Why rural rich remain energy poor

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Abstract:
The paper tries to explore the rationale behind the complexities of energy poverty among different income groups in rural communities. We attempted to understand why rural rich, despite their relatively high purchasing power use energy sources which tend to categorize them as energy poor. Using Energy Poverty Survey (EPS) – a dataset of more than 600 rural households from 27 different rural communities of Punjab, Pakistan, we presented energy access situation in rural households among different income groups. Subsequently, we used *logit* to assess access factors which could impact the energy source choices among different income groups. The insignificance of household income for traditional biomass use and high significance of community remoteness indicators imply that households give high importance on the proximity of energy sources available to them and, in many cases, will prefer to be in the state of energy poor, than to use modern energy source like LPG.

Keywords: energy poverty, rural rich and poor, rural communities, Punjab, Pakistan, fuelwood, animal waste, plant waste, kerosene, liquid petroleum gas
JEL: Q01, Q42, I32
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1. Introduction

It is an established fact that when people grow rich in developing countries they move up the energy ladder (Leach 1987; Leach 1988; Leach 1992; Davis 1995). But such steps are limited by access, which is why we often observe that higher income groups may continue to rely on traditional biomass (firewood, animal waste, plant waste) or use kerosene (Aburas and Fromme 1991; Alberts, Moreira et al. 1997; Joyeux and Ripple 2007; Haas, Watson et al. 2008; Hiemstra-van der Horst and Hovorka 2008). However in this paper, we attempt to show that access is a relative issue, having to do with household occupations, distance to towns and cities, means of transport and time involved in accessing different energy sources. We studied the fuel choices of people living in rural communities of Punjab, Pakistan, which are not connected to the natural gas grid and electricity grid[1]. The analysis is based on a specifically designed survey about fuel choices, household characteristics (such as household size and number of household members working), community remoteness and household occupations.

The issue of energy source choice in rural communities has been examined in many studies. In most of the studies, household income and consumption is included as a common determinant for explaining the energy poverty, following the pioneering research of Leach (1988). Based on national surveys, it was found that the consumption of biomass was related to income, household and settlement size and fuel prices in India, Pakistan and Bangladesh. Studies have also shown that due to non-availability of conventional energy sources like on-grid electricity and natural gas, rural communities adopt traditional biomass as a substitute for meeting household energy needs (Xiaohua and Zhenming 1997; Xiaohua and Zhenmin 2001; Wuyuan, Zerriffi et al. 2007).

We have observed that there is a clear distinction between the energy source choices and the energy source switching - more commonly referred as fuel switching, in energy poor households. E*nergy source choices* refer to the energy options available to rural households, which they opt or can opt to meet their household energy needs. Once a specific energy source is opted by a particular household, three different scenarios are possible, a) household starts using it as a main energy source, b) household starts using it, but only occasionally, hence combining it with other energy source(s), also called as fuel stacking (Masera, Saatkamp et al. 2000) and c) household stop using it and switch to other possible energy source(s)[2]. The first two scenarios clearly depend on available energy choices and number of related factors like income, price, household proximity etc, whereby households expands their types of energy sources to meet their energy needs, whereas the third scenario involves the discontinuation of previous energy source used by household and switch to available substitute(s) which could best provide them optimal combination of related factors (Rijal, Bansal et al. 1990; Davis 1995; Alberts, Moreira et al. 1997;

[1] 6 communities in our sample are without on-grid electricity. Also see section 3, Table 1.

[2] This further leads to 'fuel switching' phenomenon in rural households, which is not the main focus in our paper. For more information on fuel switching see, Hiemstra-van der Horst, G. and A. J. Hovorka (2008); Nautiyal, S. and H. Kaechele (2008); Alberts et al. (1997); Masera and Navia (1997); Masera et al. (2000); Campbell et al. (2003); Heltberg (2004); Nautiyal and Kaechele (2008);

Masera and Navia 1997; Masera, Saatkamp et al. 2000; Campbell, Vermeulen et al. 2003; Bhattacharyya 2006; Gupta and Köhlin 2006; Hiemstra-van der Horst and Hovorka 2008; Pachauri and Jiang 2008; Permana, Perera et al. 2008). The paper deals with fuel source choices, not switching choices, with the help of logit analysis, using dichotomous dependent and independent variables.

The structure of the paper is as following. Section 2 offers an overview of energy fuel sources and their respective use across different income groups in rural Punjab. Section 3 discusses the variables included in the logit analysis. Section 4 contains the logit results for 5 different energy sources and their sub-categories. In comparative terms, section 2 provides an overview of what actually rural households are doing in terms of accessing particular energy source in rural communities, whereas, sections 4 to 8 provide probabilities of using particular energy source (firewood, animal waste, plant waste, kerosene, LPG) on the basis of econometric technique. Section 9 states the conclusions with special attention to the question why rural rich remain energy poor.

2. Energy fuel choices in rural communities of Punjab

Households in rural Punjab of Pakistan use different types of energy sources in the absence of electricity and gas. Especially the absence of natural gas opens up for various energy sources for rural rich and poor. For electricity, kerosene is the most common alternative in Punjab (6 household (0.91% of total sample) also reported to be using rechargeable batteries). An overview of fuel sources available to households in rural communities is given in figure 1. The figure shows that in all energy sources, rural households use them frequently and occasionally (data for LPG frequent and occasional user is not included in the EPS).

More than 52 percent households are frequent users and rely on buying the firewood from the nearby market, whereas nearly 40 percent households collect firewood and are frequent users. 5.5% of households are those which, at the same time, collect and buy firewood from the market. Only 2.9 percent of firewood users have reported that they use firewood occasionally. In our sample of 640 households in Punjab, 90.9 percent of rural households reported that firewood is one of the energy sources among others. Firewood may be collected, bought or both collected and bought. Both activities require effort for buying firewood as people may have to go to nearby town or city.

Fig. 1: Hierarchy of Different Energy Source Choices Available to Rural Households

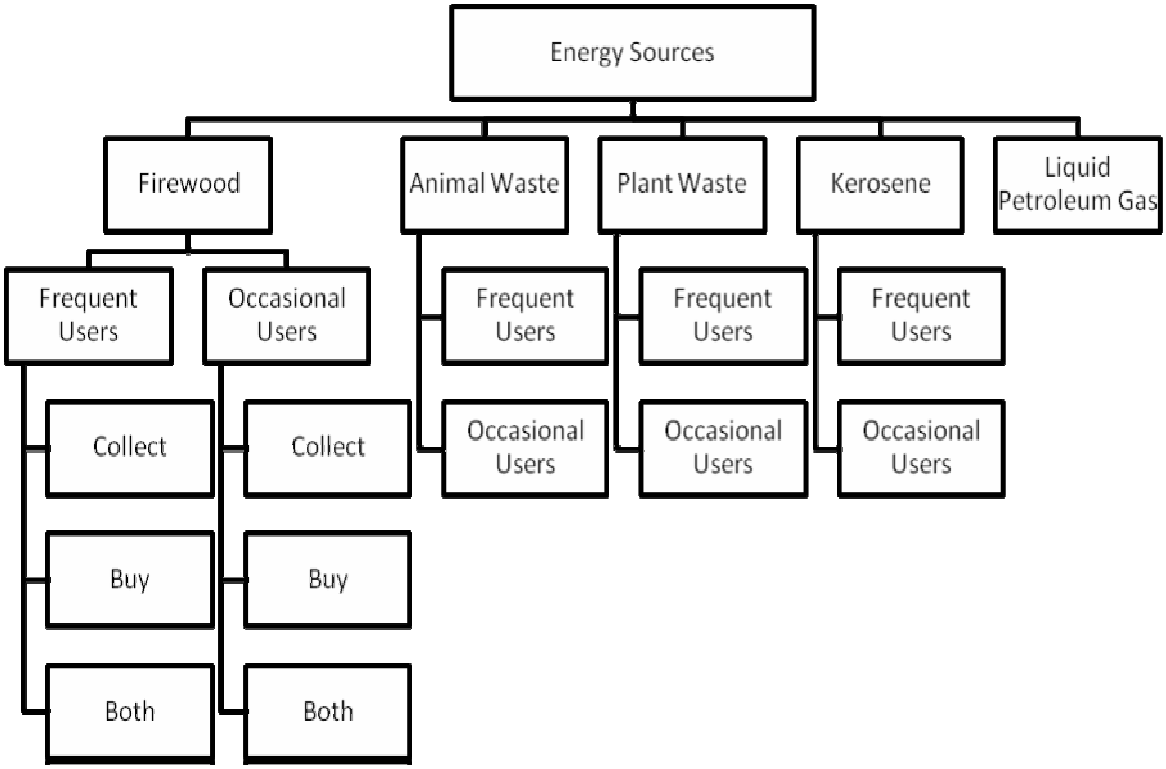
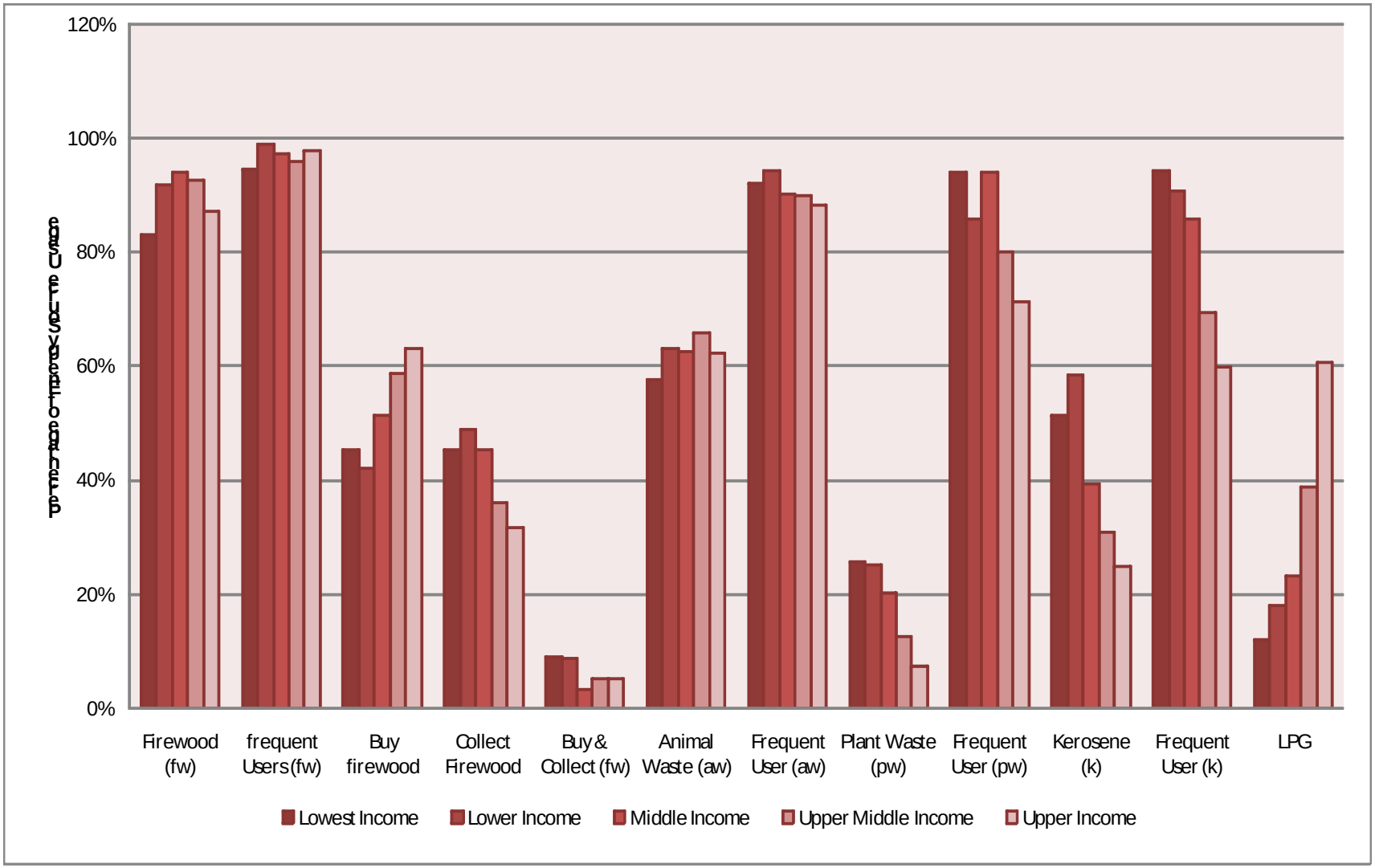


Figure 2 shows different income groups and their respective proportions (in percentages) using energy sources (listed on x-axis). When these income groups are compared, we can see that consumption levels are surprisingly equal across income groups. These consumption levels point to our main problem statement for the paper, which inquire the causes for such consumption consistency in different income groups, particularly for the traditional energy sources like firewood and animal waste. In other words, we aim to specifically analyze why rural rich remain energy poor despite of higher incomes? Apart from the infrastructural unavailability, what are the main factors in shaping energy choices available to rural households with different income levels? Why are certain energy sources given more priority than others in different income groups?

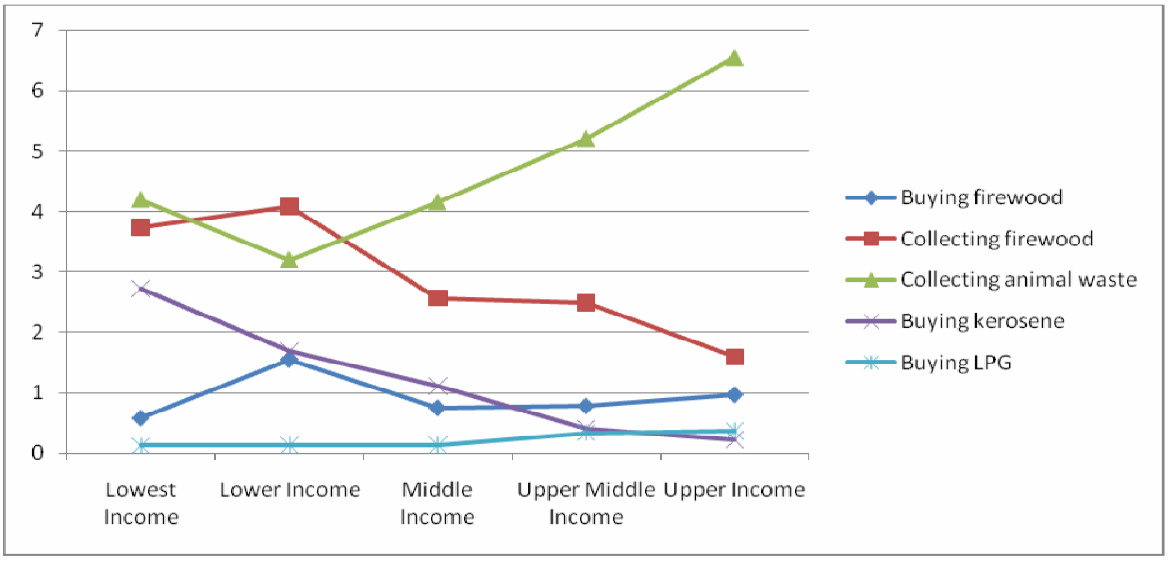
Figure 2: Proportion of Energy Sources in Different Income Groups



As this study will show, energy access is a critical mediating variable for rural households. It is also found that energy access is a relative issue, depending not only on household income, but also on factors like time and distance involved, effort required from household members for transportation collection and buying, means of transportation used, market interactions3 including source of buying or collection, price paid, number of sellers involved, credit possibilities for household etc. During the data collection using EPS, we found that many households, particularly with higher incomes, consider all these factors as important factors in deciding for particular energy source. For such households, these factors are equally important as energy source price.

In Figure 3, we can see how much time per week different income groups are spending for collection and/or buying different energy sources on average. The amount of time (per week) that people spend on buying and collecting energy sources is considerable and differs per energy source across different income groups. Collecting animal waste takes most time (more than 6 hours or more on average per week) in upper income group, due to relatively high livestock ownership in rich households. Data shows that the average time spent for collecting firewood decreases as the household income increases. In the case of LPG, there is a slight increase in average time spent at higher incomes (upper middle and upper income groups) as compared to lower income groups. This is certainly due to the increased usage of LPG in higher income groups.

Figure 3: Average Time Spent (in hours) per week in Buying and Collecting Different Energy Sources

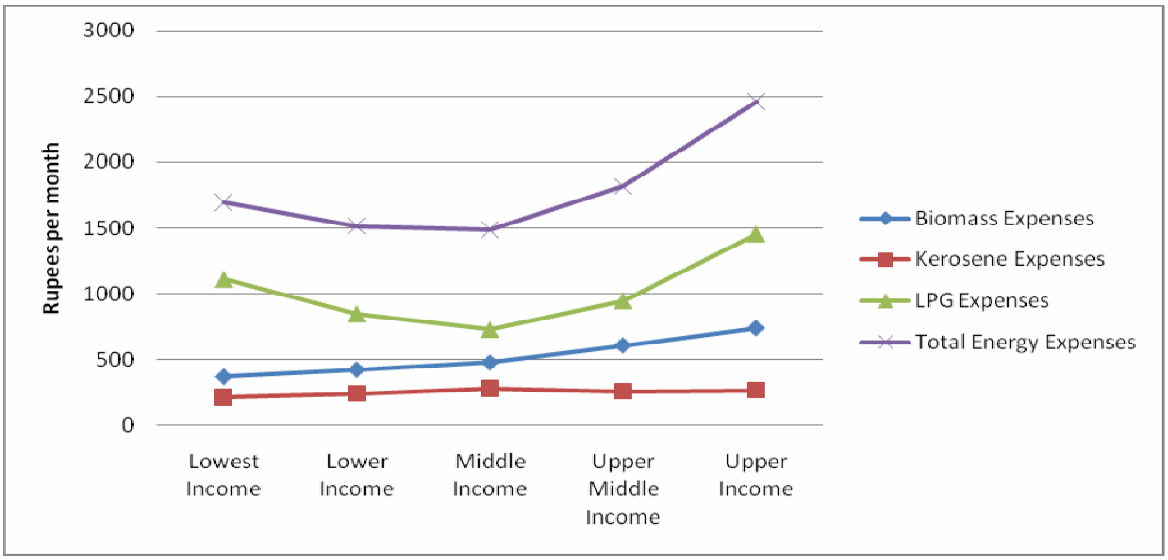


[3] The discussion of rural energy market interactions, also referred as rural energy market structure is being discussed in Mirza (2008), showing the interactions between different actors involved in delivering energy source and services to rural households.

Figure 4 shows that kerosene expense in all income groups is rather equal, whereas there is gradual increase in biomass expense from lowest income to upper income group. Traditional biomass expense represents the combined expenses for firewood, animal and plant waste bought. We can see that upper income people are spending two times as much as lowest income group on biomass. This shows that instead of gradual decline of biomass expenditure in upper income group, which is normally expected, it increases actually. This is because biomass is still one of the preferred sources of energy in upper income groups, even when used in combination with LPG.

In the case of LPG, an interesting U-shaped curve can be seen in figure 4. On average, more than Rs. 1100 are spend on LPG in the lowest income group. Most households in this group don't use LPG. Out of 66 households categorized as lowest income households, only 8 households reported that they are LPG users, representing 12.12% of entire group. LPG expense went down in lower and middle income group, whereas it started increasing in upper middle and upper income group. On average, the lowest income group spend more than lower and middle income groups on energy. These expenses tend to increase in upper middle income and upper income groups, probably due to convenient energy sources like firewood bought (compared to firewood collected) and LPG.

Figure 4: Average Monthly Expenses by Different Income Groups for Different Energy Sources



3. Data and research method

Data from the specially designed Energy Poverty Survey (EPS) is used to study the energy choices among rural households. EPS was conducted during 2008-2009 period from 11 different districts of Punjab province in Pakistan. In total, data was collected from 640 households from 27 rural

communities in 11 different districts of Punjab province. 19 communities in the sample were those without natural gas supply but with on-grid electricity. 6 communities in the sample were without any access to natural gas or electricity, whereas 2 of them were solar villages, also without any access to natural gas and on-grid electricity, located nearly 70 kilometres far from Islamabad – the capital of Pakistan. As we can see in table 1, almost all the sampled rural communities are either *very poor* or *poor*, in general. Around 88% respondents belong to age group between 18 years and 60 years. The ratio of male to female is heavily biased towards male respondents, due to the fact that the local culture doesn't permit females to interact with males other than their family members.

Table 1: Sample Profile: Some Fact and Figures

Province	Punjab	**Household Members**	
Districts	11	2 to 5	169 (26%)
Rural Communities (households)	27 (640)	6 to 10	388 (60%)
Communities with Electricity but no Gas	19 ()	11 to 15	66 (10%)
Communities without Electricity and Gas	6()	16 to 20	12 (2%)
Solar Communities without Electricity and Gas	2()	20 +	5 (1%)
Gender		**Community Prosperity Level**	
Male	599 (93.6%)	Very Poor	11
Female	41 (6.4%)	Poor	11
Age Groups		Neither Poor nor Rich	2
Below 18 Years	4 (0.6%)	Rich	0
18yrs to 30yrs	135 (21.1%)	Very Rich	0
30yrs to 45yrs	268 (41.9%)	Un-known	3
45yrs to 60yrs	164 (25.6%)		
60+	69 (10.8%)		

To better understand the energy access factors, we undertook a logit analysis using community remoteness indicators, type of occupation, household size, number of household members working and constant income as explanatory variables. A description of the dependent and explanatory variables is given below.

a. Occupations

Eight different categories of occupations were identified, namely, unemployed (individuals), farming, (construction) labour[4], shopkeeper, government employees, private employees, retired

[4] In EPS, the term *labour* is used for construction workers only as it is the most common profession among rural households. Hence all construction workers fall under *labour* category, whereas all other labor intensive professions common are included in *Others* category.

individuals, and others including drivers, barbers, etc. Construction labour is found to be the most common profession among the rural households in all the districts, with 32% households associated with it.

The second most common occupation is farming which includes almost 31% of households, followed by shop keeping (15.7%). Remaining 4 occupational categories were less than 7% separately. For that reason, initially we selected only three occupations for our model on different energy sources. However, a high co-linearity between *labourer* and other two variables (occupations) was found, which led us to drop *labourer* from the econometric analysis, and thus only include *farmer* and *shop* as occupational variables.

b. Income

Income of rural households is classified into 5 different groups, namely lowest income, lower income, middle income, upper middle income, and upper income group. The classification of income groups is based on the different ranges which are assigned to different groups based on the information collected from rural communities. Lowest income group includes all the households, which has monthly household income (total household income) ranging from 0 rupees to 3000 rupees. Similarly, lower income group includes all the households which has monthly household income ranging from Rs. 3001 to Rs. 5000, followed by the middle income group ranging from Rs. 5001 to Rs. 8000, the upper middle income group ranging from Rs. 8001 to Rs. 12000 and the upper income group to incomes above Rs. 12000. The explanatory variables corresponding to each income group are dichotomous variables that equal to 1 if the total household monthly income falls into that range category, otherwise zero.

Figure 5 shows the geographical distribution of different income groups in different districts of Punjab. Muzaffargarh (25.9%) and Rawalpindi (24%) districts are the ones with highest proportion of poor people falling into lowest income group. Sialkot and Gujrat districts are those with highest proportion of rich people representing upper income group, i.e., 36% and 33% respectively. It is also worth mentioning here that according to the set income criteria, none of the households sampled in Gujrat district belong to lowest income group, hence households in Gujrat district only represent remaining four income groups.

Figure 5: Proportion of Income Groups in Different Districts

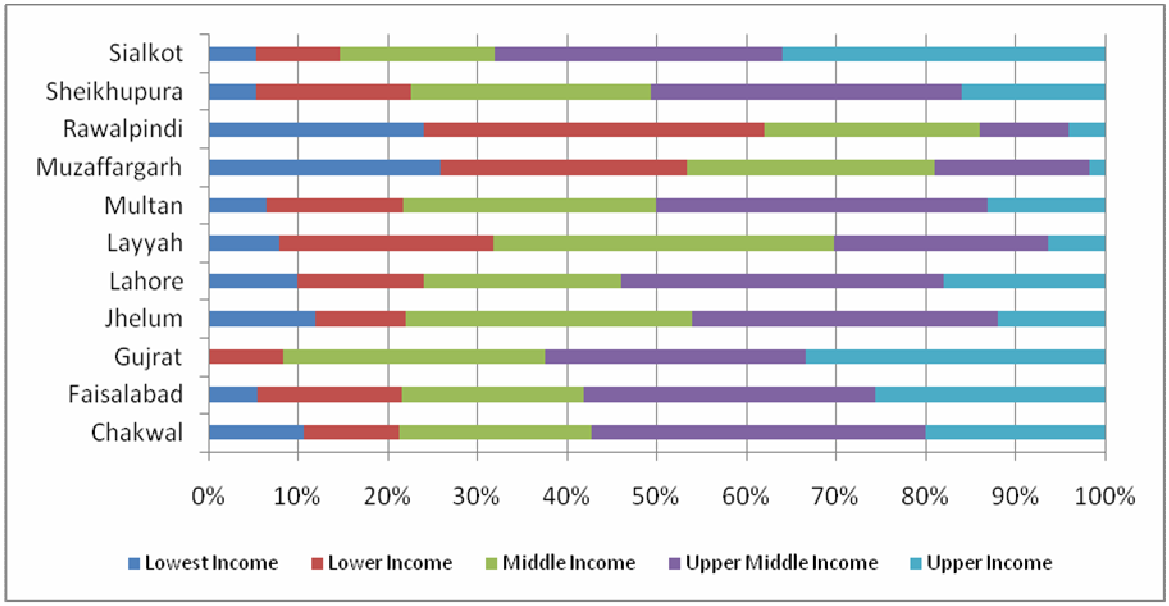


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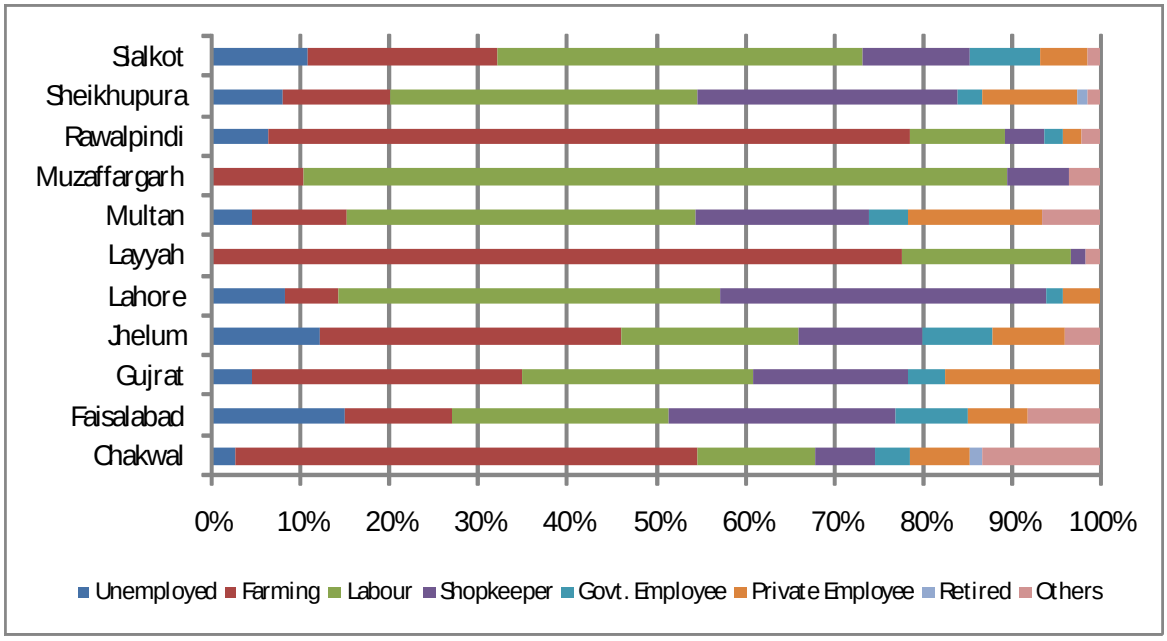
Figure 6: Occupations and their Proportions in Different Districts



To further understand the source of such income patterns in different districts, figure 6 shows the break-up of occupations adopted by rural households. We can see that in communities (Muzaffargarh and Rawalpindi) with poor income groups in majority, farming is one of the major occupations, whereas in communities (Sialkot and Gujrat) with the majority of people belonging

to upper income group, households are mostly associated with (construction) labour, government and private employees.

Table 2: Income Group Representation in All Districts

	Lowest Income	Lower Income	Middle Income	Upper Middle Income	Upper Income
Sample Mean	10.28%	17.32%	26.07%	29.42%	16.92%

Using random sampling of rural households in specific rural communities, we can see that more than 10% rural households belong to lowest income category (see table 2). Similarly, more than 17% households sampled in EPS are categorized as lower income households, whereas 26% are middle income households. According to set income criteria, we found that nearly 30% of rural households can be categorized as upper middle income households, whereas remaining 17% are categorized as upper income households.

As income in rural household is seasonal, a specific question was asked to know whether the household income remains constant throughout the year or not. As a result, a dichotomous variable *const_income* is used in the model, which equals one if the household has constant income throughout the year, and zero otherwise.

c. Community Remoteness Variables

Three different variables are used to measure the community remoteness, namely *distance from nearest village (village distance)*, *distance from nearest town (town distance)* and *distance from nearest city (city distance)*. To avoid repetition of distance from village to village, we avoided to include adjacent villages in our sample. Furthermore, due to relatively similar market situation in all villages, rural people tend to visit nearest town or city for their energy needs. This allowed us to exclude village distance variable from our analysis, leaving us with two essential variables for analyzing the effect of community remoteness on energy source choices. Table 3 provides a snapshot of community remoteness that shows minimum, maximum and average distances in kilometres from rural community to most nearby town and city. On average, rural people must travel more than 5 and 20 kilometres to reach town and city respectively. In the case where city is very far (more than 10 kilometres) from rural community, we assume that nearby town shall be preferred by rural people. Another important aspect is mode of transportation to access such far-flung towns and cities. Particularly in lower income class, rural people normally travel by foot. However, in many cases, they also use bicycles and animal carts, which make their access to town and city much

Table 3: Distance (in kilometres) of Town and City from Sampled Rural Community

	Minimum	Maximum	Mean
Town Distance	1	18	5.641406
City Distance	3	50	20.64297

convenient. In upper income classes (upper middle and upper income group), use of motor bike and tractor becomes more common.

d. Household size and Number of household members working

Household size (*hs*) represents total number of household members, including all men, women and children living together in one dwelling. In our sample, we found that the average number of household members (household size) is more than 7, with minimum of two and maximum of 30 household members. In the case of number of household members working (*nhmw*), more than 48% household reported that at least 1 household member is working, either employed or self-employed and earning income corresponding to one of the income groups mentioned earlier. Similarly, 20.4% and 15.2% reported 2 and 3 working members respectively. The minimum for number of household members is 0 (0.3% of total sample), representing none of the employed or self-employed household member, and maximum is 11 household members working in one household (0.2% of total sample).

For our logit analysis, we consider both, *hs* and *nhmw* as important variables which might have impact on the energy access for households. Our priori is that household with higher *hs* might have convenient access by engaging more households members in collecting and buying traditional and non-traditional energy sources. On the other hand, households with higher *nhmw* might have lower access to traditional energy sources, as they might not be available due to their employment.

Table 4: Explanatory Variables and their Description

Variable Code	Variable Name	Description
Independent Variables		
Td	Town Distance	Village distance in kilometres from nearby town
Cd	City Distance	Village distance in kilometres from nearby city
hs	Household Size	Total number of household members within one dwelling
Nhmw	Number of Household Members working	Total number of households working (including farming)
const_income	Constant Income dummy	1 if yes, 0 otherwise. Whether the income remains constant during the year or not
Farmer	Occupation = Farming dummy	1 if yes, 0 otherwise. Main occupation of the respondent or household head
Shop	Occupation = Shop keeping dummy	1 if yes, 0 otherwise. As per above
lwstincome	Lowest Income class dummy	1 if yes, 0 otherwise. Group with income between Rs.1 and Rs. 3000
lwrincome	Lower income class dummy	1 if yes, 0 otherwise. Group with income between Rs. 3001 and Rs 5000
midincome	Middle income class dummy	1 if yes, 0 otherwise. Group with income between Rs. 5001 and Rs. 8000
upmidincome	Upper middle income class dummy	1 if yes, 0 otherwise. Group with income between Rs. 8001 and Rs. 12000
upincome	Upper income class dummy	1 if yes, 0 otherwise. Group with income between Rs. 12001 and above [Reference Category].

Table 4 shows the independent variables used for modelling the dependent variables, i.e., different energy source users and non-users. 11 different independent variables were identified from EPS,

which might have effect on 11 different dependent variables. Apart from independent variables given, earlier we also included education variables, for respondent, other male and female members (separately) within household. However, surprisingly, all education variables turned out to be highly insignificant with high standard errors. Also, most of them were having co-linearity problems, which eventually forced us to exclude them from final energy source models and their sub-models. To analyse the influence of various explanatory variables, we used logit, a method which is especially suited for analysing the influence of various interacting variables on dichotomous dependent variables. The coefficients correspond to log of odd ratios[5].

Table 5: Dependent Variables and their Description

Dependent Variables (dichotomous)		
firewooduser	Household using firewood	1 if yes, 0 otherwise
FireAlways	Frequent firewood user	1 if yes, 0 otherwise. 0 also implies that household is occasional user.
Buy_firewood	Whether household buys firewood	1 if yes, 0 otherwise. 0 also implies that household collects firewood or collect and buy (both)
Collect_firewood	Whether household collects firewood	1 if yes, 0 otherwise. 0 also implies that household buy firewood or collect and buy (both)
A_waste_user	Household using animal waste	1 if yes, 0 otherwise.
Awaste_always	Frequent animal waste user	1 if yes, 0 otherwise. 0 also implies that household is occasional user.
P_waste_user	Household using plant waste	1 if yes, 0 otherwise.
P_waste_always	Frequent plant waste user	1 if yes, 0 otherwise. 0 also implies that household is occasional user.
K_user	Household using kerosene	1 if yes, 0 otherwise.
K_always	Frequent kerosene user	1 if yes, 0 otherwise. 0 also implies that household is occasional user.
LPG_user	Household using kerosene	1 if yes, 0 otherwise.

4. Factors effecting household using firewood

Firewood is considered to be the most readily available and preferred energy source for rural households (Davis 1995; Alberts, Moreira et al. 1997; Karekezi, Kimani et al. 2008; Mirza 2008). This also holds true for rural communities studied in Punjab where 90.9% of the households use firewood. In our analysis, we investigate determinants of firewood use, both for occasional users and frequent users.

a. Households using firewood

In the first step, we took firewood user as a dependent variable, representing the dummy which equal 1 if household uses firewood and zero if not. Using independent variables (except upper income [reference category]) listed in Table 4 and with sample size of 640 households, we found that the community remoteness indicators (town [$p<0.05$] and city distance [$p<0.01$]), household

[5] Odds ratio is the ratio of probability of events occurrence to the probability of events non-occurrence, written as P_i / 1-P_i and the natural log as ln (P_i / 1-P_i). For more information, see Gujarati, 1988 p. 482; Field, 2005 p. 225.

size ($p<0.01$), farmer ($p<0.01$), lower ($p<0.10$), middle ($p<0.05$) and upper middle income ($p<0.05$) groups turned out to be significant for firewood usage. The results for different income groups show that the use of firewood progressively increases from lower till middle income group and then decreases in upper middle income group, most likely due to shift towards advance energy source like liquid petroleum gas in higher income groups (see Figure 2). The negative coefficients for framers might be due to the fact that farming households adopt high degree of energy mix, due to their convenient access to other traditional energy sources, including animal and plant waste.

b. Frequent vs. Occasional Firewood Using Households

Rural households tend to make choices on usage frequency of energy source based on different factors. In poor households time is less important than it is for rich households. On the other hand, rich households tend to choose energy sources with greater convenience and energy efficiency than its price. An interesting finding is that they still use firewood and animal waste in combination with LPG to meet their domestic energy needs.

In our econometric analysis, a dichotomous dependent variable is created for frequency of firewood usage, where 1 represents frequent firewood usage and 0 represents occasional firewood usage. The results in model 1-A in table 6 shows that town distance ($p<0.05$), constant income ($p<0.10$) and household size ($p<0.10$) are significant for the choice of using firewood frequently or occasionally. The results suggest that the increase in town distance negatively affects the frequency of firewood usage, as households are highly dependent on firewood sellers in nearby town. Household size (*hs*) is positively significant, as expected, implying more household involvement in firewood buying and collecting activities, especially by household women and children. Instead of income groups, constant income (*cons_income)* variable turned out to be significant ($p<0.10$), suggesting higher chances of frequent use of firewood when household income is constant.

c. Households buying firewood

As we have come to know the factors or variables affecting the frequency of firewood usage among the rural households, the next step is to verify the factors which lead towards buying of firewood which can be used as an energy source. As shown in table 6, the independent variable *buy firewood* is a dichotomous variable that equals to 1 if households buy firewood, and 0 if not. If the rural households don't buy firewood, this also implies that they are more inclined towards collecting the firewood, or doing the mix of buying and collection.

In model I-B, community remoteness variables (*td* and *cd*) are highly significant ($p<0.01$), along with dummy for lower income. The negative sign in the coefficients of *td* (town distance) and *cd* (city distance) suggests that with the increase in the community remoteness (in kilometres), the odds to buy firewood decreases. This might be due to the market inter-linkages between the rural community and the nearby town and city, specifically for buying and selling firewood. This is true

in many cases, as most of the firewood or wooden log stall[6] (see Question E.F.4 in Section 3.01 of EPS Survey) is only available in nearby town or city. The negative sign also implies that if the rural communities are distant from nearby town and city, then they tend to *collect* the firewood from their community, regardless of their income class.

d. Households collecting firewood

For households collecting firewood and not buying it, distance of nearby town and city are found to be highly significant (both with $p<0.001$) and have positive influence on the dependent variable (collecting firewood). This implies that with the increase in distance from town and city, the odds of using collected firewood increases among rural households. The model also suggest that the tendency of using collected firewood among lower income and middle income group is significant ($p<0.05$ and $p<0.10$ respectively) as compared to lowest income and upper middle income group. The influence of *farmer* is as expected. The model suggests that the odds of using collected firewood decreases (negative sign) if *farmer* is reported as household occupation. As farmers are not having access to 'free' firewood, they opt to buy firewood to meet their household energy needs. Even when farmers have natural access to plant waste, due to its seasonal availability, they have to buy firewood and use it in addition to plant and animal wastes.

5. Factors explaining households using animal waste

More than 63% rural households are using animal waste as one of their energy source. Among the sample districts in EPS, around 91% households in Sialkot district reported to be using animal waste, followed by Lahore district with 88% rural household responding positively. Similarly, Rawalpindi and Layyah district turned out to have the lowest percentage of animal waste users: 86% and 75% rural households reported that they are not using the animal waste as an energy source. There are two main reasons for such practice in these districts. First, the rural communities in these districts are comparatively poorer than rural communities in other districts. Secondly, their high dependence on agriculture tends to lower their household income than household using other means for income. As a result, almost all of the animal waste produced domestically at household level is used as a fertilizer in their agricultural land, allowing them to save their expenses on fertilizers. Moreover, it was also observed that due to comparatively high livestock ownership in rich households, animal waste becomes one of their natural energy choices, which is often considered as energy source of poor households

The ratio of rural household buying animal waste as an energy source is below the share of households buying firewood. Nevertheless, if household owns livestock which produces waste usable as an energy source, then households utilize it more often as an energy source than use it as

[6] Stalls where wooden logs are sold that can be used in furniture and firewood. This is very common practice in developing countries of South Asia (India, Pakistan, Bangladesh, Nepal, Sri Lanka) and Sub-Saharan Africa.

a fertilizer. In most cases, rural households use animal waste produced from their own livestock. Around 38% also reported to buy it from the local sources like neighbour or households within their community, whereas only 1.2% reported using both ways, buying and collecting the animal waste from the community[7].

a. Households using animal waste

In the case of households using animal waste, city distance and town distance appeared to be significant at 10% and 1% significance level respectively (see Model II in Table 6). The results might imply that lower the community remoteness, higher the chances of using energy source other than animal waste, as that increases the availability of other energy sources like liquid petroleum gas. From the results, we can also see that income is having least influence in deciding in favour or against the use of animal waste. In other words, this also implies that decision to use animal waste as an energy source is independent of the household social status, specifically in the case of rural communities.

b. Frequent vs. Occasional animal waste using households

Model II-A in table 6 shows the regression results for the frequency of using the animal waste, in households which are already using it as an energy source. Apart from community remoteness indicators (both significant at 1%), number of household members working in a specific household also turned out to be significant at 5% significance level with a negative coefficient value, implying the frequent use of animal waste as an energy source decreases with an increase in employed household members. This might be due to the fact that animal waste requires relatively higher degree of household efforts to make the dung usable for burning. Therefore as the number of household members working in a household increases, the use of animal waste decreases but still remains as one of the energy source. From the given sample size of 406 households, we can also see that more than 63% households uses animal waste as one of the energy source to meet their household energy demand.

6. Factors explaining plant wastes usage

Contrary to our hypothesis, the use of plant waste among rural households is independent of land ownership. Instead, it has been observed that the relationship between the land ownership and the use of plant waste as an energy source turned out to be highly insignificant ($Chi^2=0.872$, df=1, p=0.350). Among 109 rural households using plant waste, 47% reported that they don't own any

[7] In rural communities of Pakistan, there is no formal selling of animal waste which can be later used as animal waste. Usually, animal waste is processed and dried by the females in rural households, which becomes usable for cooking purposes. If a rural household has surplus of animal waste, the females use their personal contacts with other female household members to sell or 'give away' animal waste. The practice in rich households (upper middle and upper income group) is slightly different, as the females from those households contact the females from household from low income groups (lowest and lower income group) and 'give away' the animal waste for free, provided low income household agree to process and clean the cattle shed.

agricultural land. In general, less than 18% rural households use plant waste for energy purposes, as more effort and time are required to collect it. Also, as reported by the respondents, plant waste is not an efficient energy source in terms of energy produced by it for cooking purpose, as compared to firewood and animal waste. Within different districts, 83% and 72% rural households in Muzaffargarh and Layyah district respectively were using plant waste in addition to other energy sources. On the other side, rural households in 4 districts, namely Rawalpindi, Gujrat, Lahore and Multan, were not using it at all.

a. Households using plant waste

In model III of table 6 a dichotomous variable is used for plant waste using household, which equals 1 if households are using plant waste and 0 otherwise. The result of logit shows that the all explanatory variables turned out to be significant except city distance and upper middle income. The results clearly show that the households with farming have higher odds of using plant waste as an energy source. Moreover, households with income having no seasonal impacts also reported higher odds of using plant waste. Due to high co-linearity of *shop* (shopkeepers) variable with other occupations, it was dropped from the model.

Table 6: Logit Results for Different Energy Sources

	Firewood				Animal Waste		Plant Waste		Kerosene		LPG
Dependent Variables	**User**	**Frequent vs. Occasional Users**	**Buy**	**Collect**	**Users**	**Frequent vs. Occasional Users**	**Users**	**Frequent vs. Occasional Users**	**Users**	**Frequent vs. Occasional Users**	**Users**
Explanatory Variables	**Model I**	Model I-A	Model I-B	Model I-C	**Model II**	Model II-A	**Model III**	Model III-A	**Model IV**	Model IV-A	**Model V**
Td	-.068**	-.113**	-.060***	.055***	-	-.099***	-.055*	.148	-.036*	-.327***	.094***
	(.033)	(.049)	(.021)	.021	.0478***	(.035)	.030	(.133)	(.020)	(.055)	(.021)
					(.019)						
Cd	.052***	.026	-.056***	.058***	-.053***	-.040***	.009	.034	.062***	.075***	-.036***
	(.015)	(.021)	(.008)	.008	(.007)	(.015)	.009	(.041)	(.008)	(.018)	(.008)
hs	.188***	.200*	-.003	.006	.041	.031	.088***	.077	-.027	.052	-.015
	(.063)	(.110)	(.031)	.031	(.032)	(.057)	.036	(.109)	(.032)	(.066)	(.031)
Nhmw	-.127	-.221	-.100	.067	.096	-.257**	-.185*	-.109	.021	-.230	-.154**
	(.119)	(.181)	(.075)	.075	(.074)	(.120)	.106	(.381)	(.073)	(.148)	(.076)
Const_income	.384	.975*	-.093	.339	-.193	-.305	.908**	2.198**	.158	-.379	-.752***
	(.359)	(.588)	(.261)	.274	(.258)	(.516)	.377	(.983)	(.249)	(.564)	(.245)
Farmer	-.864***	.641	.415**	-.397*	.170	.775	.693***	-.505	.295	.289	-.677***
	(.323)	(.676)	(.218)	.223	(.211)	(.524)	.235	(1.006)	(.205)	(.494)	.226)
Shop	-.225	-.354	.671	-.450	-.604	-.623	-	-	-.691	.299	.868*
	(.691)	(1.125)	(.537)	.539	(.448)	(.890)			(.553)	(1.193)	(.476)
Income Groups											
Lwstincome (Lowest Income Group)	.063	-1.308	-.710*	.433	.087	-.078	1.111**	4.097**	.964***	2.210**	-
	(.516)	(1.049)	(.420)	.425	(.383)	(.807)	.504	(1.864)	(.384)	(1.013)	2.430***
											(.465)
Lwrincome (Lower Income Group)	.972*	.444	-1.071***	.829**	.406	.397	1.053**	2.467	1.229***	1.401*	-
	(.517)	(1.297)	(.369)	.373	(.341)	(.738)	.473	(1.522)	(.344)	(.750)	1.919***
											(.365)
Midincome (Middle Income Group)	1.101**	-.408	-.502	.562*	.376	-.140	.953**	3.396**	.460	1.096	-
	(.481)	(.948)	(.325)	.331	(.303)	(.573)	.449	(1.541)	(.314)	(.715)	1.811***
											(.316)
Upmidincome (Upper Middle Income Group)	.830**	-.751	-.238	.254	.232	.027	.443	1.557	.205	.213	-.928***
	(.424)	(.852)	(.299)	.308	(.279)	(.538)	.443	(1.234)	(.294)	(.617)	(.271)
Constant	.141	2.450*	2.282***	-2.712***	1.367***	4.170***	-3.527***	-3.484	-2.125***	1.361	1.877***
	(.728)	(1.296)	(.500)	.516	(.477)	(.923)	(.675)	(2.254)	(.483)	(1.037)	(.489)
N	640	581	581	581	640	406	640	110	640	251	640
Nagelkerke R^2	.152	.130	.281	.282	.233	.215	.140	.292	.243	.421	.252

Reference category in Income groups = Upper Income group; Robust standard errors in parenthesis; *** = Significant at 1%, ** = Significant at 5%, * = Significant at 10%

Lowest, lower and middle income groups ($p<0.05$), household size ($p<0.01$), farmer ($p<0.01$) and number of household members working ($p<0.10$) also turned out to be significant. One of the reasons for significance of *hs* could be the possibility of household members to engage themselves in plant waste collection, especially females and children. Similarly, income groups with low income also have higher odds of using plant waste than households with higher income. The high significance of farmers imply that due to easy access of plant waste, odds of using plant waste are very high among households associated with farming. The model is able to explain 14% variation only, implying that still there are many unknown factors responsible for remaining 86% variation responsible for plant waste collection.

b. Frequent vs. Occasional plant waste using households

Once the plant waste is used by the rural households, the next step is to know the explanatory variables influencing its usage. In this model (see table 6 for Model III-A), most of the variables were unable to explain the variation in dependent variable. The only significant variables for plant waste user were constant income, lowest and middle income group variables (all with $p<0.05$). Results also show that lower and middle income households are more inclined towards frequent use of plant waste, in combination to other energy sources than to occasional use.

7. Factors explaining kerosene usage

Households normally consume kerosene in lanterns or for igniting traditional biomass (Hosier and Kipondya 1993; Karekezi 1994; Reddy 1995; Alberts, Moreira et al. 1997; Karekezi 2002; Heltberg 2004). Figure 2 shows that more than 50% of household in lowest income group and around 60% of household in lower income group use kerosene as one of their energy source. The consumption patterns among different income groups suggest that in the lowest income group, the consumption is affected by relatively low purchasing power of lower income group.

Subsequently, in each of the following income groups, the consumption probably decreases due to inconvenience involved in using kerosene, rather than buying power of higher income groups. Also, it has been particularly observed and confirmed (by informal interviews from respondents) that higher income groups tend to buy more convenient energy source like liquid petroleum gas, than kerosene for cooking purposes due to its relatively higher convenience and efficiency.

We can see in table 6 that the regression results confirm that the odds of using kerosene is greatly influenced by city distance, lowest and lower income groups, which are highly significant ($p<0.01$). The negative significant value for town distance ($p<0.10$) shows that with the increase in unit distance of town from rural community, the odds of using kerosene decreases. This is because kerosene is not easily available in rural communities, which means that in that case rural people need to travel to nearby towns to buy it from those few grocery stores that sell kerosene. Due to

high efforts, travelling and time constraints, rural households tend to survive with very limited kerosene supply or entirely abandon its usage.

Model IV-A in Table 6, a sub-category of kerosene usage confirms the results which are shown in Model IV – main kerosene model. In this case, town distance coefficients are even more negative, indicating that usage frequency is again highly dependent on the geographical access factor, which is highly significant ($p<0.01\%$). Similarly, the significance of lowest income groups reveals that once a lowest income class household decides to use kerosene as one of their energy source, the chances or probability of using it more frequently are much greater as compared to other income groups.

8. Factors explaining LPG usage

Liquid petroleum gas (LPG) is one of the most common substitutes for natural gas in comparatively affluent households, as it involves relatively higher initial costs due to new stove, gas cylinder and some accessories (Soussan, O'Keefe et al. 1990; Masera and Navia 1997; Viswanathan and Kavi Kumar 2005; Tonooka, Liu et al. 2006). Study from Masera et al. (2000) suggests that even though upper income households use LPG as a substitute energy source in the absence of natural gas however it is still not a complete substitute as they continue using traditional biomass in combination to LPG. Also, in our sample, more than 32 percent households reported to be using LPG instead of natural gas, but also in addition to other energy sources, like firewood, animal and plant waste, used for cooking. As shown in the Figure 2, the use of LPG tends to increase from lowest income groups till upper middle income group, however unexpectedly there is a slight decrease in its usage in upper income group. Table 6 shows the logit results for LPG use Upper income and upper middle income have high coefficient values which are highly significant ($p<0.01$), confirming the importance of income.

In the case of city distance ($p<0.01$), the odds of a household using LPG decreases with an increase of distance between rural community and city. This is due to the fact, that almost all the rural communities in the survey were lacking the required distribution network for LPG. Therefore, LPG users have to travel either towards city or town[8] ($p<0.05$) to get LPG cylinders filled.

Results suggest that LPG usage is more common in households without constant income ($p<0.01$). Hence occupations with monthly income variations (drivers, shopkeepers, barbers, businessmen etc.) have higher odds of using LPG than constant income occupations like private

[8] In many cases, even the nearby towns were not having the distribution of LPG cylinders. LPG cylinders are normally sold through agencies working under LPG distribution firms, which are more in number and are well-organized in cities.

and government employees. Household with farming as their main occupation also turned out be highly significant however with negative coefficient, which suggest that LPG is not common energy source among farmers, as they have easy access to traditional biomass.

9. Conclusions

In this paper, we have attempted to analyse the rationale of energy choices among different income groups in rural communities of Punjab. To better understand the energy access in rural households, we presented energy access factors across different income groups. To overcome the complexity of energy poverty phenomenon in rural households, we differentiated energy sources usage patterns into additional categories. This method of differentiating households on the level (frequent vs. occasional user) of their energy source usage has also helped us to understand the degree of energy mixes (deploying combination of energy sources) which households with different income groups deploy to meet their energy needs.

The results from econometric models using different energy sources suggest that energy sources among different income households are not only affected by their incomes, but are also influenced by factors like community remoteness and major household occupation. One of the important facts validated by descriptive and econometric analysis is the less influential role of income for choosing traditional energy sources than in choosing expensive and advance energy source like LPG. Our results suggest that the role of income gradually comes into play in all income groups, once the household tends to shift their choices from traditional energy sources to advanced ones.

The results point to the importance of community remoteness and immediate access. The high significance of community remoteness indicator in almost all energy sources and their respective usage for all income groups suggest that rural households tend to avoid the burden of transportation of specific energy source. It is to be noted that transporting specific energy source (LPG cylinders, fuel wood bundles or wood logs) not only involves costs, but also more efforts and time from household members. Availability of biomass also comes into play, as shown by the relative high use of firewood, animal and plant wastes by farmers. We find that in rural communities, traditional energy sources are preferred by all households, regardless of their income. However, as the price of energy sources goes up, income starts playing its influential role, a result which leads us to question the linear, unidirectional and natural approach adopted by energy ladder (Masera and Navia 1997; Masera, Saatkamp et al. 2000; Narasimha Rao and Reddy 2007; Nautiyal and Kaechele 2008). Other variables like household size (*hs),* number of household members working (nhmw) and constant income (*cons_income*) also turned out to be significant in some cases. Particularly in the case of firewood and plant waste usage, household size is revealed as an important factor.

The study is subject to limitations. Firstly, due to limitations of EPS, we are not able to explain fuel or energy switching phenomenon which is highly interconnected with energy choices available to rural households. Secondly, due to restrictions in terms of research objectives, we have not included the previous fuel usage history of rural households, which in our view would be crucial to understand fuel choices and switching phenomenon.

A robust finding of the present study is the important role of access, an issue which has obtained insufficient attention in the literature on energy fuel and which is also of importance to the issue of energy poverty and development. Future studies of energy poverty and development may benefit from our study suggesting that increases in income may not be enough and that development policy must deal with issues of energy access which is likely to differ from place to place. Energy access in rural communities is quite a complex issue, depending on means of transport available, distances to be travelled, time available and costs involved. There is also the issue of local trade and locally available resources which come into play, as this study has shown.

References

Aburas, R. and J. W. Fromme (1991). "Household energy demand in Jordan." Energy Policy 19(6): 589-595.

Alberts, H., C. Moreira, et al. (1997). "Firewood substitution by kerosene stoves in rural and urban areas of Nicaragua: social acceptance, energy policies, greenhouse effect and financial implications." Energy for Sustainable Development 3(5): 26-39.

Arnold, J. E. M., G. Kohlin, et al. (2006). "Woodfeuls, livelihoods and policy interventions: changing perspectives." World Development 34(3): 596-611.

Bhattacharyya, S. C. (2006). "Energy access problem of the poor in India: Is rural electrification a remedy?" Energy Policy 34(18): 3387-3397.

Campbell, B. M., S. J. Vermeulen, et al. (2003). "The energy transition in action: urban domestic fuel choices in a changing Zimbabwe." Energy Policy 31(6): 553-562.

Davis, M. (1995). "Fuel choice in rural communities." Energy for Sustainable Development 3: 45-48.

Field, A. (2005). Discovering Statistics using SPSS, Sage Publications.

Gujarati, D. N. (1988). Basic Econometrics, McGraw-Hill Book Company.

Gupta, G. and G. Köhlin (2006). "Preferences for domestic fuel: Analysis with socio-economic factors and rankings in Kolkata, India." Ecological Economics 57(1): 107-121.

Haas, R., J. Watson, et al. (2008). "Transitions to sustainable energy systems--Introduction to the energy policy special issue." Energy Policy 36(11): 4009-4011.

Heltberg, R. (2004). "Fuel switching: evidence from eight developing countries." Energy Economics 26(5): 869-887.

Hiemstra-van der Horst, G. and A. J. Hovorka (2008). "Reassessing the "energy ladder": Household energy use in Maun, Botswana." Energy Policy 36(9): 3333-3344.

Hosier, R. H. and W. Kipondya (1993). "Urban household energy use in Tanzania: Prices, substitutes and poverty." Energy Policy 21(5): 454-473.

Joyeux, R. and R. D. Ripple (2007). "Household energy consumption versus income and relative standard of living: A panel approach." Energy Policy 35(1): 50-60.

Karekezi, S. (1994). "Energy policy issues in Africa." Resources, Conservation and Recycling 12(1-2): 23-29.

Karekezi, S. (2002). "Poverty and energy in Africa--A brief review." Energy Policy 30(11-12): 915-919.

Karekezi, S., J. Kimani, et al. (2008). "Energy access among the urban poor in Kenya." Energy for Sustainable Development 12(4): 38-48.

Leach, G. (1987). "Household energy in South Asia." Biomass 12(3): 155-184.

Leach, G. (1988). "Residential energy in the third world." Annual review of energy 12: 47-65.

Leach, G. (1992). "The energy transition." Energy Policy 20(2): 116-123.

Martins, J. (2005). "The impact of use of energy sources on the quality of life of poor communities." Social Indicators Research 72(373-402).

Masera, O. R. and J. Navia (1997). "Fuel switching or multiple cooking fuels? Understanding inter-fuel substitution patterns in rural Mexican households." Biomass and Bioenergy 12(5): 347-361.

Masera, O. R., B. D. Saatkamp, et al. (2000). "From Linear Fuel Switching to Multiple Cooking Strategies: A Critique and Alternative to the Energy Ladder Model." World Development 28(12): 2083-2103.

Mirza, B. (2008). Energy poverty and market structure characteristics: determining the energy access for rural households in developing countries Managing Science and Technology for Sustainable Future (WASD). A. Ahmed. Brighton, United Kingdom, WASD: 111-119.

Narasimha Rao, M. and B. S. Reddy (2007). "Variations in energy use by Indian households: An analysis of micro level data." Energy 32(2): 143-153.

Nautiyal, S. and H. Kaechele (2008). "Fuel switching from wood to LPG can benefit the environment." Environmental Impact Assessment Review 28(8): 523-532.

Pachauri, S. and L. Jiang (2008). "The Household Energy Transition in India and China." Energy policy 36: 4022-4035.

Permana, A. S., R. Perera, et al. (2008). "Understanding energy consumption pattern of households in different urban development forms: A comparative study in Bandung City, Indonesia." Energy Policy 36(11): 4287-4297.

Reddy, B. S. (1995). "A multilogit model for fuel shifts in the domestic sector." Energy 20(9): 929-936.

Rijal, K., N. K. Bansal, et al. (1990). "Rural household energy demand modelling : A case study of Nepal." Energy Economics 12(4): 279-288.

Soussan, J., P. O'Keefe, et al. (1990). "Urban fuelwood: challenges and dilemmas. ." Energy Policy 18(6): 572-582.

Tonooka, Y., J. Liu, et al. (2006). "A survey on energy consumption in rural households in the fringes of Xian city." Energy and Buildings 38(11): 1335-1342.

Viswanathan, B. and K. S. Kavi Kumar (2005). "Cooking fuel use patterns in India: 1983-2000." Energy Policy 33(8): 1021-1036.

Wuyuan, P., H. Zerriffi, et al. (2007). "Household Level Fuel Switching in Rural Hubei." Program on Energy and Sustainable Development, Freeman Spogli Institute for International Studies, Stanford Univeristy, USA.

Xiaohua, W. and F. Zhenmin (2001). "Rural household energy consumption with the economic development in China: stages and characteristic indices." Energy Policy 29(15): 1391-1397.

Xiaohua, W. and F. Zhenmin (2003). "Common factors and major characteristics of household energy consumption in comparatively well-off rural China." Renewable and Sustainable Energy Reviews 7(6): 545-552.

Xiaohua, W. and F. Zhenming (1997). "Rural household energy consumption in Yangzhong county of Jiangsu province in China." Energy 22(12): 1159-1162.

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