel wood consumption in Bauchi state. Primary data were used and regress it with the help of chi square statistical tool. Study concluded that due to high price of fossil fuel majority of the household use fuel wood for cooking and heating. They found that 42% of the total respondent depend on fuel wood consumption, 2% of them use fossil fuel and 54% of them relay on both. (Akpan et al., 2007).

2.2 Fuel wood consumption and income contribution

Study of Malawi Kamanga (2008) examined the forest income among rural inhabitants. Primary data were collected through simple random sampling. OLS used against forest income and socio-economic characteristics. Study concluded that people in study area are extremely poor and 97% having income less than $1/day. Study estimated that 15% of their income come from forest resource such as fuel wood and fodder. They analyzed that poor people are highly depends on forest income and People with better access to forest have higher total income. Veldeld (2007) studied the role of forest income in 17 developing countries. Secondary data were collected through publish articles. Multiple linear regression was used to fine the relationship between total income and forest income. The study concluded that forest income contributes 22% of their total income. They found that forest income includes fuel wood, wild foods and fodder.

Arild (2014) investigated that how much household income comes from environmental resources and how rural household reliance on these incomes. Primary data were collected through simple random sampling. Simple descriptive statistics and multilevel regression were used to find which factor influence household income, Kuznets ratio were also used for total income and environmental dependency. The study concluded that Latin American site forest income contribute 29% of average household income while Asia and Africa shares are 20% and 21%. Study of Anthony (20011) identified the fuel wood consumption and income contribution. Primary data were used through simple random sampling. Descriptive statistic and multiple regression were used to determine fuel wood supply and income contribution. They concluded that fuel wood business was very profitable, which contribute 75% of their profit.

2.3 Fuel wood consumption and health impact

Internationally 3 million people depends on fuel wood such as wood, charcoal, crop residues, and dung. Household use fuel wood as primary source of energy due to inefficient stove and exposure to indoor air pollution is the main cause of health hazard in developing country. Study of Ezzati (2014) reviewed the relationship between indoor air pollution and health problem. Primary data were collected through survey method. B-logit regression were used to estimate factor affecting acute respiratory infection. They concluded that long period of exposure lead to high level of PM10 and it cause of damage of lower respiratory system. Kurmi (2018) quantify the impact of biomass smoke on the development of chronic bronchitis risk of indoor air pollution. Secondary data were collected through 63 published paper. Q-test were used to evaluate heterogeneity in group and random effect model were used to calculate the pooled effect size. They concluded that fuel wood smoke is main cause of chronic bronchitis in adults (COPD). They also estimated that fuel wood smoke is related to COPD, and its risk are double as compare to non-biomass fuel user.

Ezzati (2002), estimated the impact of indoor air pollution on human health in Kenya. Primary data were collected through random sampling and longitudinal data recorded for acute lower respiratory infection and acute respiratory infection. Linear probability model was used to identify the illness rate in all individual. They concluded that female above 5 years at higher risk of illness than man. They investigated that after age of 5 probability of being diagnosed with ALRI but not ARI. Fullerton (2008), investigated the major health problem due to fuel wood consumption. They use qualitative method to identify some common illness. They concluded that fuel wood is major cause of indoor air pollution and it increase the incidence of low birth weight, cardiovascular events, chronic obstructive pulmonary disease, tuberculosis, pneumonia and respiratory infection. All these diseases is the major cause of mortality in adults and children. Lissowska (2005), conducted the large-scale case control study in six eastern and central European countries and one center from UK. The main aim was this study to investigate the impact of fuel wood consumption on lung cancer. Primary data were collected through questionnaire method. Unconditional logistic regression method was used to estimate the odds ratios 95% confidence interval were used to identify the lung cancer due to solid fuel exposure. They concluded that individual who used fuel wood for cooking they are more elevated risk of cancer, but it is not similar for those who use for heating. They also concluded that lung cancer increases with fuel wood user and decrease with modern fuel user.

2.4 Fuel wood consumption and Pakistan

Badshah (2014), investigated the fuel wood consumption in rural area of district Tank. Primary data were collected through questionnaire and interview method. ANOVA model were used to determine wood consumption in study area and t-test used for the mean total removal and using. The study concluded that 90% of the total sampled used fuel wood for cooking and heating. Hamayun (2013), determined the role of fuel wood consumption in Gabral valleys Pakistan. Primary data were collected through questioner method and use simple descriptive statistics. They observed that 4800 tons of valuable wood use for cooking and heating. The consumption of fuel wood is different according to season. In winter season the consumption of fuel wood 60kgs per month while 25kgs in summer season. Shaheen (2011), estimated the rural dependency on forest in district Bagh AJK. Primary data were collected through questioner method and 24-hour weight survey method were used to quantify fuel wood consumption. They estimated that annually 509086 metric tons fuel wood used for cooking and heating, which is about 3kg/capita/day. Mirza (2007), investigated the consumption of fuel wood energy in Pakistan. Study based on qualitative method. The study observed that fuel wood, crop residues, dung is major source of domestic energy in Pakistan. Annually an average household consume 1480kg of dung, 2325kg of fuel wood and 1160 kg of crop residues in Pakistan.

Ali (2016), investigated the impact of fuel wood consumption forest. Primary data were collected through questioner method and descriptive statistics were used to find average consumption. The study concluded that 324kg/per week fuel wood use for cooking and heating in Kalam valley Pakistan. Zaman (2012), determined the overall demand and supply of fuel wood consumption in Pakistan predict fuel wood shortage and develop future strategy. The study concluded that fuel wood not only use in household sector, but it is also use in commercial and industrial sector. GOP (2005), estimated that 75% of the rural household use fuel wood for cooking while 14% for water heating and 11% for room heating. In the commercial sector fuel wood has been estimated about 3.3%. industrial sector consumption based on different product such as charcoal making 8%, bricks making 20%, tobacco curring 3% and other industries 18%.

Jan (2012), investigated the adoption improved cook stoves for household and communities. Primary data were collected through simple random sampling and secondary information were collected form NGOs and local government. Binary logistic regression was used against improved cook stove and unimproved cook stove. The study concluded that 20% of the total sampled households use improved cook stove. Study suggest that rate of improved cook stove may increase, when NGOs and government give incentive on new technology. Colbeck (2010), reviewed the indoor air pollution due to biomass combustion. Data were collected through published articles. The study observed that there are limited studies have been undertaken regarding indoor air pollution. Indoor air pollution has different impact on health in Pakistan. They found that women and children are more frequently affected by indoor air pollution because they spend their more of time at home. Siddiqui (2008), measured the daytime indoor air pollution from wood and natural gas. Primary data were collected in winter season through questioner and interviewed method. Electrochemical monitor was used to determine Carbon monoxide and aerosol spectrometer for PM2.5. Arithmetic mean was used to find the average value between wood and natural gas user. The study estimated the mean value of carbon monoxide for fuel wood user is about 29.4ppm while 7.5ppm for natural gas users. The mean value of PM2.5 is 2.74mg/m3 for wood user and 0.38mg/m3 for natural gas user. They also found that time spend in kitchen during fuel burning significantly related to increasing carbon monoxide and PM2.5 in wood user. The study suggest that fuel wood user is hazardous form carbon monoxide and PM2.5.

Siddiqui (2005), compared the frequency of symptoms for health diseases among women during fuel wood and natural gas use. Primary data were collected through questioner method. Simple descriptive statistics were used to compare wood and natural gas user. 95% confidence interval and prevalence odds ratios were used to identify the symptoms of respiratory infection. Mantel Haenszel chi square test were used to examine the association of fuel. The study concluded that wood user is more frequently face the health illness as compare to natural gas user. The study also demonstrated that over all throat related, nasal congestion, eye congestion and cough symptoms are significantly related to fuel wood user.

CHAPTER 3

DATA COLLECTION AND METHODOLOGY

3.1 Theoretical framework

In the conceptual view of fuel wood energy systems FAO, (2004) introduces three different wood fuel supply sources such as natural forest, wood industries, and society. Nature for direct wood fuels derived from forests , wood industries for indirect wood fuel derived as residues and by-products and society for discarded wood recovered for wood fuels from abandoned wood products, including old furniture and demolition wood from old constructions. The UBET (2004) defines wood fuels as all types of biofuels originating directly or indirectly from woody biomass. It includes the trees and shrubs grown on forest and non-forest lands, as well as industrial by products derived from primary and secondary forest industries which are used as fuel. However, Fuel wood energy use for cooking and heating with traditional cook stove, which produce high level of indoor air pollution. According to Smith (2001), fuel wood contain many pollutant such as carbon monoxide, particulate matter, sulfur oxide and nitrogen dioxide. These pollutant have been tested, with varying degree of evidence as a causal agent of several disease in the developing countries such as eye congestion, throat pain, cough, hand burn and breathing difficulties.

To reduce these health problem, we use the model of the domestic health production function to estimate the economic benefits of reducing indoor air pollution due to fuel wood burning in the rural area of district Abbottabad. Reducing air pollution leads to reduce pain and improve human productivity. This appears in terms of higher utility because utility is function of consumption, leisure, health and intensity of indoor and outdoor pollution in your surrounding areas. Therefore, by following Freeman (1993), the maximizing behavior of an individual's utility can be defined as follows;

$$U = U(X, L, H, Q) \qquad (A)$$

Where X is the consumption of marketed goods, L represents the leisure time available per period to an individual, H denotes work days lost per month due to fuel wood use and Q shows the ambient level of air pollution. An individual's work days lost due to air pollution may depend on mitigation activities with the given level of air pollution (Q) given his health status and other socio-economic characteristics. Hence, the household's health production function can be written as;

H = H (M, Q) (B)

Where,

H: work day lost due to indoor air pollution

M: Mitigation activities

Q: ambient air pollution

H could represent the individual's health status and is measured as number of days of illness. Among the mitigating activities (M) includes duration of cooking, energy source, kitchen type, use of mask during cooking, number of window in kitchen and number of persons involved in cooking. The model assumes that individuals could maintain a given health status even with higher ambient air pollution through the choice of mitigating activities. It means that there are substitution possibilities between precautionary measures and the fuel wood use. Now budget constraint of an individual can be specified as:

I = Y + w(T-L-H) = X + P_mM (C)

Where, Y is non-wage income, w is wage rate, (T-L-H) is time spend at work (T is total available time), P_m is the price of per unit of mitigating activity.

Given the pollution level (Q), price of mitigation activities (P_m), wage rate (w), income (I) and other exogenous variable, individuals maximize equation A with respect to X,M, and L given the budget constraint in equation C. By solving the utility maximization problem following problem,

MaxG=U(X, L, H, Q) + £ [Y + w(T- L- H) - X - P_mM

We obtain the individual's demand function for mitigation activities, and the marginal willingness to pay function for air quality improvement (MWP) as

M = M (P_m, H, Q, X)…………………………..(D)

MWTP = w.dH / dQ + P_m dM / dQ + (du / dH) . dH / dQ/l………….(F)

This expression in equation (E) shows that the MWTP for health benefit from pollution reduction is the sum of reduction in cost of illness, cost of mitigating and the monetary benefit realized due to decline in disultilty of illness. The estimation of MWTP requires the estimation of the health production function (B) and the demand function (D) simultaneously. Alternatively, a reduced form dose response function with health as a function of pollution and other variables can be estimated. This can be combined with the estimated demand for mitigating behavior and wage information to obtain a lower bound for (F) (Freeman 1993). This generates lower bound estimate because it does not take into account disutility from sickness (the last expression in (F)).

3.2 Study area

The study took place in district Abbottabad. According to census (2017), the total population of district Abbottabad is 1.3 million, rural population is 1 million while urban is 0.03 million. Rural areas of Abbottabad are hilly and most of them have no excess to natural gas. People of these area use fuel wood for cooking and heating. Especially people of Gallies forest division depends on fuel wood. Gallies forest division of district Abbottabad was created in 1920 and consisting of 5 subdivision which are Abbottabad Forest Sub-Division, Thandiani Forest Sub-Division, Bagnotar Forest Sub-Division, Dungagali Forest Sub-Division, and Birangali Forest, which lies in District Abbottabad. Bagnotar and thandiani forest division are selected for the study, because almost all population depends on fuel wood consumption in these areas.

Abbottabad is the city of Pakistan, which lies in Khyber Pakhtunkhwa province. The total area of district Abbottabad is 1969 km^2 and it is capital of Hazara Division of eastern Khyber Pakhtunkhwa (KPK) Pakistan. It is about 120Km, in the north of Islamabad and Rawalpindi and 150km east of Peshawar. Abbottabad has a humid subtropical climate, with mild to warm temperatures during the spring and autumn months, hot temperatures during June and July, and cool to mild temperatures during the winter. Based on weather report 2005-2015 the average temperature during the summer (May to June) is about (25°C) and an average temperature of winter (December to January) is about (7°C) during the extreme cold waves. Snowfall occurs occasionally in December and January, though it is sparse, while average annual rainfall is about 1126.9mm (per year) (timeanddate).

3.3 Data collection

The study is conducted during 2018 and data for fuel wood use, human health and rural livelihood is collected during the month of June and July from the district Abbottabad. A multistage technique was employed. At first stage district Abbottabad is selected because its forest area is about 199710 acres and 7th largest forest area in KPK. In second stage purposely Gallies forest division was selected, it has five subdivisions. In third stage, two subdivision are selected such as Bagnotar and Thandiani that has 6 and 5 villages respectively. From each division 3 villages are selected. According to 2017 census the population of Bagnotar is 13861 and Thandiani has 22000. Thirdly, 150 observations are selected from fuel wood users and selected 25 respondents from each village randomly. Lastly, 100 respondents are selected from the wood user and 100 respondents from natural gas user to find the impact of fuel wood consumption on human health. According to statistical formula our sample size should be 384.16 but we construct our sample size to 150 because our time and resources are limited. The sample size of our study is still enough because some publish study also use small sample with high population. The study of Indian state of Uttar Pradesh selected 233 household for the study with 132 million population (Reddy et al., 1999). The study of Chiradzulu District in southern Malawi selected 160 total sample size with the population of 236,000 (Kamanga et al., 2009). The study of Nepal collected data from 100 household with the population of 212,484 (Khatri et al., 2006). The study of the district Ciskei homeland in South Africa selected 110 sample size with the population of 677,920 (Shackleton, 2006). Two questionnaires are use to gather the data, one to cover the aspects of collection and livelihood and second to cover the consumption and health impacts. After pretesting, a well-developed questionnaire implemented to gather the information regarding the amount of collection of fuel wood, income from wood selling, family size, and information about socioeconomic factors. Then specifically fuel wood consumer and non-consumer households targeted to get information regarding fuel wood consumption and its negative impact on human health. The information about other socioeconomics factor affecting the fuel wood consumption and related information about the kitchen size and number of the family member involved in cooking is also collected. Particularly frequency of health symptom is also collected to investigate the impact of fuel wood consumption on health symptoms.

3.4 Methodology

The **first** objective of our study is to quantify the sources of energy for cooking and heating at the household level. To achieve this objective, we enquired about different sources of energy (fuel wood and LPG) and amount used. For this purpose, simply we ask the amount of fuel wood and LPG used and then attempted to explore the share of each source in total consumption. Finally, descriptive statistics are used to compare the sources.

The **second** objective of the study is to determine the factor affecting fuel wood consumption at household level. Fuel wood consumption depends on economic and socioeconomic factors. Price of LPG (a cleaner substitute of fuel wood consumption) is related with economic factors determining the fuel wood consumption. The high price of LPG is expected to drive the household to depend more on fuel wood consumption. Total income of the family is expected to have a negative impact on fuel wood consumption because high income motivates to shift towards cleaner sources of energy (LPG). Besides income, technically illiteracy and fear of cylinder could offset the income effect by making the contribution of income insignificant. Among the socioeconomic factors, Education of household head, family size, average distance from home to collection point and the number of family members involved in the collection process are expected to affect the fuel wood consumption. High level of education creates awareness about the negative impact of fuel wood consumption (which is assumed to be a dirty source of energy) and therefore, high education is expected have negative impact on fuel wood consumption. It is assumed that family with higher education of household head is expected to have better knowledge about the negative impact of fuel wood consumption on health. Higher education of household head also has better opportunities to earn income which will lead to reduce his dependency on fuel wood consumption. The large family is required more energy for cooking and keeping the house heated. Moreover, higher is the family more will be the economic pressure on the family. Jointly these two effects are expected to restrict the family to move towards cleaner energy source and therefore, family size is expected to have positive impact on fuel wood consumption. Distance from home to collection point taken in average because in the study area there are more than one wood collectors in many families and each could go in different direction to collect wood. Even both can go in different days of the month, implying that distance from home to collection point could vary for each collector and in different direction of different days of the month. Hence, we take average distance (home to collection point) of each household and over the different collection points. Average distance from home to collection point adversely affects the amount of fuel wood collection. Large distance leads to less amount of collection because large time goes in traveling and then there is less time for collection. This implies large distance from home to collection point is expected to lead lower consumption because of having less amount of collection. However, if there are more family people involved in wood collection process then family has large stock which is expected to motivate more consumption. This implies more number of family members involved in collection is expected to lead higher consumption. In the light of this discussion, the linear model for fuel consumption is expressed as,

$$Y_i = F(X) + e_i \qquad (1)$$

Where: X is the vector of explanatory variable

$\boldsymbol{Y_i}$ = Average fuel wood consumption (Kg/day),

$\boldsymbol{X_1}$ = Education of household head (year)

$\boldsymbol{X_2}$ = Family size (number of persons in household),

$\boldsymbol{X_3}$ = Average distance from home to collection (km)

$\boldsymbol{X_4}$ = LPG price (price + travel cost) (RS. /kg)

$\boldsymbol{X_5}$ = Number of wood collector in the family (Number)

$\boldsymbol{X_5} = \text{Total income}$

Fuel wood consumption significantly varies across seasons and therefore, average of two seasons (winter and summer) is used as dependent variable. Ordinary least square (OLS) model is employed to investigate the relationship between dependent and independent variables.

The **third** objective of the study is to determine the factor affecting total income in rural livelihood. Total income of the household is taken as a dependent variable and it depends on socioeconomic factors. Among the socio economics factors, fuel wood collection (predicted), sex of the household head, education of household members above 20 years, uneducated of household members above 20-year and market distance are expected to affect the total income. Fuel wood collection is taken as a predicted variable and it is expected to have positive impact on total income. Increase in the amount of fuel wood collection lead to increase in selling, which leads to increase in total income. Sex of the household head is taken as a dummy variable (male=1 and female=0) and it is expected to have negative impact on total income. Female-headed household often have less access to labor and less stamina to work more, which lead to decrease in total income. The number of family members above 20 years of age is divided into two groups. In the first group, only those family members are included whose education more than 10 years of schooling.

In the second group, only those family members who have education less than or equal to 10 years of schooling are included. This implies two variables. In the first variable, the number of family members who have more than 20 years of age, but education is more than 10 years of schooling. In the second variable, only those family members are included whose education less than or equal to 10 years of schooling. The young family members (above age 20) with less education is also expected to have positive impact on total income but its effect is less than those who have education more than 10 years of schooling. Market distance is measured in kilometer (km) and it is expected to have a negative impact on total income because the large distance from home to market lead to decrease in job opportunities. It is mainly because individual get lazy to travel more to avail all the opportunities efficiently. That is why the increase in market distance lead to decrease in total income. The number of wood collector in the family is taken as an instrumental variable in fuel wood collection. It is expected to have positive impact on fuel wood collection. Increase number of persons in the collection process lead to increase in fuel wood quantity, which leads to increase in total income. Total hours spend is the instrumental variable of fuel wood collection and it is measured in hours. Total hours spend is expected to have positive impact on fuel wood collection. Increase in time spends in collection process lead to increase in fuel wood quantity, which leads to increase in total income. In the light of this discussion, the model for total income can be written as below. Regression line as follows,

$Y_1 = \alpha_0 + \beta_1 X_1 + \beta_2 Y_2 + \ldots\ldots\ldots \beta_5 X_5 + e_i$ (2)

$Y_2 = \alpha_0 + \beta_1 X_{21} + \beta_2 X_{22} + e_i$

Y_i = Total household income (RS. /month)

Y_2 = fuel wood collection, (kg/day)

X_1 = sex of household head, (dummy)

X_2 = Household size (number of people in house),

X_3 = Number of family member above 20 years of age with more than, 10 years of schooling

X_4 = Number of family members above 20 years of age with less than or equal to 10 years of schooling

X_5= market access (non-forest product), (km)

X_{21}= number of wood collector in the family,

X_{22}= total hours spend in collection process (hours).

There are more than one family members who work for income therefore, we take total income of the household as a dependent variable. In the above model one variable such as “fuel wood collection” is endogenous variables, because it further depends on other variables like time spends in collection and family members involved in fuel wood collection. Hence, we used instrumental variable (IV) regression approach and employed two stage least square (2SLS) regression model. The approach corrects the endogeneity variable through instrumental variables.

The second component of **third** objective of the study is to determine the factor affecting fuel wood income in rural livelihood. More precisely, we specifically focus to investigate the wood income. Again, we employed an instrumental variable (IV) regression model because of endogeneity problem. Fuel wood income of the household depends on explanatory variables like amount of wood collection (predicted), distance from home to collection point, family size, average wood consumption at home and education of household head are expected to affect the fuel wood income. Since, the amount of wood collection further depends on factors like time spend in collection and number of family members involved in the collection and therefore, the amount of wood collection is treated is endogenous. Fuel wood collection measured in kilogram (kg) per day and it is expected to have a positive impact on fuel wood income. Increase in fuel wood collection leads to an increase in wood selling, which leads to an increase in fuel wood income. Distance from home to collection point is measured in kilometer (km) and it is expected to have a negative impact on fuel wood income. Increase in distance lead to increase in traveling time and people become lazy to travel more, which lead to an increase in fuel wood income. Family size is expected to have a positive impact on fuel wood income. Increase in family size multiplies the economics pressure which may motivate family member to work more to increase from fuel wood collection. Average fuel wood consumption is measured in kilogram (kg) per day and it is expected to have negative impact on fuel wood income. Increase in fuel wood consumption means that people use most of the fuel wood in cooking and heating instead of selling it in the market to increase income. Higher demand for fuel wood in cooking and heating process lead to decrease in fuel wood income. Education of the household head is taken as year of schooling and it is expected to have negative impact on fuel wood income. The educated household head may have a better job and earn more income as compared to uneducated person. Higher family income may lead to decrease the dependency on fuel wood income. Hence, the family with higher income can prefer to use fuel wood for cooking and heating instead of selling because high income is enough to fulfill their basic needs. The number of wood collector is used as an instrumental variable for fuel wood collection and expected to have a positive impact on fuel wood collection and income. Increase in the number of wood collector means more persons are involved in the collection process which leads to increase in fuel wood collection and income. Total hour spends in the collection of fuel wood is the second instrumental variable for fuel wood collection and it is expected to have positive impact on fuel wood collection. Higher time spends on fuel wood collection lead to increase the amount of wood quantity which may lead to increase in fuel wood income. However, in the light of above discussion fuel wood income modeled as below.

$$Z_1 = \alpha_0 + \beta_1 W_1 + \beta_2 Z_2 + \ldots\ldots\ldots \beta_4 W_4 + e_i \quad (3)$$

$$Z_2 = \alpha_0 + \beta_1 W_{21} + \beta_2 W_{22} + e_i$$

Z_1 = Fuel wood income (RS. /month)

Z_2 = Total wood collection, (kg/ day)

W_1 = distance from home to collection point, (km)

W_2 = family size (number of person)

W_3 = average wood consumption, (kg/day)

W_4= education of household head, (year of schooling)

W_{21}= number of wood collector,

W_{22}= total hours spend in collection process (hours)

In the above model "fuel wood collection" is endogenous and therefore, we employed the IV regression model or two-stage least square (2SLS) model.

The **fourth** objective of the study is to investigate the impact of fuel wood consumption on human health. In the household survey, we inquired about five health symptoms (throat pain, cough, breathing difficulties, eye congestion, and hand burn) faced by cooker during the last one month. If there are more than one cooker in the family then we investigate the health symptoms form each cooker individually and then finally we add all these health symptoms to generate a count variable (total frequency of health symptoms) and set as a dependent variable in the model. Initially, many analysts prefer linear regression model with count data but Ordinary Least Squares (OLS) regression is representing traditional statistics. However, the assumptions of Ordinary Least Square (OLS) are not satisfied with count data (Maxfield & Babbie, 2001). The OLS based on a continuous dependent variable, which means that the data must be normally distributed (McClendon, 1994). However, count data do not follow the assumptions of OLS because count data could have small values and zero often being the most commonly observed value. However, these conditions violate the above mention assumptions of OLS regression. Poisson and negative binomial regression models are designed to analyze count data. There are rare events where count data are controlled with the formulas of both poison and negative binomial regression model. However, Poisson and negative binomial regression models are differing with regard to their assumptions. Poisson regression model assumes that the variance and the mean of the distribution are equal and negative binomial regression reject this assumption. Negative binomial regression is favorable when the data is over dispersed, which mean that variance is greater than the conditional mean (Osgood, 2000; Paternoster & Brame, 1997). Many analysts noted that count data hardly shows equal variances and means, which lead to increase the acceptance of negative binomial regression (MacDonald & Lattimore, 2010). Hence, the Poisson regression model is likely to be misleading unless restrictive assumptions are met because individual counts are usually more variable "over dispersed" than is implied by the model (Gardner et al. 1995). Choosing between Poisson and negative binomial models depends on the nature of the distribution of the dependent variable. Analysts commonly select negative binomial regression mainly because the assumptions of Poisson models are often not observed with social data. However, Poisson distributions are far from nonexistent, with some researchers even observing the presence of both Poisson and negative binomial distributions within the Same study (see, for example, Braga & Bond, 2008). Therefore, analysts should measure the distribution of their data before choosing between Poisson and negative binomial regression. Measuring the distribution of count data is a fairly straightforward process. Particularly, Pearson Chi-Square goodness-of-fit tests can be incorporated along with exploratory Poisson regression models to measure the distribution of the dependent variable. This simple test Identifies the distribution of the data and ensures the selection of the correct statistical model. If y is the frequency of health symptoms faced by cookers then poison distribution can be written as,

$$Pr\left({}^{y_i}/_{x}\right) = \frac{exp(-\mu)\,\mu^{y_i}}{y_i!}$$

where yi is the number of acute symptoms faced by the cooker during the last one month, which varies across cookers (i=1…., n). Poisson distribution is assumed to have conditional mean (μ_i), which in turn depends on vector of exogenous variables x_i. The most common formulation of μ_i used in the literature is log linear model which can be expressed as:

$$Ln\,\mu_i = \dot{\beta} x_i$$

where $\dot{\beta}$ is a vector of coefficients and x_i is a vector of explanatory variables that includes duration of cooking, dummy for energy source (wood or natural gas), dummy for kitchen type (close or open kitchen), dummy for using mask, number of cooker and number of windows in kitchen. In the light of above discussion, the empirical model to explore the factors affecting frequency of health symptoms faced due to fuel wood consumption can be written as,

$Y_i = \alpha_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots\ldots \beta_5 X_5 + e_i$ (4)

Y_i = frequency of health symptom faced by family members involved in cooking

X_1 = duration of cooking per day (hours)

X_2 = energy source (fuel wood use=1 otherwise zero)

X_3 =kitchen type (Close kitchen=1 otherwise zero)

X_4 = mask using (if cooker using mask =1 otherwise zero)

X_5 = Number of cookers

X_6 = Number of windows in kitchen

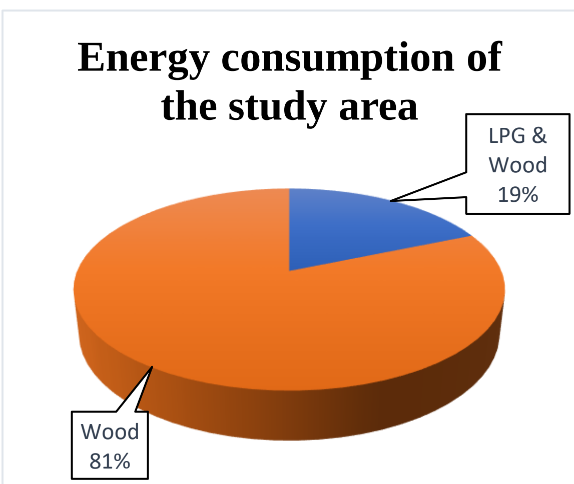
Duration of cooking is measured in hours and it is expected to have a positive impact on the total frequency of health symptoms. Increase in cooking hours per day leads to an increase in health symptoms. Dummy for energy source (fuel wood=1 otherwise zero) is expected to have positive impact on health symptoms. Fuel wood user is expected to have more frequency of health symptom because they expose more frequently to smoke which lead to increase in health symptoms. Kitchen type (open=1 otherwise zero) is expected to have positive impact on health symptoms. Close kitchen poses higher level of health risk because probability to inhale in clean is decreased while working in the close kitchen, which leads to increase in health symptom. Use of mask during cooking taken as dummy variable and it is expected to have negative impact on health symptoms. The person who use mask during cooking expected to faceless health symptom. The number of cooker in the kitchen is expected to have positive impact on health symptoms. If more than one family member is involved in the cooking process, then total health symptoms faced by that family is expected to be higher compared to the situation where only one family member is involved in the kitchen. Window in the kitchen is expected to have negative impact on frequency of health symptoms. Increase windows in the kitchen increase the probability to inhale comparatively in fresh air that leads to decrease in health symptoms.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Wood consumption

It is observed that the large amount of valuable wood is being used for cooking and heating in the rural community of district Abbottabad. Our survey indicates that 81% of the total respondent in our sample are using fuel wood for cooking and heating and only 19% are partially depends on LPG (Figure 1). Current study revealed that During summer season (from May to September) each household consume about 438kg of fuel wood per month, while in winter season (from October to April) this consumption increases to 600kg/month due to additional demand of energy for hot water and to maintain the room temperature (Table 1). However, the average consumption of summer season is about 15kg/day/household while in winter season 20kg/day/household (Table 1 and Figure 3). This implies that one person is using about 514kg of fuel wood in winter season while this consumption decreases to 375kg/capita in summer season on an average 444.5kg/capita/year of fuel wood is being used in the study area (Table 1). It reveals that consumption of fuel wood in winter season is 28 percent is higher than the summer season. The rural population of District Abbottabad is about 0.9 million. Under the assumption that our sample is truly representing the rural population then this implies that 0.33-million-ton/year of fuel wood is being used in the rural areas of District Abbottabad.



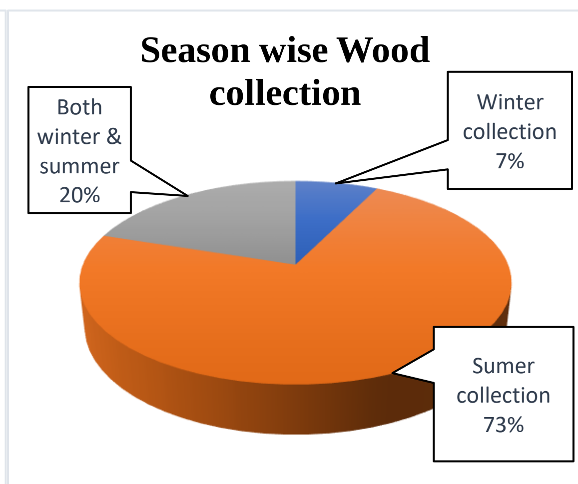


Figure 1 **Figure 2**

The use of (LPG) is recorded to 1.5kg/day/household in summer season, while in winter season this consumption increases to 2.2kg/day/household (Table 1 and Figure 3). The consumption of LPG is very low as compare to fuel wood because of high price (Rs.220/kg/day/household) of LPG, which is not bearable for the poor rural community.

However, the consumption of fuel wood comes from nearby forest. We observed that people collect fuel wood both in winter and summer season, but 73% of the total sampled household collect fuel wood in only summer season, while 7% only in winter while 20% both winter and summer season (Figure 2). Comparatively the percentage of wood collection in summer season is very high because of two reasons. First, majority of the study areas face heavy snow fall in winter season and the day length get quite short which restrict the wood collection activities to very limited range. Second, majority of the household have livestock which they bring with them while going for wood collection. They cut trees and green part goes to the livestock while the stem of the tree is used as fuel wood. In winter season it becomes hard to bring animals with them in the field and moreover it becomes hard to cut trees in winter season and to work in the field while temperature is negative. That is why very few people go to forest to collect wood in winter season.

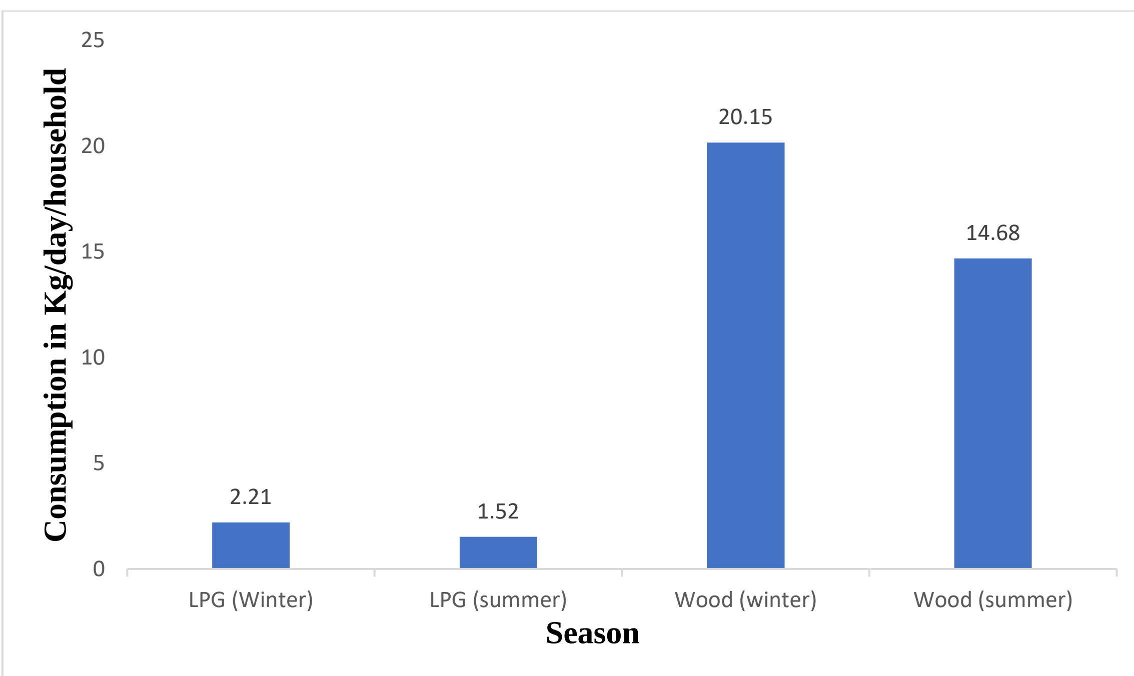


Figure 3. Average wood and LPG consumption/day/household (Kg)

4.1.1. Discussion

Dependency on the forest for fuelwood is causing severe deforestation in the Himalayas region (Ahmed et al., 2006). The present study revealed that fuelwood consumption among the rural communities of district Abbottabad ranged from 2.14 to 2.85kg/day/person with an average of 2.49/kg/day/capita (Table 1), which seems considerably higher than the value reported for the rural communities of Himalayas was about 1.49/kg/day/capita (Bhatt er al., 1994); South and South-East Asian countries are reported to consume 1.7-2.5kg/day/capita (Donovan, 1981); southern India reported 1.9-2.2kg/day/capita (Hedge, 1984); Himalayan range of Nepal recoded 1.23kg/day/capita (Mahat et al.,1987). Bhatt and Sachan, (2004) observed that the fuel wood consumption differs according to household size, large family size needs more fuel wood than those of small and medium families.

Table 1. Per household/per capita consumption of fuel wood & LPG (kg) in study area

Consumption Pattern	Winter season		Summer season		Total LPG	Total wood
	Wood	LPG	Wood	LPG	(kg)	(Kg)
Average Consumption/day/household	20	2.2	15	1.5	3.7	35
Average Consumption/month/household	600	66	438	45	111	1038
Average consumption/6 month/household	3600	396	2628	270	666	6228
Consumption Per day/per capita	2.85	0.31	2.14	0.21	0.52	5
Consumption Per month/per capita	85.71	9.4	62.57	6.4	15.8	148.3
Consumption Per year/per capita	514	56.5	375	38.57	95	889

Note: *winter season; October to April and summer season; May to September*

Note: *For finding per capita consumption we divide average household consumption by average family size, the average family size of the study area is seven (7).*

Fuel wood consumption is one of the main cause of deforestation in district Abbottabad, as the winters are very long. The local people are mostly illiterate with an average of 10.32-years of education and unaware about the conservation of valuable trees. They just took his/her ax and go to the nearest forest and cut trees. As we have observed above that 0.33 million-ton/year of the valuable wood use for cooking and heating in the study area. About 73% of total wood is being collected in summer season (Figure 2), it is observed that this is the growing season of trees and if trees will be harvested at the early stage then this will lead to deforestation. One of the very severe impacts of repeated fuelwood harvesting on the structure of the forest is the ruthless decline of large and old trees resulting in their complete disappearance. Due to indiscriminate deforestation for fuel purpose, the forest cover is on rapid decline and valuable indigenous tree and plant are in danger and if this trend continues, these forests will be ultimately wiped out

4.2 Descriptive statistics

Average fuel wood consumption is taken as a dependent variable in the equation one and it is measure in kilogram (kg) per day. The consumption of Fuel wood is significantly varying across seasons and therefore, average of two seasons (winter and summer) is used. The average consumption fuel wood in winter season and summer season is 15 and 20kg/day respectively (Table 1). Education of the household head is taken as an explanatory variable in equation one and three, it is measured in year of schooling. The mean value of education of the household head in the study area is 10.32 years of schooling and the standard deviation is 3.92 (Table 2). Average distance from home to collection point taken as an explanatory variable in equation one and it is measure in kilometers (Km). The average distance from home to collection point is about 2.698km and the standard deviation is 1.573 (Table 2). The family size is taken as an explanatory variable in the equation one and it is measured in numbers. The mean value of family size in the study area is 7.168 person and the standard deviation as 3.845 (Table 2). Number of wood collector taken as an independent variable in equation one and it is measured in number of persons involved in fuel wood collection in the family. The average number of wood collector in the household is 1.74 person and the standard deviation is 0.736 (Table 2). Total income is the dependent variable of equation two and it is measured in rupee/month.

The average household income in the study area is about Rs.39880.77 and the standard deviation as 19009.44 (Table 2). After investigating the role of fuel wood collection on the family's total income we moved one step ahead to investigate the determinants of fuel wood income itself. Hence, income earned by selling of fuel wood is taken as dependent variable of equation three and it is measured in rupee/month. The average fuel wood income of the house hold is 6793 and the standard deviation is 9349.37 (Table 2). Fuel wood collection is the endogenous variable in equation two and three. Therefore, it is important to correct the endogeneity in order get unbiased estimated of equation 2 and 3. Fuel wood collection is measured in kilogram/day. The average fuel wood collection of the household in the study area is 30kg/day and standard deviation as 17.23 (Table 2). Access to market is taken as an explanatory variable in equation two and it is measured in kilometer (Km. The mean distance is about18.335Km and the standard deviation as 7.139 (Table 2). Since, adult young people play a significant role in the family's income. Further, a young guy with education higher than matriculation contributes more in the family's income than with no education or only 10 years of schooling. Because college or university level education help to enter in better job market than without or low-level education. Hence, we divided the working labor into two categories. One, household members above 20 years of age with an education above 10 years of schooling and second, above 20 years of age but education with less than or equal to 10 years of schooling. We named the first category as educated and second as non-educated family members in working class of family members. The average number of educated persons in the household is 1.926 and the standard deviation is about 1.26 (Table 2) while uneducated household members who are above 20 years of age are household is 3.31 and the standard deviation is 2.97 (Table 2). It clearly demonstrates that educated family members in working class are less than non-educated family members in our sample. Total hours spent in the collection of fuel wood is taken as an instrumental variable of fuel wood collection in equation two and three, it is measured in hours because more time spends in the collection will lead to higher amount of fuel wood. The total hours spend in wood collection process is 2.13 hours/day and the standard deviation is about 0.93 (Table 2). The frequency of the health symptom is taken as dependent variable in equation 4. It is the summation of the frequency of five different health symptom (throat pain + cough + eye congestion + breathing difficulties + hand burn). The average frequency of wood user is about 5times/month, while among natural gas users it is about 3times/month (Table 2).

Table 2. Descriptive statistics

Variable	Mean Value	Minimum value	Maximum value	Standard deviation
Education of the household head (Year)	10.326	3	18	3.932
Average distance from home to collection point (Km)	2.698	0.25	6	1.573
Family size (Number)	7.168	2	10	3.845
Number of wood collector in the family (number)	1.74	1	3	0.736
Total income (Rupee/month)	39880.77	10000	100000	19009.44
Fuel wood income (Rupee/month)	6793	1000	35000	9349.37
Fuel wood collection (kg/day)	30	10	35	17.23
Market access (Km)	18.335	4	35	7.139
Number of family members above 20 years with education greater than 10 years of schooling	1.926	0	5	1.26
Uneducated family member above 20 years with education less than 10 years of schooling	3.31	0	10	2.97
Total hours spend (hours)	2.13	1	6	0.93
Frequency of health symptom for wood users	5	0	22	4.459
Frequency of health symptom for natural gas users	3	0	11	2.770
Duration of cooking (hours)	2.66	1	6	1.26
Number of windows in kitchen	2.47	0	5	1.706

Duration of cooking is taken as an explanatory variable in equation 4 and it is measured in hours of cooking. The mean duration of cooking in the study area is 2.66hours and the standard deviation is 1.26 (Table 2). The number of windows in kitchen is taken as an explanatory variable in the equation 4 and it is measured in number. The average number of windows in kitchen is 2.47 and the standard deviation is 1.706 (Table 2).

4.3 Factor influencing fuel wood consumption

Ordinary least square (OLS) model is used to explore the impact of different explanatory variables on fuel wood consumption. Our empirical results indicate that all variables have positive impact on fuel wood consumption except total income, education of household head and average distance from home to collection point.

Family size is found to have a positive impact on fuel wood consumption and the coefficient is highly significant at one percent level implying that one person increases in the family size lead to increase in fuel wood consumption by 0.64kg/day (Table 3). The positive impact of family size on fuel wood consumption is logical because large family size leads to increase in food demand, which leads to rise in fuel wood consumption. The average price of LPG is positively affecting the fuel wood consumption and the coefficient of LPG is statistically significant at one percent level. The coefficient shows that one rupee increases in LPG price lead to increase fuel wood consumption by 0.0056kg/day (Table 3). This implies that if prices increase by Rs.10/kg then the fuel wood consumption will increase by 1.5kg/month. The small impact of LPG prices on wood consumption is mainly because LPG users are consuming fuel wood consumption at a very small rate, only when LPG is not available in the market. However, if prices of LPG significantly reduced (through subsidy) then the poor segment of the society will also shift to LPG. Under that scenario impact of the increase in price of LPG would be significantly higher on fuel wood consumption. Hence, we can conclude that in order to shift the fuel wood consumer to LPG, prices have to be declined drastically through subsidy or some alternative approach. This could lead to preserve the forest resource for future generation. The number of wood collectors is also positively affecting the fuel wood consumption. The coefficient of wood collector is statistically significant at one percent level. The coefficient shows that one person increases in wood collection process lead to increase in fuel wood consumption by 2.46kg/day/family (Table 3). The positive impact of wood collector is logical because more wood collectors in the household lead to increase in wood collection. It is observed that population is heavily depends on fuel wood for their energy needs. Carefully, if we assume that only 50 percent of the families in the study area are involved in wood collection process and if only one person increases in 50 percent of the families then fuel wood consumption will increase by 2372 ton/month. This clearly indicates that how unemployment in the area can lead to diminish the forest resources. Hence, to protect the forest resources in the area government need to create employment opportunity to protect the valuable forest resources.

Table 3. Factor that effecting fuel wood consumption

Dependent variable: Average fuel wood consumption	
Independent variables	**Coefficient**
Family Size (number)	0.644*** (0.105)
Average LPG price (rupee/kg)	0.005*** (0.000)
Number of wood collector (number)	2.467*** (2.21)
Education of household head (year)	−0.248** (0.117)
Average distance from home to collection point (Km)	−1.139*** (0.117)
Total income	−0.00 (0.00)
Intercept	7.377*** (2.219)
R-Square	0.685
Adjusted R-Square	0.674
F-statistics	0.000

Note: ***, **, * represents the significance level at 1%, 5%, 10% respectively and Standard error in parenthesis.

Education of the household head is negatively affecting the fuel wood consumption and coefficient of education is significant at five percent level. The coefficient shows that one-year increase in education of household head leads to decline in fuel wood consumption by 0.24kg/day/family (Table 3). The negative impact of education is logical and consistent with economic theory because education leads to improve awareness about health and health preservation of natural resources like the forest. Hence, the more informed person about health will decide to decrease the consumption of fuel wood because of better knowledge about its negative effect on human health. Another reason of negative coefficient could be due to increase in income because educated person has more job opportunities, which leads to increase in total income. However, in our case income from other source has negative but insignificant impact on fuel wood consumption.

The coefficient of income from other sources is zero which demonstrate that total income has negligible negative impact on fuel wood consumption as explained above. Another reason of insignificant effect of income might be because most of the people prefer tradition way of cooking and taste of food prepared with wood. Our result is consistence with smith's (2004) study, which investigated that household do not substitute fuel wood with LPG when their income increases. We also investigated the combined impact of education of household head and total income of the family on fuel wood consumption. The coefficient is positive and insignificant, implying that education of household head and family income jointly does not have any impact on fuel wood consumption (Appendix Table 7). Insignificant impact of income might be because of low literacy rate among female in the study area, making them fear to use of cylinder (LPG). However, this issue needs to be further investigated. This implies that the provision of education at cheaper prices can contribute to improve the preservation of valuable forest resources besides improving the health consequences of female working in the kitchen. Average distance from home to collection is also negatively affecting the fuel wood consumption. The coefficient of average distance is significance at one percent level. The coefficient of average distance shows that one kilometer (1km) increase in distance leads to decrease in fuel wood consumption by 1.13 kg/day/family (Table 3). The negative impact of average distance is logical because small distance from home to collection point lead to rise in wood collection and more collection lead to increase in fuel wood consumption. This implies that in order to preserve the forest resources, new colonies or villages should be established away from the forest.

In the above discussion, we know that all the explanatory variables are statistically significant at one percent level except education of household head and average distance, which are significant at five percent level. The P-value of F statistics is (F =0.0000), indicates that the model is highly significant at one percent level. This implies that explanatory variables included in the model have strong power to explain the variability in the dependent variable. The value of R-square is (R^2=0.6855) indicating that 68.55 percent of the total variation in fuel wood consumption has been explained by explanatory variables included in the model (Table 3).

4.4 Determinants of total income in rural livelihood

Two-stage least square (2SLS) model is used to explore the impact of different explanatory variables on total income. In our regression model, fuel wood collection is endogenous variable, which could make the estimation bias and thus generate unreliable coefficient. We use Durbin Wu-Hausman test for endogeneity and our hypothesis are below:

H_0 = variable is exogenous

H_1= variable is endogenous

The p-value of Durbin Wu-Hausman test is zero, implying that null hypothesis is rejected in favor of alternative (Table 5). The test shows that variable fuel wood collection is endogenous. To solve the endogeneity problem, we take its predicted value and set two instrumental variables such as the number of wood collector in the family and total hours spent in the collection process.

In the first stage, we regress the amount of fuel wood collection against all explanatory and instrumental variables (number of wood collector in the family and total hours spend in the collection process). In our regression model, both instrumental variables are statistically significant, implying that instrumental variables are affecting the quantity of fuel wood and fuel wood collection is not exogenous. The number of wood collector and total hours spend is significant at one percent level. The coefficient of number of wood collector is positive, which shows that one person increases in collection process lead to increase in fuel wood collection by 8.61kg/day (Table 4). This implies that one person collects fuel wood collection about 258kg/month. The positive impact of number of wood collector on fuel wood collection is logical because an increase in the number of wood collectors in the family lead to increase in amount of fuel wood collection, which lead to increase in total income. The coefficient of total hour spend in the collection process is positive, thus implying that one hour increase in wood collection process leads to increase in fuel wood quantity by 4.38kg/day (Table 4). The impact of one hour increase in spending of wood collection is less than increase in one person in the wood collection which is logical because one person increases mean 8 hours increase in the collection process. Thus, the impact of increase in wood collector logically should be higher than the increase in time (measured in hours) spend in the wood collection process.

In the second stage of (2SLS), total family income is considered as a dependent variable. Family income includes income from all sources. The objective of this model is to investigate the impact of fuel wood collection on the family's livelihood. Among the explanatory variables include fuel wood quantity, number of educated persons in the family above 20 years of age, number of un-educated persons in the family above 20 years of age, sex of household head and market distance. In our regression model, all the explanatory variables are positively affecting the total income except average market distance. Fuel wood quantity is positively affecting the total income and it is significant at one percent level. The coefficient of fuel wood quantity indicates that one kilogram (kg) increase the fuel wood collection lead to increase in total income by Rs.435/month (Table 4). The positive impact of fuel wood quantity is logical because large amount of fuel wood quantity leads to increase in income from fuel wood, which leads to increase in total income. The average fuel wood income for each household is about 6793/month (Table 1). This implies that the share of fuel wood income is about 17 percent in total income. Number of educated persons above 20year age in the family is found to have positive effect on the total income. Our results demonstrate that one person increases of educated family member lead to increase in total income by Rs.6241.77/month (Table 4). The positive impact of educated person is realistic because educated person in the family is expected to have better excess to high-income employment opportunities, which lead to increases in total income. Number of uneducated persons in the family is also found have positive impact on family's total income. The positive coefficient of uneducated person in the family size implying that one person increase of uneducated person in the family leads to increases in total family income by Rs.842.11/month (Table 4). Comparison of coefficients demonstrates that the educated person in the family is contributing more in family's income than uneducated person in the family. Our study provides empirical evidence that education of masses could help to alleviate poverty in the study area because income of educated person is significantly higher than uneducated family member in the family. On the other hand, uneducated persons have fewer opportunities and they may have to work for daily wages, which lead to generate low income. Sex of household head is also positively affecting the total income. The coefficient of "household sex" shows that male-headed families have Rs.18659.47/month higher income as compare to female household headed (Table 4). The positive impact of "household sex" is rational because female-headed have less education as compare to male headed in the study area. Moreover, female worker has less employment opportunities and thus contributing less in total income. Female-headed household often have less access to labor market that lead to decrease in total income. The male headed have high education and more stamina to work as compare to female that leads to increase in total income. Market distance is negatively affecting the total income and it is observed that one-kilometer (km) increase in distance lead to decrease in total income by Rs.335.86/month (Table 4). The negative impact of average market distance is rational because large distance from home to market lead to decrease in job opportunities and people become lazy to travel large distance for job that leads lead to decrease in total income.

In the above discussion we observed that all the explanatory variables are statistically significant. However, this implies that our regression model is significant. In the first stage of our regression model, the P-value of F statistics is zero (F=0.0000), which conclude that the model is statistically significant at one percent level. In the second stage, the P-value of chi2 is (chi2=0.000), which show that the model is significant at one percent level.

The value of R-square in the first stage is (R-square= 0.5864), which shows that 58.64% of the variation in fuel wood collection is explained by all explanatory and instrumental variables included in the model. In the second stage, R-square value is 0.4696 implying that 47% of the variation in total income has been explained by explanatory variables included in the model (Table 4).

Table 4. Determinants of total income in rural livelihood

Variables	**Amount of fuel wood collection (dependent variable)**	**Total income of the family (dependent variable)**
	Coefficient (stage 1)	**Coefficient (Stage 2)**
Number of fuel wood collector (instrumental)	8.61*** (1.03)	--------
Total hours spend (instrumental)	4.38*** (0.94)	--------
Fuel wood collection	-------	435.09*** (110.24)
Sex of household head	-0.29 (2.54)	18659.47*** (2324.52)
Number of family member above 20 years with education greater than 10 years of schooling	0.40 (0.56)	6241.77*** (1013.80)
Uneducated family member above 20 years with education less than 10 years of schooling	-0.033 (0.26)	842.10*** (280.11)
Average market distance	0.073 (0.11)	−335.86* (175.26)
Intercept	-10.28** (2.59)	7796.56*** (4480.818)
R-Square	0.5864	0.4696
Adjusted R-Square	0.5681	------
Prob > F	0.00	------
Prob > chi2	------	0.000
Total observation	150	150

Note: ***, **, * represents the significance level at 1%, 5%, 10% respectively.

4.5 Determinants of fuel wood income in rural livelihood

Two-stage least square (2SLS) model is used to explore the impact of different explanatory variables on fuel wood income. In our regression model amount of fuel wood collection is endogenous variable, which could generate bias estimates therefore, need to correct endogeneity of amount of fuel wood collection. We use Durbin Wu-Hausman test for endogeneity and our hypothesis are below:

H_0 = variable is exogenous

H_1= variable is endogenous

The p-value of Durbin Wu-Hausman test is zero, implying that null hypothesis is rejected in favor of alternative (Table 5). The test shows that variable fuel wood collection is endogenous. In order to correct endogeneity of fuel wood collection, we used two instrumental variables number of wood collector in the family and total hours spends in collecting fuel wood.

Table 5 Test of endogeneity for total income and fuel wood income model

Test	Score		P-Value	
	Total Income model	Fuel wood income model	Total Income model	Fuel wood income model
Durbin Wu-Hausman chi2	15.91	12.17	0.0002	0.0005
Wu-Hausman F (1136)	16.15	12.65	0.0002	0.0005

In the first stage, we used the amount of total fuel wood collection as a dependent variable to resolve the problem of endogeneity and number of wood collector in the family and total hours spend in wood collection are used as instrumental variables. In our regression model, both instrumental variables are statistically significant. Number of wood collectors in the family and hours spend in wood collection are statistically significant at one and five percent level respectively. Number of wood collector in the family is positively affecting the total wood collection. The coefficient show that one person increase in collection process leads to increase in amount of fuel wood collection by 4.96kg/day (Table 5). This implies that the one person collects fuel wood about 148.8 kg/month and 1785.6/year. The positive impact is logical because increase in number of persons in wood collection will leads to increase in the amount offuel wood collection. The coefficient of total hour spends in collection is also have positive impact on the quantity of fuel wood. Our results demonstrate that one hour increase in wood collection lead to increase in fuel wood quantity by Rs.1.37kg/day (Table 5). This implies that one hour increase in wood collection/day lead to increase in wood quantity by 41kg/month and 493kg/year. The results are consistent with the economic theory.

In the second stage, fuel wood income is taken as dependent variable and among the explanatory variables includes, amount of total wood collection, family size, distance from home to collection point, average fuel wood consumption, and education of household head. Our result indicates that all the independent variables are affecting fuel wood income negatively except amount fuel wood collection and family size. The impact of fuel wood collection is positive, and coefficient demonstrate that 1kg/day increase in fuel wood quantity lead to increase in fuel wood income by Rs.361/month and Rs.4332/year (Table 5). This positive impact of fuel wood collection is logical because increase in amount of fuel wood collection will generate surplus of wood to sell in the market which leads to increase in fuel wood income. Family size is also observed to have positive impact on the fuel wood income. The coefficient of family size shows that one person increases in family lead to increase in fuel wood income by Rs.945/month and 11340/year (Table 5). The positive impact of family size on fuel wood income is consistent because large family size on one hand generates additional demand for consumption but on the other hand large family size also provides more labor to collect fuel wood. The positive coefficient indicates that second impact is dominant in our case and this is mainly because new peoples entering in labor force are not educated which compel them to work as fuel wood collector. The impact of family size would have negative impact if majority of people entering in labor market are educated and thus involved in other high-income generating activities. The coefficient of distance from home to collection point is negative implying that one km increases in distance lead to decrease in fuel wood income by Rs.8386/month and 100632/year (Table 5). This negative impact of distance is justifiable because increase in distance lead to decrease in wood collection due to spending productive time in traveling from home to collection point. With the increase in distance, working hours in collecting fuel wood declines that leads to decrease in fuel wood income.

Table 6 Determinants of fuel wood income

Variables	Amount of fuel wood collection as dependent variable	Income from fuel wood collection as dependent variable
	Coefficient (stage 1)	Coefficient (Stage 2)
Number of wood collector	4.96*** (1.33)	--------
Total hours spend	1.37** (0.54)	--------
Amount of total wood collection	-------	361.14*** (112.44)
Family size	0.34 (0.33)	945.43*** (260.50)
Distance from home to collection point	12.09*** (3.56)	-8386.15*** (112.43)
Average fuel wood consumption	0.12 (0.88)	-308.65*** (70.80)
Education of household head	0.47* (0.28)	−1533.32*** (137.34)
Intercept	-12.58** (4.90)	14813.13*** (3675.31)
R-Square	0.5730	0.35
Adjusted R-Square	0.5542	------
Prob > F	0.00	------
Prob > chi2	------	0.000
Total observation	150	150

Note: ***, **, * represents the significance level at 1%, 5%, 10% respectively.

The average fuel wood consumption is affecting the fuel wood income negatively which is consistent with the economic theory because increase in consumption of fuel wood leads to decline in surplus of wood that can be sold in the market. This implies higher consumption leads to lower quantity available for marketing and thus higher consumption is affecting income from fuel wood negatively. The coefficient shows that 1kg/day increase in fuel wood consumption lead to decrease in fuel wood income by Rs.309/month and 3704/year (Table 5).

Education of household head is found to have a negative impact on fuel wood income. our empirical results demonstrate that one year of schooling increase in household head leads to decrease in fuel wood income by Rs.1533/month and 18396/year (Table 5). This positive impact of education is logical because the increase in year of schooling leads to increase in opportunities for job and thus declines the dependency on fuel wood collection that leads to decline in fuel wood income.

The p-value of F-statistic is zero (F=0.00), implying that our model is statistically significant at one percent level., The value of R-square in first stage is 0.5730 implying that 57.30% variation in the quantity of wood collection has been explained by the explanatory variables. In the second stage our R-square is 0.35 indicating that 35% variation in fuel wood income has been explained by the explanatory variables included in the model (Table 5).

4.6 Comparison of different health symptom between wood users and natural gas users in term of percentage

Our respondents are divided into groups in terms of energy use i.e. fuel wood and natural gas. We attempt to estimate and compare the percentage of respondents facing different health symptoms in these two groups within last one month. The percentage value reported in Table 7, demonstrate that all health symptom faced by fuel wood users are higher than by natural gas users. The throat pain during the last one month is 48% and 34% faced by fuel wood and natural gas users, respectively (Table 7). This clearly indicates that female cooking with fuel wood are facing problem of throat more frequently than those cooking with natural gas. Our percentage is slightly higher than reported by Khushk (2005), which concluded that the prevalence of throat pain within last one month in the southern part of Pakistan is 28%. Among fuel wood users 54% respondents reported that they face cough problem compared to only 36% among natural gas users, implying that fuel wood users are suffering more from cough than by natural gas users. This finding is in line with Ellegard (1997), which concluded that 51% respondent face cough problem during the last one month. The results of breathing difficulties and eye congestion both are reported by 49% of fuel wood users compare to 35% and 34% of natural gas users, respectively. Again, the problem of breathing difficulty and eye congestion is found to be more common among fuel wood users than natural gas users. The literature in neighboring countries also supports our findings that eye irritation is significantly associated with use of fuel wood users (Saha et al., 2005). However, animal related study also supports our conclusion that wood smoke condensates and particle debris damage the eye lens by producing discoloration and opacities (Rao et al., 1995). The problem of hand burn is reported by 60% of fuel wood users compare to 44% of natural gas users. Hand burn and cough are most commonly observed in both groups (fuel wood and natural gas users) followed by breathing and throat problem.

The percentage values reported in Table 7 demonstrate that prevalence of all these health symptoms are more common among fuel wood users than natural gas users. This implying that provision of LPG gas on subsidized prices could help to decrease health spending significantly in the study area. The traditional and poor cook stove (burner) emits nitrogen dioxide, transition metals, polycyclic aromatic hydrocarbons, particulate matter and carbon monoxide, which create problem for human health. When these gases accumulated in the kitchen through incomplete wood combustion than they create multiple health-related problem for females working in the kitchen (Fullerton et al., 2009. It is observed that LPG users are also commonly facing health symptoms which might be due to poor quality of burner they are using because of income constraint. Hence, good quality of burner at subsidized prices can also lead to decline health expenditure burden in the study area.

Table 7 Comparison of different health symptom between wood and natural gas user

Health symptom	Fuel Wood user's percentage (%) (N=100)	Natural gas user's percentage (%) (N=100)	Difference in percentage (%)
Throat Pain	48	34	14
Cough	54	36	18
Breathing difficulties	49	35	14
Eye congestion	49	34	15
Hand Burn	60	44	10

4.7 Determinants of health problem

Our dependent variable is frequency of health symptoms (count variable) faced due to fuel wood consumption and for such data poison and negative binomial regression model is suggested. We employ likelihood ratio test for the over dispersion and the null hypothesis of dispersion is developed as below,

H_0 = Error does not exhibit over dispersion

H_1= Error does exhibit over dispersion

The likelihood ratio test of α=0 strongly rejects the null hypothesis, implying that the errors do not exhibit over dispersion. Thus, the Poisson regression model is rejected in favor of negative binomial regression model. Our empirical results demonstrate that all the variable have positive impact on frequency of health symptom frequency except using mask and number of windows in the kitchen. Column two of Table 6 shows the coefficient of negative binomial regression. The coefficient of cooking duration is 0.124 implying that one hour increase in cooking hours can increase the difference in logs of expected counts of health symptom by 0.12 unit/month (Table 6). The positive impact of duration of cooking is consistent with general understanding because the person who spends more time in the kitchen face higher number of health symptoms. Energy source is positively affecting the health symptom frequency. The coefficient of energy sources is 0.35 and it is statistically significant at one percent level. The coefficient is comparing wood users to natural gas users. The difference in log of expected count of health symptom is 0.35unit/month higher for fuel wood users compared to natural gas users (Table 6). The positive impact of fuel wood consumption on health symptoms is consistent with the economic theory because working in smoke (carbon monoxide, particulate matter, sulfur oxide and nitrogen dioxide) leads to increase frequency of health symptom. That is why it is emphasized to provide conducive working environment for workers who provide services to different industries. The coefficient of kitchen type (taken as dummy where 1 stand for close kitchen and otherwise zero) is offering the comparison of close and open kitchen. The coefficient of close kitchen type demonstrates that people working in close kitchen has 0.85unit/month greater impact on log counts of health symptom frequency (Table 6). The higher frequency of health symptoms faced by females working in close kitchen is consistent with the economic theory because working in polluted environment leads to faster deterioration of health (Ballis et al. 2014). During cooking, the use of mask is negatively affecting the log counts of health symptom and coefficient indicates that the mask users have 0.52unit/month less log counts of health symptoms than their counter parts (non-users). The negative impact of using mask is again consistent with medical sciences because mask help to reduce inhaling poisonous particles through breath which is expected to have negative impacts on health symptoms. Our empirical analysis indicates that number of window in the kitchen is negatively affecting the frequency of health symptom. More specifically our results demonstrate, when one window increases in the kitchen then log counts of health symptom is declined by 0.048 unit/month. The negative impact of number of windows in the kitchen on health symptoms is consistent with the medical sciences which argues that working in clean environment always leads to healthy body. The number of females involved in cooking (number of cooker) is positively affecting the log count of health symptom in our analysis. The coefficient indicates that one person increase in the cooking process contributes in log counts of health symptom by 0.159 unit/month. The positive impact of number of females involved in cooking on frequency of health symptoms is consistent with economic theory because damages of environmental pollution depend on population density. Higher the population density higher will be the damages and our empirical findings support this hypothesis.

Incidence Rate Ratio (IRR) are presented in column III of Table 6. The IRR are more straightforward to explain compared to coefficient of negative binomial regression model because exponent of coefficient is equal to IRR which can be converted into percentage simply by subtracting 1 from IRR and then multiplying by 100 i.e. (% change=100*(IRR-1)). Hence it should be clear that IRR directly cannot be explained in percentage terms, but it can be can be easily converted into percentage terms with little modification as explained above. The IRR of duration of cooking is 1.13, implying that increase in cooking by one hour leads to increase in health symptom by 13%. This clearly demonstrates that efficient source of energy (LPG) promotion could lead to decline to working hours in the kitchen. Under low income scenario it is only possible when Government can provide LPG and high-quality burner at subsidized prices. Hence, it is reasonable to conclude to that subsidy on LPG and high-quality burner can help to reduce health expenditure burden in the study area. The IRR of energy source is comparing the fuel wood and natural gas users.

The IRR of energy source is comparing the fuel wood and natural gas users. The value of IRR of energy source is 1.42, which demonstrates that fuel wood users have 42 % higher impact on health symptom as compare to natural gas users. Again, this is suggesting that promotion of LPG through subsidized prices can help to reduce health expenditures in the study areas. Similarly, IRR of kitchen type is 2.34, suggesting that close kitchen users are facing 134 % higher health symptom than those working in open kitchen. The IRR for number of windows in kitchen is 0.95 illustrating that health symptom decreased by 5% with increase in one window in the kitchen. It is observed that IRR of using mask is 0.58, which implies that mask users are facing 42% less health symptom compared to its counterparts. Hence, awareness about the importance of open kitchen and windows in the kitchen needs to be imparted in the study area. Another option could be that government with the coordination of engineering department could develop various maps appropriate for different sizes of houses to construct open kitchen with suitable ventilation and can flow these maps free of cost in the study area. The IRR for number of cooks working in the kitchen is 1.17, which demonstrate that increased in one cook in the kitchen lead to increase in health symptom by 17% (Table 6).

Table 8 Determinants of health symptoms

Frequency of Health Symptoms		
Variables	**Negative binomial Coefficient**	**Incident Rate Ratio (IRR)**
Duration of cooking (hours)	0.125*** (0.036)	1.132*** (0.041)
Energy source (1= fuel wood, 0= natural gas)	0.356*** (0.096)	1.426*** (0.137)
Kitchen Type (close kitchen=1, open air kitchen=0)	0.855*** (0.110)	2.34*** (0.26)
Mask (mask user=1, unmask=0)	−0.528*** (0.110)	0.589*** (0.064)
Number of window in kitchen	−0.048* (0.025)	0.952* (0.023)
Number of cooker	0.159*** (0.052)	1.172*** (0.061)
Intercept	0.813*** (0.182)	2.256*** (0.411)
Likelihood ratio test of alpha	0.000	0.000
Ln alpha	-2.279	-2.279
Chibar2	0.000	0.000
Total observation	200	200

Note: ***, **, * represents the significance level at 1%, 5%, 10% respectively.

CHAPTER 5

CONCLUSION AND POLICY RECOMMENDATION

5.1 Conclusion

The study quantified the sources of cooking in the rural area of district Abbottabad, where hilly forest ecosystem is facing threats due to overexploitation of fuel wood. In the study area about 81% of the sampled population use fuel wood for cooking and only 19% of them use both fuel wood and LPG. The annual fuel wood consumption in the study area is 0.33 million tons/year, which is higher than in other part of the world. Fuel wood is not only used for cooking process, but also for subsistence needs, implying that provision of LPG gas on subsidized prices alone will not resolve the issue of deforestation unless community is involved in some alternative economic activities as source of livelihood. In the study area income from fuel wood contribute about RS.6793 per month to the income of each family, which is 17% of the family's total income. The amount of fuel wood comes from nearly by forest. Our mean value demonstrates that 73% of the respondents collect fuel wood in summer, 7% in winter and 20% both in winter and summer. The major collection is taking place in summer mainly because weather conditions are favorable to work in the field. While in winter season due to extremely low temperature collectors can't go to forests for fuel wood collection. But on the other hand, summer is also growing season of trees and plants, when people cut green trees then trees cannot grow anymore, and the percentage of deforestation increases. Traditional and poor stove are being used in the study area mainly because of income constraints that leads to serious health problem even in the presence of LPG. This study examines the five-major health symptom (throat pain, cough, breathing difficulties, hand burn and eye irritation). All these health symptoms are correlated with fuel wood use. Our results demonstrate that hand burn (60%) and cough problem (54%) are more common among fuel wood users.

However, the study focused on fuel wood use, human health, and rural livelihood through primary data. The data were collected through questionnaire from the rural area of district Abbottabad. The total sample size of our study was 150. Our study is based on four different models. The first model of our study is to investigate the factor affecting fuel wood consumption and this model is analyzed by OLS. Second model is based on two-part, first part investigates the determinants of total income (fuel wood and other sources) and the second part specifically focusing on the determinants of fuel wood income. The second model is investigated by two-stage least square (2SLS). The third model is exploring the determinants of health symptoms where we employed negative binomial regression model. Hence, this study investigates the consumption of fuel wood, its contribution in rural livelihood and the impact of fuel wood burning on human health.

In the first model, fuel wood consumption is our dependent variable against all explanatory variables. Our results demonstrate that family size, LPG prices, number of wood collectors in the family has positive impact on fuel wood consumption while education of the household head and distance from home to collection point is found to have negative impact on fuel wood consumption. However, the income of the family from other sources has negative but insignificant impact on fuel wood consumption This implies that subsidy on LPG and provision of alternative livelihood to the community could contribute to reduce the deforestation in the study area. Investment on education to the new generation and establishment of new colonies away from forests could also partially help to preserve the forests.

The second model is exploring the determinants of total income (rural livelihood). We employed two-stage least square method (2SLS) because amount of fuel wood collection which is one of the explanatory variables and is found to be endogenous. In order to correct the endogeneity of amount of fuel wood collection two instrumental variables are used (number of wood collector in the family and hours spend in the collection). Amount of fuel wood collection is found to have positive impact on rural livelihood, implying that fuel wood is not only collected for energy needs but also for livelihood. On the other hand, empirical findings also explain that one educated person above 20 years of age contributes more than 7 times than un-educated person above the same age limit as educated, implying that education is one of the strongest tool to increase family income (rural livelihood) in rural areas. Higher income will not only divert the profession from fuel wood collection to others but also expected to shift the family from fuel wood consumption to LPG (a cleaner source of energy) to fulfill their energy needs. Hence, education can be used as a tool to decrease the dependency on fuel wood for income and energy purposes. It is observed that male headed family has higher income compared to female headed family. Due to cultural barrier, normally female leads the family only when male is expired or went abroad for job. In male dominant society like Pakistan, it becomes harder for female to allocate human resources efficiently which lead to lower income. The establishment of markets near the resident areas is one of the rich sources of livelihood.

The third model is based on the determinant of only fuel wood income. Again, we employed two stage least square (2SLS) model where amount of total fuel wood collection is endogenous variable. In this model we gain use the same two instrumental variables as explained in the above model. The contribution of amount of fuel wood collection in fuel wood income is slightly less than the contribution of total family's income. Family size is also found to have positive impact on fuel wood income. The coefficient of distance from home to collection point is observed to have negative impact on fuel wood income, implying that establishment of new residence areas away from forest could help to preserve the forest areas. The fuel wood consumption has negative impact on income from fuel wood which is normal because higher consumption leads to lower surplus of fuel wood available for marketing. Education of household head has negative impact on income from fuel wood which is in line with economic theory because higher education helps to explore high income jobs. As we explained earlier that higher education helps to shift from fuel wood collection to some other high-income profession. Hence, education is one of the key tools to preserve our forests.

Before exploring the determinants of health symptoms, we attempt to compared health symptoms between fuel wood and LPG users. The prevalence of health symptoms is more common among fuel wood users than natural gas users. Fuel wood users depend more on fuel wood, but they are also using LPG in extreme weather conditions. However, they have traditional and poor-quality cook stove (burner) which emits injuries smoke and it leads to increase health problem. The throat pain during last one month is 48% and 34%, among fuel wood and natural gas users, respectively. Among fuel wood and natural gas users, 54% and 36% respondents encountered cough problem, respectively. The difficulties in breathing are the same (49%) among the two groups but eye congestion is 45% and 34% among fuel wood and natural gas users, respectively. The problem of hand burn is significantly higher among fuel wood users (60%) compared to only 44% among natural gas users. The study concluded that hand burn and cough are most commonly observed in both (fuel wood and natural gas users) followed by breathing and throat problem.

Finally, we attempted to explore the determinants of health symptom due to fuel wood burning and we employed negative binomial regression model. We also estimated the incidence rate ratio (IRR) which explains the change in the dependent variable in percentage terms. Our results demonstrate that time spend in cooking is found to have positive impact on health symptoms and fuel wood users are found to have 42% higher chances to face health symptoms compared to LPG users. Open kitchen has enormous impact in the reduction of health symptoms (134%) faced by females working in kitchen compared to those working close kitchen. Hence, the awareness about the role of open kitchen in reducing health symptoms could play an enormous role. Government can launch an awareness to reduce the burden of diseased faced by female workers due fuel wood burning. The awareness about the use of mask during cooking could be another useful tool to reduce the burden of diseases due to fuel wood burning. However, This study did not focus on species of trees that are used for fuel wood purpose. Therefore, future study may focus to identify the species of trees that are frequently used for fuel wood purpose so that action can be taken to preserve those species. The future study may also address the issue willingness to pay for the availability of LGP or natural gas in the rural areas.

5.2 Policy recommendation

According to Ahmed (2006), higher dependency on the forest for fuel wood is causing severe forest depletion in the Himalayas. Based on descriptive statistic and empirical findings, following policy suggestions to preserve the forests and to mitigate the diseases among rural community are proposed.

Our consumption model of fuel wood demonstrates that high price of LPG leads to higher consumption of fuel wood. Hence, to ease the pressure on forests government should introduce subsidy on LPG in targeted areas which has easy excess to forests and are contributing in deforestation. Provision of LPG at the consumer’s doorstep could provide partial relief in terms of low prices because transportation cost is not negligible. Number of wood collectors in the family has positive but education of household head has negative impact on fuel wood consumption. This translates, reduction in unemployment and provision of education could help to reduce the dependency on fuel wood consumption.

Hence, opportunity of employment in other value chains of agriculture sector or development of industrial zones in rural areas could help to reduce the dependency on fuel wood consumption and forestry as a source of energy. The easy excess to education to poor community could lead to increase awareness about the negative impact of fuel wood consumption which will allow them to shift from fuel wood to LPG. Since, distance from home to collection point is found to have negatively impact on fuel wood consumption implying that government may impose restriction on the construction of new houses near the forest.

Our empirical results demonstrate that livelihood (income of the family) depends on the amount of fuel wood collection, implying that fuel wood is not only collected for energy needs but also for livelihood. It is also observed that educated person above 20 years of age contributes more than 7 times than non-educated adult in the family within same age bracket, implying that provision of education is extremely important to improve rural livelihood and to alleviate poverty in the rural areas. This also leads to decline dependency on fuel wood as a source of income and energy. Hence, the government should invest on subsidized education on priority basis to protect the natural resource like forest.

The availability of markets near the residence areas provides opportunities for business and contributes in improving family income. Hence, government need to introduce community-based marketing system to boost up the business opportunity and the income of the people in rural areas.

The study examined that the contribution of fuel wood income is about 17 percent in total family income. The local society and government should launch the reforestation program on cultivable waste land. These project not only help to conserve forest but also improve livelihood.

The launching of awareness about the importance of mask use during the cooking could reduce the health burden on females. However, if the government can provide mask free of cost then it is useful for rural communities.

The study investigated that open-air kitchen and window in close kitchen leads to decrease in the frequency of health symptom. The awareness about the importance of open kitchen and widows in close kitchen need to be imparted in the study area. Government with the coordination of engineering department could develop various maps appropriate for different sizes of houses to construct open kitchen with suitable ventilation and can flow these maps free of cost in the study area.

Efficient source of energy like LPG could significantly reduce the time used for cooking which could lead to decrease health burden. Hence, it is reasonable to conclude that the subsidy on LPG and high-quality burner can help to reduce health expenditure burden in the study area.

Good quality of stove (burner) at subsidized prices can lead to decline health expenditure burden in the study area. Government should introduce the efficient cook stove, which are environmental friendly and less wood consumer.

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Appendix

Questionnaire for Household Survey

Name of Respondent……………… Age: ………….. Date of Interview: ……………

Village: …................. Household size: …………….

a) Number of Male above 10 year: ………… b) Number of female above 10 year: ……………..

Sex of Household head: ☐ Male ☐ Female Education of household head (year) ……....

Number of educated person whose age is above 20 years……………….

Number of uneducated person whose age is above 20 years…………….

1. What is your energy source of cooking and heating? ☐ Fuel wood ☐ LPG ☐ both (LPG and wood) ☐ other…………

2. **Please give the information for the last one year about the sources of energy consumption and their expenditure.**

Month	**Month (use code from below)**	**Amount consumed (kg)**		**Amount purchased (kg)**		**Travel Cost.**	**Amount sold (kg)**	**Price of wood purchased/sold (RS/mound)**
		LPG	**WOOD**	**LPG**	**WOOD**			
Winter season								
Summer season								

Table 1

Note: code for month: *Winter season (September, November, October) =1, (Dec, Jan, Feb) =2 Summer season (March, April, May) =3 (June, July, August) = 4*

3. How long is your total Agriculture Land ☐ kennel……….. ☐ Marla…………
4. Do you go to forest to collect fuel wood? ☐ Yes ☐ No
5. Do you bring animals with you while going for wood collection? ☐ Yes ☐ No
6. Which animal you bring while collecting fuel wood…………......
7. How many member of household to collect fuel wood? ☐ 1 ☐ 2 ☐ 3 ☐ 4

Detail of wood collectors in the family for last one month.

	Father	**Mother/ wife**	**Son**	**Daughter**	**Other**	**Total**
Age						
Name of the product (wood=1, grass=2, other=3)						
Fuel wood Collection season (winter=0, summer=1)						
Total Amount collected in one day (kg)						
Distant form home to collection point (in Km)						
Average hours spent in the fuel wood collection						
How do you travel to forest? (use code from below)						
How do you carry wood to home? (use code from below)						

Table 2:

Code for travel: 1=walking, 2=motorbike, 3=public transport, 4=others

Code for carrying wood: 1=head, 2=cart, 3=motorbike, 4=others

8. What is your main energy source for cooking and heating?

☐Wood ☐ Natural Gas.

	Cook 1	**Cook 2**
Energy source for cooking and heating (wood=1 other wise=0)		
Number of window in kitchen		
Duration of cooking in hours (per day)		
Crowding index (number of person during burning fuel)		
Does the person use to cook is using mask (protective measure)		
Using any other protective measure to avoid from smoke		
Age of the cook		

Table 3 *Code for mask: 1=Yes, 2=No*

9. Do you feel any of the following symptom during or after cooking or heating during last one month?

Health symptom	Yes / NO	Frequency	Frequency (self-treated)	Frequency to visit Dr.	Dr. fee and medicine cost per treatment
Nasal congestion					
Throat symptoms					
Cough					
Breathing difficulty					
Eye congestion					
Hand burn					

Table 4

10. Family income of the household in last one month.

Family member	Age	Education (years)	Distance from home to market (non-forest product)	Employment source (use code from below)	Income per-month
Husband					
Wife					
Daughter1					
Son1					
Son2					
Total					

Table 5 ***Note: 1= Govt employees, 2= private, 3= self-employed, 4= wages labor, 5= other***

11. What was family's income from other sources in last one month?

S.no	Sources	Quantity sold kg/month	Quantity consumed kg/month	Market price (Rs./kg/lit/mound)
1	Wood (kg)			
2	Milk kg			
3	Desi Ghee (kg)			
4	Butter (kg)			
5	Wheat			
6	Corn			
7	Vegetables			
8	Daily wages			
9	Other			
	Total income			

Table 6

Table 7. Factor that effecting fuel wood consumption

Dependent variable: Average fuel wood consumption	
Independent variables	**Coefficient**
Family Size (number)	0.644*** (0.105)
Average LPG price (rupee/kg)	0.005*** (0.000)
Number of wood collector (number)	2.467*** (2.21)
Education of household head (year)	−0.248** (0.117)
Average distance from home to collection point (Km)	−1.139*** (0.117)
Total income and Education[1]	0.00 (0.00)
Intercept	7.377*** (2.219)
R-Square	0.685
Adjusted R-Square	0.674
F-statistics	0.000

Note: ***, **, * represents the significance level at 1%, 5%, 10% respectively and Standard error in parenthesis.

[1] Total income*Education of household head