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Wealth, education and cooking-fuel choices among rural households in Pakistan

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ABSTRACT

Clean and modern fuel for cooking is essential for safeguarding good health for women and children and enhancing the well-being of people in the least developed countries. A large section of the rural population in the least developed countries still use fuelwood, and dung cake and residue for cooking, which is harmful to the environment and human health. This paper uses the Pakistan Social and Living Standards Measurement Survey (PSLSMS), 2014-15 to investigate the cooking-fuel use patterns and factors influencing rural household choices. The results show that a significant number of rural households use fuelwood, dung and crop residue for cooking and a tiny fraction of households use natural gas. Low-income families with a lower level of schooling of household head are likely to depend on fuelwood, and dung cake and crop residues. Multinomial logit results show that household heads with higher human capital and physical and financial assets are more likely to use modern fuel such as natural gas, and are less likely to use fuelwood and, dung cake and crop residues. Empirical findings also indicate that education is the main driver of clean fuel adoption for cooking in rural Pakistan. Hence the energy policy should focus on the investment in human capital to enhance the adoption of clean fuel for cooking.

1. Introduction

In spite of increased awareness of the adverse consequences of the use of dirty fuel and innovations on clean energy technology, around 1.1 billion people (14% of world population) do not have access to electricity and 2.8 billion people do not have access to clean cooking fuel [1–3]. Indiscriminate use of firewood as a cooking fuel has significantly added to carbon emissions [4–9]. Use of firewood, dung and crop residue (dirty fuels) has a serious negative impact on human and environmental health; hence, access to and use of modern fuels are essential for enhancing people's health, protection of ecology, and socio-economic development. The quality of household energy use is linked to sustainable development [10]. Indoor air pollution from the use of dirty fuel is currently linked to over 4 million premature deaths per year, and several billion hours are spent collecting firewood for cooking, mostly by women, that could be put to more productive uses [3].

Research in developing countries has found that indoor air pollution and exposure to the byproduct of combustion of fuelwood results in various health issues [11–15]. Several studies in Africa, Asia and Latin America have found a strong correlation between the use of solid fuel and health problems like upper respiratory infection, including pneumonia, tuberculosis, dizziness, eye irritation, cataracts, sneezing, deterioration of menstrual health, persistent headaches and anemia [11–13,16–33].

Limited and unreliable access to clean fuel and the high cost of clean fuel are the key causes for the rampant use of solid fuels in developing countries [2,34]. The use of fuelwood, dung, and residue is predominant among low-income families, while richer households tend to use electricity and LPG [34]. The energy ladder hypothesis stipulates that the households will move from the use of biomass and other solid fuels to contemporary and clean fuel such as natural gas and electricity in response to higher income and other factors [35,36]. The engine of transition in the energy ladder is posited to be income and relative fuel prices [2,36–38]. Apart from the amount, the kind of fuel consumed also changes with income [39], with an inclination towards clean fuels [40], especially the use of electricity [41]. Low-income households use dirty fuels which are injurious to the environment as well as human health [42–44]; when incomes increase, generally, but not always, they change to cleaner fuels [45,46].

Besides income, taste, tradition, gender, education and other factors influence a household's decision on the choice of cooking fuel. Studies

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have found that female-headed household use clean and convenient sources of energy [47–49], because in most developing countries, female members are responsible for the collection of fuel and cooking. The use of clean fuel will reduce the burden of collection and health problems for female members due to indoor air pollution. There are also studies which have found that gender does not influence the choice of energy [50,51]. Recent studies have pointed out the importance of education on the choice of clean energy [52–57]. Therefore, the analysis of the drivers of fuel choice for cooking in developing countries should take into account household demographic characteristics, education, wealth and accessibility.

This paper brings several values to the existing literature on energy use in developing countries. First, it uses large nationally-representative household datasets covering over 64,670 households in Pakistan. Second, this study exclusively focuses on the cooking-fuel consumption patterns and determinants for rural households in Pakistan. Third, it uses several different and observable measures of wealth to establish the causal relationship between wealth and fuel choice behaviors. Fourth, it employs an alternative measure of education and accessibility to establish the casual linkage of the awareness and accessibility of choice of clean energy for cooking.

The Pakistan Social and Living Standards Measurement Survey (PSLSMS), 2014-15 has a detailed and broad range of information permitting numerous robustness tests on the role of the level of household education and wealth on the household choice of cooking fuel in rural areas in Pakistan. The following section provides a review of the literature, followed by a description of the study area, the empirical framework and the data used; the two subsequent sections discuss the results and conclusions.

2. Literature review

There is increasing evidence that besides income, a household's choice of energy for domestic use is driven by the household size and composition, education and the gender of the household heads [45,47,49,53,54,58–64]. Hence, there are a number of constraints which prevent a household from using clean and convenient sources of fuel, such as tradition, social and gender norms, access to energy, education level, and wealth.

Wealth is one of the crucial parameters determining a household's choice of fuel [39,54,55,58,61,62,65–67]. Households with higher income and assets have a higher potential, and subsequently willingness to pay for quality fuels. Therefore, as the means and revenue of the household increases, it is more likely to shift from the use of dirty fuels to clean fuels. For example, the household per capita consumption expenditure has the biggest positive influence on the per capita energy consumption in India [68].

Energy consumption in the household normally increases with an increase in wealth [39]. Some of the studies used the size of the farm and livestock owned by rural households [69,70]. Although livestock and land ownership indicate the wealth status in rural areas of developing countries, it may deter households from switching to clean energy use because the households with large landholdings and livestock assets are naturally endowed with crop residues and dung cake, and most likely to depend on it for cooking fuel. As a result, some of the recent studies have also measured wealth using the quality of housing and the ownership of durable assets [34,71].

Human capital as measured by the years of schooling of family members affects household cooking fuel choices in two different ways: first, education increases income and, hence, the ability to pay and the value of time; second, education enhances knowledge and awareness and affects cultural and consumer preferences. Households with an educated head tend to use clean and modern fuel because of the ease of use, health benefits and the opportunity cost of their labour deployment in the collection of biomass. The education level of the head of the family has been found to improve a household's interest in using a clean fuel in India [39]. Additionally, the number of educated females between 10 and 50 years old in a family have a positive impact on the choice of a clean fuel [72]. Families with a higher level of schooling of the head and spouse are more inclined to use modern fuels, as these offer significant savings in time [73]. Education plays a crucial role in fuel switching [64,74]; hence increasing levels of education are related to a higher probability of using modern fuels, and a lesser use of solid fuels [52]. Education of the household head and spouse decreases the consumption of fuelwood because education improves the decision-makers' knowledge about the costs and benefits of using clean fuels [75].

In India, females are more involved in firewood gathering than the males [70]. The presence of more women in the family increases the labour available for the collection of wood. Thus the possibility of the household moving to less time-consuming sources of energy is reduced in households with more females [64]. Conversely, a study found that the presence of children under six-years of age reduces a household's use of wood, perhaps because the time available for wood collection is reduced as a result of the time needed for childcare [76].

When the income level rises in a household, or if a woman heads the family, women's preferences are more likely to be given due recognition. Female family members are accountable for the sourcing of fuel and cooking in developing countries [77]. The involvement of female members in household fuel management ranges from gathering fuelwood when incomes are low to influencing the choice of fuel when incomes are higher [73]. With the use of clean fuel, female members have good health and more time for family and leisure; hence, when a female member is the main decision-making person, a high preference will be placed on goods that are more useful to the female members. Women have a greater preference, compared to men, for clean fuels, given their greater involvement in cooking [75]. Understanding of the roles of gender and tradition in energy policy formulation has largely been ignored [77].

Household demographics such as the age of the head of the family, adult females, children, and adult males influence a family's cooking fuel choice. The size of the family negatively relates to the use of clean cooking fuel [72], but the association may be non-linear [39]. Family size has a positive impact on gathering wood for fuel because of a higher demand for energy, and a greater labour supply for wood collection [70,76,78].

3. Objectives

Against the backdrop of the review of the literature, the objectives of the current paper are to assess the role of household demographics, education, wealth and accessibility on the fuel choice decision of the rural households in Pakistan. Specifically, it aims to use large nationally-representative household datasets covering over 64,670 households in Pakistan to investigate the cooking-fuel use patterns in rural Pakistan. Second, this study intends to untangle the factors influencing the choice of cooking fuel among rural households in Pakistan. The third objective is to employ an alternative measure of education and other key variables to check the robustness of the findings, and establish the causal linkage between education and the choice of clean energy for cooking. Fourth, it aims to use several different and observable measure of wealth to establish the causal relationship between wealth and fuel-choice behaviors.

4. Methods (data collection and data analysis)

4.1. Sampling and data [data collection]

The Pakistan Social and Living Standards Measurement Survey (PSLSMS), 2014-15 is the nationally-representative household dataset collected by the Pakistan Bureau of Statistics; hence, the standard procedures of the World Bank Living Standard Measurement Survey were followed in implementing the survey. It covers all Pakistan and a wide range of household variables. The Pakistan Bureau of Statistics designed the sampling frame for both urban and rural areas. The updated list of villages using the house listing of 2011 for the population census was taken as sampling frames for rural areas. Villages were the Primary Sampling Units (PSUs) for rural areas. A two-stage stratified sampling methodology was used to sample the households for the survey. Pursuing the proportion-to-size (PPS) approach, the PSUs were sampled. The number of households in the enumeration blocks was taken as a measure of size for both rural and urban areas.

Households listed in the sampled PSUs were taken as the Secondary Sampling Units(SSUs), and about 12 households from each urban sample SSU and 16 households from each rural sample PSU were chosen with equal probability using a systematic random sampling method. Hence 5428 sample blocks (PSUs), comprising 81,992 households (SSUs), were selected for the survey. Seven PSUs from Sindh, 13 PSUs from Khyber Pakhtunkhwa and 82 PSUs from Baluchistan (includes Panjgur and Kech districts) were not surveyed due to the security situation.

4.2. Methodology

Generally, households in developing countries use several types of cooking fuel, such as fuelwood, dung cake, crop residue, kerosene oil, natural gas, and electricity. The number of households using electricity for cooking is a small fraction, and it is not the primary source of cooking energy. Hence the primary cooking fuels can be divided into three types of fuel: fuelwood, dungcake and crop residue, and natural gas. In developing countries, households often use more than one type of fuel. However, the Pakistan Social and Living Standards Measurement Survey (PSLSMS), 2014-15 questionnaires only ask for the primary source of cooking fuel. Hence, our study focuses on the primary sources of cooking fuel in rural Pakistan. In our analysis, based on the primary cooking fuel, we classified the households into three mutually exclusive categories: (i) families using natural gas; (ii) families using fuelwood; and (iii) families using cake and residue. As the three discrete dependent variables are mutually exclusive, the multinomial logit model is best suited for the estimation.

5. Descriptive analysis

The description of variables used in the empirical analysis is presented in Table 1. In this section, we summarized the mean of the explanatory variables such as demographics, education, wealth and accessibility across the fuel types used in the econometric model.

5.1. Demographic

As the demographic variables such as the age of the household head, gender of the household head and the family size influence the household choice of fuel used for cooking, we provide the summary of the descriptive statistics to provide a quick overview of the relationship [54,66,79].

The average age of the head of the rural households was 44.7 years. The gender of the household head, i.e., 1 for the female and 0 for the males, indicates that only 8% of the rural household heads were females generally because of the absence of the male due to death or business/jobs in cities, etc. We noted that about 12% of the households using natural gas were female-headed households and only 8% using fuelwood were headed by female, suggesting the preference of clean energy by the female. The overall size of the households was about 6.57 members per household. The household with larger family size depends on fuelwood, and dung cake and crop residue because of surplus labour force needed for gathering firewood, dung and crop residue.

5.2. Education

Education influences the household decision to adopt clean energy [48,50,61,62] through the creation of awareness and increasing the opportunity cost of collection of fuelwood and dung cake for the educated member. Hence, this section reports the average education by fuel types to provide the glimpse of the relationship between education and fuel choice. The average education of the rural household head was 3.74 school years while the average education of the spouse of the household head was only 0.97 school years. The education of the household head using natural gas was 6.22 years of schooling followed by those households using fuelwood (3.61) and 2.98 for those using dung cake and residue. The education of the spouse of the household head using natural gas was 2.71 years of schooling followed by those households using dung cake and crop residue and 0.82 for those using fuelwood.

The mean education of the adult male was 4.58 school years while the mean education of the adult female was only 1.79 school years. The maximum education of the adult was 6.11 years of schooling. The average of the maximum years of schooling attained by the adult males and females was 5.46 and 2.56. The mean education of the children was 1.46, and the average education of the elderly family members was 0.22 school years. The maximum education of the elderly members was 0.25 years. The education of the oldest member of the family was 2.83 school years. About 54% of the rural population did not have any formal education; about 5% had attained less than primary school; 15% percent had completed primary school; 8% had completed middle school; 10% had completed secondary school, and only 4% had completed university. The result shows that education critically influences the household decision on cooking fuel choice in Pakistan. The family with higher education level are inclined to choose clean energy particularly gas and less inclined to use dung cake and crop residue. It is interesting to note that the education of head, spouse, elderly member, adult female, and males are equally important driver of the clean fuel choice for cooking by the household.

5.3. Wealth

Studies show that wealth influences household's clean energy choice decision [52,55,56,59], the inclusion of the wealth/asset variable is important in the energy choice model. The influence of wealth on the choice of clean energy comes from the fact that wealth increases the affordability. Although previous studies have used land and livestock as a measure of wealth [62,70], the large land and livestock asset could also lead to ample supply and the predominant use of crop residue and dung cake; therefore, we constructed the durable assets index. The straightforward and simple approach would be to add different durable asset variables and create a uni-dimensional assets index [80], but the downside of this approach is that it provides equal weight to all assets. Following the recent studies [81–84], we use a principal component analysis to compute the household assets index based on the durable assets (iron, fan, sewing machines, radio, clock, television, vcd, fridge, air cooler, air conditioner, computer, bicycle, motorcycle, car, truck, washing machine, micro oven, generator) owned by the household.

The overall average asset index was about 7.19, and it stood at 10.71 for those using natural gas, and it was 6.75 for those using fuelwood and 6.94 for those using crop residue and dung cake. The average agricultural land owned by rural households was 2.59 ha, and it was highest for those using fuelwood (2.78) followed by those using dung cake and crop residue (2.20). The average value of the non-agricultural land property was about Pakistani rupees 660,000 per household, and it stood at Pakistani rupees 1,360,000 for those using natural gas while it was Pakistani rupees 590,000 for those using fuelwood and Pakistani rupees 540,000 for those using dung cake and crop residue. The average number of livestock owned was 5.59 per household, and it was only 1.92 for those using natural gas for cooking.

Table 1
Descriptive statistics of the variables used in the study (rural).

Variable	Gas		Fuelwood		Dung & residue		Total rural	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Demographic								
Age of household head	46.13	13.10	44.42	13.28	45.03	13.38	44.72	13.29
Gender of the head (female)	0.12	0.32	0.08	0.27	0.08	0.27	0.08	0.27
Household size	6.47	3.07	6.60	3.10	6.52	3.01	6.57	3.08
Human Capital								
Education of the household head	6.22	5.40	3.61	4.67	2.98	4.10	3.74	4.72
Education of the spouse of the head	2.71	4.46	0.75	2.39	0.82	2.41	0.97	2.74
Mean education of adult	6.08	4.16	3.01	3.22	2.80	3.05	3.27	3.43
Mean education of adult male	6.94	5.04	4.35	4.55	3.70	4.05	4.47	4.58
Mean education of adult female	4.54	4.67	1.43	2.89	1.64	2.95	1.79	3.26
Max education of adult	9.52	5.23	5.83	5.31	5.38	4.97	6.11	5.36
Max education of adult male	8.12	5.55	5.32	5.24	4.67	4.81	5.46	5.27
Max education of adult female	5.98	5.72	2.09	3.99	2.42	4.12	2.56	4.38
Min education of adult	0.35	1.79	0.07	0.71	0.08	0.79	0.10	0.90
Mean education of the children	2.07	2.49	1.41	1.98	1.40	2.02	1.47	2.06
Mean education of the elderly	0.48	2.03	0.19	1.19	0.18	1.15	0.22	1.29
Max education of the elderly	0.55	2.25	0.22	1.33	0.21	1.29	0.25	1.44
Education of the oldest member	4.93	5.34	2.71	4.28	2.21	3.70	2.83	4.34
No education	34%		56%		59%		54%	
Below primary	4%		4%		6%		5%	
Primary completed	16%		15%		16%		15%	
Middle school completed	10%		8%		8%		8%	
Secondary school completed	18%		10%		8%		10%	
Sr secondary school completed	8%		4%		2%		4%	
University completed	10%		4%		2%		4%	
Wealth/Assets								
Assets Index	10.71	2.86	6.75	4.39	6.94	4.06	7.19	4.36
Agricultural land owned (hectares)	2.15	11.72	2.78	14.12	2.20	14.45	2.59	13.97
Value of non-agricultural land property (000000)	1.36	3.29	0.59	1.15	0.54	0.99	0.66	1.51
Livestock assets	1.92	9.34	6.34	34.27	4.94	13.10	5.59	29.18
No toilet	3%		24%		31%		24%	
Pit toilet	11%		33%		20%		28%	
Brick wall house	87%		48%		69%		56%	
Cement & tin roof	35%		11%		6%		13%	
Accessibility								
Distance to high school (within 30 min)	95%		61%		77%		68%	
Distance to store (within 30 min)	100%		92%		97%		94%	
Location: Province								
Khyber Pakhtunkhwa	19%		23%		5%		18%	
Punjab	52%		34%		78%		46%	
Sindh	22%		25%		14%		22%	
Baluchistan	7%		18%		4%		14%	
Number of households	6536		44,250		13,884		64,670	

Source: Authors' calculations.

About 24% of the rural households did not have toilet facilities; 28% percent had pit toilets, and 48% had a flush toilet while 86% of the rural households using natural gas for fuel have flush toilets. Approximately, 56% had brick wall houses. Although only 13% of the households had a cement or tin-roofed house, about 35% of the households using natural gas for fuel have a cement and metal-roofed house. The descriptive analysis points out that wealth is also one of the drivers of fuel choice by the household for cooking purpose. Richer household choose to use clean fuel such as gas because o their affordability while the poorer household depends on fuelwood, dung and crop residue because they cannot afford to pay for the price of the clean fuel. We also tested for the monotonicity between asset index and agricultural land holding and livestock assets we did not find a U or inverse U shape relation.

5.4. Location

Remoteness and access to market also influence the household decision to choice cooking fuel-fuelwood versus gas [57,85,86]; hence this paper uses the distance to high school and stores as a proxy for accessibility/remoteness. The distance of the high school (within 30 min by foot) indicates that only 68% of the households were within a 30-min distance from a high school. On the other hand, 94% of households can access the general store at this distance. The result confirms that proximity to market and school provides easy access to clean energy while remote household have easy access to fuelwood and are more likely to use fuelwood more. About 18% of the surveyed households were from the KPK 46% were from Punjab, 22% were from Sindh, and 14% were from Balochistan.

6. Result and discussion - empirical analysis

6.1. Choice of cooking energy using a multinomial logit model

The empirical analysis regarding the choice of the cooking fuel in the rural areas of Pakistan was carried out by employing a multinomial logit model. The dependent variables are the energy choices for cooking, i.e., natural gas, fuelwood and dung, and residues. The dung and residue category is used as the base category. The result of the multinomial logit model (odds ratio) of drivers of the fuel used for cooking is presented in Table 2. To check the validity of using the multinomial logit model, we performed a few tests and the findings which are summarized in Appendix A, indicate that the multinomial logit model is suitable for the analysis. First, we did Wald tests and LR

Table 2
Determinants of household choice of energy sources for cooking purposes using multinomial logit regression (marginal effect).

	Gas	Fuelwood	Dung cake & Crop residue
Demographic			
Age of household head	0.001** (0.000)	−0.002 (0.001)	0.001 (0.001)
Age square	−0.004 (0.000)	0.020* (0.000)	−0.016 (0.000)
Gender of the head (female)[a,b]	0.008* (0.004)	0.018 (0.017)	−0.026* (0.016)
Household size	−0.001*** (0.000)	−0.005* (0.003)	0.007** (0.003)
Human capital/education			
Below primary[a,c]	0.008 (0.006)	−0.025** (0.011)	0.017 (0.010)
Primary completed[a,c]	0.004 (0.003)	0.021** (0.009)	−0.025** (0.008)
Middle school completed[a,c]	0.006** (0.003)	0.042*** (0.012)	−0.048*** (0.012)
Secondary school completed[a,c]	0.015*** (0.004)	0.053*** (0.012)	−0.068*** (0.011)
Sr. secondary school completed[a,c]	0.013*** (0.005)	0.056*** (0.014)	−0.069*** (0.013)
University completed[a,c]	0.018*** (0.006)	0.057*** (0.014)	−0.075*** (0.012)
Assets/wealth			
Assets index	0.010*** (0.001)	−0.006* (0.003)	−0.004 (0.003)
Agricultural land owned (hectares)	−0.001*** (0.000)	0.001** (0.000)	0.000 (0.000)
Value of non-agricultural land property	0.005*** (0.001)	0.019* (0.010)	−0.024** (0.011)
Livestock assets	−0.004*** (0.001)	0.003*** (0.001)	0.003 (0.001)
Access to facilities			
Distance to high school (within 30 min)[a,d]	0.052*** (0.008)	−0.092*** (0.022)	0.040* (0.021)
Province			
Khyber Pakhtunkhwa (KPK)[a,e]	0.001 (0.018)	−0.015 (0.065)	0.014 (0.062)
Punjab[a,e]	0.002 (0.014)	−0.386*** (0.079)	0.385*** (0.079)
Sindh[a,e]	0.036 (0.023)	−0.190** (0.086)	0.154* (0.089)
Number of observation	64,670		
Wald chi2(36)	1134		
Prob > chi2	0.000		
Pseudo R2	0.183		
Log pseudolikelihood	−43,430		

Notes: marginal effect reported.
Base category is dung and crop residue.
Robust standard errors in parentheses.
*** = 1% level of significance, ** = 5% level of significance, * = 10% level of significance.
Source: Authors' calculations.
[a]dummy variables.
[b] excluded category: male head.
[c] excluded category: household head without any formal education.
[d] excluded category: households which are 30 min away from high schools.
[f] excluded category: Baluchistan.

tests for combining alternatives to test that all of the coefficients associated with an independent variable are simultaneously equal to zero. Second, we conducted the likelihood-ratio and Wald test for independent variables to inspect whether or not the independent variables differentiate between two outcomes; this test is generally used to find out if two outcomes can be combined. Third, we estimated a Small-Hsiao tests of IIA assumption to evaluate the assumption of the independence of irrelevant alternatives. The coefficient of correlation presented in Appendix G confirms that there is no multicollinearity problems among the dependent variables used in Table 2.

6.1.1. Demographic

The result shows that with one year increase in the age of the household head, the probability of adoption of gas for cooking increases by 0.1%. The coefficient of the dummy gender of the household head (1 for the female and 0 for the male) is positive and significant for natural gas, but positive and non-significant for fuelwood and negative and significant for dung cake and crop residue which is an indication that female-headed households are using more gas for cooking and less dung cake and crop residue in the rural areas of Pakistan. On an average, compared to male-headed household female-headed households are 0.8% point more likely to use gas and 2.6% point less likely to use dung cake and crop residue. As the female members of the household are mostly responsible for collecting fuel and cooking, when the female members are in charge of the decision-making, they tend to choose fuel which is convenient and easy to use. Some studies have also found the preference of the female-headed households for modern fuels [48,49]. Contrary to our findings, there are some research which have found that the coefficient of the female head dummy is insignificant. [50,51,87]

The coefficient of the household size is negative and significant for both natural gas and fuelwood and positive and significant for dung cake and crop residue, which shows that households with large families are less likely to use natural gas and fuelwood compared to dung cake and crop residue. With the increase in the family member by one, the household are less likely to use gas by 0.1% and fuelwood by 0.5% and more likely to use dung cake and crop residue by 0.7% point. As large families require more cooking fuel, households with large families are more likely to use inexpensive sources of fuel such as dung cake and crop residue. The result of the current studies on the positive correlation between the household size and preference for dirty fuel concur with the findings from other studies such as [49,50,72,88]and [89]. Our finding runs opposite to that of [86,90,91] which found a positive correlation between household size and clean fuel.

6.1.2. Education

To capture the role of education, we use the dummy variable on the level of schooling completed by the household head viz no formal education, below primary, primary, middle, secondary and university education and the results are interesting and confirm previous studies. The coefficient of the level of education is positive and progressively increasing and significant at the 1% level of significance for the use of natural gas and fuelwood compared to the households using dung-cake and crop residue. Compared to household with illiterate head, the probability of using gas is 0.6% higher for the household whose head has completed middle school, and it is 1.3% higher for those household whose head have completed high school and 1.8% higher for university completed. Similarly, the probability of using fuelwood in rural Pakistan is 2.1% higher for primary completed and 4.2% higher for middle school completed and 5.7% higher for those who have completed university compared to illiterate. However, the probability of using dung and crop residue is −2.5% for household whose head have completed primary and −4.8% for those household whose head have completed middle school and −7.5% for those household whose head have completed university. The results indicate that the higher the education levels, the higher the chances that households will use gas and fuelwood for cooking compared to dung and residue. Similar to the current paper, several studies have documented the positive influence of education in switching from dirty to clean fuel [51,52,73,79,86,91–93].

6.1.3. Wealth

The assets index is positive but significant at the 1% level of significance for households using natural gas implying that rich households in the rural areas of Pakistan are more likely to use natural gas. With the increase in asset index by 1% point the probability of using gas increases by 1% point and the probability of using fuelwood decreases by 0.6% point. The non-agricultural land property is positive (+0.5% and 1.9%) and significant at the 1% level of significance for natural gas and fuelwood, indicating that households with more non-agricultural land are mostly using natural gas and fuelwood. The likelihood of using dung cake and crop residue −2.4% and significant at 5% level of significance. The findings of the current research concur with the findings of most of the previous studies such as [47,62]. The livestock and agricultural land ownership is negative and significant for the use of natural gas, indicating that the households with more livestock and agricultural land are mostly using dung cake and crop residue. The probability of using gas decreases by 0.1% point and the probability of using fuelwood increases by 0.1% point with the increase in one hectare agricultural land. Similarly, the probability of using gas decreases by 0.4% point and the probability of using fuelwood increases by 0.3% point with the increase in one tropical livestock unit (TLU). Our findings are contrary to the findings of some of the previous research such as [70,94].

6.1.4. Location

The access to facilities is vital for using clean sources of fuel. In the current study, we use the dummy variable (if the household is within 30 min from a high school, it is equal to 1, otherwise zero) and the result is +5.2% and significant at the 1% level of significance for the use of natural gas. The coefficient of distance to high school is −9.2% and significant at the 5% level of significance for the use of fuelwood. The result on the access to facilities shows that households with better access to modern facilities have access to natural gas and are more likely to use it, and the households which are disconnected from modern facilities tend to use dung cake and crop residue. The result of the location concurs with the results from previous studies, such as [57,86,95–97].

To establish the rigor of the main findings reported in Table 2, we estimate a multinomial logit model with alternate specifications, particularly for education and wealth and present selected results in Appendix B (Table B1). In Appendix B, we estimated a multinomial logit model with the same dependent variables (i.e., natural gas, fuelwood and dung and residues) and the explanatory variables listed in Table 2 of the manuscript, except for those explanatory variables, which were replaced with the alternative specification. We estimated the model separately, and due to space constraints and for clarity, only the substituting variables are reported in the Appendix. The finding strongly supports the main findings reported in Table 2.

Sometimes the use of a large sample size in analysis results in significant findings; hence, it is necessary to perform the same analysis with a small sample and compare the results. Such analysis is normally called sensitivity analysis because we would like to estimate if the findings are sensitive to the changes in the sample size. Even with the use of a smaller sample size, if the results do not change significantly, the finding are regarded as robust. To perform the sensitivity analysis, we apply the same estimation methods (i.e., multinomial logit) and dependent and independent variables to re-estimate the functions by using different random combinations of the samples. The samples are randomly selected using a computer program, which arbitrarily selects different samples from every random selection. Appendix C (Table C1.) presents the estimated functions applying a multinomial logit model explaining the choices of energy for cooking. The result confirms our findings reported in Table 2.

Further in Appendix D, E and F to check the robustness of our findings, we ordered the sources of fuel into three categories (natural gas, fuelwood, and dung cake and crop residue) and estimated the ordered probit model (See Appendix D.1). The results of the ordered probit were similar to the results obtained from the multinomial logit model, confirming the strength of the findings reported in this section. In Appendix E, we estimated alternative specification and found similar result. We estimated the model separately, and due to space constraints and for clarity, only the substituting variables are reported in the manuscript. At times the use of a large sample size in analysis results in significant findings; hence, we performed the ordered probit analysis with a small sample (75%. 50% and 25%) and found similar results.

7. Conclusion and policy implications

The current study employs comprehensive data set from Pakistan Social and Living Standards Measurement Survey 2014 covering 64,670 rural households. The empirical results show that gender, education, wealth and location are the drivers of the fuel choices made by the rural households. We found that the female-headed households are more likely to use clean and convenient sources of fuel, such as natural gas for cooking. As the female member are responsible for fuel collection and cooking, the household tends to use clean fuel when the females make the decisions in the household. The household size indicates the labour force available in the family: a family with more individuals tends to depend on dung and crop residue as there is a lot of free labor in bigger families.

Education emerges as the critical factor which influences the choice of fuel for cooking purposes. The results show that educated households are more likely to use clean fuel for cooking, while households with a lower level of education are more likely to use dirty fuel. With education, individuals are aware of the harmful effects of dirty fuel and tend to avoid its use. Educated households are more likely to have higher incomes; hence, they can afford to purchase clean fuel.

Results confirm that wealth also drives the household decision on the fuel choice: rich families tend to use clean and convenient sources of energy such as natural gas while low-income families tend to use dirty traditional fuels. However, it is not as important as education in terms of driving the adoption of clean energy. The influence of wealth on fuel choice arises from three situations: first affordability; second, awareness of the health cost of using dirty fuels; and third, the opportunity cost of gathering dung and crop residue. The findings show that the access to facilities and fuel sources is an important determinant of a household's fuel choice for domestic purposes. Families who are far away are more likely to depend on fuelwood and dung and crop residue. One of the limitations of the current study is that the survey data has information only on primary fuel use and do not have information on secondary fuel use. If multiple sources of fuel used by the households is available in the dataset and it is used in analyzing the fuel choice, the preferred model would be multivariate probit model, and the result may change. However, we compared with a large number of research, which analyzes multiple sources of data and our socioeconomic variables influencing the energy choice is similar.

As the results are based on an extensive dataset, it has significant policy implications for Pakistan and other developing countries. The government policy should focus on both supply and demand, ensuring an adequate supply of clean fuel and create awareness about the harmful effect of using dirty fuel, by educating the populace and providing fuel subsidies for low-income households.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.esr.2019.03.005.

References

[1] K. Kaygusuz, Energy for sustainable development: a case of developing countries, Renew. Sustain. Energy Rev. 16 (2012) 1116–1126.

[2] D.B. Rahut, S. Das, H. De Groote, B. Behera, Determinants of household energy use in Bhutan, Energy 69 (2014) 661–672.

[3] IEA, World Energy Outlook, IEA Publications, International Energy Agency, 2017 Website: www.iea.org 75739 Paris Cedex 15 France.

[4] A. Ghilardi, A. Tarter, R. Bailis, Potential environmental benefits from woodfuel transitions in Haiti: geospatial scenarios to 2027, Environ. Res. Lett. 13 (2018).

[5] R. Bailis, Y. Wang, R. Drigo, A. Ghilardi, O. Masera, Getting the numbers right: revisiting woodfuel sustainability in the developing world, Environ. Res. Lett. 12 (2017).

[6] O.R. Masera, R. Bailis, R. Drigo, A. Ghilardi, I. Ruiz-Mercado, Environmental burden of traditional bioenergy use, Annu. Rev. Environ. Resour. (2015) 121–150.

[7] R. Bailis, R. Drigo, A. Ghilardi, O. Masera, The carbon footprint of traditional woodfuels, Nat. Clim. Change 5 (2015) 266–272.

[8] R. Bailis, B.D. Solomon, C. Moser, T. Hildebrandt, Biofuel sustainability in Latin America and the Caribbean - a review of recent experiences and future prospects, Biofuels 5 (2014) 469–485.

[9] R. Bailis, J.L. Chatellier, A. Ghilardi, Ecological sustainability of woodfuel as an energy source in rural communities, Integrating Ecology and Poverty Reduction, Ecological Dimensions (2013) 299–325.

[10] U. AGECC, Energy for a Sustainable Future: Summary Report and Recommendations', UN (United Nations)/The Secretary-General's Advisory Group on Energy and Climate Change. New York, USA, (2010).

[11] L.T. Ingale, K.J. Dube, D.B. Sarode, S.B. Attarde, S.T. Ingle, Monitoring and respiratory health assessment of the population exposed to cooking fuel emissions in a rural area of Jalgaon District, India, Asia Pac. J. Public Health 25 (2013) 463–475.

[12] O. Oguntoke, A.T. Adebulehin, H.J. Annegarn, Biomass energy utilisation, air quality and the health of rural women and children in Ido LGA, South-Western Nigeria, Indoor Built Environ. 22 (2013) 528–534.

[13] O. Oluwole, G.R. Ana, G.O. Arinola, T. Wiskel, A.G. Falusi, D.Z. Huo, O.I. Olopade, C.O. Olopade, Effect of stove intervention on household air pollution and the respiratory health of women and children in rural Nigeria, Air Quality, Atmosphere and Health 6 (2013) 553–561.

[14] D. Sanyal, M. Maduna, Possible relationship between indoor pollution and respiratory illness in an Eastern Cape community, South Afr. J. Sci. 96 (2000) 94–96.

[15] C. Torres-Duque, D. Maldonado, R. Pérez-Padilla, M. Ezzati, G. Viegi, Biomass fuels and respiratory diseases: a review of the evidence, Proc. Am. Thorac. Soc. 5 (2008) 577–590.

[16] D.G. Fullerton, N. Bruce, S.B. Gordon, Indoor air pollution from biomass fuel smoke is a major health concern in the developing world, Trans. R. Soc. Trop. Med. Hyg. 102 (2008) 843–851.

[17] G. Hassan, Q. Waseem, S. Kadri, A. Manzoor, K. Sajad, M. Omer, Domestic smoke pollution from biomass fuel combustion and increased prevalence of cataracts in Jammu and Kashmir, India, Ann. Trop. Med. Public Health 2 (2009) 31.

[18] K.-H. Kim, S.A. Jahan, E. Kabir, A review of diseases associated with household air pollution due to the use of biomass fuels, J. Hazard Mater. 192 (2011) 425–431.

[19] P. Lakshmi, N.K. Virdi, J. Thakur, K.R. Smith, M.N. Bates, R. Kumar, Biomass fuel and risk of tuberculosis: a case–control study from Northern India, J. Epidemiol. Community Health 66 (5) (2010) 457–461 jech. 2010.115840.

[20] V.K. Mishra, R.D. Retherford, K.R. Smith, Cooking with Biomass Fuels Increases the Risk of Tuberculosis, (1999).

[21] B.H.M. Ngahane, E.A. Ze, C. Chebu, N.Y. Mapoure, E. Temfack, M. Nganda, N.H. Luma, Effects of cooking fuel smoke on respiratory symptoms and lung function in semi-rural women in Cameroon, Int. J. Occup. Environ. Health 21 (2015) 61–65.

[22] K.P. Pant, Valuing interventions to reduce indoor air pollution—fuelwood, deforestation, and health in Rural Nepal, Pakistan Dev. Rev. (2007) 1169–1187.

[23] K.P. Pant, Cheaper fuel and higher health costs among the poor in rural Nepal, Ambio 41 (2012) 271–283.

[24] J. Pérez-Padilla, J. Regalado-Pineda, A. Moran-Mendoza, The domestic inhalation of the smoke from firewood and of other biological materials. A risk for the development of respiratory diseases, Gac. Med. Mex. 135 (1998) 19–29.

[25] R. Perez-Padilla, C. Perez-Guzman, R. Baez-Saldana, A. Torres-Cruz, Cooking with biomass stoves and tuberculosis: a case control study, Int. J. Tuberc. Lung Dis. 5 (2001) 441–447.

[26] A.K. Pokhrel, M.N. Bates, S.P. Shrestha, I.L. Bailey, R.B. DiMartino, K.R. Smith, Biomass stoves and lens opacity and cataract in Nepalese women, Optom. Vis. Sci. 90 (2013) 257–268.

[27] A.K. Pokhrel, M.N. Bates, S.C. Verma, H.S. Joshi, C.T. Sreeramareddy, K.R. Smith, Tuberculosis and indoor biomass and kerosene use in Nepal: a case-control study, Environ. Health Perspect. 118 (2010) 558.

[28] A.K. Pokhrel, K.R. Smith, A. Khalakdina, A. Deuja, M.N. Bates, Case–control study of indoor cooking smoke exposure and cataract in Nepal and India, Int. J. Epidemiol. 34 (2005) 702–708.

[29] H. Riojas-Rodríguez, P. Romano-Riquer, C. Santos-Burgoa, K.R. Smith, Household firewood use and the health of children and women of Indian communities in Chiapas, Mexico, Int. J. Occup. Environ. Health 7 (2001) 44–53.

[30] U. Singh, A. Garg, B. Rani, R. Maheshwari, M. Prasad, Indoor air pollution & its impact on public health: a review, Advances Biores 3 (2012) 21–26.

[31] N.D. Sukhsohale, U.W. Narlawar, M.S. Phatak, Indoor air pollution from biomass combustion and its adverse health effects in central India: an exposure-response study, Indian J. Community Med.: official publication of Indian Association of Preventive & Social Medicine 38 (2013) 162.

[32] B. Vipin, S.M. Iqbal, L.P. Srivastava, C. Kesavachandran, Menstrual impairment among adolescents exposed to biomass fuel smoke, J. Environ. Biol. 35 (2014) 273–277.

[33] D.B. Rahut, A. Ali, B. Behera, Domestic use of dirty energy and its effects on human health: empirical evidence from Bhutan, Int. J. Sustain. Energy 36 (2017) 983–993.

[34] B. Behera, D.B. Rahut, A. Jeetendra, A. Ali, Household collection and use of biomass energy sources in South Asia, Energy 85 (2015) 468–480.

[35] G. Leach, Energy and food production, Food Policy 1 (1975) 62–73.

[36] G. Leach, The energy transition, Energy Policy 20 (1992) 116–123.

[37] D.F. Barnes, K. Krutilla, W. Hyde, The Urban Energy Transition—Energy, Poverty, and the Environment: Two Decades of Research, Forthcoming book volume, 2002.

[38] D.F. Barnes, W. Floor, Biomass energy and the poor in the developing world, J. Int. Aff. 53 (1999) 237.

[39] M. Narasimha Rao, B.S. Reddy, Variations in energy use by Indian households: an analysis of micro level data, Energy 32 (2007) 143–153.

[40] V. Daioglou, B.J. Van Ruijven, D.P. Van Vuuren, Model projections for household energy use in developing countries, Energy 37 (2012) 601–615.

[41] P. Hills, Household energy transition in Hong Kong, Energy 19 (1994) 517–528.

[42] E. Rehfuess, S. Mehta, A. Prüss-Üstün, Assessing household solid fuel use: multiple implications for the millennium development goals, Environ. Health Perspect. (2006) 373–378.

[43] N. Bruce, R. Perez-Padilla, R. Albalak, Indoor air pollution in developing countries: a major environmental and public health challenge, Bull. World Health Organ. 78 (2000) 1078–1092.

[44] J.P. Holdren, K.R. Smith, T. Kjellstrom, D. Streets, X. Wang, S. Fischer, Energy, the Environment and Health, United Nations Development Programme, New York, 2000.

[45] O.R. Masera, B.D. Saatkamp, D.M. Kammen, From linear fuel switching to multiple cooking strategies: a critique and alternative to the energy ladder model, World Dev. 28 (2000) 2083–2103.

[46] A. Nansaior, A. Patanothai, A.T. Rambo, S. Simaraks, Climbing the energy ladder or diversifying energy sources? The continuing importance of household use of biomass energy in urbanizing communities in Northeast Thailand, Biomass Bioenergy 35 (2011) 4180–4188.

[47] D.B. Rahut, B. Behera, A. Ali, Factors determining household use of clean and renewable energy sources for lighting in Sub-Saharan Africa, Renew. Sustain. Energy Rev. 72 (2017) 661–672.

[48] M. Farsi, M. Filippini, S. Pachauri, Fuel choices in urban Indian households, Environ. Dev. Econ. 12 (2007) 757–774.

[49] M.N. Rao, B.S. Reddy, Variations in energy use by Indian households: an analysis of micro level data, Energy 32 (2007) 143–153.

[50] B. Ouedraogo, Household energy preferences for cooking in urban Ouagadougou, Burkina Faso, Energy Policy 34 (2006) 3787–3795.

[51] D. Abebaw, Household determinants of fuelwood choice in urban Ethiopia: a case study of Jimma Town, J. Dev. Areas (2007) 117–126.

[52] R. Heltberg, Fuel switching: evidence from eight developing countries, Energy Econ. 26 (2004) 869–887.

[53] D.B. Rahut, B. Behera, A. Ali, P. Marenya, A ladder within a ladder: understanding the factors influencing a household's domestic use of electricity in four African countries, Energy Econ. 66 (2017) 167–181.

[54] B.-D. Hou, X. Tang, C. Ma, L. Liu, Y.-M. Wei, H. Liao, Cooking fuel choice in rural China: results from microdata, J. Clean. Prod. 142 (2017) 538–547 Part 2.

[55] J.T. Mensah, G. Marbuah, A. Amoah, Energy demand in Ghana: a disaggregated analysis, Renew. Sustain. Energy Rev. 53 (2016) 924–935.

[56] J.T. Mensah, G. Adu, An empirical analysis of household energy choice in Ghana, Renew. Sustain. Energy Rev. 51 (2015) 1402–1411.

[57] A. Karimu, Cooking fuel preferences among Ghanaian Households: an empirical analysis, Energy for Sustainable Development 27 (2015) 10–17.

[58] S.R. Khandker, D.F. Barnes, H.A. Samad, Are the energy poor also income poor? Evidence from India, Energy Policy 47 (2012) 1–12.

[59] D.B. Rahut, K.A. Mottaleb, A. Ali, J.P. Aryal, Energy consumption transition through the use of electricity for lighting and cooking: evidence from Bhutan, Renewable Energy Focus 18 (2017) 11–21.

[60] D.B. Rahut, K.A. Mottaleb, A. Ali, J. Aryal, The use and determinants of solar energy by Sub-Saharan African households, Int. J. Sustain. Energy (2017) 1–18.

[61] D.B. Rahut, K.A. Mottaleb, A. Ali, Household energy consumption and its determinants in Timor-Leste, Asian Dev. Rev. 34 (2017) 167–197.

[62] D.B. Rahut, A. Ali, K.A. Mottaleb, Understanding the determinants of alternate energy options for cooking in the Himalayas: empirical evidence from the

Himalayan region of Pakistan, J. Clean. Prod. 149 (2017) 528–539.
[63] K.A. Mottaleb, D.B. Rahut, A. Ali, An Exploration into the Household Energy Choice and Expenditure in Bangladesh, Energy, 2017.
[64] R. Heltberg, Factors determining household fuel choice in Guatemala, Environ. Dev. Econ. 10 (2005) 337–361.
[65] W.-H. Huang, The determinants of household electricity consumption in Taiwan: evidence from quantile regression, Energy 87 (2015) 120–133.
[66] J. Gregory, D.I. Stern, Biomass Bioenergy, Fuel Choices in Rural Maharashtra vol. 70, (2014) 302–314.
[67] L. Baiyegunhi, M. Hassan, Rural household fuel energy transition: evidence from Giwa LGA Kaduna state, Nigeria, Energy for Sustainable Development 20 (2014) 30–35.
[68] S. Pachauri, A. Mueller, A. Kemmler, D. Spreng, On measuring energy poverty in Indian households, World Dev. 32 (2004) 2083–2104.
[69] J.W. Arntzen, D.L. Kgathi, Some of the determinants of the consumption of firewood energy in developing countries: the case of rural Botswana.Botswana, J. Afr. Stud. 4 (1984) 24–35.
[70] R. Heltberg, T.C. Arndt, N.U. Sekhar, Fuelwood consumption and forest degradation: a household model for domestic energy substitution in rural India, Land Econ. (2000) 213–232.
[71] D.B. Rahut, B. Behera, A. Ali, Patterns and determinants of household use of fuels for cooking: empirical evidence from sub-Saharan Africa, Energy 117 (2016) 93–104.
[72] V.L. Pandey, A. Chaubal, Comprehending household cooking energy choice in rural India, Biomass Bioenergy 35 (2011) 4724–4731.
[73] B.S. Reddy, T. Srinivas, Energy use in Indian household sector–An actor-oriented approach, Energy 34 (2009) 992–1002.
[74] S. Pachauri, L. Jiang, The household energy transition in India and China, Energy Policy 36 (2008) 4022–4035.
[75] D. Israel, Fuel choice in developing countries: evidence from Bolivia*, Econ. Dev. Cult. Change 50 (2002) 865–890.
[76] M. Nepal, A. Nepal, K. Grimsrud, Unbelievable but improved cookstoves are not helpful in reducing firewood demand in Nepal, Environ. Dev. Econ. 16 (2011) 1–23.
[77] B.C. Farhar, Gender and renewable energy: policy, analysis, and market implications, Renew. Energy 15 (1998) 230–239.
[78] P.A. Dewees, The woodfuel crisis reconsidered: observations on the dynamics of abundance and scarcity, World Dev. 17 (1989) 1159–1172.
[79] T. Ekholm, V. Krey, S. Pachauri, K. Riahi, Determinants of household energy consumption in India, Energy Policy 38 (2010) 5696–5707.
[80] M.R. Montgomery, M. Gragnolati, K.A. Burke, E. Paredes, Measuring living standards with proxy variables, Demography 37 (2000) 155–174.
[81] D. Gwatkin, S. Rutstein, K. Johnson, R. Pande, A. Wagstaff, Socio-economic Differences in Health, Nutrition and Poverty, World Bank: HNP/Poverty Thematic Group, World Bank, Washington, DC, 2000.
[82] D. Filmer, L.H. Pritchett, Estimating wealth effects without expenditure data—or tears: an application to educational enrollments in states of India, Demography 38 (2001) 115–132.
[83] D.J. McKenzie, Measuring inequality with asset indicators, J. Popul. Econ. 18 (2005) 229–260.
[84] D.B. Rahut, K.A. Mottaleb, A. Ali, Rural livelihood diversification strategies and household welfare in Bhutan, Eur. J. Dev. Res. (2017) 1–31.
[85] D.B. Rahut, B. Behera, A. Ali, Household energy choice and consumption intensity: empirical evidence from Bhutan, Renew. Sustain. Energy Rev. 53 (2016) 993–1009.
[86] L.J.S. Baiyegunhi, M.B. Hassan, Rural household fuel energy transition: evidence from Giwa LGA Kaduna state, Nigeria, Energy for Sustainable Development 20 (2014) 30–35.
[87] L. An, F. Lupi, J. Liu, M.A. Linderman, J. Huang, Modeling the choice to switch from fuelwood to electricity: implications for giant panda habitat conservation, Ecol. Econ. 42 (2002) 445–457.
[88] B. Sudhakara Reddy, A multilogit model for fuel shifts in the domestic sector, Energy 20 (1995) 929–936.
[89] K.M. Özcan, E. Gülay, Ş. Üçdoğruk, Economic and demographic determinants of household energy use in Turkey, Energy Policy 60 (2013) 550–557.
[90] R.H. Hosier, J. Dowd, Household fuel choice in Zimbabwe: an empirical test of the energy ladder hypothesis, Resour. Energy 9 (1987) 347–361.
[91] G. Gupta, G. Köhlin, Preferences for domestic fuel: analysis with socio-economic factors and rankings in Kolkata, India, Ecol. Econ. 57 (2006) 107–121.
[92] P.A. Kwakwa, E.D. Wiafe, H. Alhassan, Households energy choice in Ghana, J. Empir. Econ. 1 (2013) 96–103.
[93] N. Onyekuru, E. Eboh, Determinants of cooking energy demand in the rural households of Enugu State, Nigeria: an application of the Bivariate Probit model, Asian Journal Experimental Biological Science 2 (2011) 332–335.
[94] J.W. Arntzen, D. Kgathi, Some of the Determinants of the Consumption of Firewood Energy in Developing Countries: the Case of Rural Botswana, National Inst. of Development Research and Documentation, 1984.
[95] D.B. Rahut, A. Ali, B. Behera, Domestic use of dirty energy and its effects on human health: empirical evidence from Bhutan, Int. J. Sustain. Energy (2016) 1–11.
[96] B. Behera, D.B. Rahut, A. Jeetendra, A. Ali, Household collection and use of biomass energy sources in South Asia, Energy 85 (2015) 468–480.
[97] D.B. Rahut, S. Das, H. De Groote, B. Behera, Determinants of household energy use in Bhutan, Energy 69 (2014) 661–672.