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An Investigation of Multidimensional Energy Poverty in Pakistan

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1. INTRODUCTION

Poverty is an alarming problem all over the world. It is one of the severe challenges today faced by not only the developing nations but by the developed nations also. However, the problem is worst in developing countries [United Nations and IEA (2010)]. All these countries face poverty in different forms such as food poverty, energy poverty, shortage of natural resources, shortage of agricultural products, lack of shelter and clothing among others. It is persuasive to correlate poverty with lack of energy consumption also. Such a correlation identifies that poor use energy very inadequately [Pachauri, *et al.* (2004)]. Energy helps societies to move from one development stage to another. Worldwide energy demand is increasing while supply is decreasing due to increase in the world population, emerging economies and economic development. In current day to day life energy has become an essential requirement. For all of us energy is required for lighting, transportation, cooking, health services, and to fulfill many of our basic needs. Electricity access at household level enhances telecommunication, entertainment, and knowledge via radio, television, and computer etc.

World Economic Forum (2010) defines energy poverty as "the lack of access to sustainable modern energy services and products". The energy poverty is defined as a situation where the absence of sufficient choice of accessing adequate, reliable, affordable, safe and environmentally suitable energy services is found. In simple words, energy poverty is the lack of access to suitable traditional (fire wood, chips, dung cakes etc.) and modern energy services and products (kerosene, liquefied petroleum, gas etc.). For development of any country, energy is the first step. A person is considered to be energy poor if he or she does not have access to at least (a) the equivalent of 35 Kg per capita per year LPG for cooking from liquid and/or gas fuels or from improved supply of solid fuel sources and improved (efficient and clean) cook stoves and (b) 120KWh electricity per capita per year for lighting, access to most basic services (drinking water,

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communication, improved health services, education improved services and others) plus some added value to local production.

To enhance livelihood opportunities for all, electricity plays a major role. To change the poor's life in a better way, clean and efficient energy resources are required. Firewood collection for cooking consumes a lot of women's time. Clean energy sources for cooking like electricity, and gas etc. mean improvement in living standards and time saving also. The income poor could also be energy poor, however not all of the energy poor are income poor. Energy scarcity and poverty go hand in hand and show a strong relationship. Welfare of masses is affected by the level of energy consumption. There is a negative correlation between access to modern energy services and energy poverty. So in order to alleviate energy poverty, improvement in the access to modern energy services is very essential. Availability of cheaper energy is essential. According to United Nations, lack of electricity and heavy reliance on traditional biomass are hallmarks of poverty in developing countries. Lack of electricity enhances poverty and contributes to its persistence, as it prevents most industrial activities and the job creation. [United Nations and IEA (2010)].

To meet their survival needs in absence of efficient energy using technologies and adequate energy resources, majority of poor depend on biomass energy, animal power and their own labour. To improve the level of satisfaction of basic human needs and living standards of the people and to eradicate poverty energy resources must be improved. For the better health care facilities and education clean energy is required. Achievement of efficient energy resources can lead to the attainment of evenhanded, economically strong and sustainable development. Present study aims to investigate the level of energy poverty in Pakistan and to find the extent of energy poverty in rural and urban areas of Pakistan along with the impact of different variables on energy poverty in Pakistan.

Rest of the study is organised as follows. Section 2 gives review of literature. Section 3 is about methodology and data. Results and discussions are are presented in Section 4. Section 5 concludes the study giving some policy recommendations based on findings.

2. REVIEW OF LITERATURE

Pasternak (2000) found that there is strong relationship between measures of human well-being and consumption of energy and electricity. A roughly constant ratio of primary energy consumption to electric energy consumption was observed for countries with high levels of electricity use and then this ratio was used to estimate global primary energy consumption in the Human Development Scenario. They established positive correlation between Human Development Index (HDI) and annual per capita electricity consumption for 60 populous countries comprising 90 percent of the world's population. Results further showed that HDI reached a maximum value when electricity consumption was about 4,000 KWH per person per year.

Bielecki (2002) by using a measurement of the existing state of oil security pointed out that the threats of supply disruption had not deminished. Outlook of the oil market for coming two decades advocate that there is still need to take more steps for the oil security. It was also found that with rising importance of universal demand and trade of gas, the gas security is also becoming gradually more significant. They claimed that different severe security alarms do exist and will probably strengthen in the future. This indicates that there is no area for gratification on energy security. The present oil crisis measures require extension to cover up energy sources for developing nations and for others.

Clancy, *et al.* (2003) found that Energy security has turned into a central community issue along with concerns with sky-scraping energy prices and the incidence of regional shortage of supply. 2.8 million Households in England are classified as being in fuel poverty in 2007 (13 percent of all households). It is found that the fuel poverty in the UK is not going to be of the same order or intensity as that of sub Saharan Africa. NGOs and practitioners also point at complex processes of energy exclusion and self-exclusion at the community, household and family level, leading to distinct micro cultures of energy use.

Pachauri, *et al.* (2004) measured Energy Poverty for Indian Households using a two-dimensional measure of energy poverty and energy distribution that combine the elements of access to different energy types and quantity of energy consumed. They found that there is significant reduction in the level of energy poverty due to rapid development in India.

Stephen, *et al.* (2004) studied present and future renewable energy potential in Kenya to meet the electrification needs of the poor. They limited the study to solar and hydro technologies owing to technical and socio-economic hurdles. They assessed that present Rural Electrification Fund (REF) in Kenya realises the solar and hydro electrification potential for poor. The results showed that if there is 10 percent increase in Rural Electrification Fund (REF), annual revenue from rural electricity connections increases by 42 percent in Kenya. There exists a relation between access and use of energy and poverty.

Pachauri, *et al.* (2004) presented different approaches for measurement of energy poverty by using Indian household level data. They found positive relation between well-being and use of clean and efficient energy resources. They also concluded that use of access and consumption of clean and efficient energy increases the well-being.

Catherine, *et al.* (2007) examined UK Government's devotions to eradicate fuel poverty among vulnerable families by year 2010 and in the common people by 2016. They explained the relations among this measure of fuel poverty and the governmental objective definition, using an exclusive data set and the Family Expenditure Survey. They recognised the link between two measures. They investigated the characteristics of households in each group, and how each measure is interrelated with different household issues.

Tennakoon (2009) analysed energy poverty status of Sri Lanka. Two approaches namely Quantitative approach and Pricing approach of measuring energy poverty were used. Results of Pricing approach showed that Sri Lanka is facing high level of energy poverty (83 percent energy poverty) while results of Quantitative approach revealed that energy poverty in terms of cooking is very high due to high inefficiencies of cooking stoves.

Barness, *et al.* (2010) explored the welfare impacts of household and energy use in rural Bangladesh using cross sectional data. The result showed that although modern and traditional sources improved energy consumption of rural Bangladesh households but the impacts of modern energy sources were high as compared to traditional energy services. 58 percent households in rural Bangladesh are facing energy poverty.

Shahidur, *et al.* (2010) studied energy poverty of urban and rural areas of India. The estimates showed that in rural area of India, 57 percent households are energy poor and only 22 percent households are income poor while in urban areas of India, energy poverty is 28 percent and income poverty is 20 percent. The persons in energy poverty were also facing income poverty.

Marcio, *et al.* (2010) analysed the impact of energy poverty on inequality for Brazilian Economy using Lorenz Curve, Poverty Gap, Gini coefficient and Sen Index. It is concluded that rural electrification leads to improvement in energy equity.

Jain (2010) explored the problems related to energy consumption faced by Indian rural and urban households. The results showed that energy poverty in rural areas of India is about 89 percent and 24 percent in urban areas of India. It was also concluded that 56 percent households in India has access to electricity facilities. Poor persons spend almost 12 percent of their total income only on the energy. Energy poverty disturbs all aspects of human welfare like agricultural productivity, access to water, education, health care and job creation etc. Energy poor persons have no access to clean water and electricity and they spend a large portion of their income and time to get energy fuel. This consumption pattern of the poor persons on energy leads to the income poverty.

Mirza and Szirmai (2010) discussed the consequences and characteristics of the use of different energy services using Energy Poverty Survey (EPS) data from 2008 to 2009. They outlined that the rural population of Pakistan uses variety of energy services like firewood, plant waste, kerosene oil and animal waste. Despite these sources of energy, the population of Pakistan has to face the energy crises or energy poverty. Estimates show that 96.6 percent of rural households have to face energy short fall. In Punjab province of Pakistan, 91.7 percent of rural households of the total rural population are facing severe energy poverty.

Nussbaumer, *et al.* (2011) reviewed appropriate literature and talked about sufficiency and applicability of existing methods for measurement of energy poverty for several African countries. They proposed a new composite index, Multidimensional Energy Poverty Index (MEPI). It captures the incidence and intensity of energy poverty and focuses on the deprivation of access to modern energy services. Based on MEPI for Africa, the countries are categorised according to the level of energy poverty, ranging from sensitive energy poverty (MEPI>0.9; e.g. Ethiopia) to modest energy poverty (MEPI<0.6; Angola, Egypt, Morocco, Namibia, Senegal). It was concluded that the MEPI will only form one tool in monitoring improvement and designing and executing good quality policy in the area of energy poverty.

3. DATA AND METHODOLOGY

The study uses Pakistan Social and Living Standards Measurement (PSLM) Survey (2007-08) as latest available data set. This data set includes sample of 15512 households consisting of 1113 sample community/enumeration blocks. A two-stage stratified sample design has been adopted for this survey. Villages and enumeration blocks in urban and rural areas, respectively have been taken as Primary Sampling Units (PSUs). Sample PSUs have been selected from strata/sub-strata with Probability Proportional to Size (PPS) method of sampling technique. Households within sample PSUs have been taken as Secondary Sampling Units (SSUs). A specified number of households i.e. 16 and 12 from each sample PSU of rural and urban area have been selected, respectively using systematic sampling technique with a random start.

3.1. Methodology

For the analysis and for the measurement of energy poverty in Pakistan, study uses Multidimensional Energy Poverty Index (MEPI), proposed by Nussbaumer, *et al*. (2011). The MEPI is created by Oxford Poverty and Human Development Initiative (OPHI) with association of United Nations Development Programme (UNDP**)**. The technique utilised is derived from the literature on multidimensional poverty measures, from the Oxford Poverty and Human Development Initiative (OPHI) [Alkire and Foster (2007); Alkire and Foster (2009); Alkire and Santos (2010)], which is improved by Amartya Sen's contribution to the debate of deprivations and potential. Fundamentally, MEPI takes into account the set of energy deprivation that may have an effect on an individual. It captures five dimensions of basic energy services with five indicators. An individual or a household is considered as energy poor if the combinations of the deprivations that are faced by an individual surpass a pre-defined threshold. The Multidimensional Energy Poverty Index is the result of a headcount ratio (share of people recognised as energy poor) and the average intensity of deprivation of the energy poor.

Multidimensional Energy Poverty Index (MEPI) merges two features of energy poverty. On one side 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 (A).

Let $M^{n,d}$ indicate the set of all $n \times d$ matrices, and $y \in M^{n,d}$ stand for an achievement matrix of n people in d different dimensions. For every i = 1, 2, ..., n and j=1, 2, ..., d, the typical entry y_{ij} of y is individual i's achievement in dimension j. The row vector $y_i = (y_{i1}, y_{i2}, \ldots, y_{id})$ lists individual i's achievements and the column vector $y_j = (y_{1j}, y_{2j}, \ldots, y_{nj})$ gives the distribution of achievements in dimension j across individuals. Let $z_j > 0$ represent the cutoff below which a person is considered to be deprived in dimension j and z represent the row vector of dimension specific cutoffs. Following Alkire and Foster's (2007)'s notations, any vector or matrix v,$|v|$ denotes the sum of all its elements, whereas $\mu(v)$ is the mean of v.

Alkire and Foster (2007) suggest that it is useful to express the data in terms of deprivations rather than achievements. For any matrix y, it is possible to define a matrix of deprivations $g^0 = \left[g_{ij}^0\right]$, whose typical element g_{ij}^0 is defined by g_{ij}^0 = 1 when $y_{ij} < z_j$, and $g_{ij}^0 = 0$ when $y_{ij} \geq z_j$. g^0 is an $n \times d$ *matrix* whose ij^{th} entry is equal to 1 when person i is deprived in jth dimension, and 0 when person is not. g_i^0 is the i^{th} row vector of g^0 which represent person i's deprivation vector. From g^o matrix, define a column vector of deprivation counts, whose i^{th} entry $c_i = \left|g_i^0\right|$ represents the number of deprivations suffered by person i. If the variables in y are only ordinal significant, g^o and c are still well defined. If the variables in y are cardinal then we have to define a matrix of normalised gaps g.[1] For any y, let $g^1 = \left[g_{ij}^1 \right]$ be the matrix of normalised gaps, where the typical element is defined by $g_{ij}^1 = (z_j - y_{ij}) / z_j$ when $y_{ij} < z_j$, and $g_{ij}^1 = 0$ otherwise. The entries of this matrix are non-negative numbers less than or equal to 1, with g_{ij}^1 being a measure of the extent to which person i is deprived in dimension j. This matrix can be generalised to $g^\alpha = \left[g_{ij}^\alpha \right]$, with $\alpha > 0$, whose typical element g_{ij}^α is normalised poverty gap raised to α power.

A sensible start is to recognise who is poor and who is not? The majority of identification techniques recommended in the literature in general pursue the union/ intersection approach. A person is considered poor according to union approach, if that person is deprived 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 recognise the multidimensionally poor suggested by Alkire and Foster deprivations are compared with a cutoff level k. where k= 1,2,…,d. Now we describe the recognition method ρ_k such that $\rho_k(y_i, z) = 1$ when $c_i \geq k$, and $\rho_k(y_i, z) = 0$ when $c_i < k$. This shows that an individual is known as multidimensionally poor if that individual has deprivation level at least in k dimensions. This is called dual cutoff method because ρ_k depends upon z_j within dimension and across dimensions cutoff k. This identification principle describes the set of the multidimensionally poor people as $Z_k = \{i : \rho_k(y_i; z) = 1\}$. A censored matrix $g^0(k)$ is obtained from g^0 by replacing the ith row with a vector of zeros whenever $\rho_k(y_i, z) = 0$. An analogous matrix g^α(k) is obtained for $\alpha > 0$, with the ijth element $g_{ij}^\propto(k) = g_{ij}^\propto$ if $c_i \geq k$ and $g_{ij}^\propto(k) = 0$ if $c_i < k$.

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 multidimensionally poor: the multidimensional Headcount Ratio $H = H(y; z)$ is defined by $H = q/n$, where $q = q(y,z)$ is the number of people in set Z_k. This is entirely analogous to the income headcount ratio. This method has the advantage of being easily comprehensible and estimable and this can be applied using ordinal data.

4. RESULTS AND DISCUSSION

Table 1 shows different Dimensions, Indicators and the Cut-offs. From a human development point of view, a poverty indicator must be significantly and eventually measurable at the individual, household, or community level. It must allow a classifying of these demographic units as more or less poor. Present study uses five main dimensions and their relevant indicators for the measurement of Multidimensional Energy Poverty Index (MEPI) based upon the availability of nationwide data. All the five dimensions are weighted equally. Figure 1 shows the results of Multidimensional Energy Poverty head count for overall Pakistan at dual cutoff equal to 2 i.e. K=2. The empirical results show that in Pakistan almost 54.6 percent and 45.4 percent of households are multidimensional energy poor and energy non poor, respectively.

Table 1

Selected Indicators and their Cutoffs

Dimension/Indicator	Indicator	Variable	Cutoff (Situation of Deprivation)
Cooking	Modern cooking fuel	Type of cooking fuel	A household considered poor/deprived if using any fuel beside electricity, liquefied Petroleum Gas (LPG), kerosene oil, natural gas, or biogas for cooking purposes.
Indoor Pollution	Indoor pollution	Food cooked on stove or open fire if using any fuel beside electricity, LPG, natural gas, or biogas	A household considered poor/deprived if not using modern cook stove or use three stone cook stove or if using any fuel for cooking beside electricity, liquefied Petroleum Gas (LPG), natural gas, or biogas.
Lighting	Electricity access	Has access to electricity	There is no proper data for lighting; therefore for the purpose we use electricity access. A household considered poor/deprived if the household has no electricity connection or access to electricity facilities.
Services provided by means of Household Appliances	Household appliance Ownership	Has a fridge/ Electric fan	This dimension deals with ownership of household appliances. A household considered poor/ deprived if the household has not a fridge or electric fan.
Entertainment/ Education	Entertainment/ education appliance ownership	Has a radio/ television	This dimension deals with ownership of Entertainment/education appliance. A household considered poor/deprived if the household has not Radio or Television or Computer.

Fig. 1. Results of Multidimensional Energy Poverty Headcount for Overall Pakistan at K=2

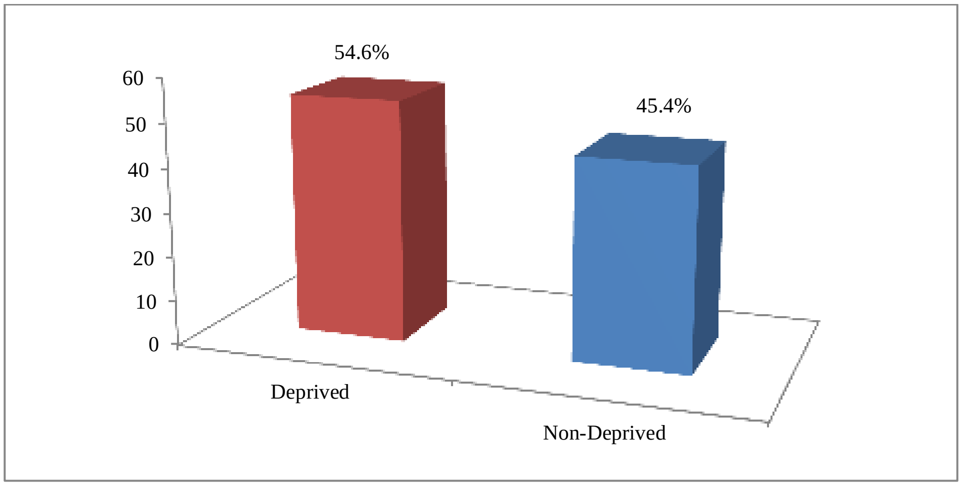


Figure 2 shows the results of Multidimensional Energy Poverty head count for urban Pakistan. It is clear from figure that only 29 percent of the households are multidimensional energy poor in urban areas of Pakistan, while remaining 71 percent of the households in urban areas are energy non-poor.

Fig. 2. Results of Multidimensional Energy Poverty Headcount for Urban Pakistan at K=2

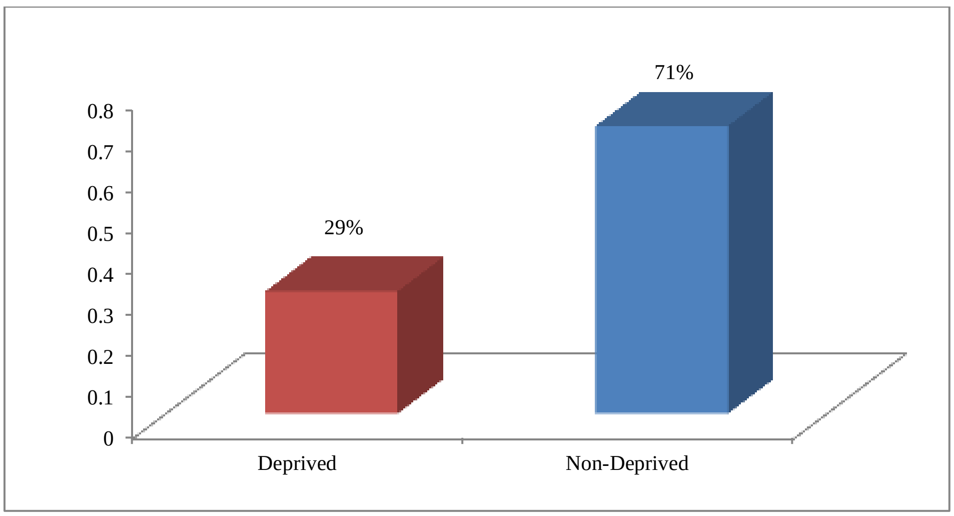
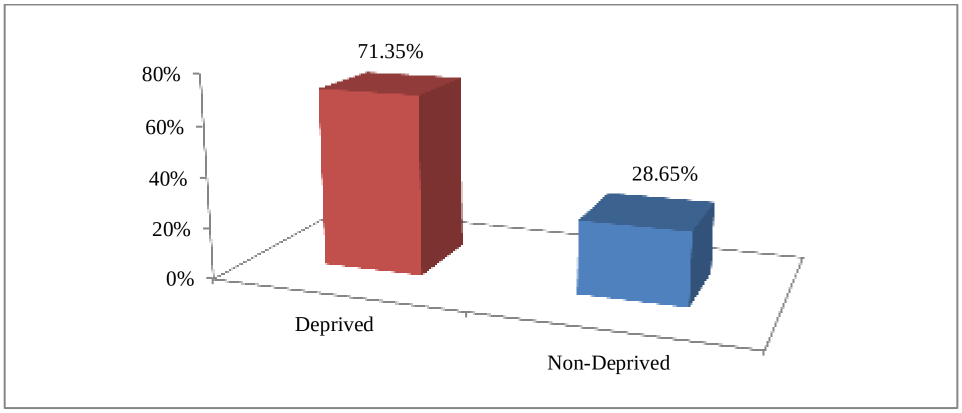


Figure 3 depicts the results of Multidimensional Energy Poverty headcount for rural areas of Pakistan. The incidence and severity of energy poverty is significant in rural areas of Pakistan. Results show that Multidimensional Energy Poverty headcount for rural Pakistan is 71.4 percent and 28.6 percent of the households residing in rural areas of Pakistan are energy non-poor.

Fig. 3. Results of Multidimensional Energy Poverty Headcount for Rural Pakistan at K=2



The analysis of breakdown of energy poverty by dimension for overall Pakistan is shown in Figure 4. Results show that households of Pakistan are most deprived in cooking fuel dimension (55 percent), while deprivation is the least in dimension of home appliances ownership (15 percent). Results further show that 52 percent, 33 percent and 19 percent of the households in Pakistan are deprived in terms of indoor pollution, entertainment appliances and electricity, respectively.

Fig.4. Dimension-wise Breakdown of Energy Poverty for Overall Pakistan

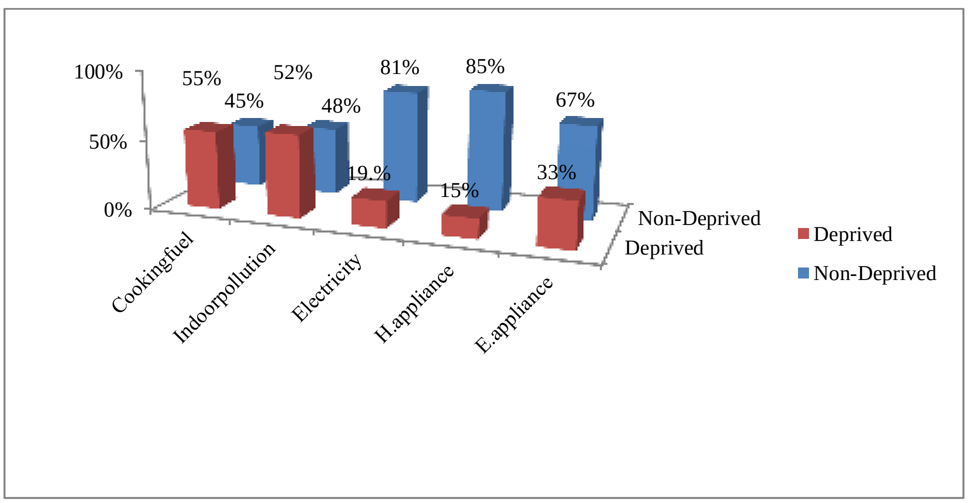


Figure 5 shows the breakdown of energy poverty by dimension for urban Pakistan. The empirical results show that in urban areas of Pakistan households are more deprived in dimension of cooking fuels (23 percent) followed by indoor pollution (19 percent). In urban areas of Pakistan only 3 percent households are deprived in dimension of home appliances ownership. In dimensions of entertainment appliances and electricity households are deprived by 18 percent and 7 percent, respectively.

Fig.5. Dimension-wise Breakdown of Energy Poverty for Urban Pakistan

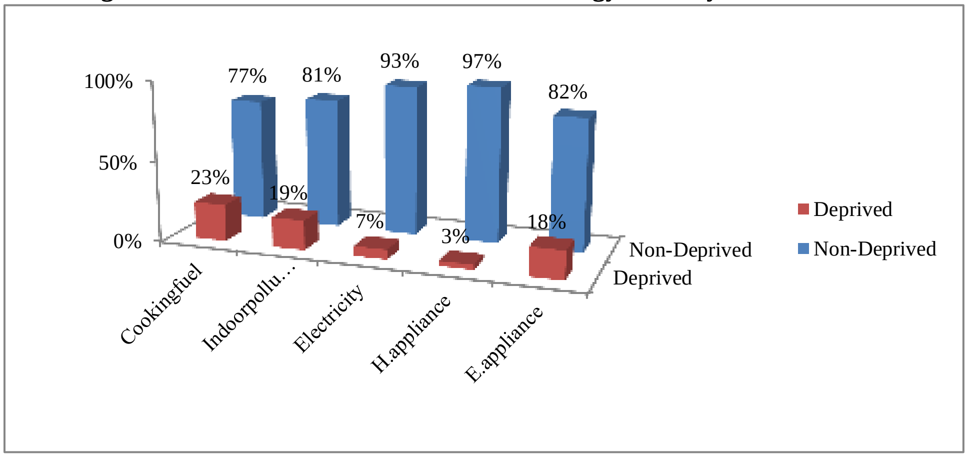


Figure 6 shows the breakdown of energy poverty by dimension for rural Pakistan. Almost one third households of rural Pakistan are deprived in dimension of indoor pollution (69 percent). As shown in Figure 6, 58 percent households are deprived in cooking fuels dimension in rural areas of Pakistan. Situation is also critical in entertainment appliances in the same region. Households' deprivation in terms of entertainment appliances, electricity and home appliances are 44 percent, 29 percent and 22 percent, respectively.

Fig.6. Dimension wise Breakdown of Energy Poverty for Rural Pakistan

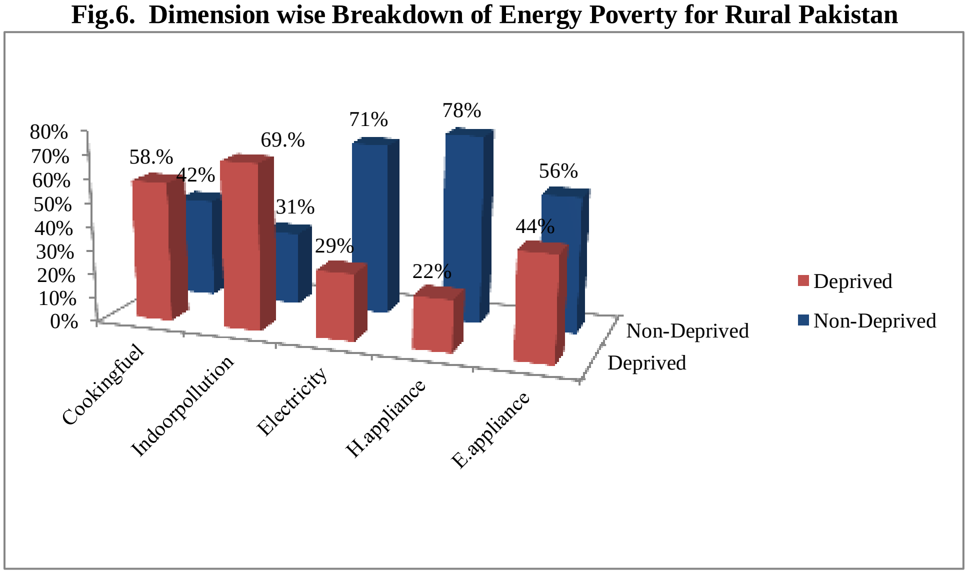


Figure 7 shows the contribution of urban and rural deprived households to Multidimensional Energy Poverty headcount for overall Pakistan. Contribution of rural and urban deprived households to multidimensional energy poverty in Pakistan is 71 percent and 29 percent, respectively.

Fig.7. Results of Contribution of Region-wise Deprived Households to Multidimensional Energy Poverty Headcount for Overall Pakistan

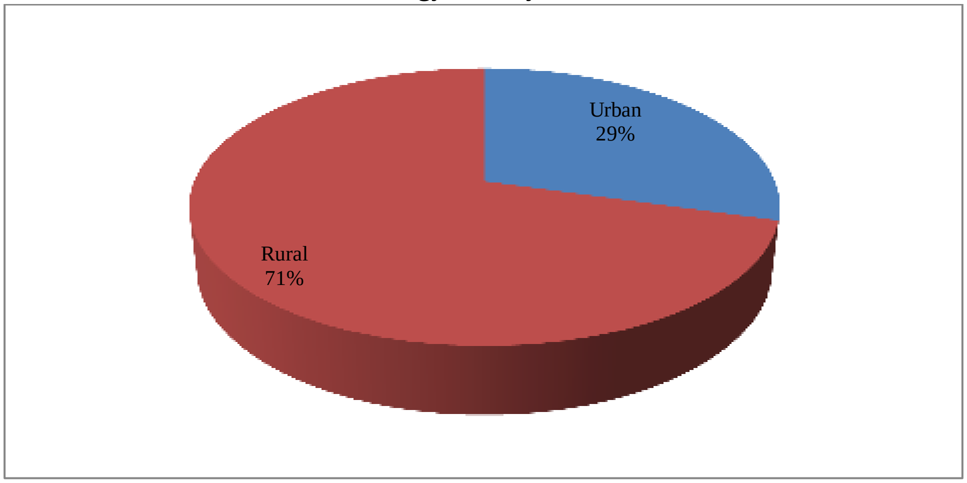


Figure 8 shows contribution of selected dimensions in multidimensional energy poverty headcount. In the paradigm of multidimensional energy poverty in Pakistan contribution of indoor pollution (32 percent) is the highest followed by the cooking fuels dimension (31 percent). Collectively these two dimensions contribute up to 63 percent in overall Multidimensional Energy Poverty headcount for Pakistan. While electricity, home appliances and entertainment appliances contribute to overall Multidimensional Energy Poverty headcount for Pakistan 11 percent, 8 percent and 18 percent, respectively.

Fig.8. Results of Dimension-wise Contribution to Multidimensional Energy Poverty Headcount for Pakistan

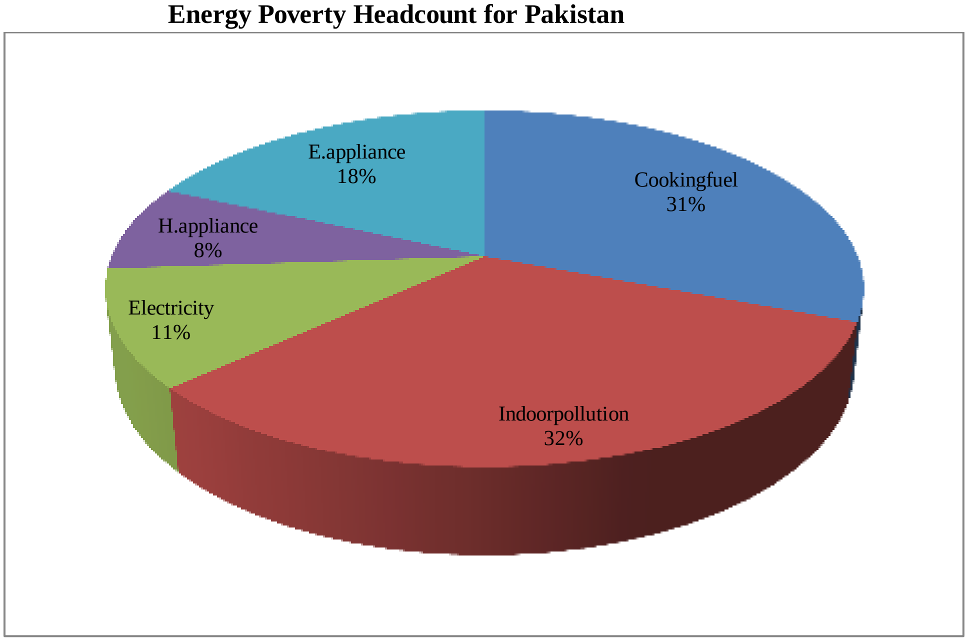
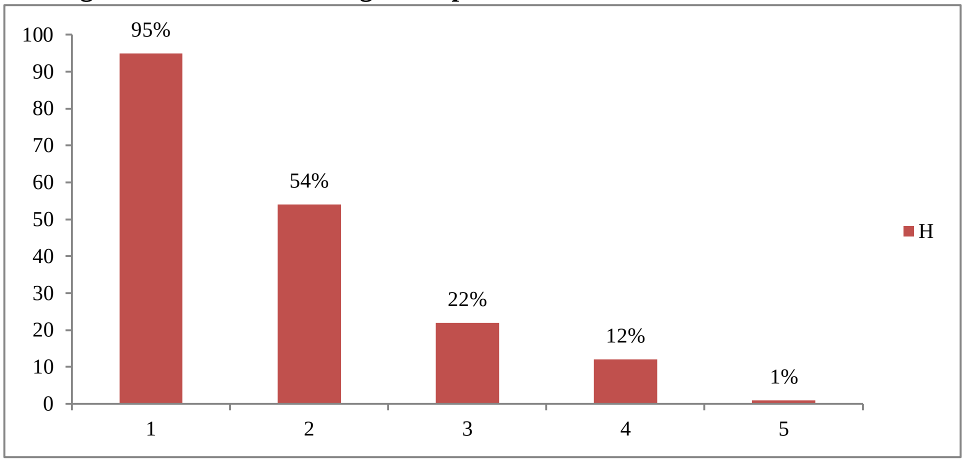


Figure 9 shows percentage of households deprived in exact number of deprivations in overall Pakistan. In overall Pakistan, 95 percent households are deprived when we set k=1. Households deprivation in energy decreases with the increase in value of cut offs.

Fig. 9. Results of Percentage of Deprived Households at Different Cut Offs



5. CONCLUDING REMARKS AND POLICY RECOMMENDATIONS

Based on results, the study concludes that there is significant and higher incidence and severity of energy poverty in rural areas as compared to urban areas, in overall Pakistan. Value of MEP Headcount for rural Pakistan is 71 percent as compared to 29 percent in urban areas of Pakistan. Results show that Multidimensional Energy Poverty headcount for rural Pakistan is 71.4 percent and 28.6 percent of the households residing in rural areas of Pakistan are energy non-poor. Households of Pakistan are most deprived in cooking fuel dimension (55 percent), while deprivation is the least in dimension of home appliances ownership (15 percent). In urban areas of Pakistan households are more deprived in dimension of cooking fuels (23 percent) followed by indoor pollution (19 percent). Almost one third households of rural Pakistan are deprived in dimension of indoor pollution (69 percent). Contribution of rural and urban deprived households to multidimensional energy poverty in Pakistan is 71 percent and 29 percent, respectively. Contribution of indoor pollution (32 percent) to multidimensional energy poverty headcount in Pakistan is the highest followed by the cooking fuels dimension (31 percent) and collectively these two dimensions contribute up to 63 percent in overall Multidimensional Energy Poverty head count for Pakistan. Study further concludes that households deprivation in energy decreases with the increase in value of cut-offs. Overall indoor pollution, cooking fuel and Entertainment appliances are the three major contributors, to overall MEP Headcount not only as a whole but region wise also.

Based on above findings, the study suggests taking special initiatives to combat Energy Poverty in most deprived areas particularly the rural areas on priority basis by allocating more funds to them. Indoor pollution and cooking fuel being the major contributors to overall multidimensional energy poverty in overall Pakistan and regions also, energy poverty in these dimensions should be individually addressed in order to reduce overall multidimensional energy poverty. Provision of subsidised solar panels, bio-gas plants and modern cooking stoves can help a lot in this regard.

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Comments

This paper is a pioneer research in the arena of energy poverty representing overall Pakistan with national representing data of PSLM 2007-08. The paper explores energy poverty in urban and rural areas with tabulation and graphical representation. A high deprivation in energy is seen in rural areas in all provinces.

My major concern with this paper is:

(1) The study uses 2007-08 data although new data set 2010-11 is also available which will give latest estimates of energy poverty.

(2) The study uses equal weights or simple averages with reference to Alkire and Foster, (2009). This can be appropriate when the dimensions have been chosen to be of relatively equal importance as seen in Alkire and Foster (2007) taking income, health, schooling and health insurance. But in your methodology it is mentioned that the study uses Multidimensional Energy Poverty Index (MEPI), proposed by Nussbaumer, *et al*. (2011). This study had used weights on the bases of degree of importance of variables from .13 to .2 for its different indictors. It would be appropriate if the study uses appropriate weights because access to electricity for lighting, access to gas/LPG for cooking had more importance versus ownership of fridge or TV for entertainment.

(3) In Table 1 for indicator 4 and 5 some clarification is needed. For indicator 4 fridge is used as variable but when you go for cutoff points you mentioned both fridge or electric fan. Same with indicator 5, radio/TV is used as variable but in cutoff point you also added computer.

(4) Finally, you had computed incidence of energy poverty by using 5 variables but not severity of energy poverty. These estimates are only for urban/ rural break down but not at provincial level but you had mentioned all in your conclusion.

Finally, I would say that the provision of modern energy services is recognised as a critical foundation for sustainable development, and is central to the everyday lives of people. Effective policies to dramatically expand modern energy access need to be grounded in a robust information-base.

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