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An Investigation of Multidimensional Energy Poverty in Pakistan: A Province Level Analysis

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ABSTRACT: Present study employs Alkire and Foster's (2007) methodology to measure Multidimensional Energy Poverty (MEP) at provincial level in Pakistan. MEP Headcount has been calculated using PSLM data. Indoor pollution is found to be the largest contributor to MEP Headcount in all four provinces of Pakistan while cooking fuel is the second largest contributor. Results of MEP Headcount show that 47%, 51%, 69% and 66% of the households residing in Punjab, Sindh, Khyber Pakhtoon Khaw (KPK) and Baluchistan provinces of Pakistan respectively are energy poor. Households of all the four provinces are most deprived in the dimension of indoor pollution i.e. in the range of 49% to 63% followed by cooking fuel i.e. in the range of 35% to 59%. Deprivation is least in the dimension of home appliances for all provinces except Baluchistan which is least deprived in entertainment appliances dimension.

Keywords: Multidimensional Energy Poverty; poverty measurement; decomposability; deprivation; Pakistan.
JEL Classifications: D12; I32; O13; Q47

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 the 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, the 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 the development of any country, the energy is the first step. A

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person is considered to be energy poor if he or she has not 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, 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, gas etc. mean improvement in living standards and time saving also. The income poor are likely to 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 along with 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 upholding, as it prevents most industrial activities and the jobs they create [United Nations and IEA (2010)].

To meet their survival needs in the absence of efficient energy using technologies and adequate energy resources, majority of poor depend on biomass energy, animal power and their own labor. To improve the level of satisfaction of basic human needs and living standard 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 and extent of energy poverty in all four provinces of Pakistan. It also investigates the impact of different dimensions of energy poverty at provincial level in Pakistan.

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 the Human Development Index (HDI) and annual per capita electricity consumption for 60 populous countries comprising 90% 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.

Clancy *et al.* (2003) found that Energy security has all over 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% 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-Sahel 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.

Stephen *et al.* (2004) studied the present and future renewable energy potential in Kenya to meet the needs of electrification 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 realizes the solar and hydro electrification potential for poor. The results showed that if there is 10% increase in Rural Electrification Fund (REF), annual revenue from rural electricity connections increases by 42% 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 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.

Elahee (2004) found that access to energy is the key to poverty alleviation. The relationship among access to energy and growth is entrenched. It is forecasted that energy access will turn into a severe problem in developing nations in the coming time, principally under the shocks of high population growth rate and increase in the fuel prices. Three different methods are proposed to alleviate poverty in different economies and communal set-ups.

Zaigham *et al.* (2005) studied that in spite of huge potential in energy resources, Pakistan greatly relies on imported energy resources to fulfill its energy requirements. Significant households of rural areas have not electrification facility due to high cost and/or too distant from national grids. Energy requirements of Pakistan are fulfilled by many conventional and commercial resources. During the last few years in energy supply, share of many primary sources remains as oil 43.5%, gas 41.5%, hydroelectricity 9.2% and nuclear electricity 1.1% while the electricity generation incorporated 71.9% thermal, 25.2% hydro and 2.9% nuclear. Pakistan has great conventional and non-conventional primary resources which are not explored due to which Pakistan has energy crisis today.

Modi *et al.* (2006) examined that the facts demonstrate that energy poverty is very severe at world level. One third population of world depends upon wood and other inefficient fuels like dung cack, crop residues etc. for cooking and one fourth of world population still has no access to electricity facilities. Among the energy poor of the world, most are living in sub-Sahel Africa and South Asia.

Tennakoon (2009) analyzed the 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% energy poverty) while results of Quantitative approach revealed that energy poverty in terms of cooking is very high due to high in-efficiencies of cooking stoves.

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

Marcio *et al.* (2010) analyzed 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 the improvement in energy equity.

Jain (2010) explored the problems related to energy consumption faced by the Indian rural and urban households. The results showed that energy poverty in rural areas of India is about 89% and 24% in urban areas of India. It was also concluded that 56% households in India have access to the electricity facilities. Poor persons spend almost 12% of their total income only on the energy. Energy poverty disturbs all aspects of human welfare like agriculture productivity, access to water, education, health care and job creation etc. Energy poor persons don't have access to clean water, 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.

Chaudhry (2010) estimated residential electricity demand responses in Pakistan's Punjab. It was found that electricity demand has positive relation with ownership of household appliances and income. Home appliance possession has improved significantly and almost all family units have electricity connections.

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 crisis or energy poverty. Estimates show that 96.6 % of rural households have to face energy short fall. In Punjab province of Pakistan, 91.7 % of rural households of the total rural population are facing severe energy poverty.

Nussbaumer *et al.* (2011) reviewed the 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 categorized 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

The study uses Pakistan Social & Living Standards Measurement (PSLM) Survey (2007-08) data. This data set includes a 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 & urban area have been selected, respectively using systematic sampling technique with a random start.

4. Methodology

For the analysis and measurement of energy poverty in Pakistan, the study uses Multidimensional Energy Poverty Index (MEPI), proposed by Nussbaumer *et al.* (2011). The MEPI is created by Oxford Poverty & Human Development Initiative (OPHI) with association of United Nations Development Program (UNDP). The technique utilized is derived from the literature on multidimensional poverty measures extraordinarily from Oxford Poverty and Human Development Initiative (OPHI) (Alkire and Foster 2007, Alkire and Foster 2009, Alkire and Santos 2010, Alkire and Foster 2010), which is aggravated by Amartya Sen's contribution to the debate of deprivations and potential. Fundamentally, the MEPI takes into account the set of energy deprivation that may have an effect on an individual. It is tranquil of five dimensions in lieu of basic energy services with five indicators. An individual or a household is recognized 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 recognized 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 $M^{n,d}$ indicates the set of all $n \times d$ matrices, and $y \in M^{n,d}$ stands 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 $y_i = (y_{i1}, y_{i2}, ..., y_{id})$ lists individual i's achievements and the column vector $y_j = (y_{1j}, y_{2j}, ..., y_{nj})$ 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_{ij}^0 is the i^{th} row vector of g^0 which represents person i's deprivation vector. From g^0 matrix, a column vector of deprivation counts is defined 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^0 and c are still well defined. If the variables in y are cardinal, then a matrix of normalized gaps $g^1$is to be defined. For any y, let $g^1 = \left[g_{ij}^1\right]$ be the matrix of normalized 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 generalized to $g^\alpha = \left[g_{ij}^\alpha\right]$, with α > 0, whose typical element g_{ij}^α is normalized poverty gap raised to the α-power.

A sensible starting is to recognize who is poor and who is not? 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 recognize the multidimensionally poor suggested by Alkire and Foster deprivations are compared with a cutoff level *k*. where *k*= 1,2,…,*d*. Now the recognition method is described as 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 i^{th} row with a vector of zeros whenever $\rho_k(y_i, z) = 0$. An analogous matrix $g^\alpha(k)$ is obtained for α > 0, with the ij^{th} element $g_{ij}^\propto(k) = g_{ij}^\propto$ if $c_i \geq k$ & $g_{ij}^\propto(k) = 0$ 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 & this can be applied using ordinal data.

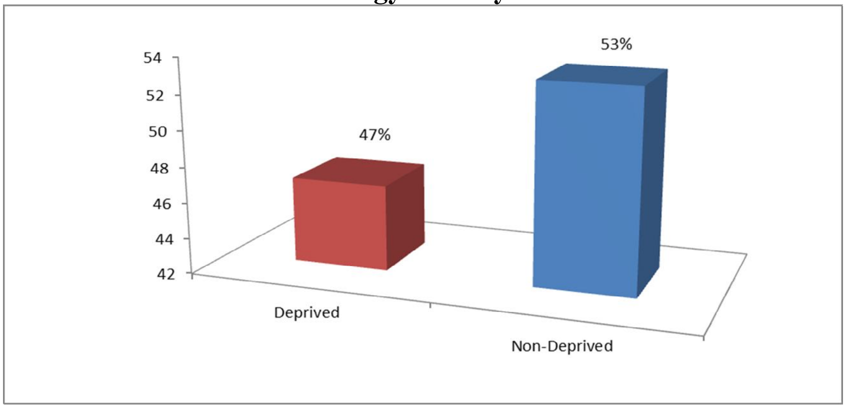
Table. 1 Selected Indicators and their Cutoffs.

Dimension/ Indicator	Indicator	Variable	Cutoff (Situation of Deprivation)
Cooking	Modern cooking fuel	Type of cooking fuel	A household consider poor/deprived if use 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 consider 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 consider 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	This dimension deals with ownership of household appliances. A household consider poor/ deprived if the household has not a fridge or electric fan.
Entertainment / Education	Entertainment / education appliance ownership	Has a radio OR television	This dimension deals with ownership of Entertainment/education appliance. A household consider poor/deprived if the household has not Radio or Television or Computer.

5. Results and Discussion

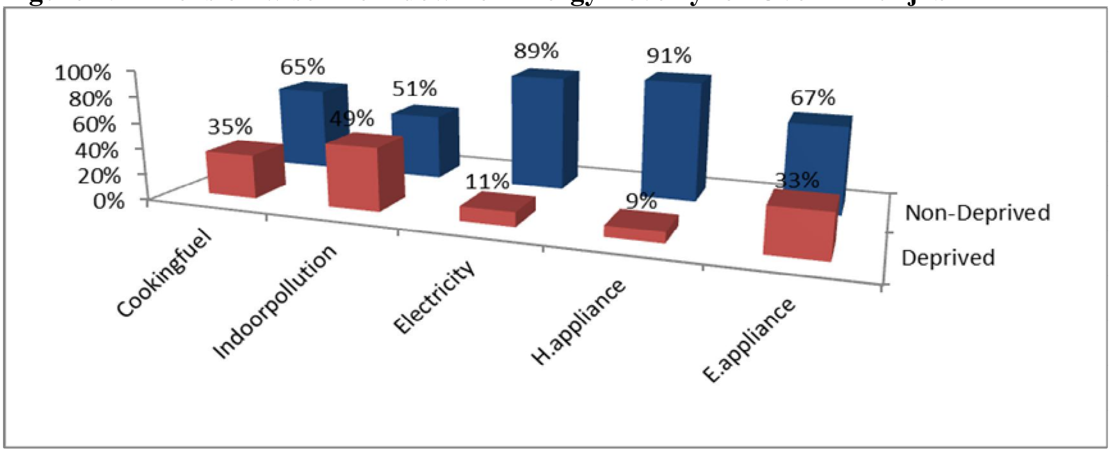
Figure 1 shows the results of Multidimensional Energy Poverty head count for overall Punjab at dual cutoff equal to 2 i.e. K=2.

Figure 1. Results of Multidimensional Energy Poverty Headcount for Overall Punjab at K=2



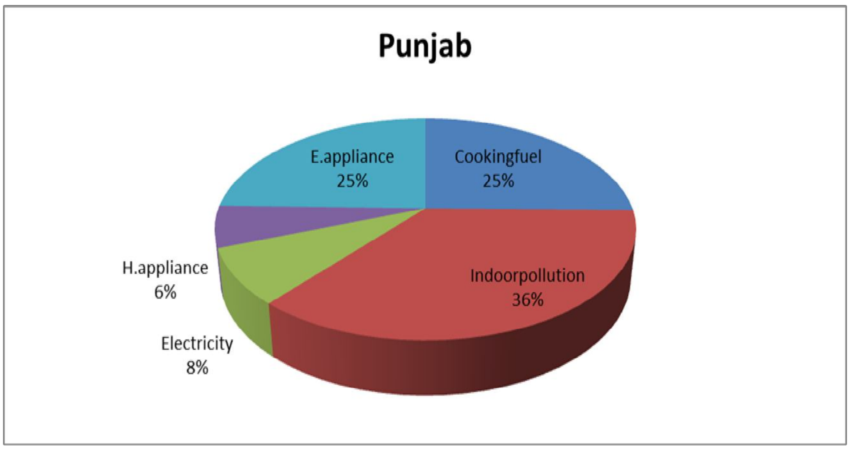
It is clear from figure 1 that in Punjab almost 47% and 53% of households are multidimensional energy poor and energy non poor, respectively. The analysis of breakdown of energy poverty by dimension for overall Punjab is shown in Figure 2.

Figure 2. Dimension wise Breakdown of Energy Poverty for Overall Punjab



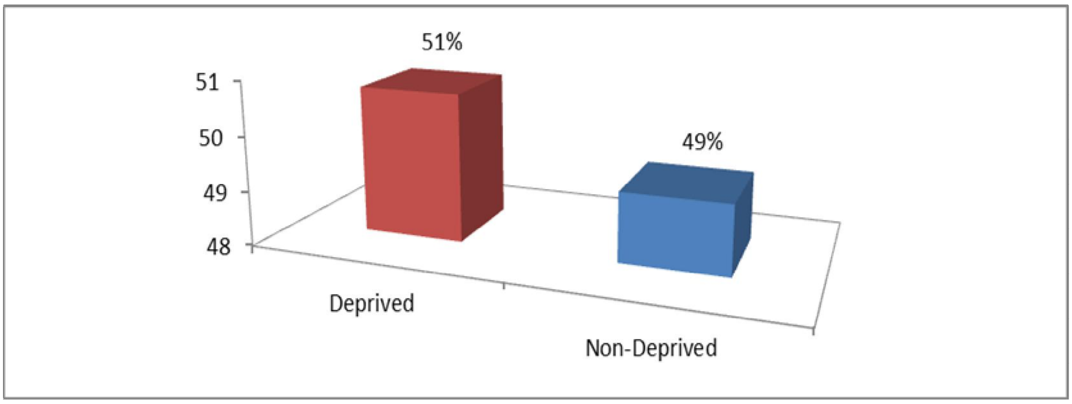
Results show that households of province of Punjab are most deprived in Indoor Pollution dimension (49%), while deprivation is the least in dimension of home appliances ownership (15%). Results further show that 35% and 33% of the households in Pakistan are deprived in terms of cooking fuel and entertainment appliances, respectively. Figure iii shows contribution of selected dimensions in multidimensional energy poverty headcount.

Figure 3. Results of Dimension-wise Contribution to Multidimensional Energy Poverty Headcount for Punjab



In Punjab contribution of indoor pollution (32%) is the highest followed by the cooking fuels and entertainment dimensions (25%). Collectively these three dimensions contribute up to 86% in overall Multidimensional Energy Poverty head count for Punjab. While electricity and home appliances dimensions contribute to overall Multidimensional Energy Poverty head count for Punjab only 14%. Figure iv shows the results of Multidimensional Energy Poverty head count for overall Sind at K=2.

Figure 4. Results of Multidimensional Energy Poverty Headcount for Overall Sindh at K=2



It depicts that in province of Sindh almost 51% and 49% of households are multidimensional energy poor and energy non poor, respectively. The analysis of breakdown of energy poverty by dimension for overall Sindh is presented in Figure 5.

Figure 5. Dimension wise Breakdown of Energy Poverty for Overall Sindh

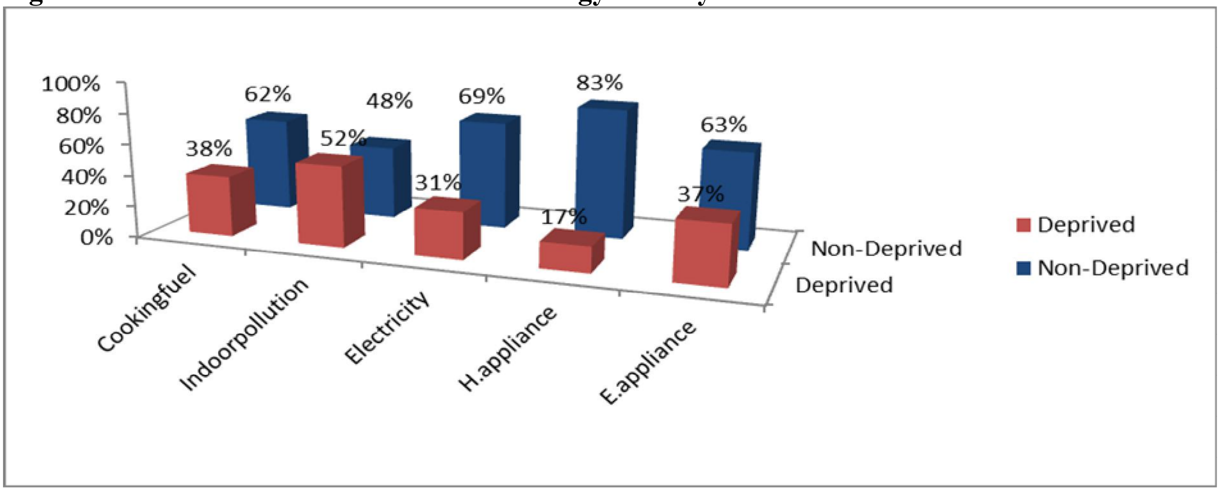


Figure shows that households in Sindh province are most deprived in indoor pollution dimension (52%) followed by cooking fuel dimension (38%). Results further show that 37%, 31% and 17% of the households in Sindh are deprived in terms of entertainment appliances, electricity and home appliances respectively. Figure 6 shows contribution of selected dimensions in multidimensional energy poverty headcount.

In the paradigm of multidimensional energy poverty in Pakistan, contribution of indoor pollution (30%) is the highest followed by the cooking fuels and entertainment appliances dimensions (22%). Collectively these three dimensions contribute up to 74% in overall Multidimensional Energy Poverty head count for Sindh while contribution of electricity and home appliances is 17% and 9%, respectively. Figure vii shows the results of Multidimensional Energy Poverty head count for overall KPK at K=2.

Figure 6. Results of Dimension-wise Contribution to Multidimensional Energy Poverty Head count for Sindh

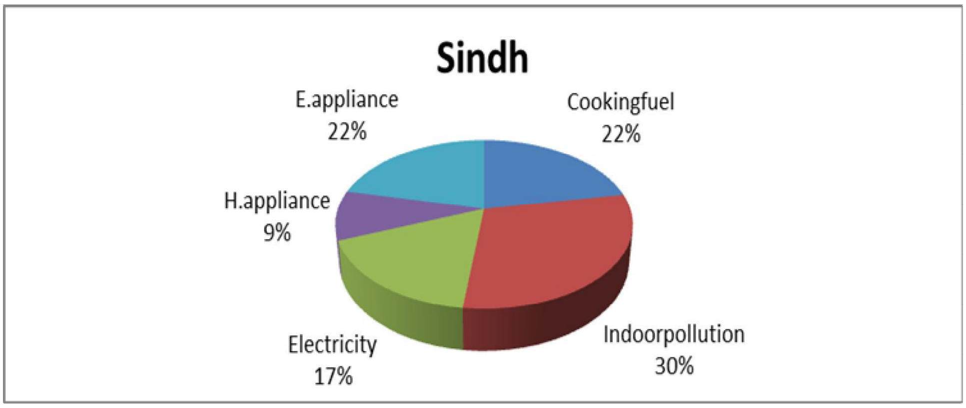
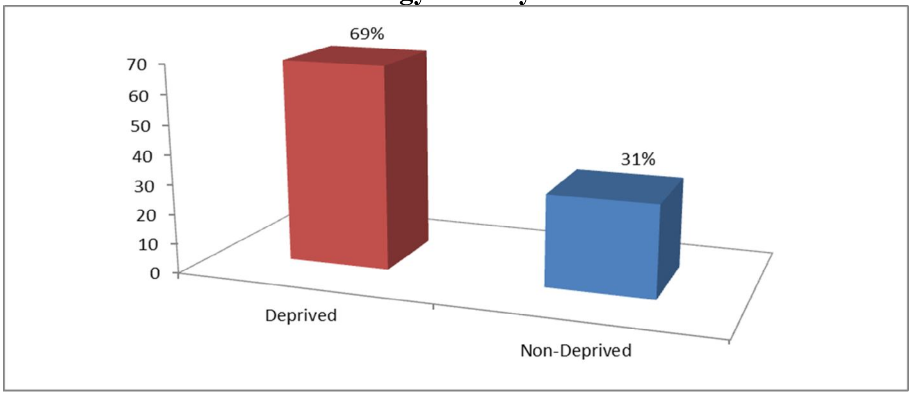
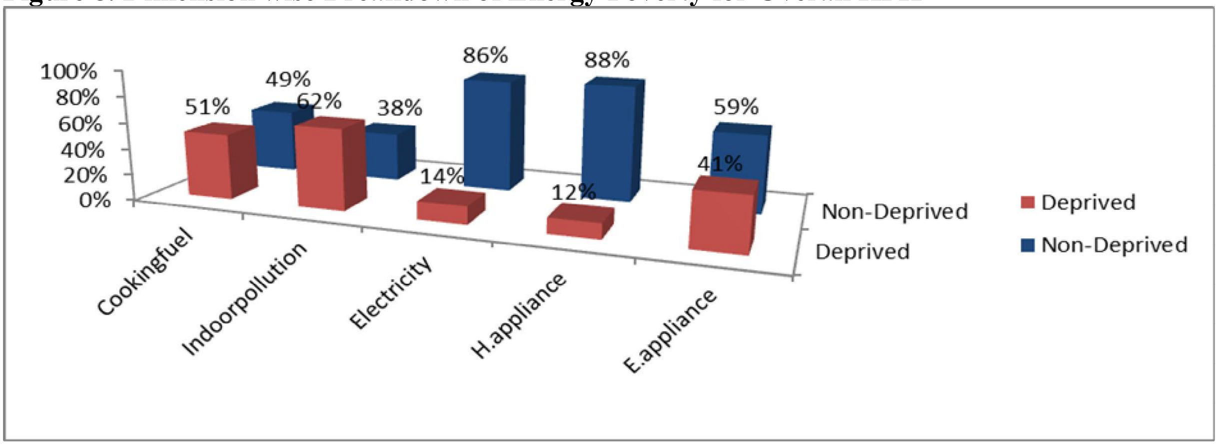


Figure 7. Results of Multidimensional Energy Poverty Headcount for Overall KPK at K=2



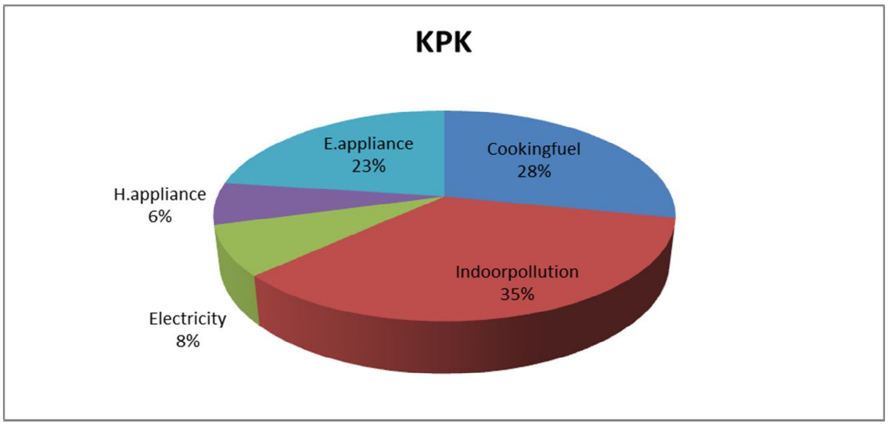
The empirical results show that in KPK province almost 69% and 31% of households are multidimensional energy poor and energy non poor, respectively. The analysis of breakdown of energy poverty by dimension for overall KPK is shown in Figure 8.

Figure 8. Dimension wise Breakdown of Energy Poverty for Overall KPK



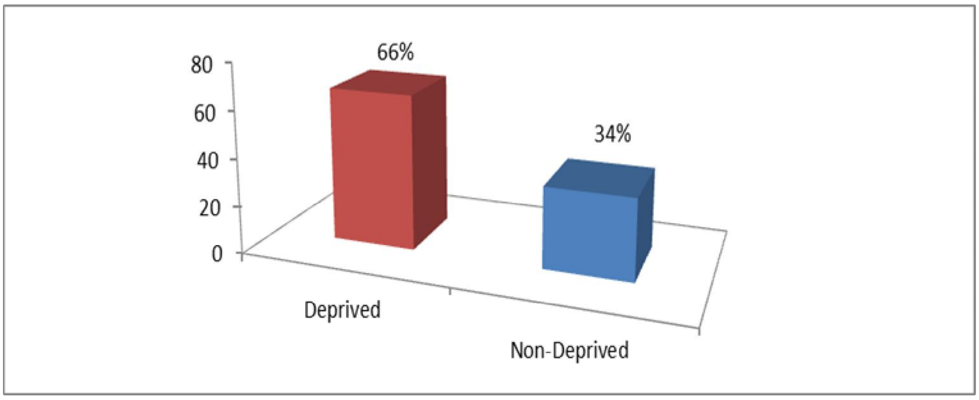
It is evident that households in KPK are most deprived in of indoor pollution dimension (62%) followed by cooking fuel (51%) while deprivation is the least in dimension of home appliances ownership (12%). Figure 9 shows contribution of selected dimensions in multidimensional energy poverty headcount for KPK.

Figure 9. Results of Dimension-wise Contribution to Multidimensional Energy Poverty Head count for KPK



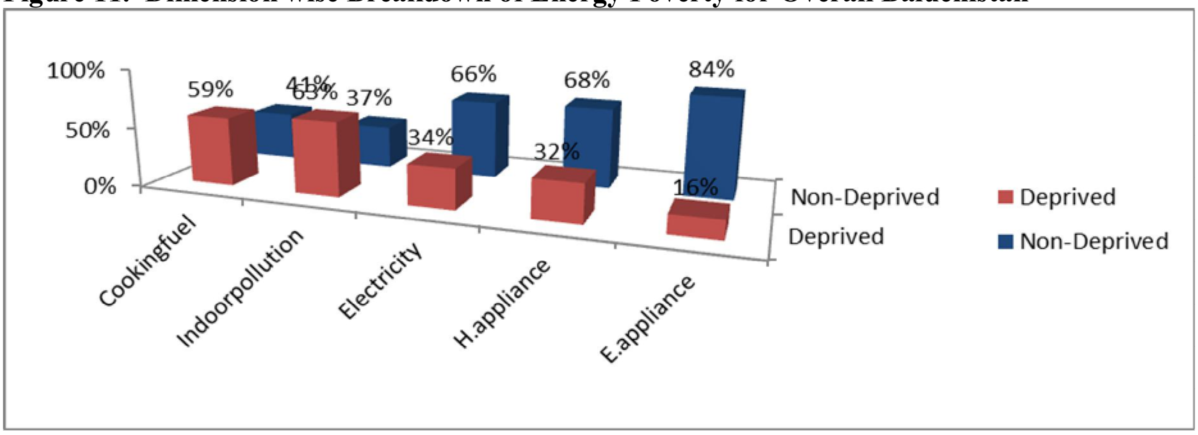
In the paradigm of multidimensional energy poverty in KPK contribution of indoor pollution is the highest (35%) followed by the cooking fuels dimension (28%) and entertainment appliances (23%). Collectively these three dimensions contribute up to 86% in overall Multidimensional Energy Poverty head count for KPK province while electricity and home appliances contribute remaining 14%. Figure 10 shows the results of Multidimensional Energy Poverty head count for overall Baluchistan at dual cutoff equal to 2.

Figure 10. Results of Multidimensional Energy Poverty Headcount for Overall Baluchistan at K=2



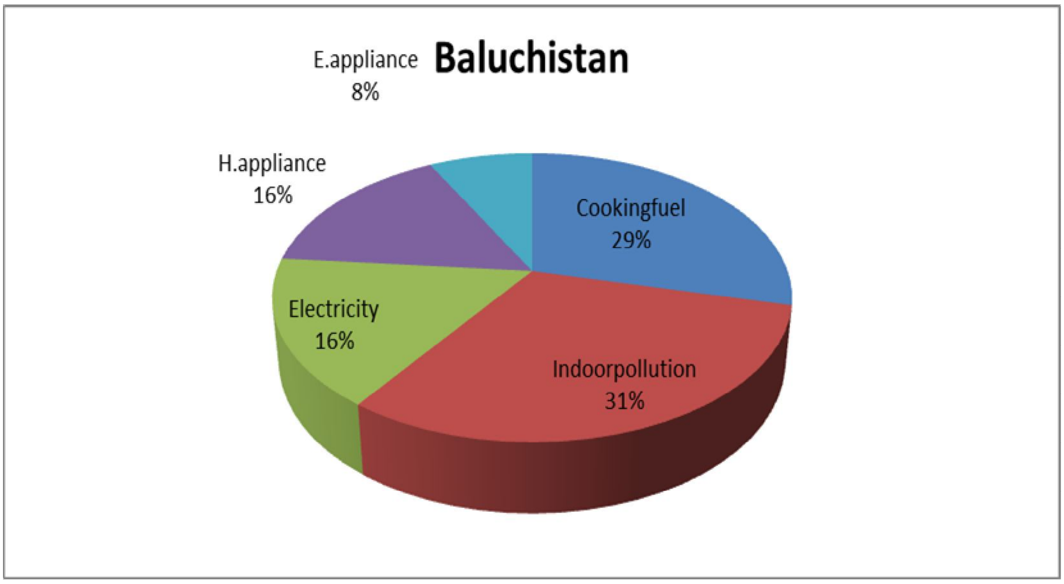
The figure depicts that in Baluchistan almost 66% and 34% of households are multidimensional energy poor and energy non poor, respectively. The analysis of breakdown of energy poverty by dimension for overall Baluchistan is shown in Figure 11.

Figure 11. Dimension wise Breakdown of Energy Poverty for Overall Baluchistan



It can be viewed that households of Baluchistan are most deprived in indoor pollution dimension (63%), while deprivation is the least in dimension of entertainment appliances ownership (16%). Results further show that 59%, 34% and 32% of the households in Baluchistan are deprived in terms of cooking fuel, electricity and home appliances, respectively. Figure 12 shows contribution of selected dimensions in multidimensional energy poverty headcount.

Figure 12. Results of Dimension-wise Contribution to Multidimensional Energy Poverty Head count for Baluchistan



In Baluchistan contribution of indoor pollution (31%) is the highest followed by the cooking fuels dimension (29%). Collectively these two dimensions contribute up to 60% in overall Multidimensional Energy Poverty head count for Baluchistan. While electricity, home appliances and entertainment appliances contribute to overall Multidimensional Energy Poverty head count for Pakistan 16%, 16% and 8%, respectively.

5. Concluding Remarks and Policy Recommendations

Present study based on results of MEP Headcount concludes that 47%, 51%, 69% and 66% of the households residing in provinces respectively of Punjab, Sindh, KPK and Baluchistan are energy poor. It is concluded that households of all the four provinces of Pakistan are most deprived in the dimension of indoor pollution i.e. in the range of 49% to 63% followed by cooking fuel i.e. in the range of 35% to 59%. Deprivation is least in the dimension of home appliances for all provinces except Baluchistan which is least deprived in entertainment appliances dimension. Indoor pollution is found to be the largest contributor to Multidimensional Energy Poverty Head count in all provinces. Cooking fuel is the second largest contributor in all provinces. Overall indoor pollution, cooking fuel and entertainment appliances are the three major contributors to overall MEP Headcount in all four provinces.

Based on above findings, the study suggests taking special initiatives to combat Energy Poverty in most deprived areas by initiating suitable measures. Indoor pollution and cooking fuel being the major contributors to overall multidimensional energy poverty in all provinces of Pakistan, energy poverty in each of these dimensions should be individually addressed in order to reduce overall multidimensional energy poverty.

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