ENERGY POVERTY AND ITS IMPACT ON ENVIRONMENT: A CASE STUDY OF PAKISTAN

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CERTIFICATE

This is to certify that this thesis entitled: **"Energy Poverty and Its Impact on Environment: A Case Study of Pakistan."** submitted by Amna Haleem is accepted in its present form by the Department of Environmental Economics, Pakistan Institute of Development Economics (PIDE), Islamabad as satisfying the requirements for partial fulfillment of the degree in **Master of Philosophy in Environmental Economics.**

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List of Abbreviation

BHPS	British Household Panel Survey
EP	Energy Poor
EPCER	Equal Per Capita Emission Rights
GHG	Green House Gases
HH	Households
HHS	Household Size
LPG	Liquefied Petroleum Gas
LDCs	Less Developed Countries
LHC	Low Income High Cost
MEPI	Multidimensional Energy Poverty Index
NO_2	Nitrogen Dioxide
O_3	Ozone three
PSLM	Pakistan Social & Living Standard Measurements
PM_{10}	Parts Per Million
WHO	World Health Organization
WAPDA	Water and Power Development Authority

Abstract

This study examined the impact of reduction in energy poverty on environment. Energy poverty is defined in several ways. For example, percentage of household expenditure on energy use or alternatively in terms of access to clean energy products and services such as electricity, natural gas and LPG etc. Pakistan Social and Living Standard Measurement (PSLM) data for 2013-14 is utilized to compute Multidimensional Energy Poverty Index. The index, based on data for different fuels heating, lightening and cooking, is computed to assess incidence of energy poverty. The list of fuel includes firewood, coal, kerosene oil, Gas (Cylinder), Gas (Pipeline), electricity from regular distribution system of WAPDA and from Generators. Multidimensional Energy Poverty Index (MEPI) is showing that 69.67 percent households are deprived of clean fuel for cooking and 47.11 percent are deprived of clean fuel for heating. However, for lighting only 9.04 percent households do not have access to clean source. The results show that per capita income is the major determinant of demand for firewood, coal, kerosene oil, electricity, gas and generator. Findings show that as households move from low income to high income group per capita consumption for firewood, coal and kerosene oil reduces, while per capita consumption for Gas (Cylinder), Gas (Pipeline) and electricity increases. Income is positively related with consumption of clean energy sources. Income is negatively related with consumption of firewood, coal and kerosene oil. Furthermore, study finds that CO_2emission can be reduced significantly through improving access (Access through subsidization, regulation and increasing supply) of low income group to the energy mix of high income group. If highest income group's energy mix is available to poor, for cooking and heating purposes, the emission will decline to 755.869 metric ton (per month) from current emission of 2039.520 metric ton (Per month). Per household emission will also decline by 44.69 kgCo/kwh if highest income group energy mix is available to all households.

Chapter 1: Introduction

Poverty is becoming a frightening problem. This problem is not only faced by developing countries but developed countries are also in the circle. However, poverty problem is more severe in the developing nations (Jones, 2010). The nations are facing poverty in various dimensions such as shortage of natural resources, lack of shelter, shortage of agricultural products, clothing, food poverty, and energy poverty. Estimations found that "1.4 billion people- over 20percent of Global population"- are suffering from lack of access to electricity and "2.7 billion people- contributing 40 percent of global population", are using biomass for their survival.(Guruswamy, 2011). Projections by El-Katiri and Fattouh (2011) indicate that problem will become worse by 2030 as 1.2 billion people will not have access to electricity, and number of people living on traditional biomass will increase from "2.7 billion" to 2.8 billion in 2030.

World Economic Forum (2010) defines energy poverty as: "Lack of access to sustainable modern energy services and products". Similarly United Nations described energy poverty as, "the absence of sufficient choice of accessing adequate, reliable, affordable, safe and environmentally suitable energy services"(Modi, McDade, Lallement, & Saghir, 2006). In simple words, "the energy poverty is lack of access to clean energy services and products such as electricity, natural gas and LPG etc".

Alternatively, energy poverty can be defined as no access to:

- "equivalent 35 Kg per capita per year LPG for cooking or gas fuels or from improved supply of solid fuel sources and improved (efficient and clean) cook stoves"(Barbier, 2014; Sher, Abbas, & Awan, 2014). or

- “120KWh electricity per capita per year for lighting, access to most basic services (drinking water, communication, improved health services, education improved services and others)”[1](Barbier, 2014; Sher et al., 2014).

Energy plays an important role in our daily life. We need it for lighting, health services, transportation, cooking, and to meet our day to day basic needs. To make poor’s life standard better, access to efficient and clean energy source is required. Clean energy includes electricity, gas and LPG for cooking lighting, and heating purpose. Since negative correlation exist between energy poverty and access to modern energy services, there is need to improve access to modern energy services. (Pachauri & Spreng, 2004).

According to United Nations, scarcity of electricity and dependence on biomass is sign of energy poverty in developing nations. The shortage of electricity intensifies poverty as it becomes constraint for most developmental activities and for the employment opportunities (Jones (2010); (Siddiqui, 2004). In the LDCs, large number of people in rural areas, approximately 80 percent of rural households, use solid fuels like charcoal, wood, dung, coal and crop residues while 85 percent of household dependent on wood and its byproducts(Guruswamy, 2011; Leite et al., 2016).This means that only 15 percent of the poor enjoy availability of modern fuels [i.e., electricity, natural gas, liquefied petroleum gas (LPG)] for cooking (Guruswamy, 2011).Over dependence on biomass results in higher GHG emission resulting in the global phenomenon of climate change. Consequently, It has adverse impact on human health also(Leite et al., 2016; Warwick & Doig, 2004).

There are also worse environmental effects of dependence on biomass emissions. For example, the dependence on wood for fuel purpose puts significant pressure on forests, specifically in regions, where energy is scarce (Von Schirnding et al., 2002).Reliance on wood for energy is a

[1] *This threshold for energy poverty has been used in Pakistan and Indonesia.*

major reason for deforestation resulting oil erosion, disturbing other valuable ecosystem services, including drought resistance, flood control, rainfall, enhancement of water quality, and habitat for biodiversity.(Gonzalez, 2015), (Cairncross, O'Neill, McCoy, & Sethi, 2003). Moreover burning agriculture wastes and dung cakes emit methane and carbon dioxide (Sagar, 2005). By burning biomass, black carbon is emitted, which is the biggest reason for global warming (Ramanathan & Carmichael, 2008).Biomass smoke consists of many types of pollutants like carbon monoxide, hydrocarbons and nitrogen oxides.(Smith, Samet, Romieu, & Bruce, 2000).

Due to lack of access to modern energy services for cooking, the households use cooking stoves or fuel wood, which causes indoor and outdoor pollution. These pollutants are referred to as short lived pollutants, which stay for shorter time in the atmosphere, while black carbon have 1500 times greater climatic impact than carbon dioxide. (Sumiya, 2016). Black carbon does not have only temperature rising impact but it also affect the sunlight reflected from ice, cloud and snow (Quinn et al., 2011). Providing the modern energy to households is expected reduce carbon emission and it is an important component to develop climate adaptive capacities among communities (Sumiya, 2016). Energy Poverty also has massive menace for human health. According to the WHO (World Health Organization), dependence on biomass for heating and cooking is cause of about four million premature deaths per year from lung cancer, cardiovascular, asthma, pneumonia and ARIs (Acute respiratory infections) diseases (Gonzalez, 2015).

This study looks at the prevailing conditions of Energy Poverty in Pakistan. Pakistan is a relevant case for this study for a number of reasons. For example:

- The evidence shows that energy demand for various fuel components varies significantly across income groups.(Khan & Ahmad, 2008).

- In rural and urban areas large segment of people are still dependent on traditional fuel. About 29 percent of population in Urban Areas and 71 percent in rural areas are identified as energy poor.(Sher et al., 2014).
- Pakistan's energy infrastructure is poorly managed, inefficient and under-developed.

In this study we focus on first two issues. In past two decades industrialization, urbanization, growth in agriculture sector and private sectors, rural electrification and rising per capita income have resulted in an unusual rise in energy demand. However, no considerable effort has been made to a matching increase in supply.(Tariq, 2013-2014).

1.2: Research Questions

The study will focus on energy demand and energy poverty at household level to answer the following questions;

i) What is the household demand for various component of energy?

ii) Is energy poverty at household level an issue in Pakistan?

iii) What is the current status of CO_2emissions from household energy use? Does it differ by income groups?

iv) What are the environmental consequences (i.e. emission reduction) of reducing energy poverty? If energy poverty is reduced, by changing energy mix from higher pollution to low pollution fuel, to what extent CO_2 emissions will change?

1.3: Objectives of the Study

The objectives of study include are as follows:

i)Analyze the current household demand of different energy sources by income groups.

ii) Energy poverty has become critical issue across countries and Pakistan is no exception. We examine the prevalence of energy poverty in Pakistan.

iii) Analyze the impact of reduction in energy poverty on environment i.e. emission reduction.

The study is organized as follows: in chapter 2 a brief review of literature is given. Data and methodology related issues are discussed in chapter 3. Results are discussed in chapter 4 and 5, while concluding remarks and policy implications are presented in the final chapter.

Chapter 2: Review of Literature

Understanding the demand for energy is critical for several reasons. First one is that due to increase in income there is increase in energy demand. Secondly, larger demand for energy than anticipated increases can lead to significant increases in energy prices. Third, Emissions from fossil-fuel use are a key contributor to climate change, so forecasting their likely path is important to understanding the range of possible effects of increased greenhouse gases in the atmosphere. This section provides a brief summary of the various research studies related to the Energy Poverty and its impact on environment, respectively.

2.1 Household Energy Demand

Number of studies like Lenzen et al. (2006) show that strong correlation exists between income and energy . For example , Morello, Schmid, and Abramovay (2011) find that household income and firewood consumption as fuel is inversely correlated to each other, which means when income of household increases, consumption of firewood decreases and HH (Households) switch to another fuel. Study also found that as income increases beyond the threshold level, unavoidably increases GHG (Green House Gas) Emission. On the other hand case study in Ghana founds that there exist positive relationship between GDP growth rate and fuel wood consumption (Quartey, 2014). As house hold income level raises, consumption of Gasoline moves upward and firewood consumption goes down (Morello, Schmid, & Abramovay, 2012)

Baatz (2014) investigated the relationship between the duties for the reduction of GHG emissions and the climate changes. The study focused on the two basic significant factors of GHG (Green House Gas) emissions: Nation states and Individuals. EPCER (Equal per capita emission rights) approach is used by the study, according to which there exists a strong correlation between GHG emissions, wealth and consumption. The study used the integration and isolation approach which supported result. The study at the end concluded that it is quite difficult to measure with the help of integrationist approach to what extent people should be permit to emit the GHG in the absence of any regularity authority.

Number of researches has examined the association between “Aggregate EnergyConsumption and GDP” by showing that when countries are at low income levels “income elasticity” is higher (Galli, 1998).

Similarly another study Gertler, Shelef, Wolfram, and Fuchs (2011)shows that when poor households’ income goes up, their energy demand increases as households buy energy-using accessories (Refrigerator, Television, air conditioner etc.) for the first time. That energy use items also cause to GHG emission. Study provides analytical support for these hypotheses by investigative the causal impact of large increases in household income on asset accumulation and energy use in the context of Mexico’s conditional cash transfer program. Findings show that if a country’s growth has been pro-poor, the responsiveness of energy use to income is nearly double that of a country with GDP growth that has been less favorable to the poor.

The relations between high energy prices, low income and a low energy efficient resources available to the household is usually considered to be the main cause of energy poverty (Boardman, 2013; Hills, 2011).Parker, Rowlands, and Scott (2005) found that major reduction in emission came from the households who have most desire to save and have high income level. Furthermore, Ekins and Dresner (2004) also made the contribution by pointing out that 30percent of those households who suffer from fuel poverty are paying high energy bills, and carbon taxes can effect worse. (Roberts, Vera-Toscano, & Phimister, 2015) theystudy “How impact of personal carbon allowances on low income households” and found that carbon footprint has positive relationship with income. On the other side, in the lowest income groups, carbon footprints disperse widely, and this variation is due to change in housing quality i.e. its energy performance. Furthermore, another study estimated the "carbon footprint of low income households", by addressing the question whether fuel poverty is inconsistent with carbon saving. Study concludes that programs struggling for reducing carbon footprints are more effective for lower income dwellings than any in other social class (Pett, 2009).

2.2 Energy Poverty

Energy poverty arises as a research subject in the 1980s in Great Britain (Bradshaw and Hutton, 1983; Boardman, 1991). The writers know about the ambiguity related to the terms of fuel and energy poverty (Ürge-Vorsatz & Herrero, 2012). Energy poverty can be described "as lack of access of quality energy carriers, mostly in developing countries"(Buzar, 2007; Mayer, Nimal, Nogue, & Sevenet, 2014; Sagar, 2005). Similarly , EP can be closely related with the conception of 'affordable warmth' (Boardman, 1991), but other energy services (lighting, cooking etc.) are also taken into consideration. On the other hand fuel poverty referred as; "a household's incapability to ensure an sufficient thermal system in its living space"(Boardman, 1991, 2010; BERR, 2001), However, term Energy Poverty (EP) can also be used as a vast idea not only relating to the access of energy ,but also interrelated to more multifaceted issues like availability of modern energy services(Ürge-Vorsatz & Herrero, 2012).

Number of studies are conducted to estimate energy poverty, Dubois (2012) used the ten percentile rule threshold for actual energy expenditure . But this doesn't consider the households who ration their energy consumption. Energy poverty measurements vary from country to country. In Scotland energy poverty threshold mainly based upon ten percent required expenditure, on the other side in England, energy poverty defined as if individual lives in household whose income falls below 60percent of median income and energy expenditure is above household median expenditure (Hills, 2012).

Similarly, studies aim to address a gap in the fuel/energy poverty literature, which only concentrate on its human and social health implications rather upon climate change impact (Boardman, 2013; Pett, 2009).

Research related to energy poverty has been much concerned with means of measuring the phenomenon, in order to be able to observe its progress over time and the potential impact of policy measures. The most important indicator used is the 10percent indicator which quantify that how many number of households are fuel poor, Boardman (1991)provides that household fall in category of fuel poor if it spend more than 10 percent of its income on energy services. This is based on British data from 1988, when median energy expenditure calculated to 5percent, the double of which number considered to be irrationally high expenses(Boardman, 2013) whereas being the most commonly used indicator, it has been more criticized recently. Due to these criticism, a new indicator LIHC (Low income High Cost) has been introduced by Hills (2011); (2012) which gives a more trustworthy account of the phenomenon. Mayer et al. (2014), used the term energy poverty to define a condition when a household has to face serious monetary problems because of excessively higher energy costs, which may also be applied both to the transport and housing sector. Study provides a method that estimates the energy costs and also provides findings at the household level. While fuel poverty for the housing sector has been calculated at the national scale, study shows that how the national scale indicator can be implemented to the local level. Other studies that have examined households' twofold energy burden (Rosales-Montano et al., 2009).

2.3 Energy Poverty and Environment

Chakravarty and Tavoni (2013) work with aim to estimate whether increase in modern energy services could considerably increase CO_2 emission. Paper used the robust model for estimation of future and current energy consumption. This model used for calculating the current and future generation energy consumption difference distribution. Study found that energy poverty reduction will raise energy consumption by 7 percent till 2030. This 7 percent increase in consumption would ultimately increase 16-131 $GTCO_2$.Research find that level of income and GHG (Green House Gas) emissions are positively associated, if there is improvement in living standards of low income people, it would result in increase in greenhouse gas emissions. But this type of relationship might not be applicable for every type of consumption, especially for low income groups (Dragusanu & Wilson, 2008).

Lavaine (2015)inspected the relationship between atmospheric pollution, environmental disparities and the overall mortality rates in France by using panel data for the time period 2000-2004. Spatial autocorrelation technique is used to check the concentration of O3, NO2 and PM10 which resulted positive effect of NO2 on mortality. Study also used pooled OLS estimation which detected a positive influence of Ozone (O3) on the atmosphere. In the last, result of fixed effect model study fixed effect model and multivariate model supported the results of OLS estimation. Study diagnosed that NO2 affects the health of women more than that of men, because of which the country (France) has to make changes in the policies related to health. The results of study are consistent with the previous studies related to environmental disparities. Study identified the need to conduct studies on various geographical areas of France.

Sher et al. (2014)study intends to examine the level of Energy Poverty (EP) in Pakistan and to find the quantity of energy poverty in urban and rural areas of Pakistan. The study collected data from PSLM (Pakistan Social & Living Standards Measurement) Survey 2007-08. For the measurement of energy poverty, the study uses Multidimensional Energy Poverty Index (MEPI). Findings showed that rural Pakistan facing 71 percent MEP (Multi-dimensional energy poverty) while 29 percent in urban areas of Pakistan. Study found that there is significant and more intensive Energy poverty exists in rural areas and this condition not only prevails in Pakistan but in all provinces also.

Roberts et al. (2015) tested the overall energy poverty in UK. The major focus for the study was to determine whether there is a difference between rural energy poverty and urban energy poverty. The study used panel data for the time period 1997 to 2009 having unbalanced panel data, countries were Scotland, England and many others. The data was taken from the BHPS (British Households Power Surveys). The major energy components used were Electricity, Liquid Fuels, and Gas Fuels Gas. By using dummy variable technique, different dummy variables were constructed for rural and urban areas and nature of housing, temperature across space and time, difference in the energy price and personal characteristics were taken as control variables. By using 15,144 observations for rural and 46,211 observations were taken for urban areas. The study concluded that there is almost no difference of energy poverty between rural and urban areas. The results indicated that personal characteristics and impact of certain housing varies across the urban and rural areas.

Large number of studies are conducted to demonstrate how energy poverty led to Environmental depletion and it is accepted that if energy poverty prolonged in the state/region consequently more poor air quality and depleted forests there(Hiemstra-van der Horst & Hovorka, 2009; Pereira, Freitas, & da Silva, 2011).

Literature helps to understand multi dimensions of energy poverty. There has been much research conducted to measure this type of poverty at household level like ten percentile rule, median rule, MEPI (Multidimensional Energy Poverty Index). Most of research focus was on energy poverty and climate change, energy poverty and environmental disparities. Several studies found that energy poverty is negatively correlated to income. Literature also identifies thatdifference in rural energy poverty and urban energy poverty could be estimated.

It is important to conduct study with aim that if there is increase in clean energy consumption what would be the impact on CO_2 emission. This study will focus that if clean fuel is provided to low income household emission will increase or decrease.

Chapter 3: Methodology and Data

3.1 Energy Demand Function

By using the regression, study will estimate the demand function:

$$\mathbf{Y_{ij}^{m} = \alpha_{0j}^{m} + \alpha_{sj}^{m} X_{s}^{m} + \varepsilon_{ij}} \qquad (1)$$

Where

i = 1……. n (Households)

j= 1……….7 (Fuel items)

m= 1……….5 (Income Groups)

s= 1,..,4 (for explanatory variables)

where:

$\mathbf{Y_{ij}^{m}}$= Dependent variable, measuring consumption of jth fuel by the i^{th} household in m^{th} income group.

$\mathbf{X_{is}^{m}}$ = Explanatory variable (s) for the i^{th} household in the m^{th} income group.

Income Groups	**Monthly Income (Rs)**
1	≤ 15000
2	15001-30000
3	30001-50000
4	50001-70000
5	70001 above

Description of Variables:

A. The dependent variables are:

Fire Wood: Monthly per capita consumption (Y_{i1}^{m}) is estimated in kilogram, by i^{th} household in m^{th} income group.

Kerosene oil: Monthly per capita Consumption (Y_{i2}^{m})is estimated in liter, by i^{th} household in m^{th} income group.

Coal: Monthly per capita Consumption (Y_{i3}^{m})is estimated in kilograms, by i^{th} household in m^{th} income group.

Gas (Cylinder): Monthly per capita Consumption (Y_{i4}^{m}) is estimated in kilograms, by i^{th} household in m^{th} income group.

Gas (Pipeline/LPG): Monthly per capita consumption (Y_{i5}^{m}) is measured in cubic feet's, by i^{th} household in m^{th} income group.

Electricity: Monthly per capita Consumption (Y_{i6}^{m})is estimated in Kilo Watt Hours (kWh), by i^{th} household in m^{th} income group.

Generator Expense: Monthly per capita Consumption (Y_{i7}^{m}) for petrol is estimated as generator expense, by i^{th} household in m^{th} income group. Petrol is measured in liter.

B. Explanatory variables are:

Income per capita: Monthly household income per capita measured in rupees.

Household consumption of the fuel item is expected to rise positively as income rises.

HHS: Household size measured as number of persons in a household. Household size is included because when family size increase there would be change in demand for fuel items. It will check for the presence of economies of scale in fuel consumption.

Region: Dummy variable for rural/ urban is used. (= 1if the household lives in rural area and it is '0" otherwise.). Region is a control variable checking for regional differences in consumption of fuel items in rural and urban areas.

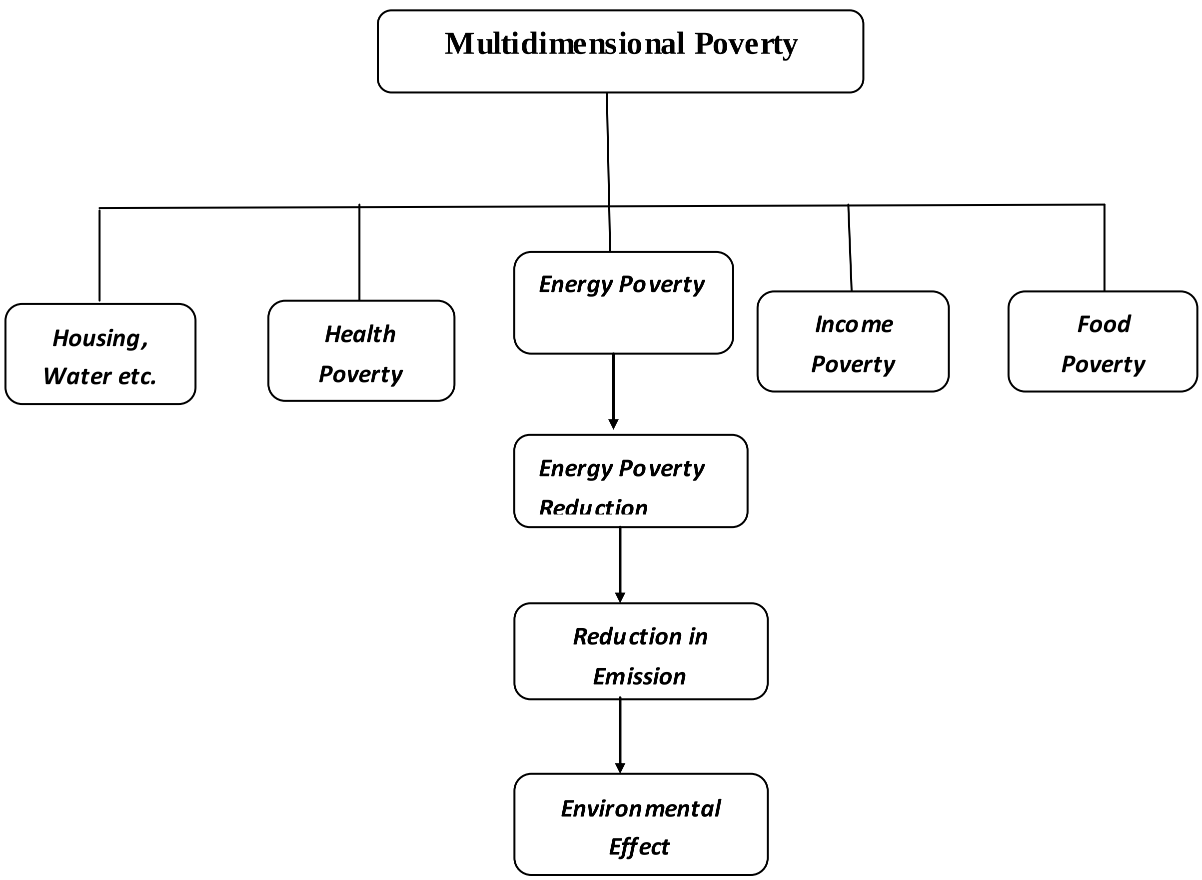
Education: Refers to the number of schooling years of the head of household. Education is expected to raise the demand for cleaner fuels as the educated head of the household will be more aware about clean and environment friendly fuel items.

Per Capita Income Square: Due to nonlinear effect of per capita income, we include per capita-squared as explanatory variable.

3.2 Computing Energy Poverty

Figure 1 showing that multidimensional poverty can be categorized in seven categories health poverty[2], income poverty[3], food poverty[4], energy poverty[5], housing poverty[6] water poverty[7] and education poverty[8](Gordon, 2005) .Study is focusing upon environmental effects, so we will only focus upon energy poverty. Energy poverty puts question for global climate challenges, when energy poverty is reduced consequently there is emission reduction and reduction in emission will effect environment in better way.

Figure 1: Flow chart Diagram



[2] *Health poverty:* Women/ men who did not receive treatment for a recent serious illness or who did not receive any antenatal care.
[3] Income Poverty: Person who living below 1$ per day.
[4] *Food Poverty:* Body Mass Index of 16 or below (severe underweight).
[5] *Energy Poverty: person who has not access to energy services for cooking, heating and lightening.*
[6] Housing Poverty: living in dwellings with 4 or more people per room (severe overcrowding) or in a house with no flooring (e.g. a mud floor).
[7] *Water Poverty:* access only to surface water (e.g. rivers, ponds) for drinking or living in households where the nearest source of water was more than 15 minutes away.
[8] Education poverty/ Deprivation: Household who did not complete primary school or who are illiterate

3.2.1: Ten Percentile Rule

Household is considered to be energy poor according to the Ten-Percent-Rule (TPR) if “he (has to) spend more than ten percent of their net income on adequate energy services”. (Dubois, 2012; Schuessler, 2014)

Data for income and household expenditure on different fuel items has been collected from Pakistan Social and Living Standard Measurements (PSLM) 2013-2014 contain easily extractable information on actual spending for energy services. But due to fluctuation of energy prices this may not give reliable result, that’s why study will also use another method to measure energy poverty.

3.2.2: Multidimensional Energy Poverty Index

The MEPI (Multidimensional Energy Poverty Index) is “Product of a headcount ratio and average intensity of deprivation of energy poor”. (Nussbaumer, Bazilian, & Modi, 2012; Sher et al., 2014) .Head count ratio calculates “the share of people in total population who are energy poor”. In essence, MEPI record “the set of EP deprivations that affect a person”. A threshold set in the MEPI, then calculated headcount compared to this threshold. If the deprivation faced by household exceeds the threshold, person is categorized as energy poor. (Nussbaumer et al., 2012).Multidimensional Energy Poverty Index (MEPI) combines two characteristics of energy poverty. One is the incidence of poverty defined as “the percentage of people who are energy poor, or the headcount ratio (H)”and the other is the “intensity of poverty defined as the average percentage of dimensions in which energy poor people are deprived”.

Table 1: Selected Indicators and their cutoffs

Dimensions	**Indicator**	**Variable**	**Deprivation Cut Off**
Cooking	Modern Cooking Fuel	Type of Coking Fuel	A household consider poor/deprived if use any fuel beside electricity, LPG, Natural Gas or biogas for cooking purpose.
Lightening	Electricity Access	Has access to electricity	A household consider poor/deprived, if household has no electricity connection or access to electricity facilities
Heating	Modern Heating Fuel	Has electricity and Gas access	A household consider poor/deprived if use any fuel except electricity, LPG, natural Gas for heating purpose.

Let, M^{ip} shows the set of all entries i×j matrices and can be defined as: "number of people in j dimensions. i= 1,2, 3,………. n (No of individuals), p=1,2, 3, …. d (No of Dimensions j) the typical entry Y_{ip} contains individual i's achievement in dimension j". It is row vector which enlist the individual i's achievement in p dimensions, while column vector includes distribution of achievements in dimension j across individuals. Let $Z_p>0$ the "cut off"[9] below which a person is considered to be deprived in dimension j and z represent the row vector of dimension specific cutoffs(Alkire & Foster, 2011).

A person is considered poor according to union approach, "if that person is underprivileged in only one dimension". While according to intersection approach "an individual 'i' is considered to be poor if that individual is deprived in all dimensions". If the equal weights are given to all dimensions the technique to recognize the multidimensional poor suggested by Alkire and Foster

[9] *Cut off level is 30 percent.*

deprivations are compared with a cutoff level k. On the basis of this identification method, Alkire and Foster define the following poverty measures. The first natural measure is the "percentage of individuals that are multidimensional poor", and multidimensional Headcount Ratio is defined by "H = q/n, where q = q(y,z) is the number of people in set Z".

3.3 Environmental Impact of Energy Poverty

Study collected data for quantity consumption of firewood, coal, kerosene oil, electricity, gas (pipeline), gas (cylinder) and generator fuel (Petrol) from PSLM 2013-2014. Data for per unit emission from different fuel items has been collected from Environment Impact Assessment (EIA, 2015) . Data for per unit emission was collected in kilo watt hours[10] and data for quantity consumption is in reported units e.g. kilograms, liter. Study converted this reported data in emission unit and then used per unit emission data for calculation of emission from fuel items. Emission data has been used for net gain estimation of emission reduction

$$\text{Total Emission}_j = \text{Total Quantity Consumption}_j \text{ (Per unit Emission}_{j)}$$

J = 1,2,………7 (Fuel Items)

3.4 DATA

The main data source for Study is PSLM (Pakistan Social & Living Standard Measurement) Survey 2013-2014. This data set includes sample of 17989 households. Data for consumption of firewood, kerosene oil, charcoal, coal, dung cakes, Natural Gas, Gas (Cylinder/LPG), electricity and generator expense collected. PSLM survey collects data on key Social indicators as well as on Consumption and Income, while in different sections information is also collected about "household size,the level of savings, the number of employed people and their employment status, consumption pattern, main sources of income and the consumption of the major food items".

[10] *See Appendix table 26*

Descriptive Statistics of Variables

Table 2 showing mean values for each variable. As variable showing that mean consumption of firewood decreases from 90.72 kg to 69.51 kg as we move from lower income group to higher income group. Electricity variable showing that mean consumption for electricity rises from 159.60 Kwh to 199.72 Kwh, as we move from lower income to higher income level. Mean consumption for coal has been decreased from first to third income group 113.99 kg to 75 kg and there is no consumption for higher income groups. Variable of gas (Cylinder) also showing that mean consumption varies from 6.20 kg to 6.913 kg for five income groups. Mean consumption of Gas (pipeline) has been increased from 507.13 to 597.14 cubic feet for first income group to highest income group. This indicates that when household has more income they depend on gas instead of other fuel to meet their daily need. As the income level increases mean consumption of kerosene oil reduced from 1.65 liter to 1.45 liter. Mean consumption of petrol for generator has been decreased from lower to highest income group. Highest income group household has more reliance on clean fuel like electricity and gas, due to which they use less quantity of petrol for generator.

Table 2: Descriptive Statistics of Variables (Mean)

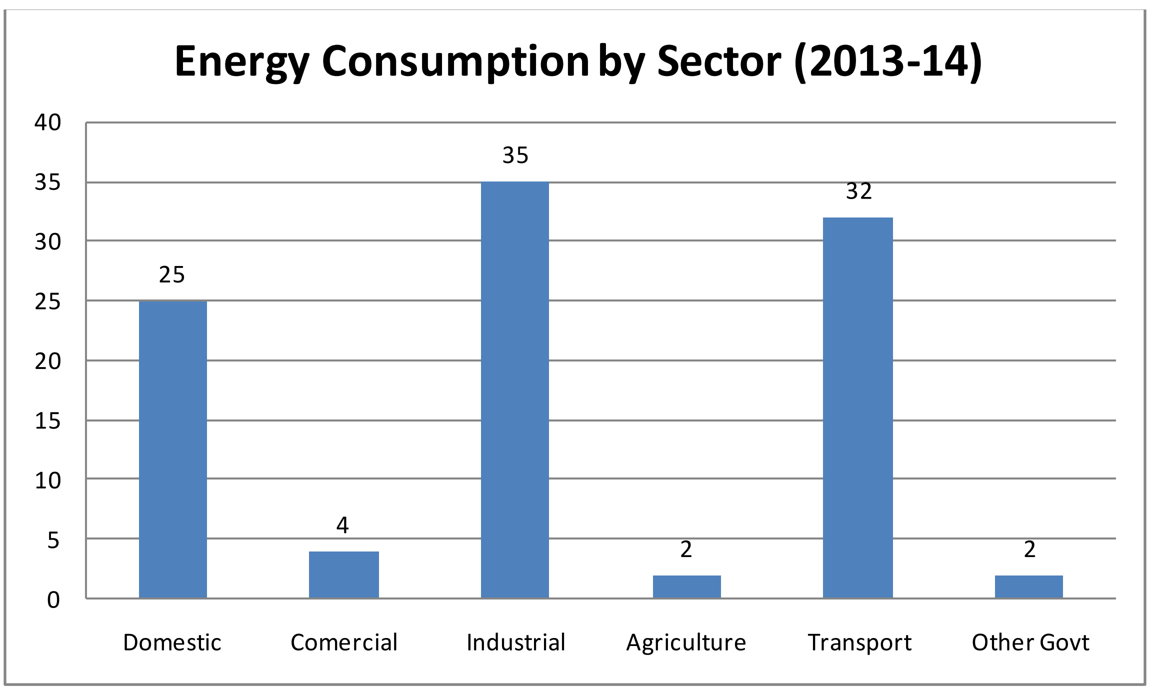
List of items	Ist Income Group (N=6916)	2nd Income Group (N=6414)	3rd Income Group (N=2712)	4th Income Group (N=1239)	5th Income Group (N=475)
Firewood (kg)	90.72	89.96	84.66	88.95	69.51
Electricity (kwh)	159.6039	175.50	171.17	193.35	199.72
Coal (kg)	113.99	124.00	75.00	-	-
Gas Cylinder (kg)	6.20	5.32	6.82	4.53	6.913
Gas Pipeline (Cube feet)	507.13	479.65	495.37	588.57	597.14
Kerosene oil (liter)	1.65	1.68	1.90	1.25	1.45
Generator fuel (liter)	6.20	5.65	5.19	3.50	2.75
Income (Rs)	7251.64	21399.02	39163.82	59952.38	82325.08

Chapter 4: Results and Discussion of Energy Demand

4.1: Energy Demand Function

Current energy use pattern is shown in Figure 2, below. It shows the households consume about ¼ of the total energy. Figure 2 is also showing that on average industrial sector consumed 35.3 percent of energy, followed by transport sector with share 32.2 percent. The agriculture sector, commercial and Government sector respectively consumed 2 percent, 4 percent and 2 percent of total energy. (Pakistan, 2013-14). In this study, we focus mainly on energy demand and energy poverty critically linked with households. In order to link the energy demand pattern with emissions and to pollution reduction, we first estimate the household demand for each component of energy.

Figure 2: Energy Consumption by Sector (percent of total energy)



*****(Pakistan, 2013-14)

4.1.1)Fire Wood Consumption-Per-capita

The aggregate firewood consumption function is estimated, including income per capita, income-squared, family size, education and region as independent variables. We find that per capita income has positive effect and it is statistically significant. The coefficient of income-square is negative as expected and statistically significant. This shows that income increase has a positive effect on demand for firewood and the effect is linear. The coefficient for region is also positive effect but statistically insignificant. It indicates no significant difference in consumption of firewood in the urban and rural areas. The family size coefficient is negative as expected. This shows presence of economies of scale in consumption of firewood. As family size increases the per capita consumption goes down. Education has positive impact but insignificant. F value shows estimated model is overall fit, while adjusted R^2 is also significant.

We have also estimated the firewood consumption function for five different income groups, including income per capita, income-square, family size, education and region as independent variables. Findings show that per capita income coefficient has positive effect but nonlinear, it is increasing till 3^{rd} income group, statistically significant, while after 3^{rd} income group start decreasing and statistically insignificant.

The coefficient for region is also positive effect for all income groups but statistically insignificant. It indicates no significant difference in consumption of firewood in the urban and rural areas. Coefficient of family size is negative for all income groups except third income group. Coefficient of Education has statistically insignificant and positive impact on all income groups demand function. F value shows that model is not good fit for highest (5^{th}) income group demand function.

Table 3: Results : Fire Wood Consumption-Per-capita

list of variables	Aggregate	1st i-group	2nd I-group	3rd I-group	4th i-group	5th i-group
(Constant)	28.200 (19.282)[11]	24.269 (9.893)	3.252 (.730)	-5.405 (-.931)	-16.376 (-1.403)	12.987 (.371)
Per capita income	.001 (5.306)	.001 (1.655)	.004 (5.520)	.003 (5.448)	.002 (2.812)	-3.261E-5 (-.024)
P capita income square	-4.184E-9 (-.786)	3.787E-7 (4.021)	-3.005E-8 (-.930)	-4.711E-8 (-2.672)	-1.767E-8 (-1.626)	9.922E-9 (.190)
Region	1.016 (1.423)	.794 (.862)	1.395 (1.161)	.961 (.577)	6.623 (2.280)	.023 (.007)
Family Size	-2.168 (-19.131)	-1.732 (-10.132)	-.570 (-1.907)	-.163 (-.472)	.308 (.442)	-.506 (-.301)
Education	.201 (.496)	.591 (1.131)	-.659 (-.982)	.528 (.521)	.5 (.305)	1.439 (.755)
R^2	.170	.186	.342	.470	.538	.127
	3220	2154	757	208	67	30
F value	165.081	122.932	97.871	45.273	18.351	.944

4.1.2) Coal Consumption Per-Capita

The aggregate coal consumption function is estimated, including income per capita, income-squared, family size, education and region as independent variables. We find that per capita income has positive effect and it is statistically insignificant. The coefficient of income-squared is negative as expected and statistically insignificant. This shows that income increase has a negative effect on demand for coal and the effect is linear. The coefficient for region is also positive effect but insignificant. It indicates no significant difference in consumption of coal in the urban and rural areas. The family size coefficient is negative as expected. This shows presence of economies of scale in consumption of coal. As family size increases the per capita consumption goes down. F value shows that mode is good fit.

[11] *t > 1.67 Significance level*

Coal consumption function for different income groups is estimated, including income per capita, income-squared, education, family size and region as independent variables. We find that per-capita income has positive and statistically significant impact on coal consumption. Income square coefficient is negative and statistically significant for lowest income group, while it is statistically insignificant for 2nd income group.

The coefficient of region is positive for both groups but statistically insignificant, indicates no urban/rural significant difference in consumption of coal. Coefficient of family size positive for both income group but statistically insignificant, for 2nd income group the result indicates that significant economies of scale exist in the coal consumption. Education has insignificant impact on coal consumption. F value shows model is not good fit for 2nd income group demand function.

Table 4: Results : Coal Consumption Per-Capita

List of Variables	Aggregate	1st i-group	2nd I-group
(Constant)	13.768 (.388)	23.054 (8.09)	2.414 (.062)
Per Capita Income	.014 (1.780)	.041 (2.509)	.004 (5.532)
Per Capita Income Square	-4.184E-9 (-1.597)	3.787E-7 (4.010)	-3.005E-8 (-.930)
Region	8.658 (.643)	.792 (.860)	2.693 (.365)
Family Size	-3.907 (-1.497)	-1.724 (-10.072)	-.503 (-.235)
Education	.201 (.496)	.591 (1.131)	-.659 (-.982)
R^2	.291	.421	.641
Number of observations	47	31	11
F value	4.411	4.913	3.120

4.1.3) Kerosene oil Consumption Per-Capita

The aggregate kerosene oil consumption function is estimated, including income per capita, income-squared, family size, education and region as independent variables. We find that per capita income has negative impact and statistically insignificant. The coefficient of income-square is positive and it is statistically significant. This shows that income increase has a positive effect on demand for firewood and the effect isnonlinear. The coefficient for region is also positive but statistically insignificant. It indicates no significant difference in consumption of kerosene oil in the urban and rural areas. The family size coefficient is negative as expected and highly significant. This shows presence of economies of scale in consumption of kerosene oil. As family size increases the per capita consumption goes down. Coefficient of education has positive impact and statistically insignificant. F value showing that overall model is good. Kerosene oil consumption function for five income groups estimated, including income per-capita, income squared, family size, education and region as independent variables. Per capita income coefficient is linear , it starts decreasing from 1^{st} group to 5^{th} income group, while positive for first three income groups and have negative effect for 4^{th}, 5^{th} income group. Per capita income coefficient is statistically insignificant for all income groups. Coefficient of per income squared is nonlinear and statistically significant only for 1^{st} and 3^{rd} income group.

The coefficient for region have negative effect but insignificant. It indicates no significant difference in consumption of Kerosene oil in the urban and rural areas. The family size coefficient is negative for all income groups expected and nonlinear effect. Family size coefficient is significant only for first two income groups. Education coefficient is statistically significant only for 1^{st} income group. F value showing that for 4^{th} and 5th income groups demand function is not good fit.

Table : Results: Kerosene oil Consumption Per-Capita

List of variables	Aggregate	1st i-group	2nd I-group	3rd I-group	4th i-group	5th i-group
(Constant)	.544 (12.527)	.399 (5.343)	.392 (3.345)	.246 (.747)	.409 (.942)	2.469 (.985)
Per Capita Income	-5.662E-6 (-.931)	4.207E-7 (0.19)	2.212E-5 (1.133)	1.646E-5 (.591)	-1.920E-5 (-.453)	-1.846E-4 (-.893)
Per capita income square	1.577E-9 (5.722)	8.598E-9 (4.338)	1.570E-9 (1.847)	1.374E-9 (2.135)	7.632E-10 (.623)	5.907E-9 (.922)
Region	.031 (1.252)	.065 (1.917)	-.002 (-0.66)	-.035 (-.354)	-.002 (-.036)	-.288 (-1.569)
Family size	-.041 (-12.368)	-.032 (-6.266)	-.024 (-3.104)	-.008 (-.432)	-.019 (-.874)	-.082 (-.697)
Education	177.678 (-.367)	.004 (.298)	-.020 (-1.374)	-.007 (-.166)	.013 (.651)	-.004 (-.067)
# of observation	1272	830	323	80	25	10
R^2	.211	.224	.331	.590	.280	.475
F value	67.835	47.661	31.471	21.601	1.553	.904

4.1.4) Electricity Consumption Per-Capita

The aggregate electricity consumption function is estimated, including income per capita, income-squared, family size, education and region as independent variables. We find that per capita income has positive effect and it is statistically significant. The coefficient of income-squared is negative as expected but statistically insignificant. This shows that income increase has a positive effect on demand for electricity and the effect is linear. The coefficient for region is also positive effect and significant, indicating significant difference in consumption of electricity in the urban and rural areas. The family size coefficient is negative as expected and highly significant. This shows presence of economies of scale in consumption of electricity. As family size increases the per capita consumption goes down. Coefficient of education is positive and statistically significant.

The electricity consumption function is estimated for five income groups, including income per capita, income-squared, family size, education and region as independent variables. Per-capita income has non linear effect; it is positive for first three income groups and statistically significant. For 4th income group its impact is negative which shows there is decrease in per capita demand for electricity for higher income groups. Per-capita income squared coefficient has negative effect for 3rd and 5th income group, while have positive effect for other income groups and statistically significant. It shows that per-capita demand for electricity increases for ist two income groups, as we move toward higher groups demand starts decreasing. Family size has negative impact for all groups but significant impact only for 1st and 2nd income group indicating significant economies of scale only in the first two groups. The coefficient for region is also positive effect for all income groups, significant only for 1st income group t but insignificant for higher income group. It indicates no significant difference in consumption of electricity in the urban and rural areas. Education coefficient also has nonlinear but positive impact and statistically insignificant for higher income groups. F value shows that for highest 4th and 5th income groups' model in not good fit.

Table 6:Results: Electricity Consumption Per-Capita

List of Variables	Aggregate	1st i-group	2nd I-group	3rd I-group	4th i-group	5th i-group
(Constant)	40.855 (18.189)	31.106 (10.418)	20.492 (2.556)	-10.832 (-.921)	51.408 (1.913)	-6.182 (-.147)
Per Capita Income	.003 (11.911)	.003 (3.530)	.003 (2.515)	.005 (5.114)	-.001 (-.316)	.002 (1.033)
Per capita Income square	-3.182E-8 (-5.221)	9.230E-7 (8.417)	1.631E-7 (2.707)	-7.091E-8 (-2.892)	5.066E-8 (2.255)	-1.815E-8 (-1.121)
Family size	-4.204 (-24.716)	-3.308 (-14.966)	-1.903 (-3.514)	-.136 (-.174)	-2.215 (-1.308)	-1.579 (-.649)
Region	6.281 (6.052)	6.774 (5.4290	3.587 (1.855)	4.273 (1.409)	5.238 (.915)	2.514 (.275)
Education	2.459 (4.110)	2.861 (4.023)	1.760 (1.534)	1.863 (1.027)	-5.802 (-1.734)	10.719 (1.872)
Number of observation	15662	12018	2652	708	191	89
R^2	.076	.097	.160	.192	15.434	.131
F Value	257.332	259.46	100.826	33.449	.293	2.534

4.1.5) Gas (Cylinder) Consumption Per-Capita

The aggregate Gas (Cylinder) consumption function is estimated, including income per capita, income-squared, family size, education and region as independent variables. We find that per capita income has positive effect and it is statistically significant. The coefficient of income-square is positive but statistically insignificant. This shows that income increase has a positive effect on demand for Gas (Cylinder) and the effect is linear. The coefficient for region has also negative effect but insignificant. It indicates no significant difference in consumption of Gas (Cylinder) in the urban and rural areas. The family size coefficient is negative as expected. This shows presence of economies of scale in consumption of Gas. As family size increases the per capita consumption goes down. Education has also negative impact but it is statistically insignificant. F values showing overall model is good fit.

The Gas (Cylinder) consumption function is estimated for five income groups, including income per capita, income-squared, family size, education and region as independent variables. Per-capita income has nonlinear effect, it has positive effect for first all income groups, statistically significant and become constant for higher income groups, which shows there is no increase/decrease in demand function for Gas when household move from low to high income group. Per capita income squared has positive impact for first two income group while negative for higher income and statistically insignificant. Region Coefficient and Education coefficient has negative impact on all income groups but statistically insignificant. F value shows that for high income groups model is not good fit.

Table7 :Results: Gas (Cylinder) Consumption Per-Capita

List of Variables	**Aggregate**	**1st i-group**	**2nd I-group**	**3rdI-group**	**4th i-group**	**5thi-group**
(Constant)	2.420 (13.239)	2.259 (8.047)	.946 (1.974)	.475 (.313)	-10.455 (-2.216)	-7.825 (-.822)
Per Capita income	3.149E-5 (1.294)	7.253E-5 (.865)	1.259E-4 (1.657)	2.726E-4 (2.081)	.001 (2.249)	.001 (1.272)
Per capita income Square	7.946E-10 (.701)	9.582E-9 (1.153)	6.359E-9 (2.042)	-1.697E-9 (-1.993)	-2.403E-8 (-1.803)	-2.497E-8 (-1.450)
Region	-.057 (-.646)	-.017 (-.145)	-.022 (-.168)	-.221 (-.480)	.447 (.940)	-.377 (-.497)
Family Size	-.174 (-13.316)	-.153 (-7.989)	-.075 (-2.334)	-.060 (-.670)	.463 (1.992)	.406 (.817)
Education	-.068 (-1.656)	-.098 (-1.868)	-.002 (-.030)	-.003 (-.013)	-.044 (-.206)	-.140 (-.656)
Number of observation	1614	1082	395	96	25	12
R^2	.151	.145	.362	.190	.445	.406
F value	57.405	36.594	44.306	4.278	3.205	.956

4.1.6) Gas (pipeline) Consumption Per-Capita

The aggregate Gas consumption function is estimated, including income per capita, income-squared, family size, education and region as independent variables. We find that per capita income has positive effect and it is statistically significant. The coefficient of income-square is negative as expected and statistically significant. This shows that income increase has a negative effect on demand for firewood and the effect is linear. The coefficient for region is also positive effect but statistically insignificant. It indicates no significant difference in consumption of Gas through pipeline in the urban and rural areas. The family size coefficient is negative as expected. This shows presence of economies of scale in consumption of Gas. As family size increases the per capita consumption goes down. Education coefficient has also positive impact but statistically insignificant. F value shows that overall model is good.

The Gas (Cylinder) consumption function is estimated for five income groups, including income per capita, income-squared, family size, education and region as independent variables. Per-capita income has negative impact on 1st income group demand function and statistically insignificant, while positive for all other income group demand functions. This coefficient is statistically significant for middle income groups. Family size has negative impact for all income groups on consumption of gas (pipeline) but it is statistically insignificant for higher income groups. Coefficient of region has positive impact on first, 3rd and fifth income group but statistically insignificant. Education has also positive impact but statistically insignificant. F value showing that 4th income group demand function is not good fit.

Table 8 :Results: Gas (pipeline) Consumption Per-Capita

List of Variables	Aggregate	1st i-group	2nd i-group	3rd I-group	4th i-group	5th i-group
(Constant)	146.636 (12.357)	132.768 (7.011)	56.056 (2.767)	61.475 (1.239)	7.583 (.064)	32.265 (.566)
Per Capita income	.007 (6.297)	-.006 (-.006)	.014 (4.332)	.010 (2.141)	.016 (2.239)	.4.571E-4 (.201)
Per capita income Square	-7.126E-8 (-2.797)	5.360E-6 (8.793)	-1.522E-7 (-1.081)	-3.992E-8 (-.374)	-2.216E-7 (-2.093)	1.464E-8 (.726)
Region	.372 (0.74)	1.278 (.191)	-1.819 (-.362)	-13.140 (-.978)	2.495 (.096)	15.683 (1.456)
Family Size	-10.497 (-12.837)	-7.805 (-6.417)	-4.092 (-2.990)	-2.923 (-.947)	-1.165 (-.167)	-4.525 (-1.217)
Education	.481 (.157)	.412 (.101)	3.795 (1.268)	.586 (.071)	-18.634 (-1.215)	11.562 (1.825)
#of observation	6570	4613	1405	387	117	44
Adjusted R	.050	.090	.183	.160	.146	.549
F value	68.826	90.747	62.894	14.564	3.834	9.495

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4.1.7) Generator Expense Function Per-capita

The aggregate Generator consumption function is estimated, including income per capita, income-squared, family size, education and region as independent variables. We find that per capita income has negative effect and it is statistically insignificant. The coefficient of income-square is negative as expected and also statistically insignificant. The coefficient for region is also negative but statistically insignificant. It indicates no significant difference in consumption of fuel for generator in the urban and rural areas. The family size coefficient is negative as expected. This shows presence of economies of scale in consumption of fuel for generator. As family size increases the per capita consumption goes down. Education coefficient also has negative and insignificant impact. F value showing that overall model is good fit for per-capita consumption of generator.

Table 9:Results: Generator Expense Function Per-capita

List of Variables	**Aggregate**
Constant	2.926 (4.441)
Per Capita income	-1.488E-5 (-.111)
Per capita income square	-1.647E-9 (-.165)
Family size	-.148 (-3.900)
Region	-.379 (-.943)
Education	-.203 (-1.756)
# of observation	310
R^2	.071
F value	4.674

4.2: Income Elasticity[12]'s of Different Fuel Items

Table 10 shows that if there is 1 percent increase in income, then there will be 0.13 percent increase in firewood consumption. If there is 10 percent increase in income, then fire wood consumption will go up by 1.32 percent. Similarly, if there is 1percent increase in per capita income for first income group, firewood consumption will increase by 0.161 percent. For 2nd income group one-unit increase will lead to 0.932 percent increase, similarly 1.108, 1.174 and 0.454-unit increase for 3rd, 4th and 5th income group.

Second row of table shows that if there is 1 percent increase in income then there will be 0.011 percent increase in kerosene oil consumption. If there is 10 percent increase in income, then kerosene oil consumption will go up by 0.11 percent. Similarly, if there is 1 percent increase in

[12] *ε^d=(∂Y/∂X)*(mean value of X/ Mean value of Y)*

per_capita income of 1st income group HH then kerosene oil consumption will increase by 0.107 unit. If there is 1 percent increase in per capita income of 2nd and 3rd income group there will be 0.504 and 0.875 percent. If there is 1 percent increase in per _capita income of 4th income group, kerosene oil consumption oil will decrease by 0.054 units. If there is 1percent increase in per _capita income of 5th income group, kerosene oil consumption oil will increase by 0.952 units.

Third row of table shows that if there is 1 percentincrease in income then there will be 0.069 percent increase in Gas consumption. If there is 10 percent increase in per-capita income, then Gas consumption will go up by 0.69 percent. Similarly, if there is 1 percent increase in per-capita income of 1st income group household then Gas consumption will increase by 0.11 percent. If there is 1 percent increase in per capita income of 2nd income group, then Gas consumption will increase by 0.726 percent. While this 1 percent change for 3rd, 4th and 5th income is higher as compare to lower income groups. Findings show that if there is 1 percent increase in per-capita income of 3rd income group, Gas consumption will increase by 1.52 percent. 4th income group has highest 1 percent change in consumption. If there is 1 percent increase in per _capita income of 5th income group, Gas consumption will increase by 3.67 percent.

Third row of table shows that if there is 1 percent increase in per-capita income then there will be 0.157 percent increase in Gas consumption. If there is 10 percent increase in per-capita income, then Gas consumption will go up by 1.57 percent. Similarly, if there is 1 percent increase in per-capita income of first income group HH, then Gas consumption will increase by 0.12 percent. If there is 1 percent increase in per capita income of 2nd income group, then Gas consumption will increase by 0.59 percent. If there is 1percent increase in per capita income of 3rd income group then Gas consumption will increase by 0.770percent, while this per unit change for 4th income is higher as compare to lower income groups. Findings show that if there is 1 percent increase in per-capita income of 4th income group, Gas consumption will increase by 1.173percent. If there is 1percent increase in per -capita income of 5th income group, Gas consumption will increase by 0.25percent.

Table shows that if there is 1 percent increase in per capita income, then there will be 0.199 percent increase in Electricity consumption. If there is 10 percent increase in per-capita income, then Electricity consumption will increase by 1.99 percent. Similarly, if there is 1percent increase in per capita income for first income group, electricity consumption will increase by 0.233percent. For 2nd income group one-unit increase will lead to 0.532 percent increase, similarly 0.901, 0.069 and 0.810percentincrease for 3rd,4th and 5th income group.

Results from table shows that as per capita income of HH increases, consumption of generator decreases. If there is 1 percent increase in per-capita income, then Generator consumption will decrease by 0.049 percent.

Last row of table shows that if there is 1 percent increase in income, then there will be 1.171 percent increases in coal consumption. If there is 10 percent increase in income, then coal consumption will go up by 11.71 percent. Similarly, if there is 1 percent increase in per capita income for first income group, firewood consumption will increase by 1.809 percent. For 2nd income group 1percent increase will lead to 0.806 percent increase in coal consumption. There is no consumption of coal for higher income group.

As table showing that income elasticity of demand for different fuel items is rising for one to fourth income groups, but it suddenly declines for highest income group. By raising the income of the poor moves their demand for energy along the extensive margin as they buy energy-using assets for the first time. As incomes rise families formerly living in poverty will for the first time purchase household electrical appliances. Study (Gertler et al., 2011) argue that if the reduction in poverty is rapid, there could be a surge in the demand for energy. As households come out of poverty their demand moves mostly along the extensive margin leading to a large discrete jump in demand for energy.

Table 10: Income Elasticity's of Different Fuel Items

List of variables	Aggregate	1st i-Group	2nd i-Group	3rd i-group	4th i-group	5th i-group
Fire Wood	0.132	0.161	0.932	1.108	1.174	0.454
Kerosene Oil	0.011	0.107	0.504	0.875	-0.0540	0.952
Gas (Cylinder)	0.069	0.112	0.726	1.519	6.233	3.671
Gas (Pipeline)	0.157	0.119	0.592	0.770	1.173	0.248
Electricity	0.199	0.233	0.532	0.901	0.069	0.810
Generator	-0.0487	_	_	_	_	_
Coal	1.171	1.809	0.806	--	--	--

Chapter 5: Result and Discussion of Energy Poverty

5.1: Computing Energy Poverty

Table 11 showing that from 2005 to 2014 monthly expenditure of households for different fuel items has been increased tremendously. As table shows that total expenditure on fuel and electricity items was 825 rupees, while it three times greater in 2014. To meet their survival needs in the absence of efficient energy, use technologies and adequate energy resources, majority of poor depend on biomass energy, animal power and their own labor. To improve the basic human needs and living standard of the people and to alleviate energy poverty, availability of modern energy resources must be improved

Table 11: Average Expenditure on Energy by Components (Rs)

Average Monthly Expenditure	2005-2006	2010-2011	2013-2014
Total	825	1470.31	2007.94
Fire Wood	166.24	287.56	362.46
Kerosene	14.20	15.31	9.15
Charcoal	0.06	0.09	0.36
Coal	0.68	0.54	2.83
Dung Cakes	35.46	74.90	105.72
Gas	119.47	174.75	279.59
Electricity	413.19	780.33	1036.97
Match Box	14.44	24.29	28.15
Other Agriculture Waste	48.27	95.84	141.87
Electrical Items	12.97	16.70	40.84

*PSLM (2005-2006); (2010-2011, 2013-2014)

Table 12 is showing the monthly percentage expenditure by five income group households on fuel items. If we apply here 5 percent threshold for expenditure first, second, third and fourth income groups are energy poor. Similarly, if we apply 10 percent threshold level then according to this rule all income groups are energy poor. Due to this reason of misleading result study has not used monetary expenditure to compute energy poverty level.

Table 12: Percentage expenditure on Fuel items

Income Groups	percent of expenditure
Ist	8.39
2nd	7.81
3rd	8.09
4th	9.19
5th	5.74

Different indicators, cut offs points and the dimensions of energy poverty are reported in table 13, below. This study has used three main dimensions and their applicable indicators for the estimation of MEPI (Multidimensional Energy Poverty Index) based upon the accessibility of nationwide data taken from PSLM 2013-14. Findings reveal that 69.67percent household was suffering due to lack of access to clean energy for cooking purpose. Similarly, 47.11percent households had no access to clean energy for heating and 9percent lack access for lightening, which indicates the use of alternative and more polluting energy sources to full fill their daily needs.

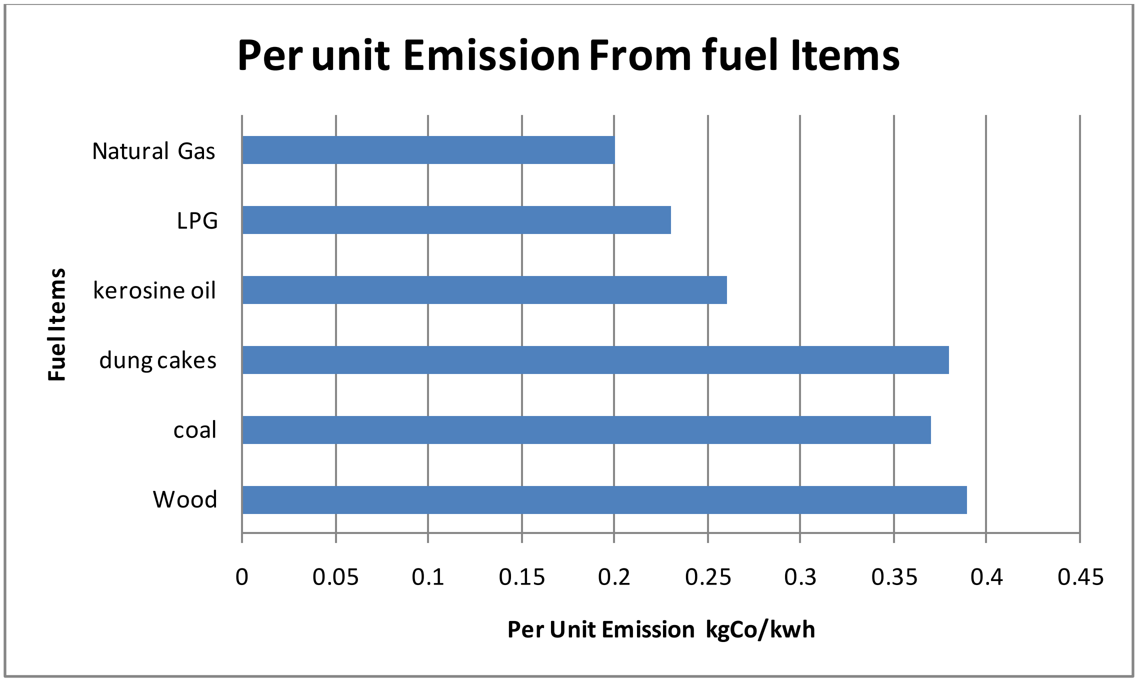
Table 13: Selected Indicators and their cutoffs

Dimensions	Indicator	Variable	Deprivation Cut Off	percent of HH
Cooking	Modern Cooking Fuel	Type of Coking Fuel	A household is considered poor/deprived if uses any fuel beside electricity, LPG, Natural Gas or biogas for cooking purpose.	*69.67 %*
Lightening	Electricity Access	Has access to electricity	A household is considered poor/deprived, if household has no electricity connection or access to electricity facilities	*9 %*
Heating	Modern Heating Fuel	Has electricity and Gas access	A household is considered poor/deprived if uses any fuel except electricity, LPG, natural Gas for heating purpose.	*47.11 %*

Wood is the largest contributor to carbon emission 0.39 kgCo/kwh. As per estimation show there is 46percent households dependent on firewood for cooking and heating purpose, so there is need to provide clean energy and less carbon emitting fuel like natural Gas and liquefied petroleum gas, which has lowest carbon emission to a higher fraction of households.

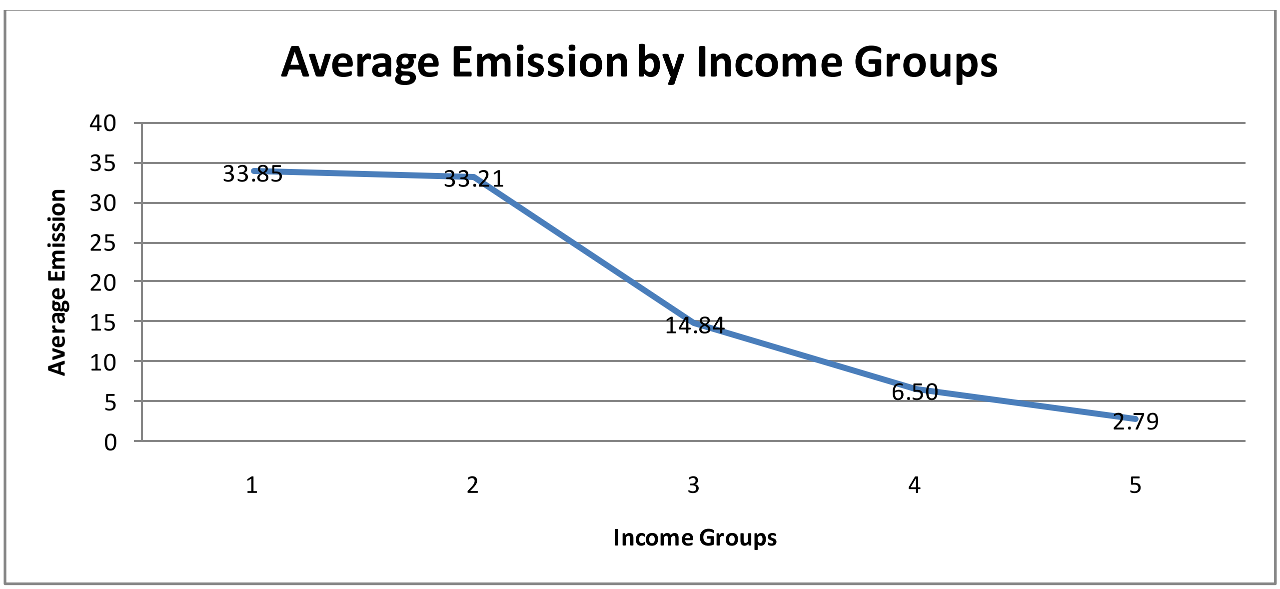
Dung cake another major contributor to CO_2 which emits 0.38 kgCo/kwh is used by 22.2 percent households for cooking. CO_2 emission can be reduced by providing clean energy to these households relying on dung cakes. 7.14percent households depending upon kerosene oil for lightening, if electricity is provided to this portion of energy poor people, carbon emission can be significantly reduced.

Figure 3: Emission from Different Fuel Items



*EIA (2015)

Figure 4: Average Emission of CO2 by different income groups



*Own Estimation

Figure 4 shows that average emission of Co decreasing when income is increases. Emission is negatively related to income.

5.2: Consumption and emission by income groups

5.2.1) Per Household Firewood Consumption and Emission

Table 14 shows that there is maximum number of households consuming firewood in low income group followed by second income group. Moving from low income group to high income groups, reduction in consumption of firewood has observed, where quantity consumption has reduced from 91.94 kg to 69.52 kg and emission also reduced. by providing 5th group energy mix to lower income group, there is reduction in emission from 0.011 kgCo/kwh to 0.008 kgCo/kwh. This indicates negative relationship between energy poverty and better environment, resulting reduction in environmental stress in form of emissions. Increasing income of household has made it possible to avail better energy sources and consequently retain the environmental stress.

Table 14: Per Household Firewood Consumption and Emission

Firewood (kg)	**Income groups**				
	1	**2**	**3**	**4**	**5**
No of Household	2155	758	209	68	31
Quantity Consumed (average)	91.9439	89.9670	84.66	88.95	69.52
Emission (Average)	.011105	0.0108	0.0102	0.0107	0.0084

5.2.2) Per Household Coal Consumption and Emission

Table 15 shows that number of household using coal energy source for cooking purpose decreases, while moving toward high income group. Higher income groups relay on better technology and environmental friendly energy sources, like gas and electricity. The reduction of coal consumption ultimately reduces the emission as well. As we can see when income of people increases, coal consumption reduces, there is no consumption of coal in the 5th income group. If clean energy is provided to household for cooking purpose and shifted toward high income group energy mix, there is major reduction in emission 0.005 kgCo/kwh to 0.033kgCo/kwh

Table 15: Per Household Coal Consumption and Emission

Coal (kg)	Income groups				
	1	**2**	**3**	**4**	**5**
No of Household	32	12	2	-	-
Quantity Consumed	113.99	124	75	-	-
Emission	0.00501	0.0054	0.0033	-	-

5.2.3) Per Household Kerosene Oil Consumption and Emission

Table 16 shows that as the income level increases the kerosene quantity consumption by households reduce from 1.65 liter to 1.45 liter and emission are also retained. This indicates the negative relationship between income and kerosene consumption. Income growth facilitate household to use electricity and other environmental friendly energy sources. If we provide highest income group energy mix to lower income group household, the remarkable reduction in emission from 0.043 kgCo/kwh to 0.031 kgCo/kwh. Moving to better environmental friendly energy sources are signifying the policy attention to alleviate energy poverty for better environment in future.

Table 16: Per Household Kerosene Oil Consumption and Emission

Kerosene oil (liter)	Income groups				
	1	**2**	**3**	**4**	**5**
No of Household	831	324	81	26	11
Quantity Consumed	1.65	1.69	1.90	1.25	1.45
Emission	0.0437	0.0446	0.0503	0.033	0.031

5.2.4)Per Household Electricity Consumption and Emission

Table 17 shows that electricity has less quantity consumption in lower income groups, because this income group has no access to electricity for heating and lightening purpose. Electricity consumption is higher in highest income group 199.772 kwh. More emission in lower income group because they rely on energy sources other than electricity (clean fuel), which cause more emission. Emission has been decreased from lower to higher income groups 127.683 kgCO/kwh to 119.77 KgCo/kwh.

Table 17: Per Household Electricity Consumption and Emission

Electricity (kwh)	Income groups				
	1	**2**	**3**	**4**	**5**
No of Household	12019	2563	709	192	90
Quantity Consumed	159.60	175.50	171.173	193.353	199.722
Emission	127.6832	140.404	136.939	127.682	119.777

5.2.5) Per Household Gas (Cylinder) Consumption and Emission

Table 18 shows that average consumption of Gas (Cylinder) has been increased from first income group to highest income group. Similarly, Emission level has been decreased from 0.482 kgCO/kwh to 0.382 kgCO/kwh. This indicates that when household has more income they depend on gas instead of other fuel to meet their daily need and this dependence on clean fuel cause to decrease emission also.

Table 18: Per Household Gas (Cylinder) Consumption and Emission

Gas Cylinder (kg)	Income groups				
	1	**2**	**3**	**4**	**5**
No of Household	1083	396	97	26	13
Quantity Consumed (Average)	6.312	5.324	6.821	4.531	6.913
Emission (Average)	.482	.4064	.5207	.3459	.3817

5.2.6) Per Household Gas (Pipeline) Consumption and Emission

Table 19 shows that average consumption of Gas (pipeline) has been increased from first income group to highest income group. Similarly, Emission level has been decreased from 112.446 kgCO/kwh to 74.754 kgCO/kwh. This indicates that when household has more income they depend on gas instead of other fuel to meet their daily need and this dependence on clean fuel cause to decrease emission also

Table 19: Per Household Gas (Pipeline) Consumption and Emission

Gas Pipeline (cube feet)	Income groups				
	1	**2**	**3**	**4**	**5**
No of Household	4614	1406	388	118	45
Quantity Consumed (Average)	507.133	479.645	495.372	588.567	597.143
Emission (Average)	112.446	106.351	109.839	130.503	74.754

5.2.7) Per Household Generator Fuel Consumption and Emission

Table 20 shows that average consumption of petrol for generator has been decreased from lower to highest income group. Highest income group household has more reliance on clean fuel like electricity and gas, due to which they use less quantity for generator. Consequently, dependence on clean fuel also causes to decrease emission 0.161 KgCo/Kwh to 0.071 KgCo/kwh.

Table 20: Per Household Generator Fuel Consumption and Emission

Generator Fuel (liter)	**Income groups**				
	1	**2**	**3**	**4**	**5**
No of Household	215	78	10	6	2
Quantity Consumed (Average)	6.20	5.65	5.19	3.5	2.75
Emission (Average)	.161	.147	.135	0.0909	0.0714

5.3: Net Gain in Emission Reduction from Provision of Similar Energy Consumption across income Group

Changing the consumption pattern of population to move away from burning fossil fuel will affect the global warming reduction too (Pramanik, Rangaswamy, & Gates, 2015). The climate change put a question about consumption and production, because closely connected to consumption pattern of fossil fuel.

Table 21 showing that as we move from lower income group to higher income group emission of CO2 are reduced from 33.85percent to 2.79percent.Lowest income group has highest contribution to emission. Does this mean that efforts to improve/raise income of household will improve environment?

Table 21: Average emission by income groups

Income Groups	**Monthly Income (Rs)**	**Average Emission (percent)**
1	≤ 15000	33.85
2	15001-30000	33.21
3	30001-50000	14.85
4	50001-70000	6.50
5	70001 above	2.79

To improve the environment, if 1st income group households shifted to 5th income group household's energy consumption pattern, there will be 2039.52 metric ton emission reduction. When clean energy electricity and gas is provided to lowest income group households, there will be increase in co emission, which result 1283.651metric ton emission. Hence there is net gain of 755.869 metric ton emission of Co. This net gain is achieved only in case of lowest income group.

Table 22: Monthly Total Emission by Income groups

Income Groups	Monthly Income (Rs)	Mean Total Expenditure (Rs)	Total Emissions (Metric Ton)
1	≤ 15000	1373.86	2053.67
2	15001-30000	1553.06	522.10
3	30001-50000	1573.38	139.73
4	50001-70000	1669.92	45.10
5	70001 above	1664.62	14.15

Table 23 showing that per household emission is highest for first income groups, while lowest for higher income group. Emission decreasing 240.46 Kg CO/kwh to 195.76 Kg CO/kwh from lower to higher income groups. Because higher income groups rely on clean fuel e.g. electricity, Natural Gas and Gas (Lpg), while lower income groups have dependence on firewood, coal, kerosene oil which are dirty fuel. Net gain estimation shows that if we provide highest energy mix to lowest income group, there is loss of 44.69 Kg CO/kwh emission per household. Similarly, if fifth income group household energy mix is provided to second, third and fourth income groups there is 56.03 KgCO/ kwh, 54.18 KgCo/kwh and 91.41 KgCO/kwh emission loss per household.

Table 23: Monthly Per Household Emission

Income Groups	Monthly Income (Rs)	Per Household Emission (kgCO/kwh)	Net Gain
1	≤ 15000	240.46	-44.69
2	15001-30000	251.79	-56.03
3	30001-50000	249.95	-54.18
4	50001-70000	287.17	-91.41
5	70001 above	195.76[13]	0

[13] *5th Income Group is base group for net Gain.*

Chapter 6: Conclusions and Policy Implications

6.1 Conclusions

In this study energy poverty and its impact on environment has been examined. Study defined energy poverty from perspective of not only availability issue but also discussed its environmental effects by using CO_2 emissions. Relationship between Energy poverty and its impact on environment has been explained using the PSLM data 2013-14. Study has illustrated through narration of energy poverty (EP) and benefits of this energy poverty (EP) alleviation on environment. Based on results, study reveals that there is 69.67 percent MEPI for cooking, while 47.11 percent HH are energy poor in heating. Almost one third households of Pakistan are deprived in dimension of cooking (69percent) and half of households are underprivileged in heating. Demand function for firewood, coal, kerosene oil, electricity, Gas and generator shows that there is significant impact of per-capita income on demand for these variables. findings of the study aredemonstrating, that as we move from low income to high income group per capita consumption for firewood, coal and kerosene reduces, while per capita consumption for Gas (Cylinder), Gas (Pipeline) and electricity increases with increase in per capita income of Household. Study also found that CO2 emission can be significantly reduced by providing higher income group energy mix to lower income group. Per household emission will decline 44.69 kgCo/kwh if highest income group energy mix is provided to low income group households. As the higher income energy mix is more environmental friendly in comparison to lower income group's energy mix in Pakistan. This investigation concluded that, energy poverty is affecting environment adversely in Pakistan. Reducing the energy poverty will help Pakistan to withstand environmental sustainability in future.

6.2: Policy Implications

Study suggest following policy implications.

In order to reduce pollution, policy makers should increase supply of clean energy and should be accessible to population at each level.

Promotion of subsidized modern cooking stoves can also help a lot in emission reduction factor.

Study suggests that for provision of clean energy e.g. should focus upon decentralized renewable energy[14]"based system which is less expensive, less polluting and easily adopted by communities".

Study also suggests that policy makers should implement strategies which endorse different forms of power generation source e.g. solar plants, bio-gas plants, preferably with cleaner fuels.

6.3: Future Research

Study suggest following fields for further research

- Due to indoor and outdoor pollution there are incidences of disease occurring. Health cost can also be estimated by using energy poverty.

[14] Decentralized energy, as the name suggests, is produced close to where it will be used, rather than at a large plant elsewhere and sent through the national grid. This local generation reduces transmission losses and lowers carbon emissions. Security of supply is increased nationally as customers don't have to share a supply or rely on relatively few, large and remote power stations.

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Appendix

Table 25: Comparison of Nominal and Real Change in consumption pattern

Monthly expenditure	2010/11- 2005/06 (Nominal)	2010/11- 2005/06 (Real)	2013/14 - 2010/11 (Nominal)	2013/14 - 2010/11 (Real)
Fire Wood	121.32	-3.01	74.9	24.22
Kerosene	1.11	-3.79	-6.16	-2.47
Charcoal	0.03	-0.007	0.27	0.099
Coal	-0.14	-0.25	2.29	0.862
Dung Cakes	39.44	4.52	30.82	13.63
Gas	55.28	-14.36	104.84	36.68
Electricity	367.14	12.12	256.64	85.5
Match Box	9.58	-0.53	3.86	1.14
Other Agriculture Waste	47.57	3.85	46.03	15.87
Electrical Items	3.73	-2.43	24.14	-12.7

Figure 5: Comparison between real expenditure

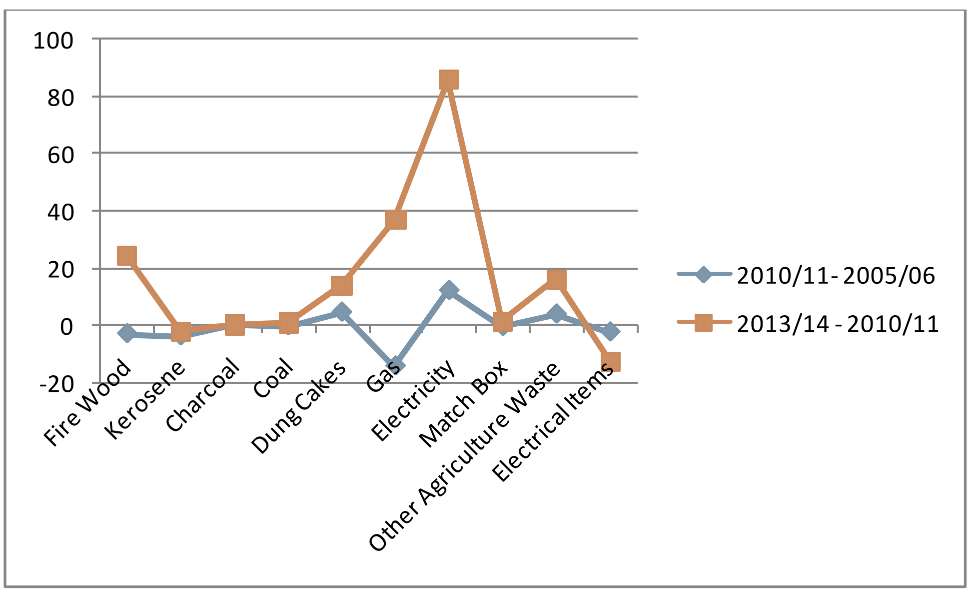

Figure 6 : Comparison between nominal expenditure

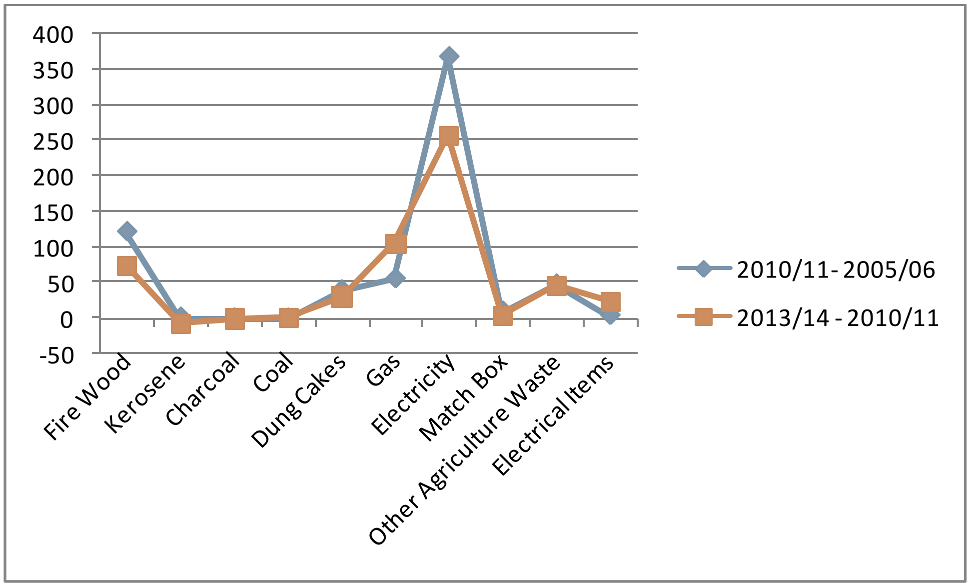

Table B: 1st Income Group Descriptive statistics

List of items	mini	maxi	mean
Firewood	1.00	1200.00	90.7271
Electricity	1.52	7587.25	159.6039
Coal	.50	500.00	113.9938
Gas(cylinder)	.50	72.00	6.3121
Kerosene oil	.13	20.00	1.6498
Generator Expense	2.50	3.00	2.7500
Education	0	20	8.69
Income	1	1500	7251.64
Family size	1.00	47.00	6.6544
Region	1	2	1.34

Table C: 2nd income Group Descriptive statistics

List of items	mini	maxi	Mean
Firewood	5.00	600.00	89.9670
Electricity	2.28	3793.63	175.5049
Coal	8.00	200.00	124.0000
Gas(cylinder)	1.00	50.00	5.3236
Kerosene oil	.12	15.00	1.6862
Generator Expense	.17	25.00	5.6574
Education	0	20	8.73
Income	15100	30000	21399.02
Family size	1	27	6.544
Region	1	2	1.37

Table D: 3rd income Group Descriptive statistics

List of items	mini	maxi	Mean
Firewood	4.00	320.00	84.6603
Electricity	2.28	1820.94	171.1727
Coal	50.00	100.00	75.0000
Gas(cylinder)	1.00	50.00	6.8211
Kerosene oil	.50	12.00	1.9025
Generator Expense	.16	30.00	5.1910
Education	0	20	8.58
Income	30400	50000	39163.82
Family size	1	30	6.2019
Region	1	2	1.38

Table E: 4th income GroupDescriptive statistics

List of items	mini	maxi	Mean
Firewood	20.00	300.00	88.9559
Electricity	4.55	1773.44	193.3525
Gas(cylinder)	.30	16.00	4.5308
Kerosene oil	.50	2.50	1.2538
Generator Expense	1.00	6.00	3.5000
Education	0	20	8.75
Income	50500	70000	59952.38
Family size	1	23	6.4343
Region	1	2	1.38

Table F: 5th income Group Descriptive statistics

List of items	mini	maxi	Mean
Firewood	20.00	160.00	69.5161
Electricity	4.10	1213.96	149.7218
Gas(cylinder)	1.00	12.00	5.0000
Kerosene oil	.50	3.00	1.6727
Generator Expense	2.50	3.00	2.7500
Education	1	18	8.22
Income	71000	99000	82325.08
Family size	1.00	19.00	6.6923
Region	1	2	1.43

Table 25: Number of Households access to fuel Items

Fuel items	# of Household
Firewood	8435
Kerosene oil	1285
Coal	110
Gas (Pipeline)	6371
Gas (Cylinder)	1630
Generator Expense	342
Electricity	16044
Dung Cake	3991
Agriculture waste	4557

Table 26: Conversion Units

Fuel Items	Converting unit to kwh
electricity	1
firewood	3229 kg
kerosene	9.821liter
Gas	13.099 kg
Natural Gas	0.902 Cubic Feet
Coal	7734 Kg
Generator (petrol fuel)	10.786 liter

Table 27: Per Unit Emission from different fuel items

Fuel Items	Per Unit Emission (KgCO/Kwh)
electricity	0.8
firewood	0.39
kerosene	0.28
Gas	0.23
Natural Gas	0.2
Coal	0.34
Generator (petrol fuel)	0.28