Assessment of Energy Sources Used for Cooking by the Slum Dwellers of Rawalpindi

By

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Dedication

To my beloved parents and sisters and my respected teachers!

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First of all, I am grateful to Allah Almighty for His mercies and grace that has seen me through my education and carrier.

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Abstract

In this era of technology and upgradation of renewable energy sources, Pakistan, a developing country is still relying on the energy sources which are inefficient and exhaustible. As energy plays a vital role in meeting most of the basic requirements of households e.g. gas, electricity and petroleum, it puts an extra burden on the shoulders of slum residents in case of Pakistan. The aim of this research is to assess the use of energies among the slums of Rawalpindi city, Pakistan. Stratified random sampling technique was used to select for 400 households for the research, half of which use firewood only while the rest use both natural gas and firewood. The results show that slums which use firewood for cooking purposes are spending a significant proportion of their income on this source. While the cooking practices are not healthy in both type of slums, the households which use firewood throughout the year were found more vulnerable to respiratory diseases and they themselves are eager to shift to some other source of energy which is clean and cheaper. The households which have access to gas, have better living conditions but are compelled to use firewood in winter due to load shedding of gas which has encouraged some of the household to shift to some other source of energy. This research suggests that the changes in Government policies be employed to facilitate the slum dwellers with the source of energy, which is cheaper, clean and inexhaustible, and readily available. In the light of this, solar cooking stoves seem to be a viable option, for it is a renewable source of cooking energy which would need Government involvement and help for its implementation.

Chapter 1: INTRODUCTION

1.1 Overview and Background

Perpetually increasing daily requirement of energy has formed the world into global village and this need for energy to satiate the human social and economic development, health and welfare is growing by each day. In today's world, 1.4 billion people are still lacking access to electricity which in turn is associated with tradition use of biomass fuels (Owusu & Asumadu-Sarkodie, 2016). Around 3 billion people worldwide have been recorded relying on wood, dung and leaves for cooking fuel which in inefficient setups poses threats to human health, often leading to mortality amongst women and children. Exposure to cooking smoke of biomass fuel causes 1.6 million death annually. Indoor cooking setups leading to increased levels of indoor air pollution is associated with increased risk of acute respiratory infections, chronic obstructive pulmonary disease (COPD) and lung cancer in women (Edelstein, Pitchforth, Asres, Silverman & Kulkarni, 2008). Exposure to household air pollution doubles the risk of child pneumonia and other acute respiratory infections (Kjellstrom, Friel, Dixon, Corvalan, Rehfuess, Campbell-Lendrum & Bartram, 2007).

1.2 Problem Statement

Biomass fuels are still in use by the urban households in Pakistan. Partial combustion of such fuels leads to production of cooking smoke which can result in posing threat to human health. Mortalities of 28,000 individual per year and 40 million cases of acute respiratory illness suggests that use of biomass and solid fuels should be recognized as a major health hazard to the population residing in urban areas (Colbeck, Nasir & Ali, 2010). Number of

respiratory illness can be caused due to combustion of unprocessed fuels, often leading to death. According to world health organization, household air pollution due to cooking smoke contributes to 9% of total diseases prevailing in Pakistan (Naz, Page & Agho, 2017). The intensity of biomass fuels for cooking purposes is more significant in the areas where households usually have low income levels. Wood smoke contributes to almost 3% of the global burden of diseases, consequently causing 1.6 million deaths every year. Health issues attributed to negative impacts of woods smoke include breathing difficulties, chronic respiratory diseases, asthma, wheezing, sinus problems, stinging eyes and reduced lung functions. The most vulnerable groups to negative impacts of cooking smoke are women, children and low-income groups including slums dwellers (Jan, I., 2012). In order to provide the slum dwellers with the basic facilities and reduce their financial burdens, a renewable and affordable source of energy has become an inevitable necessity to go along the lines of sustainable development in Pakistan.

1.3 Research Questions

This research study addressed the following research questions:

1. What type of cooking energy sources are available and used by slum dwellers of Rawalpindi city?
2. What are the reasons for using traditional energy sources by the households of urban slums?
3. What are the financial and health impacts of energy sources currently in use?
4. What are the factors influencing the willingness of households to pay for clean energy?

1.4 Research Objectives

The main objective of this research study was to assess energy being used in slum dwellers for the purpose of cooking in the Rawalpindi city. The specific objective of the research is as follows:

1. To investigate the sources of energy and their characteristics among the households of urban slums
2. To investigate the factors affecting the choice of a household
3. To identify factors influencing the willingness of slum dwellers to shift to clean energy source for cooking purposes
4. To explore barriers towards clean and reliable energy for urban households
5. To establish a strategy to facilitate households of urban slums to adopt clean energy for domestic use

1.5 Significance of Study

The use of unclean energy source such as firewood is still being used by the households of urban slums. As a result, deforestation and changes in ecosystems are happening as well as climate change due to the carbon emissions from these energies. These sources have also negative impacts on human health. The conclusions of this research are anticipated to contribute to a better understanding of the adoption of clean cooking energies, the households' perception towards clean cooking energy and the barriers for using clean energy consumption. The findings of this research could also be used as an input for decision making by Government, planners, policy makers and implementers of clean

energy technology. The findings of this research can play a vital role in spreading awareness regarding negative impacts of using firewood as a cooking source on health of household members.

1.6 Limitation of Study

The constraint faced in this research study while surveying the targeted slum area was the hesitance and deceitfulness of respondents while filling the questionnaires. Most of residents were not willing to disclose their information regarding their way of living, income levels, location and facilities (like gas and electricity) used by them. As majority of them were residing illegally on the land and facilities used by them are via illicit ways.

1.7 Structure of Research

The thesis write-up is divided into five chapters:

a. **Chapter One:** This chapter presents the general introduction of research topic, background of the study, covers the problem statement, research questions, significance and objective of the study and limitation of study.
b. **Chapter Two:** This chapter discusses the review of literature, for the relevant theoretical and empirical work, discusses sources of energy, socioeconomic profile of slums and their health issues, willingness to shift towards clean energy, the research framework and the proposed research model.
c. **Chapter Three:** This chapter covers the overview of research methodology to carry out the research study. The chapter presents the sample size, sampling framework, methods of data collection and techniques used to analyze the data.

d. **Chapter Four:** This chapter comprises of data analysis and interpretation of results based on the data collected, their correlation analysis and factor analysis to identify factors influencing willingness of slums to use clean energy.

e. **Chapter five:** This chapter is focused on conclusion which are drawn on the basis of theoretical results integrated with existing literature. Furthermore, practical implications of the research findings are highlighted, recommendations and future research are outlined.

f. **References:** In APA style, it has a list of all references.

g. **Appendix:** Questionnaire is attached in this section.

Chapter 2: LITERATURE REVIEW

Over the last few decades, there has been rapid and massive growth in the urbanization of developed and developing countries. This growing factor is not uniform if we compare developing and developed countries. In developed countries, increment of urbanization factor is drastically much more than the developing ones. Facts revealed that the expansion in urban areas is a prime concern for less developed countries. As in rural areas, people lack basic facilities of life such as satisfactory health care facilities, accommodation, sanitized water, electricity, employment opportunities, education facilities etcetera. The availability of these accessibilities encourages the rural population to move towards urban areas. As these amenities and services are way costly and out of reach for these migrated people. With their limited income resources, to settle themselves in urban life, these migrated people practice illegal ways to take possession of vacant places within or outskirts of cities or suburbs of cities. The transformation of people causes generation and creation of slum areas in the cities.

According to the research, around one billion people are residing in slum areas. Most of slum dwellers are found in less economically developed countries, that makes it 30 % of total population (United Nations, 2015a). The inhabitants of slum dwellers are more likely to be increase by two billion by 2030 and to three billion by 2050.

Research of UN-Habitat suggests that, within developing countries in year 2012, around 863 million populations or 33 % of urban population is residing in slums. In year 2012, urban population was as high as 62% in sub-Saharan Africa, 35% in southern Asia, 31 % in southeastern Asia, 28% in Eastern Asia, 25% in western Asia; similarly, 24% in Oceania,

24% in Latin America & Caribbean and 13% in North Africa. The total population of urban areas has increased drastically between the years 1990 and 2010.

Forest depletion or deforestation encompasses the process of steady or fast, temporary or permanent eradication of trees that results in extinction and suppression of forest or trees covered locality (Jones, 2000). Not only for healthy lifestyle, but also for survival of our Planet, forest cover is crucial to sustain our ecosystem for every country (either they are developed or not). However, the outrageous practice of cutting down the forest aggressively is a danger to environmental sustainability (Berek, 2012). Deforestation can occur due to Human and natural factors. Natural factors mentioned in literature includes, fire from lightening, Windstorms which break the trees or severe weather conditions (Spurr & Barnes, 1980). But the leading cause of deforestation is human activity with uncontrollable rate of cutting down activity. Countries which are suffering poor socioeconomically, force their population to exploit natural resources for commercial gain. (Odihi 2003; Lambin & Geist, 2003; Vance & Iovanna, 2006).

About two and half billion population of world relies heavily on biomass. That includes wood, dung, and shrubs (Vance & Iovanna, 2006). The consumption of biomass fuel is hazardous not only to environment but also and to individual's health. Almost 3% of all diseases are results of smoke produced by woods that further results in premature death of around 1.6 Million (Odihi, 2003).

Billions of others go through some other serious chronic diseases such as asthma, respiratory syndromes & lungs and eye diseases (Vance & Iovanna, 2006).

Population growth is a demographic measure which estimates the contribution of deaths, births and migration to population over time (McFadden & Oxenham, 2018). World population is increasing tremendously in the recent centuries as compared to previous ones (Keilman, 2019). As depicted in the following figure we can see with the passage of time, centuries by centuries population is multiplying.

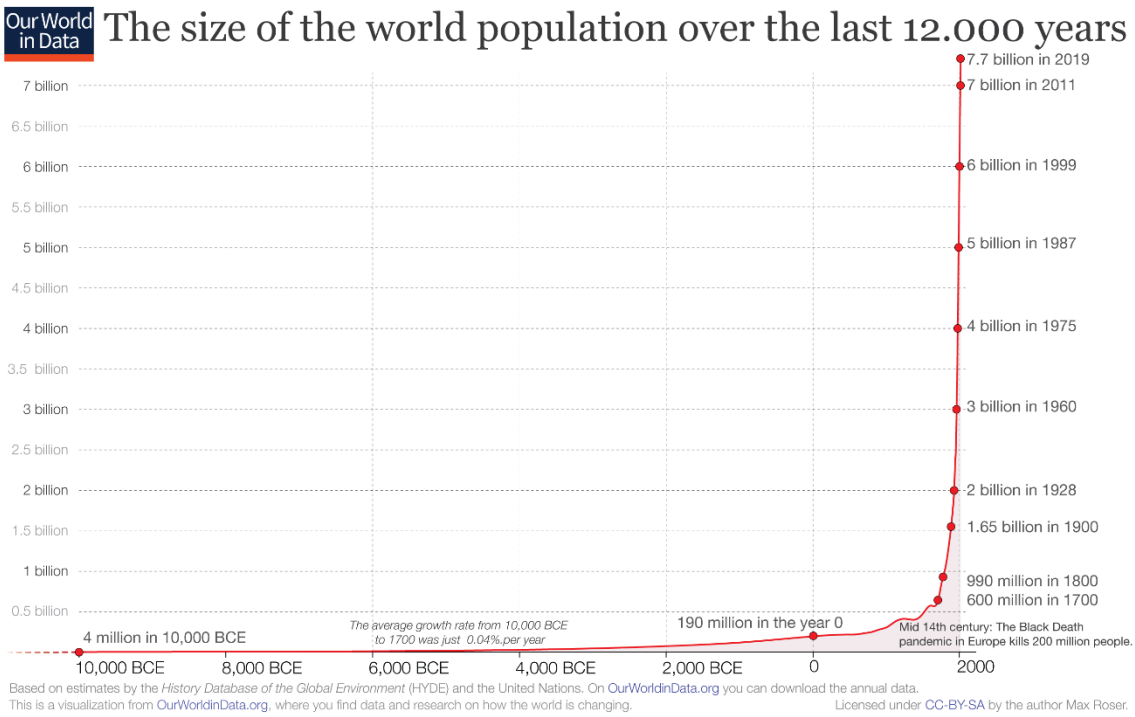

Table 2-1: Size of world population over last 12,000 years, (Roser, Ritchie & Ortiz-Ospina, 2019, May)

The Figure 2-1 shows how rapidly the growth rate of the world population changed over time. The population raised slowly in the beginning and it took almost seven centuries for the population doubling from 0.25 billion, in the early 9th century, to 0.5 billion in the middle of the 16th century. As the growth rate escalated gradually, the population doubling

time declined but remained in the order of centuries into the first half of the 20th century. These rates geared up significantly in the mid of the last century.

The fastest doubling of the world population took place between 1950 and 1987 which was from 2.5 to 5 billion people over the period of 37 years. This period garnered a peak population growth rate of 2.1% in 1962.

While still increasing to an extent, the population growth rate has slowed down. In the figure below, UN projections have been depicted to show how the doubling time is predicted to be changed until the end of this century. By the year 2088, it will once again have taken nearly 100 years for the population to double to a predicted 11 billion.

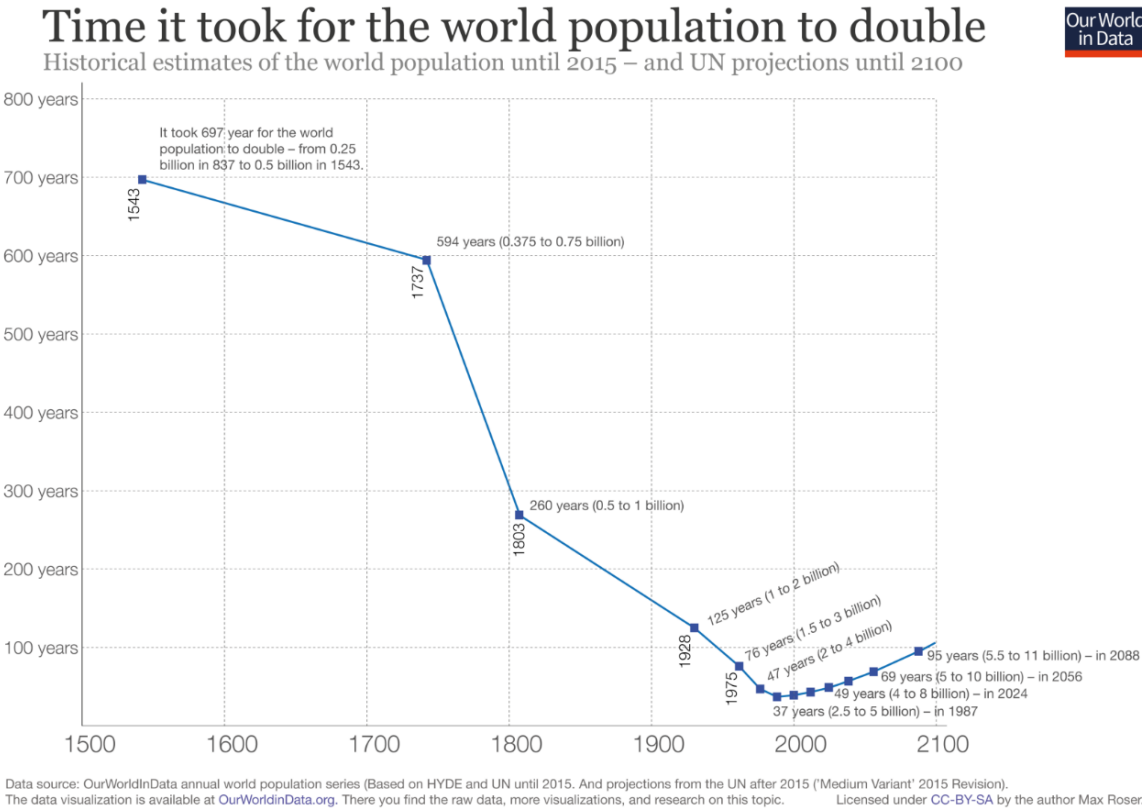

Table 2-2: Estimation of world population from 2015-2100, (Roser, Ritchie & Ortiz-Ospina, 2019, May).

The world has now exceeded the peak rate of growth and the period between each billion is predicted to continue to rise. It is estimated to take approx. the period of 13 years to reach 8 billion in 2024; 14 years to reach 9 billion in 2038; 18 years to reach 10 billion in 2056; and a further 32 years to reach the 11th billion in 2088 (Kelley, 1988).

We are currently living in an unusual era in demographic history. For many centuries, world population grew at very steady pace, so gradually in fact, that to reach 1 billion of population, it took more than 1 million years which took place 20 centuries ago. However, the rate accelerated, and over a short period of 120 years the population had doubled to 2 billion.

It took the period of 35 years to reach the population level of three billion while the fourth billion took just 15 years. Presently, world population is more than 5 billion, and demographers do not estimate a smooth growth until the end of the next century over 10 billion. Most of the population growth in modern era took place in the countries of third world (Kelley, 1988).

The United Nations predicts that world population growth will decline considerably, reaching its peak by 2100 at 10.9 billion, over the period of 21st century (United Nations, 2016).

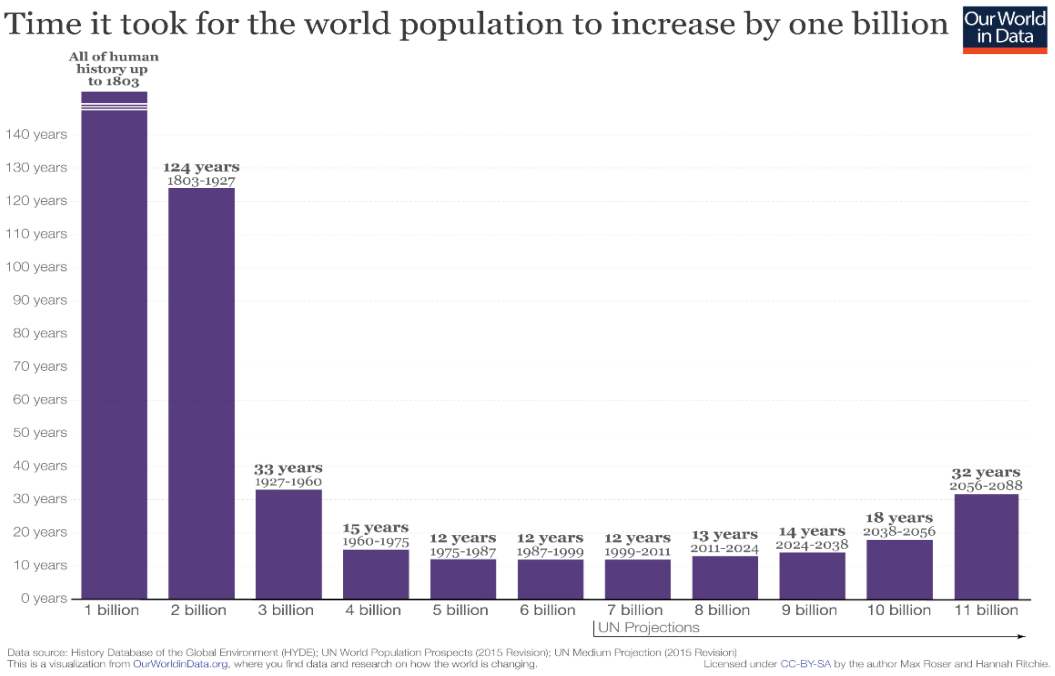

Figure 2-1: Increment in world population by one billion, (Roser, Ritchie & Ortiz-Ospina, 2019, May).

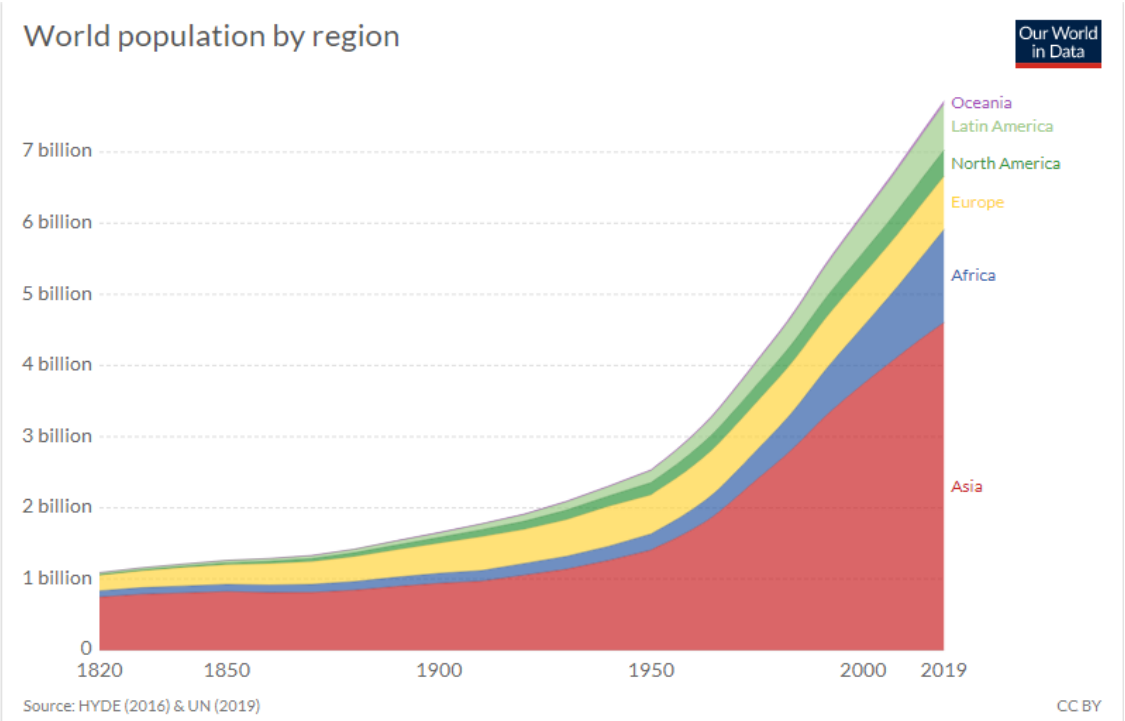

Figure 2-2: World population by region, (Roser, Ritchie & Ortiz-Ospina, 2019, May).

2.1 Slums

The idea of slums was originated in 1812 where it is originated with words “criminal trade” or “racket”. In encyclopedia of *Britannica*, slum is stated to be “a residential area that is physically and socially depreciated and where satisfactory family life is impossible”. The United Nations terms slums as the region of high population density, deprived with basic living conditions and spaces with high population density but with underprivileged infrastructure. The living conditions with underprivileged conditions, consequently, have undesirable effect on both the physical (Ezeh et al., 2017) and mental health (Subbaraman et al., 2014) of their inhabitants. Hence, it is important to upgrade the infrastructure of hygiene, sanitation and the system of water supply. (Ezeh et al., 2017; Van der Bruggen, Borghgraef, & Vinckier, 2010). According to United Nation report (United Nations, 2016), overall cities comprises more than half of the population of world. Futurists have forecasted that this pattern will grow rapidly in next coming decades, more particularly in Africa and Asia (Kraas & Schlacke, 2016; United Nations, 2016).

These regions of the world are having more of the slums and informal settlements due to increase in urban growth and the frequent movement of people from villages to cities in seek of better income opportunities or cities’ facilities (Ezah et al., 2017). Another report by the United Nations (UN) guesstimates that almost one billion of the total population of the world that makes it on-sixth of total population, lives in slums. As predicted near 2030, almost Five billion individuals will be residing in urban areas, whereas in year 2007, the number was 3.2 billion in 2007.

In the era of industrial revolt, firstly slums were originated within the cities and close to the manufactures or factories so that it's easy for workers to walk to their workplace (Baloch et al, 2017). With the advent of this concept, mostly people living the life below poverty line and lowest earners are compelled to live in Slums (Javed et al., 2016). Due to Poorer socio-economic situations they have no other option than to live in slums. People residing in such areas are more prone to catch transmissible diseases due to malnutrition and living conditions at slums for instance unhygienic sanitation, food they take and bad health conditions (Kamruzzaman & Hakim, 2015). Usually the slum inhabitants in developing countries are mostly the ones who are leading life in poverty. Their chances to get good income are very low. In few basic necessities of life sufficient supply of water is most important of all (Vlahov et al., 2007). But regrettably, most of the times, slums households do not have any system or infrastructure to have access to clean water (Kamruzzaman, & Hakim, 2006). Although few public areas facilitate supply of water, but that water is not good in quality. Sanitation planning is also very pitiable in slums (Panda et al, 1993).

The streets in slums are too narrow and unpaved. During rainy season, water stagnation is also a problem. Secondly this causes unhygienic condition of slums which makes favorable conditions for diseases to spread out (Dziuban et al, 2006). One feature of slum is that slums are usually not owned by its residents rather it's the property usually they are owned by Government, Governmental organizations or disputed land or unclaimed land. Therefore, slum dwellers seek the land which is not been progressive or productive they utilize it by settling in there. As a result, we can say that Slums are result of Bad

management by government, corruption, dysfunctional land markets, bad financial system, failed policies and unwilling political system Energy Profile (Kamruzzaman, 2015)

Pakistan is situated in South Asia and covers the area of 796,096 km^2 of land with latitude of 24 and 36 north latitude and a longitude of 61 and 76 east longitude (Bhutto, Bazmi & Zahidi, 2011). Country depends heavily on fossil fuels (Douggar, 1995; Valasai 2016 & Valasai 2017). According to research, approximately 60% of Pakistan's total foreign currency is being used to import fossil fuels. However, this country has limited restrictions and have its own fossil energy resources and has low energy consumption per capita of 501.6 kg of oil equivalent as compared to the world average of 1790 kg of oil equivalent (Baloch, et al., 2017). Pakistan has therefore met with major challenges regarding energy sector to meet growing demand at a rate of 11 to 13% per year (Baloch et al., 2017).

2.1.1 Coal

Coal is the most abundant fossil fuel amongst the different traditional energy sources in Pakistan. The estimation of coal reserves is around 185.175 Billion tons. It makes Pakistan Top Fourth Country (Mirjat et al, 2017; Valasai et al, 2017). Some theorists have suggested that by using this huge coal potential, Pakistan can produce an estimated value of 100,000 MW of electricity which can be consumed for almost 30 years (Javaid, et al).

The total coal reserves have been reported to be 186,007 million tons by Hydrocarbon Development Institute of Pakistan (HDIP) as of June 2014 in the country, marked as measured reserves; 7775 million tons, indicated reserves; 19,412.5 million tons; inferred reserves; 44,524 million tons and hypothetical reserves being 114,293 million tons.

2.1.2 Natural Gas

In year 1952, the first gas reserve was found at Sui district of Balochistan. Later, few more reserves were found across Pakistan mainly in Sindh and Baluchistan. Subsequently, it comprises 47 % of sum of total energy supply. Hence, ranging from industrial sector to commercial and domestic level all major parties consume natural gas. However, this indigenous source of gas is now believed to be exhausting as the Sui gas reserves have depleted over the years. Due to which ensuring the supply of natural gas with increasing demand is becoming a serious challenge (Rauf et al, 2015).

2.1.3 Crude Oil and Petroleum Products

Total sedimentary area of Pakistan is around 827,268 km^2. That means this area can be explored for oil and gas. Our transport sector followed by industrial sector has high demand for petroleum and oil because mainly our transportation is mainly through roads. According to a few reports, the rate of success of exploratory activities in Pakistan is quite high, believed to be seven times the world average (Alahdad, 2012).

2.1.4 Wood Fuels

In Rural areas, people usually use the biomass or wood fuel. They get the supply of wood fuel from local traders. Though, the size, source and nature of any biomass and wood fuel differ owing to requirement (Bhutto, Bazmi & Zaidi, 2011). In rural, as well as urban slums, people collect biomass energy or wood-fuel freely from public area, forests, free land, farmlands and unclaimed areas.

In public and community forests and uncultivated land, people collect mainly firewood and biomass as traditional rights. Under these civil liberties, people can remove fallen or dead trees with cutting tools to meet their domestic needs. Nevertheless, while collecting wood

energy, people do not respect the restrictions defined in the legal definition of rights. Additionally, to picking up dead and fallen trees, they cut or severely cut standing trees (Bhutto, Bazmi & Zaidi, 2011).

2.1.5 Animal Dung

Animal dung is a major source of biomass and dry dung. It has almost as same energy as the firewood having the burning efficiency of only 10%. Approximately 150 million tons of animal dung is used worldwide as fuel. Traditional fuels such as dung, manure and crop are used to pay for the energy of everyday use to contribute to low-income urban households. In Pakistan 62% of the population lives in rural areas. Therefore, in rural areas and the slums of urban areas use firewood for their domestic use. If it's unavailable it can be replaced by animal dung or crops (Baloch, et al, 2017).

People leading life in rural areas and families with comparatively low income relies mainly on traditional biomass for instance, animal dung, charcoal and fuel wood. Average of 30% of total low-income families and people residing in rural areas of the country majorly depend on traditional biomass fuels which include charcoal, fuelwood, animal dung etc. to meet their needs regarding energy daily. Of all the energy consumed in Pakistan, traditional biomass constitutes 30% of it (Khan, 2015).

According to the Pakistan Social & Living Standards Measurement Survey (2008–2009), around 53 % of total domestic, and 68% of rural areas, depend on charcoal and wood whereas about 53% of the country's total households and 69% of rural households rely on charcoal and wood for cooking purposes (Alahdad, 2015). Energy plays a vital role in the daily life of a household. While poverty is a condition for people who are deprived of basic

needs of life, it is concluded that there has a lot of association between energy and poverty (Ahmed, Ahmed & Akhtar, 2006).

From the aspects of basic facilities i.e. access to clean and drinking water, health facilities and education poor people are usually deprived of such services and thus have very limited or less access to the sources of energy. Families with low income depend on traditional biomass. According to WHO (2005), 30% of population in Pakistanis using biomass fuel (WHO, 2005). From the survey of 1998, 54 % of population is consuming firewood, 18% dung and 14% crops waste (Fatmi, 2005). The usage of biomass fuel is injurious and damaging to health. So, in literature there is been discussion to replace biomass fuel with some other source that is not hazardous to health and the surroundings (Fawz-ul-Haq, Jilani & Haq, 2005).

3% of global infections and syndromes are produced by indoor pollutions mainly from Bad Smokes of Slums. That results in premature death of 1.6 million babies in one year and further around one million deaths of children under age of 5 years (Warwick & Doig, 2004). Million other people have lots of health-related issues like asthma, sinus issues, breathing & wheezing problems eyes' infections (Boy, Bruce, & Delgado, 2002; Chen, Verrall, & Tong, 2006). Countries who are suffering socioeconomically, force their population to exploit natural resources for commercial gain. (Odihi 2003; Lambin & Geist 2003, Vance & Iovanna, 2006).

About two and half billion population of world relies on biomass fuel, such as wood, dung, and shrubs (Vance & Iovanna, 2006). The consumption of biomass fuel is hazardous to environment and to individual's health. Almost 3% of all diseases are results of smoke

produced by woods that further results in premature death of around 1.6 Million (Odihi, 2003).

Billions of others go through some other serious chronic diseases such as asthma, respiratory syndromes & lungs and eye diseases (Vance & Iovanna, 2006).

2.2 Socioeconomic Profile

Slum dwellers constitute 31.6% of the world's urban population i.e. 924 million people according to global report on Human settlements 2003. South Asia has been the host to the second largest number of slums after Sub-Saharan Africa. According to lead.org, an (independent organization for research in Pakistan), billion people are moving to cities altogether. About 37 % of population is residing in urban areas by this time and it is increasing with rise of 3.97 % per year (according to the survey of 2010-11) by the time of 2007, total slum population is 47 % total urban population.

Although, Islamabad is a very well-planned city having over one million of citizens, has got number of migrants due to economic, social and environmental planning in last few decades. According to CDA, 0.1 Million people are residing in slums of Islamabad. In Lahore, 30 percent of the legitimate land is occupied by slum dwellers (Nawaz, 2018)

Socio-Economic Opportunities Index was (SEOI) was designed to assess the level of deprivation. The results showed that 48 percent of people living in slums were deprived of necessities of life. Mostly were uneducated and literacy rate being as low as 55 %. Out of which 56 were males and 46 were females. Those who were literate were not educated above matric. Employment rate was 77% overall. Employment rate was among male was

around 88 % and 75% among females. But they were not doing proper full-time jobs. Their jobs were of very low income and average Rs 525 was their whole day expense. Saving was nothing.

Socio-economic profile of individuals plays a major role is making decision for selection of the energy source, their perception about that energy, health risks involved with that energy and awareness related to health risks involved. Their perception on exposure, diseases and then management with that diseases and diagnosis is dependent on their level of education and the type of profession they are in. Through this research paper we can conclude that education and profession catalyze the decision of choices in selecting the energies.

Another study was conducted (Egondi, 2013) where it was found that individualistic attributes for instance sex, age, period of stay in particular slum, marital status and profession does matter in perception of health risks involved and awareness of health risks associated with energy being used in households. It was concluded in the results that individuals with primary education were more aware of air pollution and its health impacts as compared to individuals who were lesser in education or didn't attend the school. So, education was directly associated with perceived air pollution. Secondly people with informal employments were not aware of air pollution and its harmful effects on one's health as compared to people with formal employments.

People who were working in informal, forms of employment perceived lower health risks formed due to air pollution and was vice versa with people who were doing more formal sort of jobs. Perception of health risks involved was also dependent on marital status,

qualification and profession. Married couples were more aware of health risks as compared to unmarried people (Faheem, Mehmood, & Shah, 2012).

A study was conducted in Peshawar, to assess how many people were using clean energy and how many of them were aware that what kind of energy is good for individual's health and environmental friendliness. In this study results showed few people were willing to adopt anything that is expensive to their current cooking methods but are willing to adopt if it's easily available. But study confirmed that individual's qualification, monthly income depends on making choice that either they should use biomass stoves or not. Not only individual's choices and convenience, some other external factors such as socio-economic, political, economic, institutional factors also matter to change people's mind. (Jan, 2012).

Thus, we can conclude that unplanned or poorly planned housing is major indicator of slums conditions which includes no privacy of families, bad management of living and improper temperatures inside. Government employees with low salary packages and usually on lower positions and labors are compelled to live in such areas as they are left with no other option (Qadeer, 1983).

Defined by United Nations Habitat, slum is considered to be a household that has water prone to contamination; sanitation facilities are non-existent to the extent that human waste is present in human living areas. In one room of 4 square meters more than three people are living, which is not healthy. The structure is not durable. It cannot stand the extreme weather conditions, High or Low temperatures. They lack any security because they are made on temporary basis and are on verge of dislodgement at any time (Jene Cates, 2017, July 6). Slums are usually started at outskirts of Urban areas and then with passage of time

they expand their boundaries on publicly owned or disputed lands hence forming formal settlements that makes poor people to be attracted to them (Rosa, 2011).

The streets in slums are usually too narrow and unpaved. During rainy season, water stagnation is a routine problem. Secondly this causes unhygienic condition of slums which makes favorable conditions for diseases to spread out (Dziuban et al, 2010). One feature of slum is that slums are usually not owned by its residents rather it's the property that belong or owned by Government, Governmental organizations or disputed land or unclaimed land. Therefore, slum dwellers seek the land which is not been progressive or productive. They utilize it by settling in there. As a result, we can say that Slums are result of bad management by government, corruption, dysfunctional land markets, bad financial system, failed policies and unwilling political system (Kamruzzaman, 2015).

A study was conducted in Arif Wala to explore the living conditions of Slums. It was mentioned in the paper that housing interior was in poor conditions. Houses were made of mud. There was no proper infrastructure. Sewerage system was not up to the mark. There is not even a formal setting of kitchens. Kitchen or cooking areas were exposed to dirty garbage, unhygienic conditions and poor sewerage system. Availability of sui gas was almost unavailable. Firewood was the source of energy to cook or to heat up. Crime rates in slums areas were high as compared to non-slum areas and number of people addicted to drugs is highest in these areas (Faheem, Mehmood & Shah, 2012).

2.3 Health Conditions due to Cooking Smokes

According to literature, poor sanitation conditions and dirty environment in slums is highly associated to health-related problems like respiratory issues, stomach problems and other

contagious diseases. (DaVanzo, Butz & Habicht, 1983; Jain, 1985; Merrick, 1985; Rahman et al., 1985; Victoria et al.,1988; Gubhaju, Streatfield & Majumder, 1991).

Diarrhea is a serious health problem and has caused around 3 million deaths in 1992 (Grant, 1994). Minimum of 3 million toddlers have also been died of respiratory diseases due to bad hygienic conditions and poor circumstances of sanitation (Pio, Leowski & Ten Dam, 1984; Leowski, 1986). Majorly, poor sanitation conditions in slums are results of these diseases (Stephens, Mason & Isely, 1985). Few of the diseases spread out because people residing in slums are not aware of personal hygiene (Stanton, Clemens & Khair, 1988; Henry & Rahim, 1990) and because of dirty water or poor management system of sanitary conditions (Briscoe, 1987; Briscoe, Baltazar & Young, 1988) and not disposing off human feces properly (Baltazar & Solon, 1989; Han & Moe, 1990).

Problems are not only related to poor sanitation and waste management, but also due to bad smokes and insufficient ventilation. This problem of domestic smokes and bad ventilation in kitchen or cooking systems produce the acute respiratory infections. Or the people residing in slums where there is bad smoke producing due to animal dung, firewood and bad ventilation of slums. The smoke that is caused by combustion of biofuels impacts resident's health badly especially the respiratory problems. Poor ventilations make the problem tougher. Though these acute respiratory health risks are associated with people living in urban areas (Pandey et al., 1989; Armstrong & Campbell, 1991).

Pakistan comes at 9 in the list of populous countries and its population is still increasing with 4.38 percentages annually. One third of its population is residing in urban areas (Grant, 1994). A survey from a study of 1990-91 showed that kids under the age of 5, 16

percent of them got acute respiratory infection within two weeks of survey. Also, cough complemented by rapid breathing. Almost 40% of population is settling in katchi abadis, where they are living in less than 500 square meters of the houses (National Institute of Population Studies & IRD/Macro International, 1992).

In Urban area, contamination through air and water is being faced by most of the earth population (Bickerstaff, K.; Walker, 2001). There are many studies on the relationship between air pollution and different health issues related to stomach and respiration (Leem et, al, 2006; Pope & Dockery, 2006; Azizullah, Khattak, Richter, & Häder, 2011; Moore, Gould, & Keary, 2003; Kuddus, & Rahman,2015; Smith, Mehta, 2003; Aeusezahl-Feuz, 2004).

2.4 Awareness of Risks Involved with Health Issues

Biomass fuels used as primary source of cooking is used throughout the country. Improved stoves are considered to be reducing the level of bad air pollution (Bruce, McCracken, Albalak, Schei, Smith, Lopez, 2004). Changing the method has proved to be reducing the mortality rates within slums. In rural population, the level of awareness is quite very low, and they are the most who are vulnerable to be affected by the smoke. The lack of familiarity with this concept is linked with lesser willingness to change (Khushk, Fatmi, White & Kadir, 2005).

Making people aware about the risks involved with these exposures can make them change their behavior towards consumption of energy usage (Berry et al, 2013; Elliot et al, 1999; Hillier, 2016). Thus, it is very important to project new behaviors to change the perception and knowledge about environmental hazardous results of bad smoke (Sjöberg, Moen & Rundmo, 2004).

A study was conducted in Peshawar, to assess how many people were using clean energy and how many of them were aware that what kind of energy is good for individual's health and environmental friendliness. In this study results showed many few people were willing to adopt anything that is expensive to their current cooking methods but are willing to adapt if it's easily available. But study confirmed that individual's qualification, monthly income depends on making choice that either they should use biomass stoves or not. Not only individual's choices and convenience, socio-economic, political, economic, institutional factors also matter to change people's mind. (Jan, I., 2012).

2.5 Willingness to Pay for Clean Energy

Pakistan is energy deficient country. People with low income cannot afford fuels due to high prices. That makes people depends highly on local forests to fulfill their domestic needs. The major reason behind not adapting the clean energy is not being aware of these facilities. Usually three-stones or open-mud stoves are used in urban slums and rural areas of Pakistan. These sources tend to be low efficient (Masera, et al, 2007; Mehta, Shahpar, 2004). People in slums have very low income and average Rs. 525 was their whole day expense. Saving was nothing. (Faheem, Mehmood, & Shah, 2012). Apart from health issues, social and economic problems are also associated with biomass fuels especially if it's being consumed in inefficient way (Agarwal, 2010). There are few women in Pakistan who spent up to 6 hours to look for firewood. Likewise, extra physical and financial efforts are also involved in all these hassles (Jan, I. 2012).

2.6 Willingness to Shift to Clean Energy

Pakistan is energy deficient country. People with low income cannot afford fuels due to high prices. That makes people depends highly on local forests to fulfill their domestic needs. The major reason behind not adapting the clean energy is not being aware of these facilities. Usually three-stones or open-mud stoves are used in urban slums and rural areas of Pakistan. These aforementioned sources tend to below efficient (Masera, et al, 2007; Mehta, Shahpar, 2004).

There is challenge in developing countries that energies are distributed unevenly. 90 % of the world's population is unable to access modern, convenient and environmentally friendly energies (Barnes & Floor, 1996). Around 250 Million around the world depends on Woody and non woody for instance, shrubs, agricultural waste and dung biomass fuel and charcoal. 1.6 Billion People in today's world are without electricity and that is a big hurdle in implementing the sustainable development and renewable energies in rural areas as well as urban areas in developed countries (Ailawadi, & Bhattacharyya, 2006). In Urban slums, biomass fuels are consumed more frequently and are relatively more frequent where people are earning lesser than the average. 3% of global infections and syndromes are produced by indoor pollutions mainly from Bad Smokes of Slums. That results in premature death of 1.6 million babies in one year and further around one million deaths of kids' underage of 5 years (Warwick, H., & Doig, A. 2004). Million other people have lots of health-related issues like asthma, sinus issues, breathing & wheezing problems eyes' infections (Boy, E., Bruce, N., & Delgado, H. 2002) & (Chen, L., Verrall, K., & Tong, S. 2006).

Apart from health issues, social and economic problems are also associated with biomass fuels especially if it's being consumed in inefficient way (Agarwal, 2010). There are few women in Pakistan who spent up to 6 hours to look for firewood. Likewise, extra physical and financial efforts are also involved in all these hassles (Jan, I. 2012).

The overall thinking at individual is very important to reduce atmospheric pollution, to improve public health. Nevertheless, to minimize the risks associated with health will be dependent on the factor that what people perceive about it and their acceptance to adapt something that is healthy for them and for their environment as well.

Energy consumption is an indicator of industrial economy and prosperity of the people in a country. Energy resources are rapidly depleting due to drastically increasing global population and materialistic lifestyles of the people. Furthermore, the growing use of energy across the world has adversative effects and implications on the environment and ecosystem. Amongst the causes of environmental degradation, use of fossil fuels for energy generation is a major one. The increasing consumption need and demand for energy depict that energy will be one of the major future problems of the world (Sen Z, 2004).

Alternative renewable resources of energy, which are clean and, are required to meet this demand and to combat the adverse environmental problems at the same time. Renewable energy sources such as solar energy have the potential to fulfill the energy demand without producing the greenhouse gases and affecting the ecosystem. Pakistan is currently facing a severe energy deficiency. Energy supply and demand gap is large and is increasing with time. The country has limited resources of fossil fuel and need to import to reduce this gap (Muneer, Maubleu, Asif, 2006; WAPDA, 2016). Due to the shortfall of energy, people in urban areas still face issues for gas connection (Farooq & Shakoor, 2013). In order to

relegate the energy shortfall in the country, it is pertinent to diversify the energy resources like solar, hydropower, wind and biogas.

Pakistan is situated in the high solar isolation area on the Earth (Gadiwala, Usman, Akhtar & Jamil, 2013). The potential of solar energy resources can be used to create solar energy in replacement of firewood, natural gas & other sources for the domestic usage of household i.e. Solar Cooker or Solar water Heaters. (Farooq & Kumar, 2013).

In South Asia the households follow the energy ladder comprising fuels like crop waste, dung, kerosene, firewood, *Gobar* gas, LPG, and electricity for cooking purposes. Evidence suggests that the change and shift to energies are more likely to be adopted in urban and semi-urban areas than rural areas (Viswanathan, Kumar, 2005).

2.7 Proposed Research Model

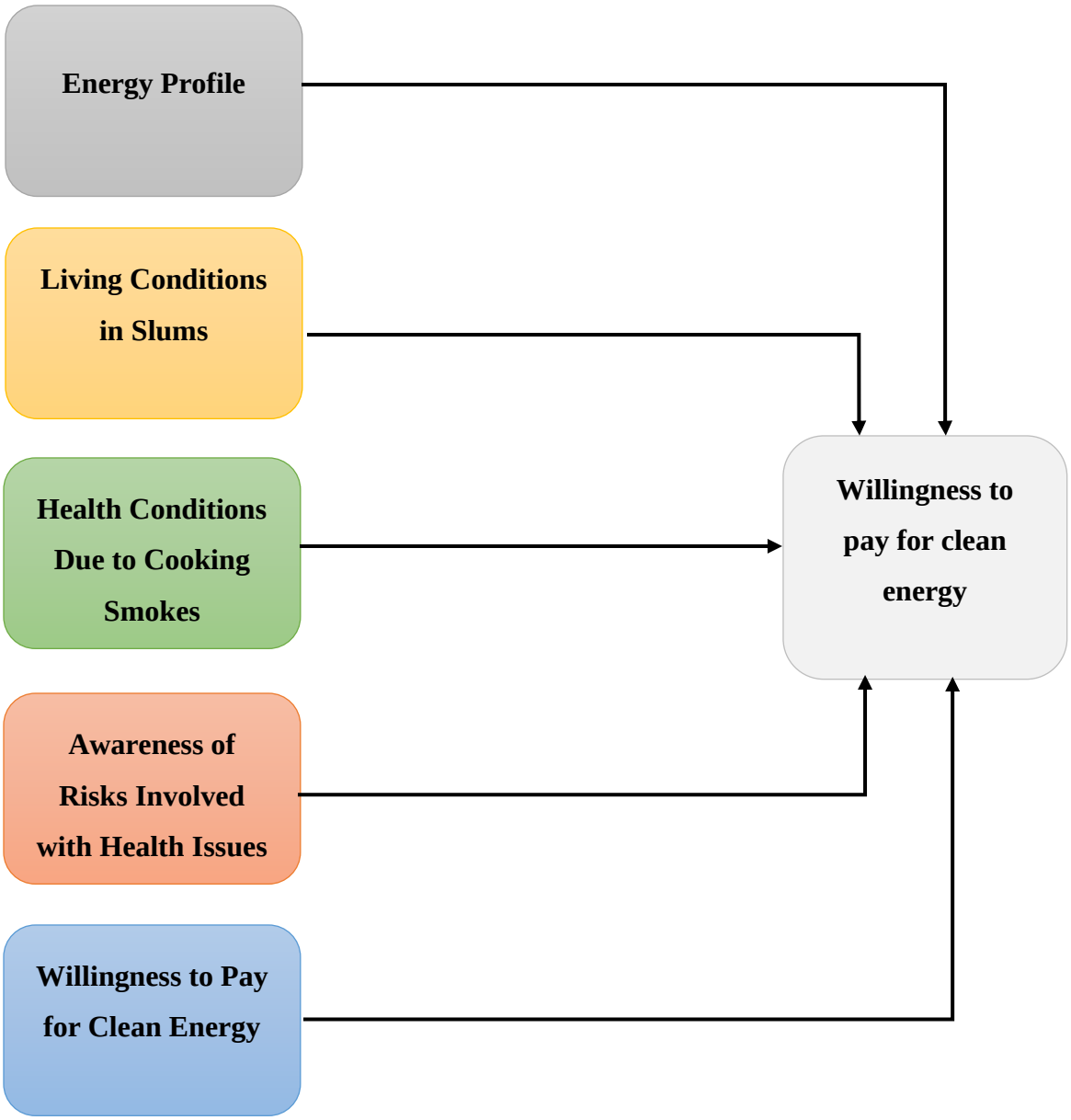

Figure 2-3: Proposed research model

Chapter 3: RESEARCH METHODOLOGY

3.1 Introduction

This chapter highlights and elaborates the research technique and methodology that has been conducted during this research study on the targeted slum areas. It also depicts contextual study of these areas in terms of its topographical, demographic and socio-economic features. Furthermore, it illustrates the sampling procedure, approaches used for data collection, data analysis, tools and techniques to carry out this study. Statistical Package for the Social Sciences (SPSS) version 20.0, statistical software platform was used to evaluate the questionnaires attained from the respondents while surveying study areas.

3.2 Areas under Research

The city of Rawalpindi, which is commonly known as Pindi, situated in the Punjab province of Pakistan. Capital of Pakistan, Islamabad is adjacent to Rawalpindi.

These two joint cities are recognized as the "twin cities". It is located on the coordinates of 33°36′N 73°02′E (pbs.gov.pk). The city is surrounded by Islamabad area on North and East and with motorway and Taxila cities on West. Its area spreads to 250 square Kilometers on the south-western side to the national capital of Islamabad.

The City-District of Rawalpindi covers seven autonomous tehsils i.e. Rawalpindi, Gujarkhan, Taxila, Muree, Kotli sattian, Kahuta and Kallar Syedan. Rawalpindi is the military headquarters of the Pakistan Armed forces. The administration of Rawalpindi city is called Rawal Town administration. The main Rawalpindi City is Rawal Town.

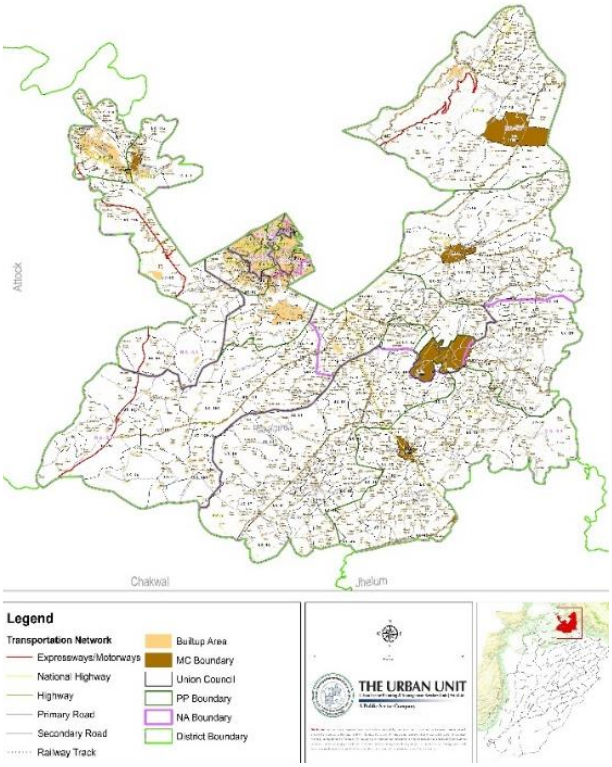

Figure 3-1: Location of Rawalpindi

Rawalpindi area falls under the jurisdictional responsibility of Rawal Town, Rawalpindi Cantonment Board and the Rawalpindi Development Authority. The city was declared as interim capital which witnessed serious housing shortage in the city with the increased business opportunities. Till then, the city grew tremendously but the infrastructure and services could not keep pace with the population growth.

Rawalpindi is considered as the fourth largest city of Pakistan by population and the third-largest metropolitan area of the country (pbs.gov.pk). The population, inhibiting approximately 2.1 million persons in 2017 (pbs.gov.pk). It is estimated that the population will reach 3.2 Million persons by the end of 2020 (Population Census Organization, 1998).

84% of the population is Punjabi, 9% is Pashtun, and 7% is from other ethnic groups (pbs.gov.pk).

3.2.1 Location of Slum Areas under Research

As research objective of this study is to analyze the use of energy and its impact on the household in the slums of Rawalpindi City. Four areas of the city were selected, includes Gharibabad (near to Chaklala Cantonment, as shown in Figure 3-3), Do Manzli (near to Rawalpindi Cantonment, as shown in Figure 3-4), Gawalmandi Supply and Gawalmindi – along Nullah (as shown in Figure 3-5).

Figure 3-2: Targeted slum areas of Rawalpindi

Majority slum dwellers of Gharibabad have ownership rights and are settled legally. It is surrounded by Chaklala Cantt, Railway Scheme Chaklala and Chaklala Scheme-III.

Figure 3-3: Location of Gharibabad slum area

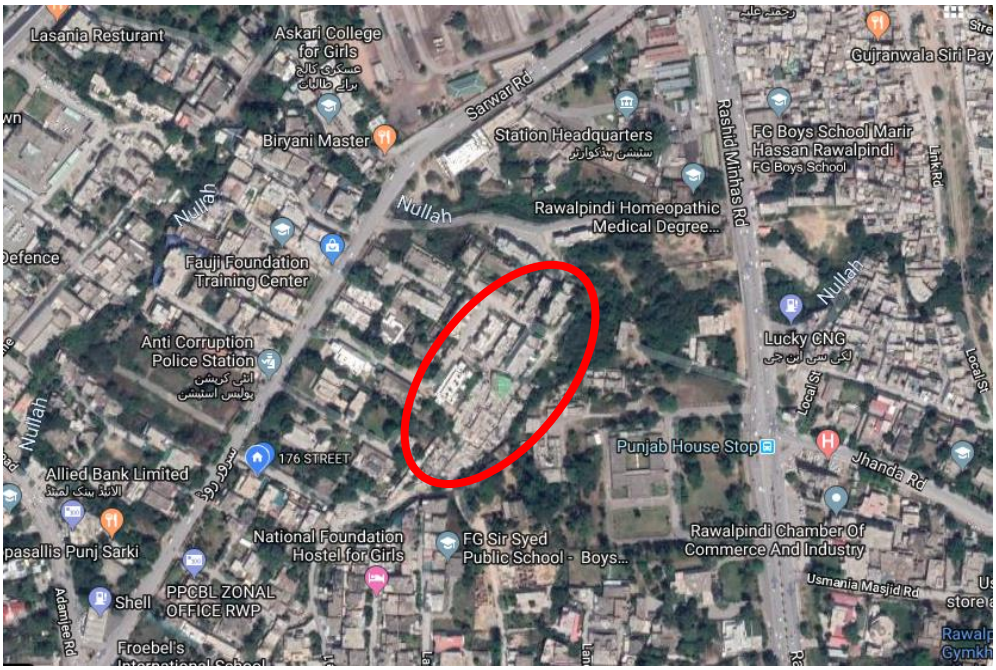

Figure 3-4: Location of Domanzli slum area

Domanzli is situated near the Rawalpindi Station Headquarters. Slum inhabitants of Domanzli have no property rights on the land they are resided. As this land is in the ownership of Government officials and the slums dwellers of Domanzli are working as housekeepers in the house of these Government officials.

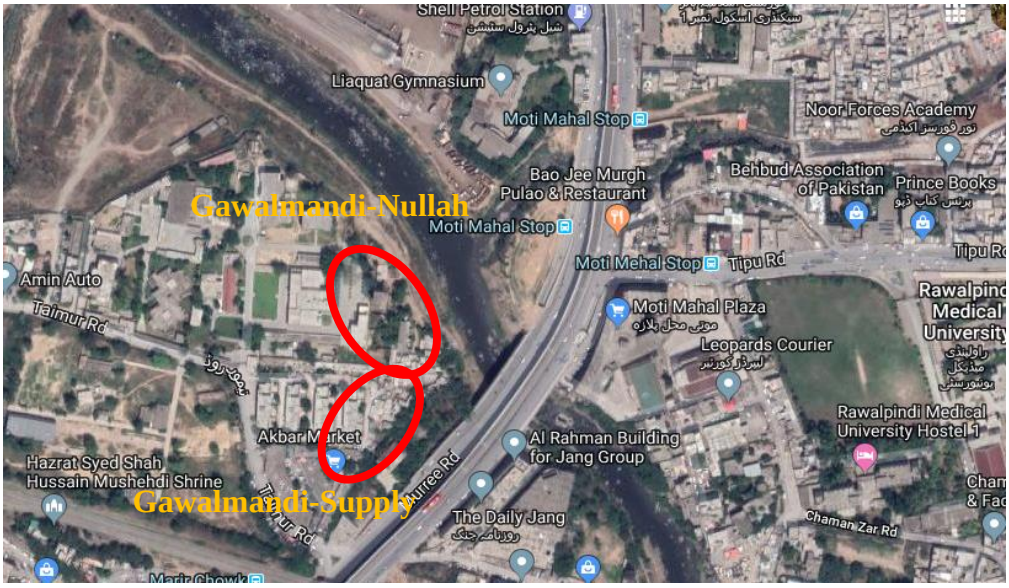

Figure 3-5: Location of Gawalmandi-Supply and Gawalmandi-Nullah slum areas

Whereas, the Gawalmandi found near the Chaman Colony and Mohan Pura. For this research study, Gawalmandi is divided into two sections with the name of Gawalmandi-Nullah and Gawalmandi-Supply based on the names used by the residents of these slums. Households of Gawalmandi have illegal possession on the land they are living. These slums are financially deprived and lower middle class. These areas were considered most conforming to the objectives of this research. Survey of these slum residents was conducted by distributing questionnaires among them.

3.2.2 Geographic Location Characteristics

3.2.2.1 Climate

The climate of Rawalpindi is mostly considered moderate and warm. As compared to winter, the summers have much more rainfall. The average calculated annual temperature is 21.5 °C in Rawalpindi. The average annual rainfall is 941mm.

November is considered the driest month with 16mm of rain. The precipitation reaches its peak in July with an average of 237mm. June is the warmest month of the year, temperature in this month is 32.0 °C average. January is the coldest month of the year on average temperature of 9.8 °C (en.climate-data.org).

3.2.2.2 Population

Rawalpindi is considered the one of the highly populated cities of Pakistan as compare to other cities. The population was counted more than 3.26 million individuals during the 6th Population and Housing Census 2017 as against the recorded population of 1,927,612 persons as per the Census of 1998, showing 69.045 growth rate over a period of 1998-2017 (Rehman, 2017). According to 6th Population and Housing Census, country's total population has been recorded at 207.744520 million which depicting an average annual growth rate of 2.4% from calendar year 1998, when the last population census was conducted. This included 132,189,531 rural and 75,584,989 as urban population, which showed 2.23% and 2.7% percent growth rate over a period of 1998-2017 (Rehman, 2017). By various surveys and assessments, it can be concluded that approximately 23 to 32 million people in Pakistan are slum inhabitants (Janjua, 2014).

The targeted slum area of this study comprises of 2158 people and 400 households. Most of these slum inhabitants are with temporary residents who shifted to the city to avail best employment opportunities.

3.2.2.3 Housing

Mostly slums and shanty settlements are found in the least-habitable parts of the city e.g. on steep hillsides, in low-lying grounds adjacent to Nullah prone to flooding, or along the downstream course of industrial waste residue. Majority of slum dwellers are settled illegally beside these locations. Inhabitants living in these areas are highly exposed to natural disasters and pollution-borne diseases. Most of the housing units are made up of iron sheets, cardboard, wattle and are comprise of one to two rooms. Majority of houses are limited to dimensions of 250-300 square feet and have minimum or no space between them. The houses are overcrowded with average 6 members per house.

3.2.2.4 Employment and Economic Activities

Unemployment rates are very high due to little to no education for slum dwellers, particularly in case of women. Furthermore, due to shortage of competitive job markets, many slum dwellers are compelled to find work in vicinity to slums located in urban areas. Such employment can either be a part of the illegal or legal informal economy with no contract or social security cover. Mostly jobs include domestic work, street hawking, packaging and product assembly, garland-making, embroideries on clothes, shoe repairing or polishing. Few people sort and recycle trash of different kinds, from electronics garbage to household trash, and selling them to get some monetary amount. From this little income, frequently the poor workers have to pay bribes to the police or other government staff in

order to be ignored. In such circumstances, many households are trapped into poverty, unable to afford clean energy resources, cannot bear sub-standard housing, water supply, electric facilities and minimal social services.

3.3 Study Methodology

The growth in urbanization and movement of slums towards urban areas has become a critical factor to control the growth strategies in under development countries. Poverty is another crucial factor on it. To improve the economic condition of Pakistan, it is pertinent to exterminate the problems of slum residents in the country.

The primitive aim of this research is to study socio-economic conditions of residents of slum dwellers and assessment of energy sources used by the slum dwellers of Rawalpindi. To achieve the goal of this research, basic survey was carried out to find the energy sources used by the households and based on those sources two strata were formed. These strata had households using two different sources of energy in two arrangements. Four areas of slums were selected based on these strata to highlight the socio-economic conditions and impacts of these sources of energy on the households. A questionnaire was designed (attached in appendix) to determine the socio-economic conditions, type of energy resources used and its effects in the perspective of their financial and health situations.

3.3.1 Sampling Size

The total estimated population of Rawalpindi is 3.2 Million where the targeted four slum areas of this city comprise of 2158 population. The amount of questionnaire circulated

among these areas were 400. So, the total of 100 questionnaires were rotated in each area and the sample size of 400 was opted for this study using the following equation:

$$n = \frac{N}{1 + N(e^2)}$$

Where:

n = the sample size

N = the population size

e = tolerance at desired level of confidence (0.05) at 95% confidence level

3.3.2 Sampling Framework

Stratified random sampling was used to get the response of 400 household samples. Basic field survey was conducted to determine the types of energies being used by the households of selected areas of slums. Two strata were formed on the basis of these types of energy and two areas of slums belonged to each stratum.

3.3.3 Sources and Methods of Data Collection

Questionnaire (attached in appendices) was formulated based on the indicators selected through literature review. Further it was divided into six sections: Socioeconomic profile, house conditions, energy use in the household, health conditions, awareness of cooking smoke regarding illness and willingness to change cooking practices. The questionnaire design was carefully read and re-read, and open-ended questions were categorized into

different themes through content analysis. The similar answers were categorized into similar themes in order to run numerical analysis.

3.3.4 Data Analysis Techniques

These survey questionnaires were disseminated among these slum inhabitants and interviews of residents were performed. One hundred questionnaires were filled in by the residents of each slum area so the total of four hundred questionnaires were circulated and answered. Then the response of completed questionnaires was rechecked after collecting them and coded, prior to enter data into the SPSS software. This application helps in computing complex statistical and quantitative data analysis. The collected data obtained from the slum respondents was entered in this software to proceed the statistical analysis. Output generated by the SPSS application was in the form of frequency distribution and cross-tabulations which supports to portray sampling data in the shape of tables. Moreover, two Microsoft applications i.e. Microsoft Excel and Microsoft Word were used to represent the data in tabular and chart icon.

3.4 Ethical Requirements

In the data collection process, employee's comments were not shared with any irrelevant company or individual and they were kept confidential.

Chapter 4: DATA ANALYSIS AND INTERPRETATION OF RESULTS

Key objective of this research was to assess usage of existing energies used for cooking, their impact on finances and health on the households and to introduce the clean, cheap and reliable energy for the domestic use of slum areas under study. This chapter presents the analysis and interpretation of data collected from survey of slum dwellers. Further these gathered statistics were inserted into the SPSS software (as described in the previous chapter 3 as well) to generate the output in tabular form. Different analyses were performed such as descriptive analysis, correlation, and factor analysis were applied on the collected data to conclude the results. These findings and results are also described in this chapter.

4.1 Socioeconomics Characteristics of Sampled Respondents

The data collected from the slum houses under research, were four hundred (400) in number comprising of around 2158 residents. Table 4-1 portrays size of household, number of males, female, infants and the number of working individuals in the household.

The minimum household size consists of one person and the maximum household size is 14 while the average household size of these four research zones is 5.4. The table below shows the distribution of household size amongst the four slum areas. The household size of slums of Gawalmandi is slightly more than that of Domanzli and Gharibabad combined.

Table 4-1: Characteristics of sampled respondents

Parameters	Minimum	Maximum	Mean	Std. Deviation
Size of household	1	14	5.40	2.201
Number of male household members	0	6	1.84	0.999
Number of female members	0	10	3.56	1.722
Number of children less than 5 years	0	3	1	0.946
Number of working household members	1	6	1.49	0.769

Table 4-2 shows the distribution of sample population residing in the four areas and their average household size. It can be observed that average household size of slums of Gawalmandi is greater than the slums of other areas.

Table 4-2: Size of households

Area	Size of household	Average household size
Domanzli	555	5.55
Gharibabad	495	4.95
Gawalmandi - Along Nullah	526	5.26
Gawalmandi - Supply	582	5.82

4.1.1 Poverty Intensity Coefficient

For the further clarification on the poverty intensity and how it's distributed amongst these households, a detailed analysis on SPSS was carried out. A variable of poverty intensity was formulated using the basic indicators which could help in determining the economic situation and wellbeing of households. This economic situation was based on the variables which have been discussed in detail in previous analyses. For the purpose of computing the poverty intensity, following variables were standardized and their z-scores were computed.

i. Per Capita income
ii. Household head education
iii. Number of educated female members in a household
iv. Mean of education levels of female members
v. Number of rooms in a household
vi. Construction material of a house
vii. Number of hearths
viii. Availability of amenities
    a. Water
    b. Gas
    c. Electricity
    d. Sanitation
ix. Availability of facilities
    a. Mobile phone

b. Telephone

c. TV

d. Internet connection

e. Refrigerator

Their z-scores standardized the output values of interval scales and dichotomous questions. A variable was computed taking mean of these z-scores and the descriptive analysis was run to find the mean, standard deviation, maximum and minimum values of this poverty intensity coefficient which are depicted in the table below:

Table 4-3: Poverty intensity coefficient

	N	Minimum	Maximum	Mean	Std. Deviation
Poverty Intensity coefficient	400	84.18	823.62s	238.8	100.2408

For the computation of poverty intensity coefficient, per capita income is a significant variable. In Table 4-3, the minimum value 84.18 depicts that the household equipped with minimum facilities with low per capita income whereas maximum value 823.62 shows that household having majority facilities with maximum per capita income. Based on these values including mean and standard deviation, this coefficient was recorded into different variables which categorized households into different classes, explaining the poverty intensity. As data is more skewed towards the minimum value with a very high standard deviation, the coefficient was divided into four classes as shown in table below.

Table 4-4: Household classes

Coefficient Value	Class	Interpretation
550 - Max	A	Very low poverty level
300-550	B	Low poverty level
150-300	C	Medium poverty level
Min – 150	D	High poverty level

Regarding these classes, the main point should be kept in mind that class-A households are not high-income households. They are relatively better than class B, C and D economically and financially. In the same way, class-B households are relatively better than class C and D households. Class-D households are considered relatively the least privileged households.

4.1.2 Classification of Households

Table 4-5 below shows the distribution of households of all the areas against their classes. Almost three quarters of households (73.8%) lie in the class C which depicts that most of the slums are deprived of basic facilities and are financially weak. Out of class C households (n=295), 55% (162) households are in the area of Gawalmandi while rest of households lie in the area of Domanzli and Gharibabad. Class B has 14% of the total households with majority (38%) lying in the area of Gharibabad while Gawalmandi (both

slums) and Domanzli have equal number (17) of households in this class. Households which fall in class A, comprise of very small percentage (1.8%) of the total households which depicts that few households are equipped with more basic facilities and good incomes. Out of these 7 households of class A, 4 are in the area of Gharibabad while the other three are equally distributed in the rest of the three slums.

Table 4-5: Distribution of respondents in classes

Area of Respondents	**Class A**	**Class B**	**Class C**	**Class D**	**Total**
Domanzli - Sarwar Road	1 (0.3%)	17 (4.3%)	65 (16.3%)	17 (4.3%)	100 (25.0%)
Gharibabad	4 (1.0%)	21 (5.3%)	68 (17.0%)	7 (1.8%)	100 (25.0%)
Gawalmandi - Along Nullah	1 (0.3%)	10 (2.5%)	83 (20.8%)	6 (1.5%)	100 (25.0%)
Gawalmandi - Supply	1 (0.3%)	7 (1.8%)	79 (19.8%)	13 (3.3%)	100 (25.0%)
Total	7 (1.8%)	55 (13.8%)	295 (73.8%)	43 (10.8%)	400 (100.0%)

Class-D constitutes of least facilitated households which are 43 in number, most of which (17) lie in the slums of Domanzli. There are 19 houses in both slums of Gawalmandi and 7 in the slums of Gharibabad falling in this class.

For the purpose of finding out which of the four slums has the best living conditions based on poverty intensity coefficient, weighted mean method was applied. Class A households were given the highest rank i.e. 4, class C was assigned a value of 3 and so on. The lowest rank was given to class D i.e. 1. These weights were multiplied by the number of households for each class and weighted mean was computed which explains the average condition of the households in each area of slums. For instance, taking values from the table for the slums of Domanzli to find out the weighted mean:

$$\text{Weighted mean} = \frac{\sum RiXi}{\sum Xi}$$

Where R_i represents the respective rank for the households for each class and X_i represents the number of households in that class.

$$\text{Weighted mean (Domanzli)} = \frac{4*1+\ 3*17+\ 2*65+1*17}{1+17+65+17} = 2.02$$

This value 2.02 explains that an average household in Domanzli, lies marginally above the class C as this class was given the rank of 2. This formula was applied for all the slums and following results were obtained:

The Table 4-6 shows that living conditions in the slums of Gharibabad are better than the rest of the slums as its weighted mean falls between 2.0 and 3.0 and has the highest average per capita income of Rs. 4672. This means that an average household of Gharibabad is more facilitated than the slums of other areas and has better living conditions. This is justified by the numbers of households falling in the class A and B which are maximum for Gharibabad and lower number of houses in class D.

Table 4-6: Distribution of slums in classes and their per capita income

Area of Respondents	Class A (4.0)	Class B (3.0)	Class C (2.0)	Class D (1.0)	Weighted mean	Average per capita income (Rs.)
Domanzli - Sarwar Road	1	17	65	17	2.02	4075
Gharibabad	4	21	68	7	2.22	4672
Gawalmandi - Along Nullah	1	10	83	6	2.06	3930
Gawalmandi - Supply	1	7	79	13	1.96	3563
Total	7	55	295	43	2.065	

The weighted mean values of Domanzli and Gawalmandi (lies along the Nullah) are very close, but the latter's value is slightly greater than the former. On the other hand, the households of Domanzli have a higher average per capita income than that of Gawalmandi (along Nullah) with the difference of Rs. 146. This indicates that the average per capita income of Domanzli is more than that of Gawalmandi (along Nullah), reflects the financial

position of the households. Whereas in case of discussing living conditions and other factors which have been described above are considered, it is depicted that slums of Gawalmandi (along Nullah) are availing better conditions than those of Domanzli.

The lowest weighted mean and lowest average per capita income of Gawalmandi shows their living conditions and financial position which are worst among the residents of other areas. The weighted mean of 1.96 shows an average household in this area lies below class B and are deprived of basic facilities and amenities.

4.1.3 Gender Distribution in Slums

The total number of respondents was 400 out of which 228 (57%) were females and 172 (43%) were males. This unequal distribution can be explained as the mostly women are housewives and left at home and men usually set out for work. Table 4-7 shows the distribution of male and female headed houses. Almost 96% houses are headed by men while female headed houses contribute 4% to this distribution.

Further analysis revealed that none of the house has female household head in the class A. All 7 houses which fall in class A have male household head which indicates that households which don't have male as household suffer more from low living standards and are financially weak. Only one house with female head lies in the class B which further implies that houses with relatively better living conditions have male household heads because females in these slums usually work as domestic servants and they don't earn as much as men.

Table 4-7: Distribution of males and females in slum areas

Area of Respondents	Gender of the Respondents		Gender of Household Head	
	Male	**Female**	**Male**	**Female**
Domanzli - Sarwar Road	9	91	95	5
Gharibabad	15	85	93	7
Gawalmandi - Along Nullah	77	23	97	3
Gawalmandi – Supply	71	29	98	2
Total	172	228	383	17
	(43%)	(57%)	(95.8%)	(4.3%).

4.2 Literacy Level of Household Heads

The respondents were asked about the literacy level of household heads. The graph below shows the level of education household heads attained:

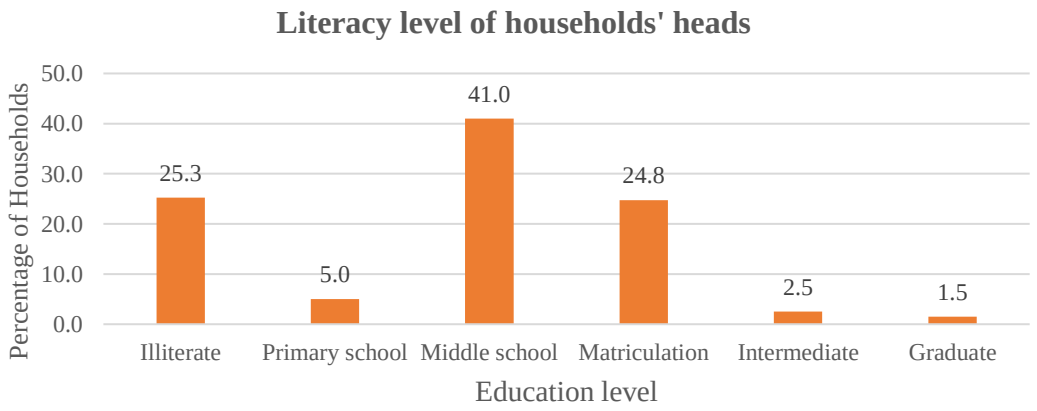

Figure 4-1: Literacy level of households' heads

This shows that most of the household heads (41%) attained education up to middle school only while almost 25% passed the matriculation. The household heads having 12 and 14 years of education constitute only 2.5% and 1.5% of the total households, respectively. The graph also shows that almost one-fourth (25.3%) of the total household heads are illiterate and 5% passed the primary school.

The ratio of households with no literate family members to households with at least one literate family member was found to be 1:4.

4.3 Female Literacy Rate

Area wise percentage of educated female members is depicted in the Table 2-1 which explains that only one-fifth (268) of the female population is educated. Out of these 268 females, only 1.2% has attained the matriculation degree while the rest have just passed the middle school.

Among Pakistani slum dwellers, there is insignificant trend towards the female education due to early marriages, insufficient financial resources and are forced to stay within the house premises. While, higher education of women is as much important as for the men so that they have better access to information and knowledge which would be beneficial in their domestic activities. This also depicts that the higher the education level of female members, the more will be awareness about the clean energy resources used in the houses.

Table 4-8: Female Literacy Rate

Area of Respondent – No. (%)	Household Population	Male Members	Female Members	Female Educated Number
Domanzli - Sarwar Road	555	218 (39%)	337 (61%)	56 (17%)
Gharibabad	495	166 (34%)	329 (66%)	43 (13%)
Gawalmandi - Along Nullah	526	164 (31%)	362 (69%)	102 (28%)
Gawalmandi - Supply	582	187 (32%)	395 (68%)	67 (17%)
Total	2158	735 (34%)	1423 (66%)	268 (19%)

4.4 Monthly Income of Household

Monthly income interval of slum households is illustrated in the Table 4-9. The maximum monthly household income recorded amongst the four areas is Rs. 40,000 while minimum monthly income is Rs. 8,000 whereas; the average monthly income is Rs. 19,305. The lowest average monthly income was calculated in the vicinity of Gawalmandi. Majority income of 63%, amongst these areas lies in the range of Rs. 10,000-20,000 and one-third of the households' income lies between Rs. 20,000-30,000. Maximum income range being

between Rs. 30,000-40,000, earned by only 1.3% of the population which shows that the population of understudy zones are financially challenged. Residents of these areas do not have enough earnings to improve their living standard and are not capable of accumulating savings at the end of the month because electricity and cooking expenses.

Table 4-9: Monthly income of household

	Income Intervals (Rs.)					
Area of Respondents	**8k-10k**	**10k-20k**	**20k-30k**	**30k-40k**	**Mean Income (Rs.)**	**Per capita income – (Rs./month)**
Domanzli - Sarwar Road	2.0%	65.0%	32.0%	1.0%	19,370	4075
Gharibabad	5.0%	58.0%	35.0%	2.0%	20,610	4672
Gawalmandi - Along Nullah	5.0%	60.0%	34.0%	1.0%	18,580	3930
Gawalmandi - Supply	2.0%	69.0%	28.0%	1.0%	18,660	3563
Total	3.5%	63.0%	32.3%	1.3%		

Average per capita income earned monthly amongst all the households is Rs. 4060. The value given by World Bank for threshold value of poverty line is $1.9 per day earned by a

single member of a household, which if converted into Pakistan currency per month yields the value of Rs. 9000. This leads us to the conclusion that all the households of our sample lie far below the poverty line because in each area average monthly per capita income is less than Rs. 9000.

The above table suggests that both slums of Gawalmandi have the lower monthly per capita income than the rest of the slums. The average monthly income of the total sample population is Rs. 19,305. This implies that both the slums of Gawalmandi are on the lower side and have worse financial conditions than the slums of Domanzli and Gharibabad. The average income of the slums of Domanzli and Gharibabad is higher than the average income of all the households with Gharibabad having the highest average monthly income and per capita income amongst all the slums. This shows that slums of Gharibabad have a better financial standing and it may be added that they have a better living conditions than the households of other areas.

4.5 Occupations in households

63% of households have only one working member and one-fourth of the households have two working members. Whereas, only one house has the maximum number of working members which is six. Slum inhabitants having working members of 3 to 5 comprise of only 8% of the total households. It was observed that households which consist of more than one working member usually have one working female along with male member.

Table 4-10: Classification of employed population

Area of Respondents	Basic Source of Income				
	Labor	**Government Servant**	**Private Job**	**Private work at Home**	**Total**
Domanzli - Sarwar	19.0%	5.8%	0.3%	0.0%	25.0%
Gharibabad	13.3%	9.3%	2.3%	0.3%	25.0%
Gawalmandi - Nullah	25.0%	0.0%	0.0%	0.0%	25.0%
Gawalmandi - Supply	23.3%	1.3%	0.5%	0.0%	25.0%
Total	80.5%	16.3%	3.0%	0.3%	100.0%

Most of female workers were illiterate and were working as domestic servants in nearby houses. Their duties included housekeeping, cleaning, babysitting, dry cleaning, dishwashing, ironing et cetera. Women of all ages were found to be performing these duties ranging from the age of 10 to 65. Despite having multiple female working members, there was no interrelation exists that shows a direct proportion relationship between monthly income and number of working members. As research analysis exhibits that the household with maximum working members also lie in class D which deduce that earning of working female members don't contribute as much to the total income of house since their wages range from Rs. 2000 to 4000 per month only.

Above table reflects the types of occupation of these slum dwellers have, to make their earnings. Majority of the working members (80%) of these households are labors i.e. masons, plumbers, electricians, carpenters and street hawkers. The rest of the working

members are government servants (16%) and private employees (3.0%). These employees are mainly doing clerical jobs in these sectors. Only one out of 400 households have a working member which works privately at home. This large percentage of labor class justifies the low-income levels in these slums. Results are consistent with previous studies where researcher has mentioned the lower living standard and most of the residents have lower jobs (Mahabir, R. et al, 2016).

4.6 Number of Rooms

Number of rooms is considered as significant parameter to measure the socioeconomic conditions of slum dwellers. Table 4-11 shows the number of rooms occupied by the slum inhabitants.

Table 4-11: Number of rooms

Area of Respondents	**Number of Rooms**					
	1	**2**	**3**	**4**	**5**	**Total**
Domanzli	1.8%	20.5%	2.8%	0.0%	0.0%	25.0%
Gharibabad	1.8%	20.8%	2.3%	0.3%	0.0%	25.0%
Gawalmandi - Along Nullah	5.3%	19.3%	0.3%	0.0%	0.3%	25.0%
Gawalmandi - Supply	8.3%	14.0%	2.5%	0.3%	0.0%	25.0%
Total	17.0%	74.5%	7.8%	0.5%	0.3%	100.0%

The frequency indicates that almost three-fourths of the houses have two rooms. Maximum number of rooms in any household is five while very few houses (1%) have four and five rooms. Commonly 80% of the households from Gawalmandi slums are living in a single room which implicates that living conditions in slums of Gawalmandi are worse than those of the other slum areas.

4.7 Material of House

Houses of respondents were marked as *Pakka* and *Katcha*. *Pakka* houses are those which are properly built, constructed with either bricks or concrete while *Katcha* houses are made up of mud and wood or materials which are not durable and long lasting.

Table 4-12: : Condition and material of slum houses

	Condition of House		**Material of House**		
Area of Respondents	***Pakka***	***Katcha***	**Mud and Woods**	**Brick Masonry**	**Concrete**
Domanzli - Sarwar Road	21.5%	3.5%	3.5%	21.5%	0.0%
Gharibabad	22.3%	2.7%	2.7%	22.3%	0.0%
Gawalmandi - Along Nullah	24.8%	0.2%	0.2%	24.5%	0.3%
Gawalmandi - Supply	23.8%	1.3%	1.3%	23.8%	0.0%
Total	92.3%	7.7%	7.7%	92.0%	0.3%

4.8 Facilities Status

Table 4-13 represents the possession of facility of mobile phone, TV, telephone (landline), internet connection and refrigerator used within the targeted research areas.

Table 4-13: Facilities status

	Frequency	Percent (%)
Possession of Mobile phone		
No	37	9.3
Yes	363	90.8
Possession of TV		
No	44	11.0
Yes	356	89.0
Possession of Telephone (Landline)		
No	386	96.50
Yes	14	3.5
Availability of Internet Connection		
No	399	99.8
Yes	1	0.3
Possession of Refrigerator		
No	325	81.3
Yes	75	18.8

Majority of the households (90%) have access to mobile phone and TV. Few of them (3.5%) have telephone facility while only one household has the facility of internet connection. Amongst these households, maximum households (81%) do not have

refrigerators. Further analysis of the data reveals that most of the households who have no access to these facilities are in the vicinity of Gawalmandi, for instance, all the households with the facility of telephone lie in the areas of Domanzli and Gharibabad which implies that slums of Gawalmandi lack more facilities than the other areas. The results are linked with previous studies (Abubakar, Romice & Salama, 2019) who investigated the facilities available in different slums. Results showed that slum dwellers had very less facilities of electronic or telecom device.

4.9 Residency Period

Table 4-14 shows that major part of slums population has been residing in these communities for a long period of time. In fact, almost one-fifth of the households have been settled here since the time of independence due to meager income. These slums inhabitants were also enquired how long they have been living in these areas. Their response declared that more than half of the inhabitants (almost 57%) have resided from 5 to 20 years while above 40% of them living there round about more than 20 years. Only 11 households (3%) have settled in these zones from five years approximately.

The results of the study were consistent with various other researches (Hasan & Mohib, 2002), where researcher mentioned that houses were as old as from 1950's in Karachi. 60% of households are being forced to live in these areas due to poverty. They have insufficient resources to alleviate their lifestyle while one-third of the dwellers were settled here because their low income does not support them to shift towards facilitated locations. Even if they have good earnings, inflation and high land costs does not allow them to attain good quality life. Residents of two households stated that reason for living in these slums, is just

that their workplace and schools are near to this place which saves their transportation charges.

Table 4-14: Residence period of inhabitants

	Area of Respondents				
Age of Household	**Domanzli - Sarwar Road**	**Gharibabad**	**Gawalmandi - Along Nullah**	**Gawalmandi - Supply**	**Total**
Less than 5 years	0 (0.0%)	10 (2.5%)	0 (0.0%)	1 (0.3%)	11 (2.8%)
Between 5 and 20 years	20 (5.0%)	38 (9.5%)	83 (20.8%)	86 (21.5%)	227 (56.8%)
Between 21 and 50 years	40 (10.0%)	7 (1.8%)	17 (4.3%)	11 (2.8%)	75 (18.8%)
More than 50 years	40 (10.0%)	45 (11.3%)	0 (0.0%)	2 (0.5%)	87 (21.8%)

4.10 Cooking Arrangement

As discussed in the previous chapter of literature review that the effect of cooking smoke on a household, is an essential section of this research. While surveying respondents were asked about their cooking setups within their houses. Their responses express that maximum number of households (70%) cooked outside the living area, in courtyard.

Because the households cannot afford a separate room (called kitchen) for cooking and are compelled to cook in the courtyard.

Table 4-15: Cooking arrangement

Setup of Cooking	Frequency	Percentage
Outside the living area	280	70%
Cooks outside the house	5	1%
Separate kitchen	87	22%
Inside the living area	28	7%
Total	400	100%

Most of these houses have open courtyards which does not require ventilation for the cooking smoke. The results are same as the previous studies (Khan, 2010) and (Abubakr, 2017). Khan showed results that only 6% of the people were having separate kitchen and most of the people had to go out to cook which shows consistency in results.

Only one-fifth of the houses (21.8%) have a separate kitchen for cooking purposes, most of which lie in the area of Domanzli and Gharibabad. A separate kitchen shows these households are concerned about their health conditions and are aware of the hazards of cooking inside the living area. High percentage of such houses in Domanzli and Gharibabad shows that these areas have relatively better living situations than the slums of Gawalmandi. Only 21 houses in the area of Gawalmandi have separate kitchen for cooking

purposes which constitutes only 5% of the total houses. There is a total of 28 households (7%) who cooked their food within living area and rooms, out of which 15 are located in Domanzli and Gharibabad and 13 are in Gawalmandi. Results are consistent with the study conducted in Karachi, where only 6% of the slum population has separate kitchen which shows strong consistency (Hasan, & Mohib, 2002).

4.11 Ventilation System in Separate Kitchen

The Figure 4-2 represents the percentage distribution of ventilation condition in 87 houses where separate kitchen for cooking exists, indicating that more than one-third of such houses (36%) have exhaust fans in their kitchen for ventilation and all these houses were located in Domanzli and Gharibabad only. Almost half of these 87 houses (46%) have kitchens which are well ventilated with windows.

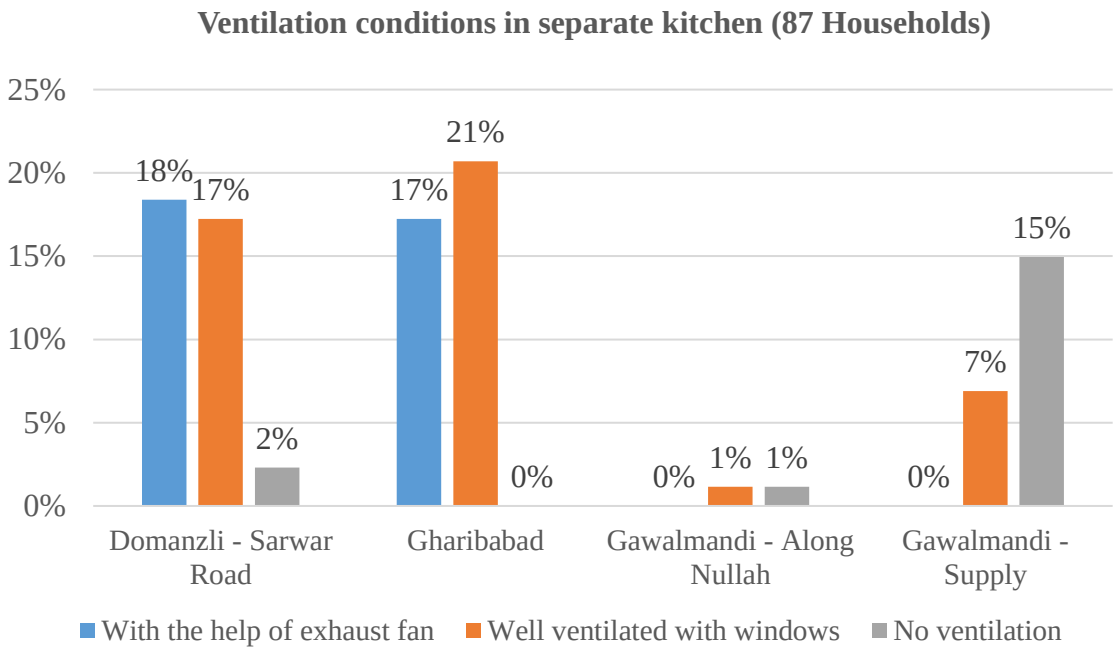

Figure 4-2: Ventilation system in separate kitchen

The graph clearly shows that most of such houses (38%) lie in the areas of Domanzli and Gharibabad while only 7 houses in Gawalmandi (both along Nullah and Supply) are well ventilated.

Third type of kitchen is those which have no ventilation i.e. they are neither provided with the exhaust fan nor have windows for the purpose of ventilation. The poor ventilation conditions in the area of Gawalmandi are depicted in the graph shows the relatively worse living conditions than the slums of other areas. Results showed consistency with previous studies where most of slums had ventilation system if they had separate kitchens (Khan, 2010).

4.12 Ventilation System in Indoor Cooking Setup

The following Figure 4-3 shows the percentage distribution of 28 houses where cooking activity held within the living rooms. More than half of these slums (57%) have windows for proper ventilation in their living area, with the majority lying in the slums of Gharibabad and Domanzli. There are 6 houses where proper ventilation is done through exhaust fan, out of which 3 houses are in Garibababad and 7 houses are situated in Gawalmandi-supply. Meanwhile the rest of the houses had no ventilation in the living area with equal distribution of houses in the slums of both Gharibabad and Gawalmandi.

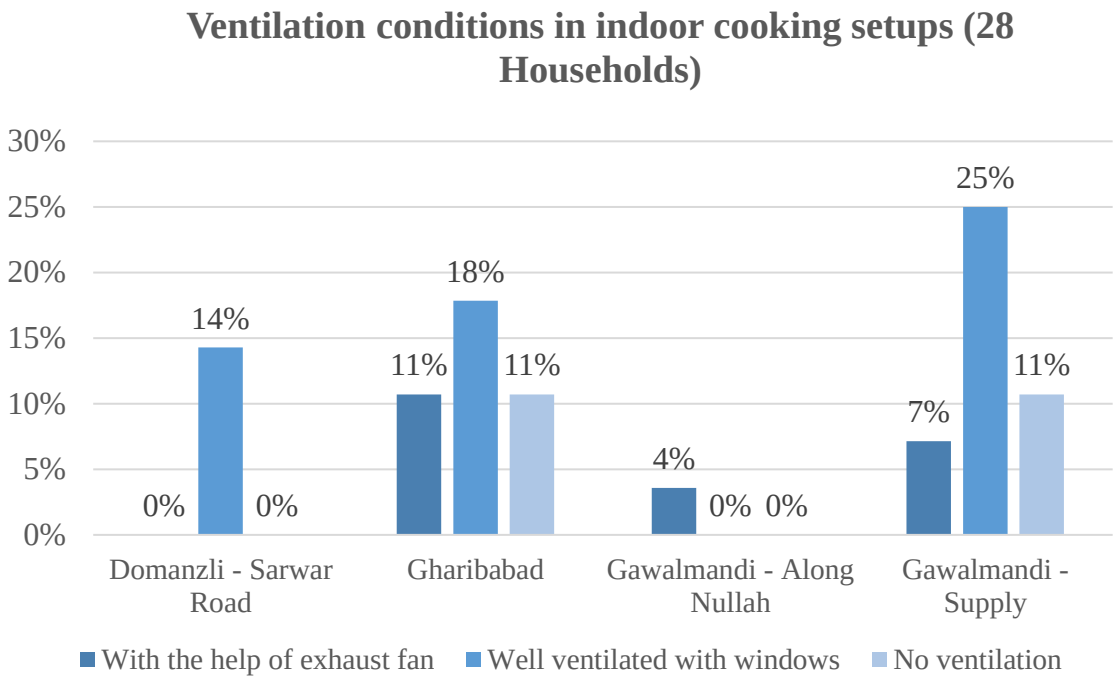

Figure 4-3: Ventilation system in indoor cooking setups

4.13 Facility of Electricity, Gas and Water Supply

Table 4-14 represents the percentage distribution of basic facilities such as electricity, gas and water amongst the slum dwellers. All the households have access to electricity. The table below shows the distribution of monthly cost spent on electricity during summers and winters by the slums of four areas.

The study does not show consistency with previous studies (Khan, 2010), showed only 42% have the electricity and (Hasan & Mohib, 2002) showed that 40–50 % have electricity. But they themselves mentioned that most of the population has unregistered electricity connections so that this research study cannot rely on people living in slums, who answered the questionnaires properly in this study and in the previous studies as well.

The Figure 4-4 below depicts that both slums of Gawalmandi are spending more on the electricity than the other two slums. This can be explained by the size of households which is more in the slums of Gawalmandi than the other two. The graph also shows that consumption of electricity in all the slums are more during summers than winters. This is mainly due to the usage of fans during summers.

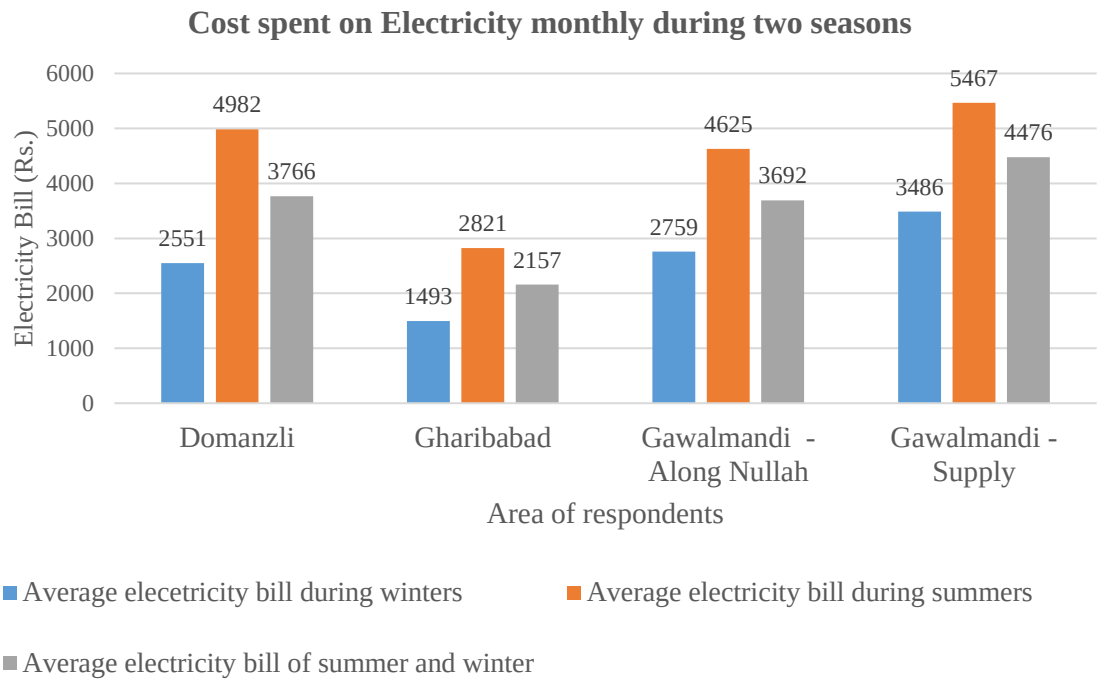

Figure 4-4: Cost spent monthly on electricity

As discussed under the heading of Monthly Income of Household, slums of Gawalmandi have the low-income levels yet they are spending more on electricity. Roughly one-fifth (20%) of the monthly income is spent on electricity alone by these households. While almost 15% of the monthly income is spent on electricity by the households of Domanzli and Gharibabad. This implies that households of Gawalmandi which have low monthly

earnings are spending more on the expenditure of other energies than the households of other slum areas.

Majority of the slums (97%) in the areas of Domanzli and Gharibabad have the facility of gas whereas slum residents of Gawalmandi do not have gas facility. They have been using firewood for cooking purposes. It is pertinent to mention that the households of Domanzli and Gharibabad have access to gas in the season of summers only. Due to shortage of gas in these areas in winters, they were also forced to use firewood for cooking purposes. Results concluded that all but three households of Domanzli & Gharibabad, use gas in summers and firewood in winters. While all the households of Gawalmandi slums use firewood throughout the year for cooking purposes.

Although the households of Domanzli did not have land ownership but provision of gas in these slums have been made possible with the help of surrounding military houses and quarters. For the Cluster of 4 to 5 houses, a gas-meter has been installed and residents of those houses share their gas bills. Whereas, the households of Gharibabad have land possession which make them to have gas-meter legally installed outside their houses.

It is important to mention here that all the households of Domanzli and all except three households of Gharibabad use natural gas as a primary source of energy for cooking purposes while all the households of Gawalmandi (n=200) use firewood throughout the year. Also, this specifies that slums of Gawalmandi are less privileged than the slums of Domanzli and Gharibabad. At the same time, it is an alarming situation for the slums of Gawalmandi who are using firewood for cooking, produces smoke and particles which are injurious to household members and become a cause of various diseases.

Table 4-16: Facility of electricity, gas and water in slum areas

	Domanzli - N (%)	Gharibabad N (%)	Gawalmandi - Nullah N (%)	Gawalmandi – Supply N (%)
Availability of Electricity				
No	0 (0.0)	0 (0)	0 (0)	0 (0)
Yes	100 (25)	100 (25)	100 (25)	100 (25)
Availability of Gas				
No	0 (0.0)	3 (0.8)	100 (25)	100 (25)
Yes	100 (25)	97 (24.2)	0 (0)	0 (0)
Availability of Water Supply				
No	80 (20)	85 (21.25)	6 (1.5)	16 (4)
Yes	20 (5)	15 (3.75)	94 (23.5)	84 (21)

Amongst these slums, 53% of households have proper water supply lines while the rest of the households deprived of this facility and they acquire water (for drinking, cooking and washing purposes) from nearby water filtration plants. Majority of these underprivileged houses (82%) are amongst the slums of Domanzli and Gharibabad. The results are consistent with many of the studies where researchers have mentioned unavailability of gas or solar sources and people have no option rather than to use firewood. (Khan, 2010),

(Hasan., & Mohib, 2002). Not only in the context of Pakistan, almost everywhere is the world, slum dwellers are using firewood and other sources of energies because they are deprived of proper gas system or other formal source (Abubakr, 2017; Brakarz, & Jaitman, 2013; Ahmed, Mustafa & Khan, 2015) i.e. to cook food within slums (Arimah, 2010) (Friesen, Taubenböck, Wurm, & Pelz, 2019; Ezah et al, 2017). This concluded that due to unavailability of proper source, slum dwellers are forced to use firewood and therefore facing severe health issues.

4.14 Cooking Energy Resources

The Table 4-17 shows resources of energy used by households of the four under research areas. It was observed that firewood was used by all the households of our population sample for cooking purposes while natural gas is used by only the households of Domanzli and Gharibabad. Where the slums of Gawalmandi doesn't have provision of gas in their area which make them to use firewood to cook food throughout the year.

Gas meters were installed in the households of Domanzli and Gharibabad. In winters (in the months of November to March), due to load shedding of gas, the households are compelled to use firewood for cooking purposes. There were only three houses found in the slums of Gharibabad where they don't have access to natural gas, so they depend on the usage of firewood for cooking purposes throughout the year. These three houses lie in class C and have the average per capita income of Rs. 3500 which is below the average per capita income of all the houses.

This distribution is justified as the households of Gharibabad and Domanzli have better living conditions and high average per capita income. Further analysis of the cost spent on energy reveals that the slums of Gawalmandi consumed a significant amount of their income on transportation of energy (wood). Due to which they (residents Gawalmandi) are less capable of affording the other facilities as compared to the households of Gharibabad.

Table 4-17: Cooking energy resources

Source of Energy	Domanzli - Sarwar Road	Gharibabad	Gawalmandi - Along Nullah	Gawalmandi - Supply	Total
Firewood					
No	0	0	0	0	0
	(0.0%)	(0.0%)	(0.0%)	(0.0%)	(0.0%)
Yes	100	100	100	100	400
	(25.0%)	(25.0%)	(25.0%)	(25.0%)	(100.0%)
Natural Gas					
No	0	3	100	100	203
	(0.0%)	(0.8%)	(25.0%)	(25.0%)	(50.8%)
Yes	100	97	0	0	197
	(25.0%)	(24.3%)	(0.0%)	(0.0%)	(49.3%)

The Figure 4-5 portrays the percentage distribution of households use firewood throughout the year, gas in summers and firewood in winter against classes. It is evident from the above table that half of under research population sample use firewood throughout the year. On comparison it can be seen from the graph that 81% of the households which use firewood fall in class C which is more than those which use gas in summer and firewood in winter constituting 66% of the population. This significant difference shows that

households using firewood for cooking purposes are less privileged and financially weak than those who are using natural gas along with firewood.

The respondents were asked why a certain form of energy is used for cooking purposes. Majority of the respondents (94%) which use firewood (throughout the year), have been using this source since they did not have access to natural gas, and they are compelled to use this source. Only 4.5% respondents said that this source was easily approachable while 1.5% of this population said it was affordable.

As mentioned in previous topic, these results are consistent with previous studies (Abubakr, 2017; Brakarz & Jaitman, 2013) and (Ahmed, Mustafa, & Khan, 2015). These researchers state that most of the slum residents are deprived of natural gas or any other convenient source of energy.

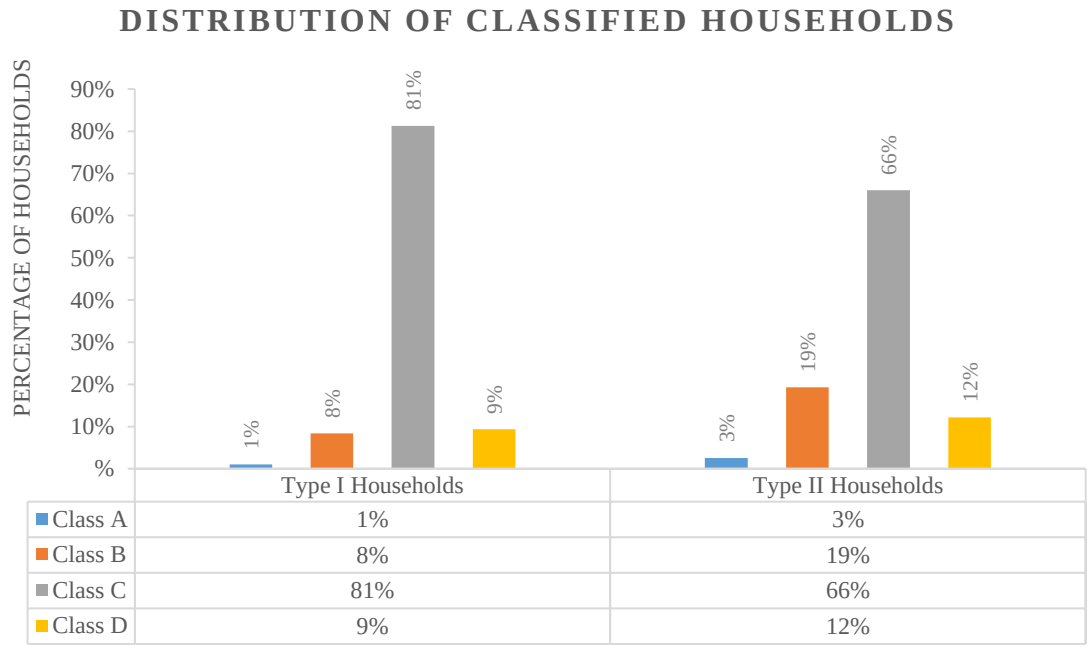

Figure 4-5: Use of energy in household classes

Households which frequently used gas (almost 70% of the time) and use firewood in absence of gas i.e. in winter, recognized natural gas as their basic source of energy for cooking purposes. More than two-thirds of such households (68%) were using natural gas because it cooks faster than other energy sources. 15% of respondents considered that gas was easily accessible, response of other 12% was that it does not cause air pollution and is ecofriendly while only 5% of them perceived that affordable source of energy for cooking purposes with ease. Further these respondents added that they are not interested in the usage of firewood energy but unfortunately, they are compelled to use it in winter due to lack of gas energy in their areas.

In the survey, while querying to slum residents about the benefits of energy resources, it was determined that 99% of the respondents who used firewood throughout the year, considered that it is not beneficial for them. Only 1% of them think that it cooks faster.

85% of households which determined that gas is their basic source of energy for cooking purpose stated that the benefits for using this source of energy made their cooking faster than other sources. 9% claimed that it is pollution free source of energy while other 4% declared that it is easier to cook with this source and 2% considered that it is easily accessible and affordable.

The households using firewood throughout the year will be referred to as *Type I* households which include all the households of Gawalmandi and three households of Gharibabad. While households using gas during summers and firewood during winters in the absence of gas will be referred to as *Type II* households which include all the households of Domanzli and 97 households of Gharibabad.

4.15 Period of Using Energy Source

Respondents were also inquired about how long they have been using the source of energy. 13% of Gawalmandi slums (both areas) have used firewood for more than 20 years while most households (61%) have been using it for more than 10 years. 80% of Domanzli slum dwellers got their gas meters 8 years ago and the rest of them have started using gas facility in recent years. Whereas most of the slums (71%) of Gharibabad have been using natural gas for cooking purpose for more than 10 years while the rest have started using natural gas recently.

4.16 Cost of Energy

The graph below shows the percentage distribution of 197 households which use both gas and firewood for cooking purposes. Gas is mostly used in summer and intermittently in winter. During load shedding of gas, firewood is preferably used in winter. As natural gas is mostly used throughout the year that is why cost spent on cooking for these households has been considered using natural gas only.

It is clear from the graph that most of the houses (68%) were spending money between Rs. 600 to 1000 on cooking using natural gas. The average amount spent on cooking using natural gas is Rs. 950 which was only 5% of the average income of Rs. 19,305 among the four areas. The maximum amount spent on gas by these households is Rs. 2500 per month.

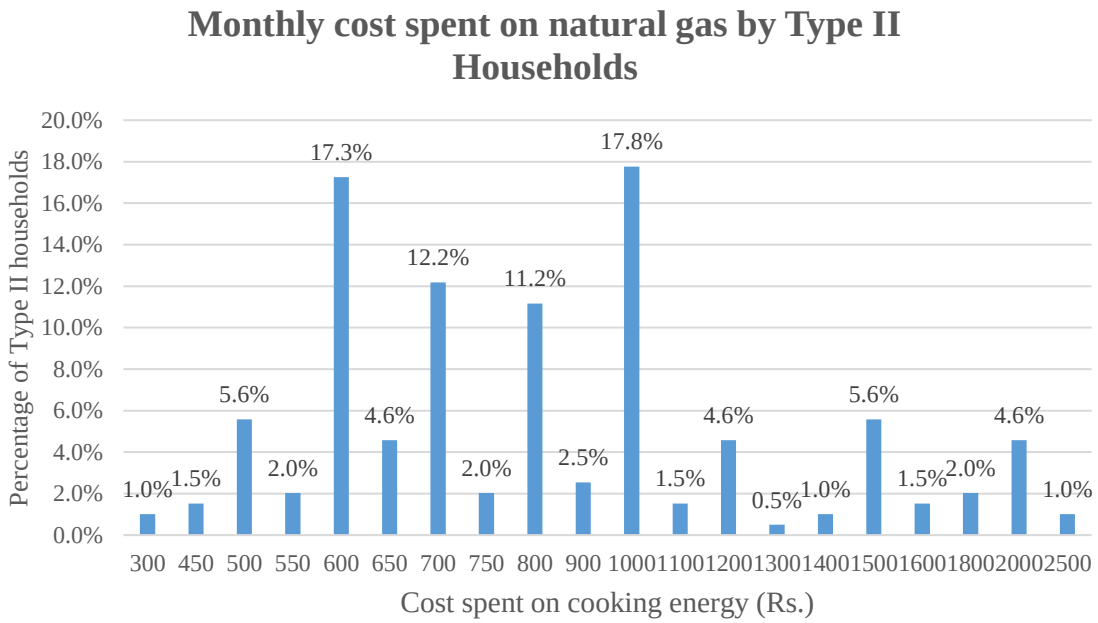

Figure 4-6: Cost of energy

4.17 Usage of Firewood

The Figure 4-7 shows the distribution of 203 households which use firewood only, plotted against the monthly cost spent on cooking. This cost includes the price of firewood and cost spent on the transportation of wood. It is evident from the graph that 37% of households spent approximately Rs. 6000 per month for cooking via firewood. The average cost spent on cooking using firewood is Rs. 6300.

Households of Gawalmandi used firewood for cooking purposes and their per capita income lies below the average per capita income amongst of the four areas. The average amount spent on the transportation of this source is Rs. 4150 per month which is two-thirds of the average cost spent on cooking using firewood. For transportation of firewood, more than 90% of these households use rickshaw while the rest use pick-up and motorcycles.

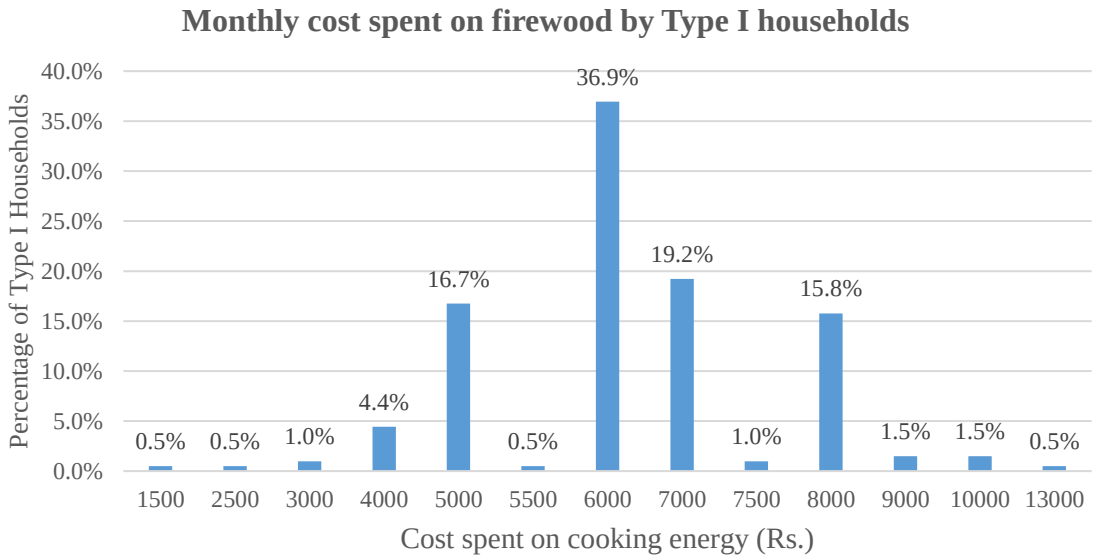

Figure 4-7: Cost spent on firewood

Out of these 203 households, 81% of the households fall in class C whose per capita income is less than the average per capita income of 400 households i.e. Rs. 4060 per month. This means an average household in these slums whose per capita income is less than the average per capita income spends more than Rs. 6000 for cooking purposes only. This is one-third portion of the average income of the four areas i.e. Rs. 19,305. Similarly, 10% of these households lie in class D whose average per capita income is even lower than those of class C.

On comparison of these two types of households based on the type of energy used for cooking, it is pertinent to mention that average amount spent on cooking by the households using firewood only is more than six times the amount spent on cooking using gas. As already known from the Table- (which tells firewood households lack more facilities and their per capita income is also low), households using firewood for cooking purposes are

living a low-quality life and the significant portion of their income is spent on cooking. The ratio of the amounts spent on cooking using firewood and natural gas is an indicator of the fact that households using firewood for cooking purposes need some alternative source which should be cheap and does not burden them financially.

4.18 Preference for Cooking

The respondents of households who are using firewood and gas were asked, if they have a choice, what source they would prefer for cooking purposes. The response of respondents (203) who used firewood (throughout the year for cooking), preferred natural gas over firewood energy source, as it is a clean or pollution free and cooks faster.

All the respondents from 197 households which use natural gas for cooking also preferred natural gas over firewood. As they are not interested to use firewood but due to load shedding of natural gas in winter, they are compelled to use it.

4.19 Diseases

Respondents were asked about their health conditions in general. Diseases generally prevailing in the area were fever, cough and sore throat. They were then asked particularly about the prevalence of respiratory symptoms/diseases in any of the household members which could cause due to use of firewood for cooking. Below is the graphical representation of percent households which showed prevalence of respiratory symptoms/diseases. It can be observed from the graph that these respiratory symptoms/diseases are more prevalent amongst the Type I households which use firewood throughout the year. The most prevalent symptoms were cough, chest pain, eye-irritation,

phlegm and shortness of breath which occur amongst 92%, 84%, 80%, 70% and 79% of Type I households, respectively. Moreover, 14%, 5% and 2% households showed the prevalence of Asthma, COPD and lung cancer, respectively, which are respiratory diseases.

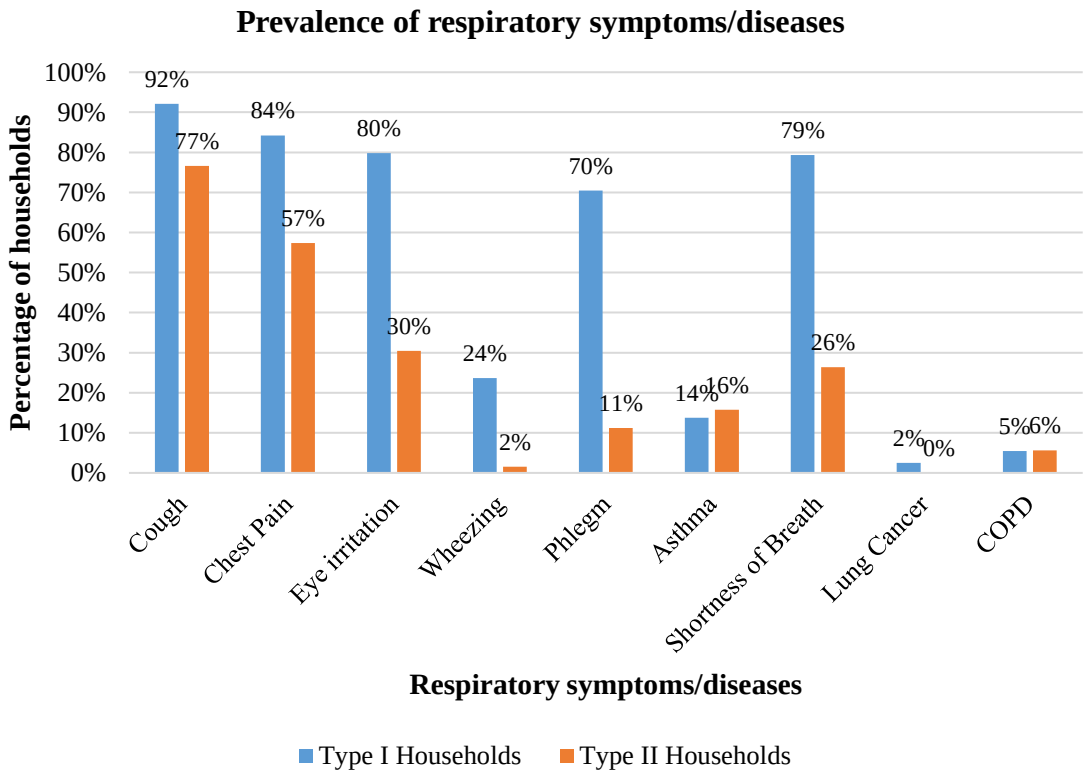

Figure 4-8: Prevalence of respiratory symptoms/diseases

Amongst Type II households, the most prevailing respiratory symptoms are cough (77%), chest pain (57%), eye-irritation (30%) and shortness of breath (26%). These symptoms are occurring less frequently amongst these households than Type I households' members, but the percentages of occurrence are still significant. This is because they were using firewood as well during winters in the absence of natural gas. The percentage of households showing the cases of asthma and COPD are a little higher than those who use firewood only for cooking. This could be in those households which have recently started using natural gas

for cooking purposes and the person who has been cooking meals might have been using firewood for cooking most of their lives. The other possible reason includes genetic inheritance of the disease. It is evident from the graph that people using firewood throughout the year show more respiratory symptoms than those who use gas and firewood.

Amongst the households with indoor cooking setups (n=115), households with no ventilation in the cooking area showed more prevalence of respiratory symptoms amongst the household members than the households which had ventilation in the rooms where cooking setups were laid. There was no significant difference of prevalence of respiratory symptoms amongst the households which cooked inside the living area or in a separate kitchen.

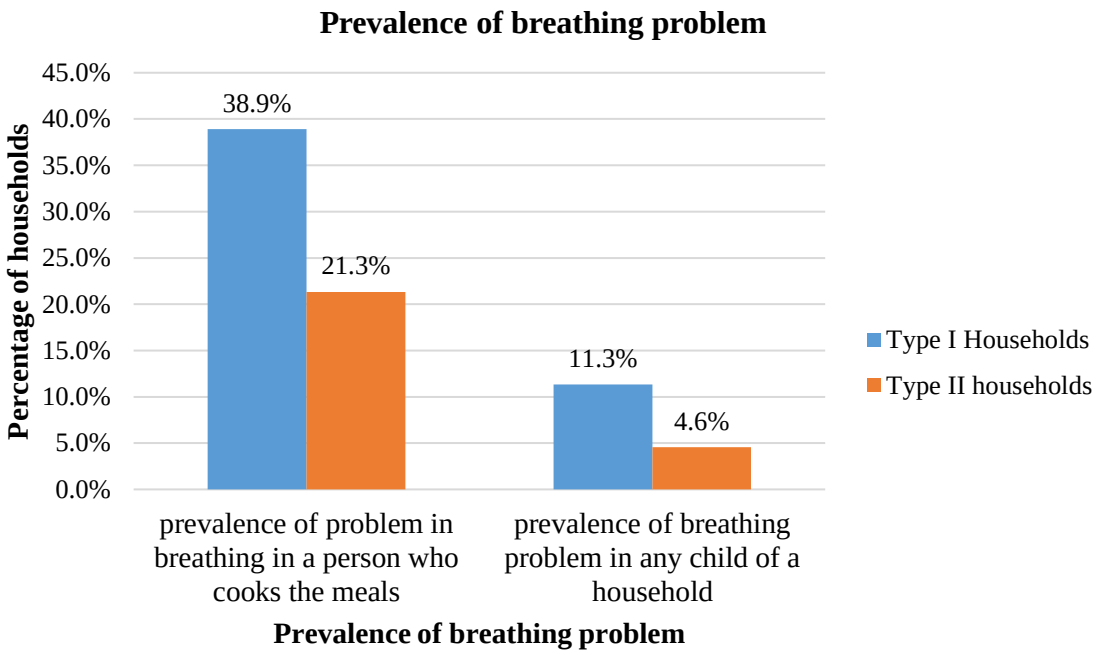

Figure 4-9: Prevalence of breathing problem

The Figure 4-9 shows the prevalence of breathing problem in the person who cooks the meal and any child less than 5 years. The reason why children less than 5 years are considered is because children of this age accompany their mothers during their chores and mothers usually keep them around while performing kitchen duties. So these children are more likely to suffer from breathing problems too.

The prevalence of breathing problem amongst the cooks and children of households using firewood for cooking is 38.9% and 11.3%, respectively. Only 21.3% and 4.6% of 197 households which use both natural gas and firewood have shown prevalence of breathing problems in female cooks and children, respectively.

It is evident that prevalence of breathing problems in female cooks and children is more significant in Type I households than that of Type II. The results are constant with previous studies (Khush et al, 2005) and (Hasan & Mohib, 2002), where the former one has discussed the problems such as sneezing, sore throat, hoarseness, coughing and itching of eyes. The latter one has mentioned that his survey revealed the following common health issues: cough, flu, fever, high blood pressure, headaches, stomach aches, diabetes, malaria, diarrhea, piles, kidney problems, measles, hernia and paralysis. This shows that results are consistent with previous studies.

4.20 Awareness

In order to know the awareness level of the respondents regarding ‘clean energy’, they were asked if they had any idea about the term ‘clean energy’. It was found out that majority of the households (95%) had no idea what clean energy is. The remaining 5% claimed to

know the term ‘clean energy’ but on further questioning, it was revealed that they were not familiar with the term ‘clean energy’.

Further it was asked from the respondents what do they think when they hear the term ‘clean energy’. The pie chart below shows the percentage of responses to the question “What do you think clean energy means?”

The pie chart shows that majority of the respondents (84.5%) believed that natural gas is clean energy. While 12.8% of the respondents thought that clean energy is a source of energy which does not cause pollution. A very few numbers of respondents (1.3%) responded that it is a source of energy which is not harmful to health. Only 3 respondents believed that this term refers to clean food and 3 respondents had no idea what clean energy is.

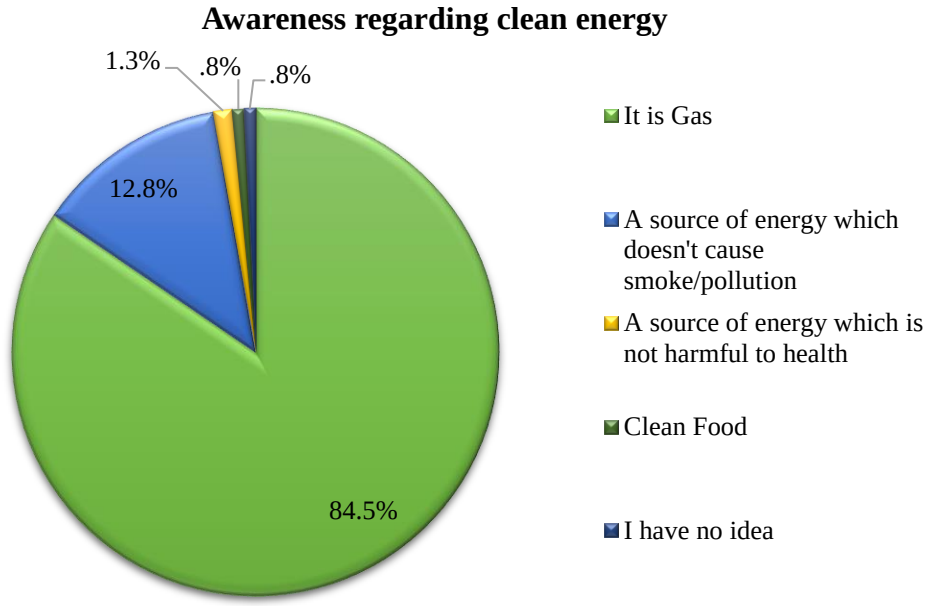

Figure 4-10: Awareness regarding clean energy

It is interesting to point out here that the slums of Gawalmandi which only used firewood for cooking had only two types of responses. 99% of these households thought that clean energy is natural gas. While only 1% respondents thought of it as a source of energy which doesn't cause smoke/pollution.

This implies that Type II households i.e. slums of Gharibabad and Domanzli, had more varied responses. In these households, the responses other than given by type I households, were close to what clean energy means. This can be explained by the level of education of Type II households' heads as they are more qualified, and this qualification can be linked with better knowledge of energy they are using for cooking purposes. The results showed consistency with previous researches (D'souza, 1997) and (Anwar, Green, & Norris, 2012). They argued that usually people are aware of health risks.

4.20.1 Awareness Regarding Cooking Smoke

All respondents were asked regarding the cooking smoke which is produced by the burning of firewood if it is harmful to health or not. The purpose was to know the level of awareness of respondents regarding the effects of cooking smoke. Majority of the households (99%) responded affirmatively while only 1% population were of the view that it does not affect health, all of which were from Type II households. While (Mahabir et al, 2016) have argued that 73% were aware of unhealthy smokes. Furthermore, another research (Fatime et al, 2014) discussed that mostly people know smoke is injurious to their health, but they are not well aware about the alternative sources of clean energy.

All the respondents with no awareness regarding negative impacts of cooking smoke due to firewood were from the households whose family heads and female members were illiterate. Also, all the respondents from the households having literate female members and family heads were aware of the effects of cooking smoke on health. This implies that level of awareness regarding impacts of cooking smoke is related to the level of education of household members.

Further it was asked from the respondents how they think it is detrimental to health. Out of the respondents which were aware that cooking smoke poses threat to health, majority of the population (33%) associated it with breathing problems, 8% with skin burn and 23% with eye irritation. While one-third of the households were aware that cooking smoke is not good for health and may cause diseases without being more specific. Most of these households belong to Type II which can be explained by the usage of firewood for a shorter period in a year in those households.

In order to find out the respondents' view regarding impact of cooking smoke and indoor air pollution on health, they were asked if the following health conditions and diseases can be caused by cooking smoke. The following bar graph shows the percentage of population which associated impact of cooking smoke with the health conditions such as cough, digestion problem, chest pain, eye irritation, wheezing/phlegm, skin burn and shortness of breath and diseases like Asthma, lung cancer, COPD and T.B. The respondents associated smoke more commonly with eye irritation, cough, and shortness of breath and skin burn. Majority of the population recognized smoke as a cause of Asthma, Lung cancer, COPD and T.B.

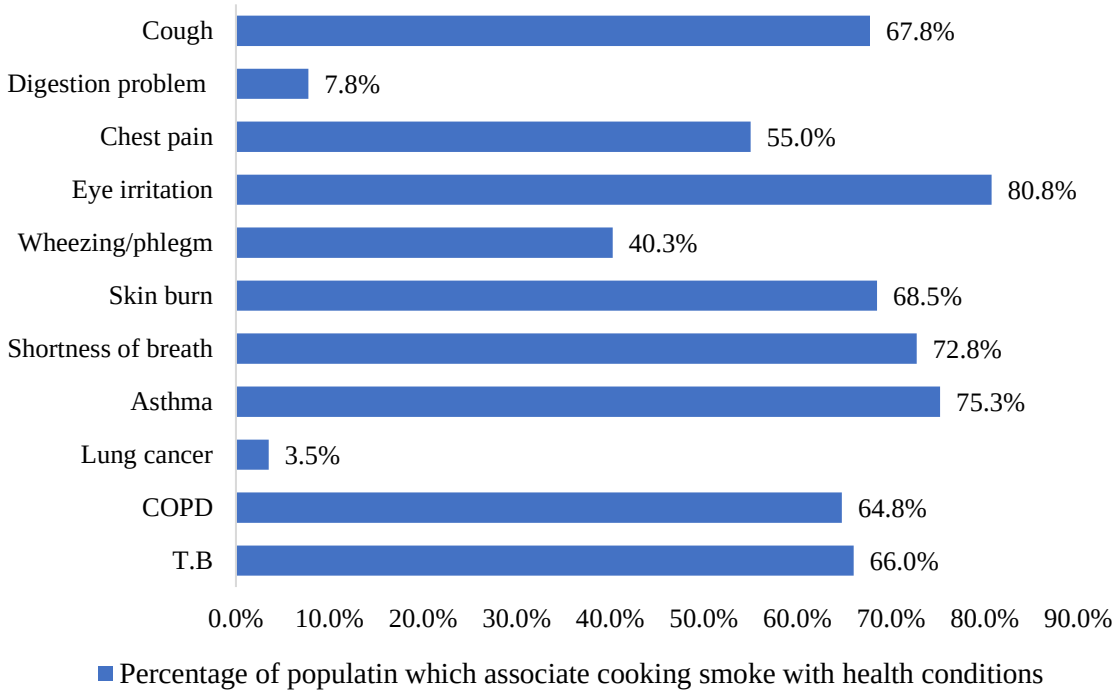

Figure 4-11: Awareness regarding potential risks of cooking smoke

This information reveals that most of the population considered smoke, which is produced by burning of firewood, as a threat to their health and associated it with respiratory diseases. The results are constant with previous studies of (Khush et al, 2005) and (Hasan, & Mohib, 2002), where the former one have discussed the problems of slum dwellers who faced sneezing, sore throat, hoarseness, coughing and itching of eyes. While (D'souza, 1997) has mentioned that sinus and eyes related problems. These issues prevail in slums due to bad smoke. Another research (Fatime, et al, 2014) have also suggested that in Pakistani slums, health issues exists due to bad smokes of firewood being used in slums as a cooking source of energy.

Majority (97%) of the respondents were found to be concerned about the health of cooks and children of household regarding the use of firewood as a cooking energy.

The respondents were asked about their opinion on which source of energy they consider the best for cooking purposes in all regards. Majority of the population (99%) considered natural gas as the best resource regarding its ease of use, cost and impact on the environment. Three respondents considered electric stoves as the best option while only one respondent was of the view that firewood is the best option regarding ease of use. The research shows constant results with previous studies. Result is relevant to the previous study of (khan, 2010) where most of the people were in favor of gas.

4.21 Opinion on Household Income Influencing the Cooking Choice

Previous studies have shown that choice of cooking energy for a household depends on the total income earned by it. Respondents were asked to agree or disagree with the statement "Household income influences the choice of cooking energy". One third of the respondents (33%) agreed with the statement, majority (90%) of which belong to type II households. 60% respondents disagreed with the statement, majority (75%) of which belonged to type I households and 29 respondents remained neutral. The study conducted in slum areas of Peshawar (Jan, I., 2012), where researcher has precisely discussed that purchasing power play important role while choosing the cooking source of energy.

4.22 Willingness

Respondents of both Type I and type II households were asked if they were willing to shift to some other source of energy.

All the respondents of Type I households which use firewood only, were willing to shift to some other source of energy. Out of these, 80% wanted to shift to natural gas because it cooks faster and saves time. The rest of the respondents were willing to shift because firewood causes pollution and diseases.

Out of the 78 households with no literate members, majority of the households (60%) were not willing to shift to some other source of energy for cooking. 64% of households with at least one literate family member willing to shift to some other source of energy whereas the remaining 34% do not want this transition. This shows that the households which comprise of at least one literate family member were more likely to transfer from traditional energy to clean energy.

Majority of the respondents (80%) of type II households did not want to shift to some other source of energy because they considered natural gas as the best energy source for cooking purposes. Among rest of the respondents, majority of the respondents were willing to shift to some other source because there is no gas in winter in these households and they want some other source which provides continuous supply to these households throughout the year. Only two respondents were willing to shift because they thought that natural gas was expensive which can be reasoned with their low per capita income. These respondents belong to class C households.

After giving some insight to these respondents regarding clean energy, they were asked if they were willing to shift to clean source of energy whose price is higher than the source currently in use. Majority (94%) of the respondents belonging to type I households were willing to shift to clean energy even if it is expensive. Most of the rest of the respondents

which were not willing to shift belong to class C which shows that their low per capita income is influencing their willingness to shift.

The higher percentage of type I households willing to shift to expensive clean energy shows how desperate are they to get rid of firewood which is not only costly but also pose threats to their health. Majority (96%) of the respondents of Type II households were not willing to shift to clean energy because they thought that natural gas was the best option. The results are consistent with previous studies (Jan, 2012), (Khan, 2012) & (Hasan & Mohib, 2002). All studies argued that people who were using firewood were willing to give up on it but conversely; people who were using natural gas as cooking source of energy, were not willing to change the energy source.

4.23 Willingness to Pay for Clean Energy

Respondents of both type of households were asked how much they are willing to pay monthly for clean energy. The graph below shows that Type I households are willing to pay more for clean energy. Almost 70% of these households are willing to pay more than Rs. 1000 / month for clean energy.

Majority of the respondents (74%) of Type II households are not willing to pay more than Rs. 500 / month for clean energy. This is because they are not willing to shift to some other source of energy and will only be willing if it costs them less than the source currently in use. One-fourth of these respondents are willing to pay more than Rs. 500/month whereas only two respondents are willing to pay more than Rs. 1500/month.

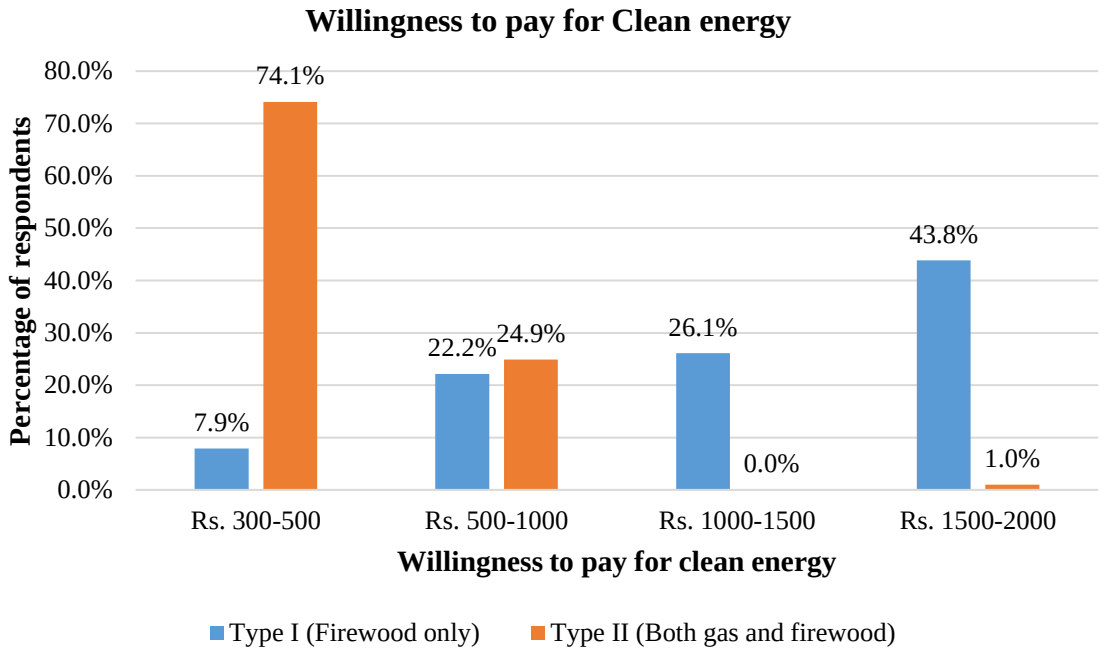

Figure 4-12: Willingness of respondents to pay for clean energy

These results show that Type I households are in dire need to shift to some other source of energy which should be cleaner, cooks faster and is inexpensive. The results are consistent with the study of (Bhutto, Bazmi & Zahedi, 2011). He argued that slum dwellers in Pakistan cannot afford the clean energy. However, he suggested through analysis that they will adopt the clean energy resources if Government support them. He further suggested that NGO sector should also contributes to initiate the procedure.

4.24 Help and support from Government for shifting to Cleaner Source of Energy

Majority (87%) of the Type I households wanted support from Government in the form of provision of gas supply. Only 13% of the respondents wanted cheaper clean energy.

Most of the type II households (59%) wanted the provision of natural gas during winters too in the form of help from government. As previously discussed under the section of Willingness, this affirms most of the respondents' view who did not want to shift to some other source of energy as they considered natural gas the best source for cooking. 31% of the type II households wanted cheaper clean energy while 10% sought a continuous source of energy fulfilling the requirements of cooking throughout the year as a support from government for shifting to clean energy.

This deduces that most of the households prefer using natural gas as a source of cooking energy. They are willing to shift to some other source only if it is cheaper and available throughout the year to facilitate their cooking practices.

4.25 Barriers in Employing Clean Energy

Respondents were asked what barriers they think would prevent them from having clean energy. Majority (47.2%) of the respondents with most of them belonging to Type II households, considered low income as the main barrier. 38% of the respondents identified inflation while 10% recognized poverty as the main barrier in implementation of clean energy with majority of these respondents belonging to type I households. Only 4% thought that expenditures would be the major barrier with all its respondents belonging to type I households.

4.26 Correlational Analysis

Researchers have examined different questions to respondents to assess the relationship between selections of energy source with different factors.

In descriptive date, education level of Household's head was directly associated with household income i.e. the more the head was qualified the more earnings he was having as compared to less qualified individuals. The value of spearman is 0.78 ($p<0.001$) which shows high correlation between these two factors. Similarly, Level of education of female individuals in the family was also highly correlated with household income i.e. the value of spearmen 0.552 ($p<0.001$), that shows more the number of educated people is there, greater will be earnings as compared to less educated of females. The results are consistent with previous studies (Qureshi & Ali, 1988) suggested that people within slums areas may have higher earnings if they are qualified or at least may have better earnings as compared to less qualified dwellers.

Level of education of household head was also found to be directly correlated with the cooking setup. The more the educated household head was, better were the cooking conditions in a household. The value was as high as 0.78 ($p<0.001$), means strong positive relationship. The cooking setup was separate in the households where households were headed by more educated heads. The results are correlated with previous study (Han & Moe, 1990) described the strong relationship between these two items. He suggested that if the head of household is educated, he/she will be cautious about the choice of cooking energy used.

Educated household heads were more willing to use clean energy that wasn't harmful to their health and environment as well. The value of spearman for this relationship is 0.73 ($p<0.005$). It means education plays significant role in creating awareness for the usage of clean energy and educated people are more concerned about their health. In one of the

previous studies (Bhutto et al, 2011), strongly emphasized on importance of education and providing awareness to slum dwellers. As his study proved strongly that education and awareness programs play important role in making choices for clean energy. The more people were aware of hazards of biomass and firewood and the more were in favor of clean energy.

Furthermore, gas bill was found to be weekly correlated to size of household. Although household size has an impact on the amount of gas bill, but it has a very low correlation value. This is due to the reason that Gas in Pakistan is comparatively cheaper as compared to other sources and amount of bills does not increase with the size of households. The study is consistent with a previous study, conducted on different available sources of Pakistan (Rehman et al, 2017). In his study he has mentioned that natural gas is the cheaper resource in the country and thus have higher demand because it is more convenient to use gas than to collect firewood, cylinders or charcoals.

Correlation matrix also reveals that households with more female educated members were not fond of using firewood as a cooking source and a negative relationship between these two items was found with the spearman value of -0.238 ($p<0.005$). This implies that educated female members are aware of the negative impacts of using firewood and want to shift to cleaner source for cooking. The results are consistent with the preceding study of (Gulyani & Talukdar, 2010) where she argued that females do not prefer to use charcoal or firewood, rather they prefer Natural gas over firewood because of health hazards and the time and efforts it takes.

Households with higher income levels were less likely to consume the firewood as spearman value was 0.156 ($p<0.005$) that shows very weak correlation between these items. Those with higher incomes were more likely to use sources other than firewood which was mainly natural gas. The spearman's value of correlation between higher incomes and usage of gas was 0.75 ($p<0.001$) which predicts that households with higher income levels prefer natural gas over other sources of energy. These results are consistent with previous studies of (Masera et al, 2007), (Mehta & Shahpar , 2004) and (Agarwal, 2010). The results show that people who compelled to use firewood, were not using this energy source by choice. Another study (Agarwal, 2010) suggested that people in South Asian countries are using firewood because they cannot afford other clean energies as they are not easily and conveniently available in slum areas (Barnes & Floor, 1996).

Similarly, households with better housing conditions and material of house were found less likely to have respiratory symptoms i.e. members of *Pakka* houses had better health conditions than that of *Katcha* households. Conversely, household members of *Katcha* houses were more likely to have respiratory symptoms. The spearman's correlation between the condition of house and prevalence of phlegm was -0.129 ($p<0.005$), with shortness of breath -0.122 ($p<0.005$) and with lung cancer -0.07 ($p<0.005$). This implies that better house conditions have positive effects on the household members. The results are consistent with previous studies (Boy, Bruce & Delgado, 2002) and (Chen, Verrall, & Tong, 2006). It is affecting the health of adults and the kid's underage of 5, are dying more frequently due to indoor household pollutions (Warwick & Doig, 2004).

It was revealed from the matrix that preference of switching to some other source was highly correlated with the household income with the spearman value of 0.87 ($p<0.001$)which means people who were earning better were more willing to switch from any inconvenient source to a convenient one. We can conclude house of income plays important role while making such choices. People with high income were also willing to pay for clean energy that would not harm their health (Spearman value 0.62, $p<0.001$). People in Pakistan will be willing to switch from the source of energy they are utilizing, if they are aware of health hazards associated with traditional source of energy and its affordability. Results showed consistency with previous study, conducted in scenario of Pakistan (khan, 2010), (Rauf et al, 2015), (Hasan & Mohib, 2002), (Jan, 2012) and (Khushk et al, 2005). Researchers strongly emphasize to create awareness of clean energy, because people who are aware of health risks are more willing to buy clean energy. Researches (Berry et al, 2013), (Elliot et al, 1999) and (Hillier, 2016) highlights that many people who are aware about the risks involved with these exposures, can change their perception about the energy sources.

The prevalence of cough, chest pain, phlegm and eye irritation were negatively correlated with presence of gas at home with spearman values -0.216 ($p<0.001$), -0.284 ($p<0.005$), -0.49 ($p<0.001$), and -0.326 ($p<0.001$) respectively. These results show that use of cleaner source of energy has no negative impacts on the health of household members. Whereas, all these spearman values of correlation of prevalence of above-mentioned respiratory symptoms with the usage of firewood were positive as 0.65 ($p<0.005$), 0.69 ($p<0.005$), 0.556 ($p<0.001$) and 0.78 ($p<0.005$), respectively. That shows people who were using firewood were more prone and exposed to respiratory symptoms and eye problems.

Previous research shows that air pollution causes health problems in slum areas (Bruce, McCracken, Albalak, Schei, Smith & Lopez, 2004).

Furthermore, people who showed prevalence of respiratory symptoms were more willing to shift to clean energy than the other groups. The value of spearman correlation between willingness to adopt clean energy and individuals suffering from cough, chest pain, and phlegm and eye irritation was 0.472 ($p<0.001$), 0.630 ($p<0.001$), 0.715 ($p<0.001$) and 0.618 ($p<0.001$), respectively. This shows if people are aware of health risks involved regarding unclean cooking energy, they will be more willing to use clean energy which leads us to conclude that awareness is a key to change households' choice for cooking energy source. Results were consistent with previous studies (Leem et, al, 2006), (Pope & Dockery, 2006), (Azizullah, Khattak, Richter & Häder, 2011), (Moore, M., Gould, P., & Keary, B. S. 2003) (Kuddus, A., & Rahman, A., 2015), (Smith & Mehta, 2003) and (Smith, Mehta & aeusezahl-Feuz, 2004). The studies have proved through empirical and statistical testing that most of the sinus and respiratory issues in slums prevail due to bad pollution in their areas.

Children were found to have breathing problems when other source than gas was being used. Wherever firewood was being used, children were having more breathing problems which is depicted by weak correlation of spearman value -0.125 ($p<0.001$). Also, the households having children with breathing problems were more likely to adopt clean energy. Spearman value of 0.97 ($p<0.001$) showed high correlation between these two items. Previous study areas (Pandey et al., 1989) suggested that kids are more vulnerable to health problems than adults. Another study stated that bad pollution results in premature

death of 1.6 million babies in one year and around one million deaths of children underage of 5 years (Warwick & Doig, 2004).

Respondents were enquired about their concern for family's health. Results showed that households who were more concerned about their family health were more educated. This means that education and awareness play an important role in creating awareness. The spearman value between these two variables was 0.54 ($p<0.001$). Previous researches (Berry et al, 2013), (Elliot et al, 1999) and (Hillier, 2016) emphasized very strongly that by educating people about the risks involved with health hazards and the benefits of clean energies, it will change their mindset to use clean energy instead of unhealthy ways of cooking.

Additionally, those who were concerned about their family health regarding cooking practices were more aware of the negative impacts of cooking smoke. The value between these two items was as high as 0.71 ($p<0.001$). In a research (Gulyani & Talukdar, 2010), the researchers have highlighted the same point.

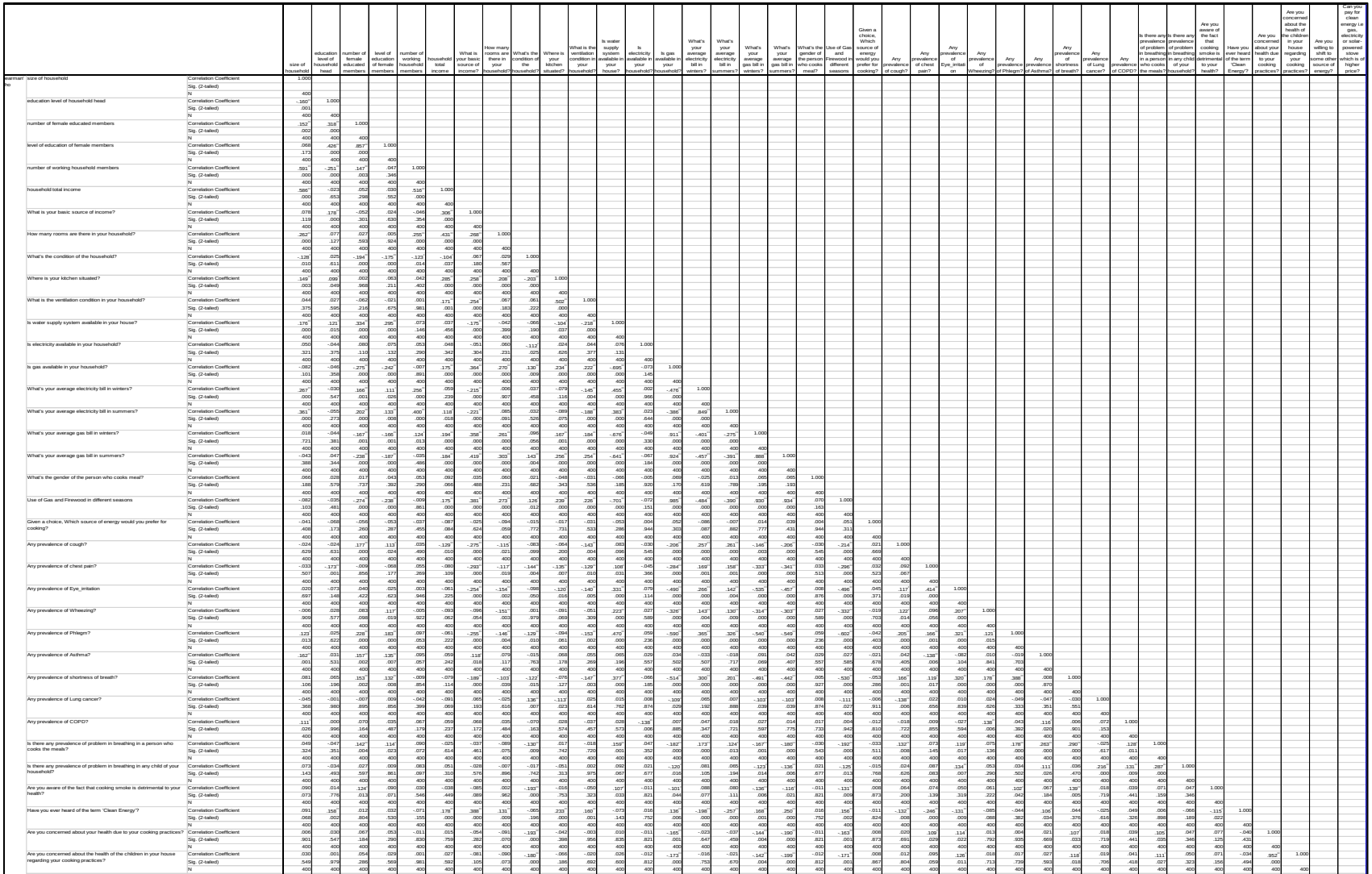

Figure 4-13: Correlational Analysis

People who were using gas weren't willing to switch their energy source. The correlation was negative value of -0.802. It means gas is convenient as easily available and isn't bad for health that is why people doesn't want to switch from gas connection.

Respondents who were educated were willing to pay for clean energy. The value of correlation is 0.73. That means people who are aware of health risks and who are at the health risks are more willing to switch their source of energy.

4.27 Factor Analysis to Identify Factors Influencing Willingness of Slum Dwellers to Use Clean Energy

In order to find the factors determining the willingness of slum dwellers to shift to clean energy, factorial method was applied under PCA (principal component analysis) method by inputting all variables concerning respondents' view on use of energy. Under this methodology, each identified component interprets a percentage of the variance that has not been interpreted by previous components. In the context of social sciences, an explained percentage of 60% of the variance or less can be accepted but in this analysis, this explained percentage is going to be taken as approx. 70%. Kaiser's criterion (eigenvalue > 1) was used for factor identification. KMO criterion and Bartlett's test of sphericity were applied prior to the PCA method to measure question and sampling adequacy. The result of this analysis via KMO index and Bartlett test of sphericity revealed satisfactory values (KMO = 0.739 and $p < 0.001$ on Bartlett). The Bartlett's test shows whether the correlation matrix is an identity matrix or not. This conclusion implied that statistically

significant correlations exist between questions, and that the sample size meets the criteria to be used for factor analysis.

Table 4-18: KMO and Bartlett's test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.739
Bartlett's Test of Sphericity	Approx. Chi-Square	8467.659
	df	595
	Sig.	.000

Out of the initial number of variables, ten components were identified by the Kaiser criterion, explaining a total of 71% of the observed variance; a percentage which is considered

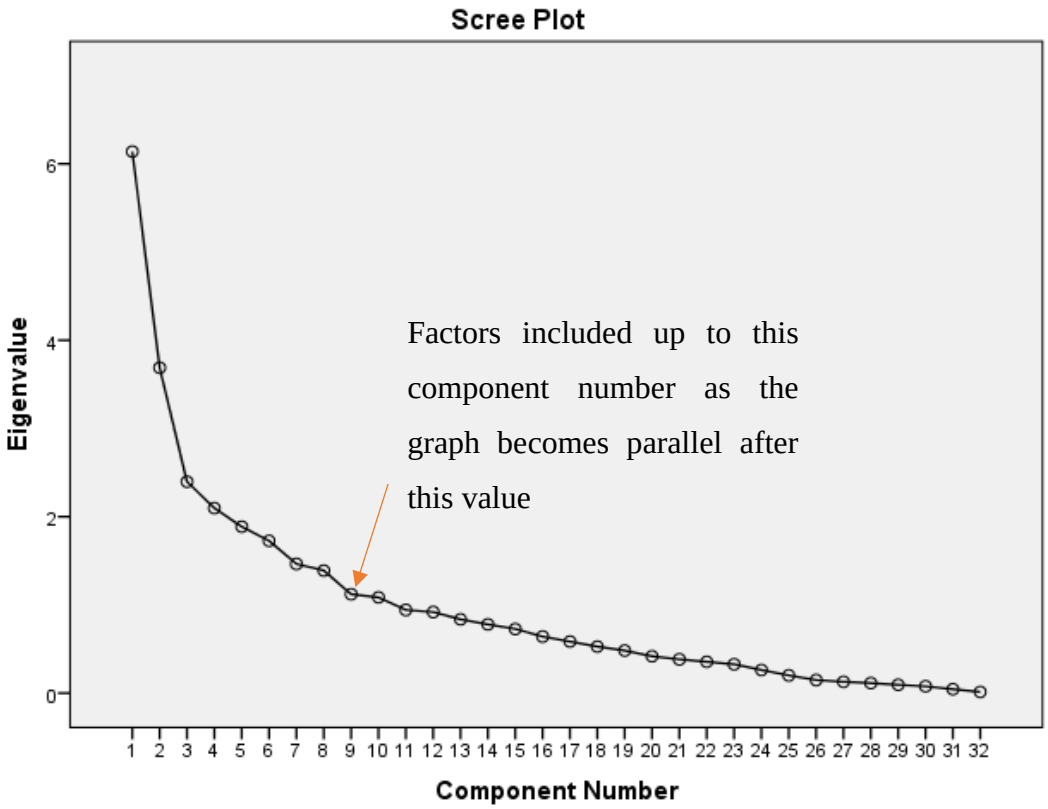

Figure 4-14: Factor influencing the willingness of households

satisfactoryfor research in social sciences. A rotation of the initial factors was afterwards performed by the Varimax method. The rotation enabled the simplification of the initial factor table.

The scree plot above shows the component which contribute in determining the factors influencing the willingness of households. On examination of this plot, it was found that 9 components having eigenvalues more than 1 explained the variation of 69%. The difference between eigenvalues after the 9th component was minimum. Thus the 10th component was omitted.

Table 4-19: Comparison of Scree plot and Eigen values

Factor number	Scree Plot	Eigen values > 1
1	*Accepted*	6.139
2	*Accepted*	3.689
3	*Accepted*	2.397
4	*Accepted*	2.097
5	*Accepted*	1.887
6	*Accepted*	1.726
7	*Accepted*	1.464
8	*Accepted*	1.389
9	*Accepted*	1.121
10	Omitted as scree plot curve gets parallel to axis after factor no.9	1.085

The nine components were then analyzed based on the values in the rotated matrix and the analysis was repeated several times to include only those factors whose extraction value in communality table was more than 0.3 and those items which were selected which were showing correlation more than 30% with the nine components. These factors have high correlation amongst themselves but are not correlated across the components. In order to find out which factors contributed the most to these components, detailed reliability analysis was applied, and those loading factors were excluded which lowered the value of Cronbach's alpha coefficient. Cronbach's alpha coefficient's value of 0.7 was considered satisfactory and based on this criterion all the nine components were tested. The factors contributing to the nine components along with their factor loading are shown in Table 4-20.

Statement	Factor Loading								
	Factor - 1	**Factor - 2**	**Factor - 3**	**Factor - 4**	**Factor - 5**	**Factor - 6**	**Factor - 7**	**Factor - 8**	**Factor - 9**
Affordability of household to pay for clean energy	0.909								
Level of Affordability to pay for clean energy	0.778								
Size of Household		0.927							
No. of working household members		0.747							
Household total income		0.656							
Per capita income		-0.605							
Education level of Household head			0.633						
Literacy status of female household members			0.877						
Situation of cooking setup in a household				0.742					
Ventilation condition in the cooking area				0.913					
Level of concern about health of a person who cooks the meal regarding cooking practices					0.969				
Level of concern about children in households regarding cooking practices					0.965				
Amount spent on the facility of electricity during summers						0.728			
Amount spent on the facility of electricity during winters						0.769			
Possession of Mobile phone							0.829		
Possession of Television							0.728		
Prevalence of Asthma								0.649	
Prevalence of breathing problem in a person who cooks the meal								0.722	
Prevalence of breathing problem in children of household								0.552	
Prevalence of cough									0.698
Willingness to change to clean energy appliance									0.656

Table 4-20: Factor Matrix for willingness to pay for clean energy

4.28 Findings of Factor Analysis

Factor analysis was carried out in order to find the factors influencing the willingness of households to pay for clean energy. The analysis was run on 32 parameters which were reduced to 21 parameters and were clustered in the 9 factors shown in table above. Some of the parameters contributing to the factors can be grouped and perceived as the factors lying under the same umbrella. Further grouping of these factors enables us to conclude 8 factors mentioned below:

Factor-1: Household's financial strength to pay for clean energy:

- Affordability of household to pay for clean energy
- Level of Affordability to pay for clean energy
- Willingness to change to clean energy appliance

Factor-2: Socioeconomic profile of a households

- Size of Household
- No. of working household members
- Household total income
- Per capita income

Factor-3: Literacy level of a household

- Education level of Household head
- Literacy status of female household members

Factor-4: Cooking setup and ventilation condition in a household

- Situation of cooking setup in a household
- Ventilation condition in the cooking area

Factor-5: Level of concern regarding health of household members

- Level of concern about health of a person who cooks the meal regarding cooking practices
- Level of concern about children in households regarding cooking practices

Factor-6: Cost spent on energy

- Amount spent on the facility of electricity during summers
- Amount spent on the facility of electricity during winters

Factor-7: Level of familiarity with Information Technology devices

- Possession of Mobile phone
- Possession of Television

Factor-8: Prevalence of breathing problems and diseases amongst household members

- Prevalence of Asthma
- Prevalence of cough
- Prevalence of breathing problem in a person who cooks the meal

- Prevalence of breathing problem in children of household

While willingness to pay for clean energy is a dependent variable, the above explanatory variables are the 8 factors influencing the willingness to adopt clean energy for cooking. The analysis on SPSS shows that these factors are statistically significant to influence the willingness.

Amongst the above factors, household's financial strength to pay for clean energy is the most influencing factor, followed by socioeconomic profile, literacy level, cooking setup and ventilation conditions, concern regarding health, cost spent on other energy sources, familiarity with Information technology devices and prevalence of breathing problems and diseases in household members.

Some of these results are similar in a way to the study of (Adepoju et al, 2019). The most influencing factor from Yusuf's study was awareness about renewable energy sources. In the above factor analysis, variable of awareness was included initially among the 32 parameters. As per this research, the analysis found level of concern regarding health due to cooking practices more influencing than the level of awareness regarding cooking smoke. This suggests that households which are more concerned about their health regarding cooking practices are more willing to pay for clean energy.

The most influencing factor i.e. financial strength of households to pay for clean energy suggests that slum dwellers need financial support from government to provide these households with clean energy sources. As discussed under the section of willingness, households were willing to shift to clean energy source only if it was to be provided at

cheaper rates than the sources currently in use. Government should also encourage the use of clean energy through different policies such as by creating environment for the easier production of clean energy equipment. This will help to build a sustainable renewable energy markets for easy purchase of clean energy products.

The factor of households' socioeconomic profile (Factor-2) which hugely relies on the per capita income suggests that households with higher per capita income will be more willing to use clean energy. Similarly, literacy level of a household (Factor-3) suggests that willingness to pay for clean energy is influenced by the level of education. As discussed under the section of awareness regarding cooking smoke, it is evident that level of awareness regarding cooking smoke is related to the education of household members.

Cooking setup and ventilation conditions in slums are poor which causes indoor air pollution and lead to many diseases. Factor-4 consists of the factors determining the situation of cooking area in a household which also influences the willingness of households to pay for some other source.

Cost spent on other energy sources such as electricity also influences the willingness of households to pay for clean energy. More cost spent on other sources of energy will restrict the households to pay for clean energy. Factor-7 suggests the more the households are familiar with communication devices, more they will be aware of the effects of energy sources they are using. This directly corresponds their use of telecom devices with their awareness level regarding impacts of cooking smoke.

Although last amongst the other factors, but with huge impact on the willingness of households, Factor-9 suggests that prevalence of breathing problems amongst the households also prompts them to shift to some other source which is cleaner. As evident from the results, breathing problems and diseases were more common amongst the households which used firewood for cooking purposes, and they were more willing to pay for clean energy. Government should conduct awareness programs to educate and aware slum people against the diseases caused by cooking smoke.

Chapter 5: CONCLUSION AND RECOMMENDATIONS

This chapter provides an overview of the research study, summarizes the research findings, conclusion and recommendations. Some suggestion and future research would also be recommended based on the finding of the study undertaken.

5.1 Conclusion

This study focused on cooking energies amongst the low-income households specifically to the urban slums of Rawalpindi. The study explained the creation of slums and number of factors influencing choice of cooking energy. The results revealed that out of 400 households, almost half of them used firewood throughout the year and the other half were using natural gas during summers and firewood during winters, showing all the households were using firewood. While cost spent on cooking purposes using firwood was a significant proportion (33%) of the households' total income, resultantly limiting them to spend efficiently in order to better their living conditions. It was revealed from the descriptive and correlation analysis that respiratory symptoms and diseases were significant amongst the households with majorly prevalence of cough, chest pain, phlegm and shortness of breath. This shows that households are not only financially challenged but also vulnerable to respiratory illnesses and do not have enough savings to protect themselves from various diseases. Given that majority of the households were aware of the negative impacts of cooking smoke, people were willing to adopt the source of energy that would be harmless to their health and would be ecofriendly. Households using firewood primarily for cooking purposes were willing to adopt the alternative source of energy to save costs spent on cooking energy whereas households using firewood partially in the absence of gas were

willing to switch only if an uninterrupted source of energy is provided throughout the year for cooking purposes. While both types of households were willing to pay for clean energy if it is inexpensive and economical than the sources which are currently being used for cooking purposes.

The results also shown that level of awareness regarding cooking smoke is associated with the education level of household members. While prevalence of respiratory symptoms prompts the households to shift to some clean source of energy. It was also revealed through this research that level of concern about health of household members regarding cooking practices among these households was significant.

It was found that most households were not familiar with the concept of clean energy and referred to clean energy as natural gas only. Majority of the households were found willing to use clean energy source for cooking purposes and were willing to pay Rs. 1000/month on clean energy for cooking purposes. Major factors which influence the willingness of households to pay for clean energy are socioeconomic conditions of household, housing conditions and awareness regarding negative impacts of cooking smoke.

5.2 Recommendations

The initial speculation of budget, miss-management of regularity authorities, lack of support from government, absence of governmental appropriate policies are major barriers to upgrade the development of clean energies other than natural gas in country. Proper policies framework is required to create awareness amongst overall public including the slum dwellers and to promote the usage of solar stoves overall. Utilizing the solar energy

on domestic as well as commercial level will be beneficial for environmental and socio-economic factors on long-term. Some of the recommendations are mentioned that need to be taken in order to promote the use of alternative sources of clean energy other than gas

- Consumption of firewood should be discouraged through Government interventions as it leads to deforestation and poses great dangers to human health
- Awareness campaigns should be planned to create awareness for health risks involved with the usage of cooking smokes and proper ways to reach out to them as it influences the households' willingness to shift to clean energy source
- Include the technologies of solar energy in national policies for cooking purposes
- Investors and entrepreneurs should be promoted to invest in and encourage private sector participation for improved cook stoves
- Provision of incentives to motivate entrepreneurs to come forward and invest in the deployment of renewable sources of energy
- Initiative should be taken to design solar cooking stoves locally to make them affordable for the urban slums
- Awareness regarding depletion of natural gas resource should also be spread in order to influence the willingness of households using natural gas to shift to clean source of energy

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APPENDICES

Appendix A: Research Questionnaire

National University of Science & Technology

NUST Institute of Transportation

Respondent # _____

Part 1: Socioeconomic profile

1. What is your household size?
2. What is the gender of the household head?
    a. Male
    b. Female
3. What is the age of household head (Head of the family)? (years)
4. What is the number of male household members? (No.)
5. What is the education level of household head? (years)
6. What is the education level of female household members? (mean in years)
7. What is the number of children below 5 years? (No.) (Take mean)
8. What is the number of working household members? (No.)
9. What is the total sum of money in Pakistani Rupees (Pak Rs.) earned by all members of the household per month?
10. What is the reason for settling in slums?
11. Does this household possess mobile phones? (frequency) (Per person) (Y/N)

12. Does this household possess a TV? (frequency)(Y/N)

13. For how long this household has lived in this city?

14. What is the household's main source of income? (Encircle)

    a. Self-employment

    b. Formal employment

    c. Casual labor

    d. Other_____

15. What kind of dwelling does this household have? (Encircle)

    a. Single room

    b. Two rooms

    c. Three rooms

    d. More than three rooms

16. Which meals do you take regularly in a day? (Breakfast, Lunch, Supper) (Encircle)

    a. One

    b. Two

    c. All

Part 2: Housing & kitchen conditions

1. What is the condition of the house? (Encircle)

    a. Pakka

    b. Katcha

    c. Thatched Hut

2. What is the construction material of the house? (Encircle)
    a. Mud (and wood)
    b. Bricks
    c. Concrete
    d. Other_____
3. Where is your kitchen situated? (Encircle)
    a. Within living area
    b. Outside the living area
    c. Separate area
    d. Separate room
4. How many kitchens are there in your household?
5. What is the ventilation condition in your kitchen? (Encircle)
    a. Cooks outside
    b. With the help of electricity i.e. exhaust fan
    c. No ventilation
    d. Well ventilated
6. Mark the amenities available in the household. (Encircle)
    a. Water Supply
    b. Electricity
    c. Sanitation
    d. Gas supply
    e. Telephone
    f. Internet

g. Refrigeration

7. How many people can your kitchen accommodate?
8. If there is a provision of electricity in your household, what is the monthly average of its bill?

Summers	**Winters**

9. What is the monthly average of a gas bill if your household has the facility of natural gas?

Summers	**Winters**

Part 3: Energy profile

1. What is the gender and age of the household member who cooks the meal?
2. What is the form of energy being used for cooking?
    1) Crop Waste
    2) Wood
    3) Coal
    4) Electricity
    5) Cow dung

6) Kerosene
7) Natural Gas
8) LPG Cylinders

Other_____

3. Why do you prefer using this form of energy for cooking? (Encircle)
    a. It is affordable
    b. It is easily reachable
    c. It doesn't cause pollution
    d. It cooks food faster than the others
    e. Other _____
4. What are the benefits of using this source of energy?
5. How long have you been using this source of energy?
6. How much money does the household spend on cooking energy monthly?

    _____

7. How many hours are spent in the kitchen for the purpose of cooking?
8. How many times you cook in a day?
9. How much time is required to cook a meal once?
10. How many hearths are there for cooking?
11. Is cooking done for any purpose other than preparing meals?
12. How is this energy transported to this household (if other than piped natural gas)?
13. How do you store this energy (if other than piped natural gas)?
14. How much money is spent on the transportation of this energy (if other than piped natural gas)?

15. Is the abovementioned source of energy only source used throughout the year for cooking purposes? (Encircle)

Yes No

16. If not, specify the sources used in the below mentioned seasons:

Summers	**Winters**

17. Why are different sources of energy being used in different seasons?

18. Given a choice which form of energy would you prefer for cooking? (Encircle)

Part 4: Health conditions

1) Is there any prevalence of the following diseases generally in a household?

	Yes	**No**
1) Cough		
2) Chest Pain		
3) Eye Problem/Eye Irritation		
4) Wheezing		

5) Phlegm		
6) Asthma		
7) Shortness of Breath/Breathing Discomfort		
8) Lung Cancer		
9) COPD – chronic obstructive pulmonary disease		
10) Others_____		

2) Is there any prevalence of problem in breathing in a person who cooks the meals?

3) Is there any prevalence of problem in breathing in any child of your household?

Part 5: Awareness

1) Are you aware of the fact that cooking smoke is detrimental to your health?

_____

2) If yes, how do you think it is detrimental to your health?

_____

3) Do you think some fuels are better than the one currently in use?

   a. Environmentally

_____

b. Financially

_____

c. Ease of usage

_____

4) Do you think Indoor Air Pollution can cause any of the following diseases? (Encircle)

a. Cough

b. T.B

c. Digestion Problem

d. Chest Pain

e. Eye problem/eye irritation

f. Wheezing

g. Burning

h. Asthma

i. Shortness of breath/Breathing discomfort

j. Lung cancer

k. COPD – chronic obstructive pulmonary disease

l. Others_____

5) Have you ever heard of the term ‘Clean Energy’?

_____

6) What do you think ‘Clean Energy’ means?

_____

7) List down all the energies you're aware of?
8) What is your level of agreement with the statement: "Household income influences the type of energy used by the household"?
    a. Agree
    b. Disagree
    c. Neutral
9) Are you concerned about your health due to your cooking practices?
10) Are you concerned about the health of the children in your house regarding your cooking practices?

Part 6: Willingness

1) Are you willing to shift to some other source of energy?
    a. If yes, to which form and why
    b. If not, why?
2) Can you pay for clean energy i.e. gas, electricity or solar-powered stove which is of higher price?
3) How much you can afford to pay for clean energy?
4) Can you change to clean energy home appliance?
5) What do you need from government in the form of support for using clean energy?
6) What are the main barriers in promotion of Clean Energy for cooking?