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Patterns of Household Energy Sources in Rural Pakistan

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Abstract

Household energy consumption plays a vital role in improving living standards, promoting sustainable development, and enhancing the socioeconomic well-being of rural communities. However, many rural households in Pakistan continue to rely on a combination of traditional and modern energy sources due to differences in socioeconomic conditions, infrastructure, and access to energy resources. This study aimed to examine the patterns of household energy sources used for cooking, heating, and lighting in rural District Chitral and to investigate the association between household characteristics and energy choices. A quantitative research approach with a cross-sectional survey design was adopted. Primary data were collected from household heads using a structured questionnaire, while descriptive statistics and the Chi-square test were employed to analyze the data and examine the relationships between household characteristics and energy sources. The findings indicate that traditional biomass, particularly firewood, remains the dominant source of energy for cooking and heating, whereas electricity is the primary source for lighting. The study further reveals that households commonly practice energy stacking by combining traditional and modern fuels to satisfy different domestic energy needs. Household energy choices were found to be significantly associated with several demographic, socioeconomic, and accessibility factors, including education, occupation, household income, electricity availability, and proximity to energy resources. The study concludes that improving access to affordable and reliable modern energy, together with socioeconomic development and infrastructure expansion, is essential for promoting a gradual transition towards cleaner household energy use in rural Pakistan.

Keywords: Household Energy, Rural Households, Energy Consumption Patterns, Energy Choice, Biomass Energy, Chi-Square Analysis, District Chitral

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1: Introduction

Energy is one of the fundamental drivers of economic development and household welfare. At the household level, energy is indispensable for cooking, heating, lighting, and other domestic activities. The type of energy used by households has significant implications for health, environmental sustainability, and overall living standards. Consequently, household energy consumption has become an important development issue, particularly in developing countries where access to clean and modern energy sources remains limited.

In many developing countries, households continue to rely heavily on traditional biomass fuels such as firewood, animal dung, charcoal, crop residues, and leaves to meet their daily energy requirements because modern energy sources are either unavailable or unaffordable. According to the International Energy Agency (IEA, 2006), more than two billion people depended on biomass for their household energy needs, and this figure was projected to increase to approximately 2.7 billion by 2030 due to population growth. Continued dependence on traditional fuels has adverse consequences for public health, environmental quality, and sustainable development.

Providing affordable and clean household energy is indispensable for poverty alleviation and rural development (Ekholm et al., 2010). However, the limited availability of modern energy supplies has compelled rural communities in many developing countries to rely extensively on traditional biomass fuels. Barnes and Flor (1996) reported that the lack of convenient and modern energy sources affects nearly 90 percent of the population in several developing countries, thereby restricting improvements in household welfare and economic opportunities.

Pakistan faces similar challenges in meeting the growing demand for household energy. A substantial proportion of rural households lack access to reliable and modern energy sources and therefore depend on inefficient fuels such as firewood, kerosene, and animal or plant residues for cooking and heating. Pakistan's energy sector has struggled to satisfy increasing demand because of its overreliance on petroleum fuels, rising oil prices, climate-related challenges, inadequate development of alternative energy resources, and limited technological advancement (Hasan, Subhani & Osman, 2012; Kucukali & Baris, 2010). Consequently, the country has experienced persistent energy shortages, with the electricity shortfall exceeding 6,000 megawatts in 2011 compared with 4,000 megawatts in 2004 (Amer & Daim, 2011). Moreover, energy demand has continued to rise as a result of industrialization, urbanization, rural electrification, and increasing use of electrical appliances (Government of Pakistan, 2007–08).

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Although electricity has become the dominant source of lighting because of expanding rural electrification, traditional fuels remain the primary energy sources for cooking and heating in rural Pakistan. Firewood, in particular, continues to account for a large share of household energy consumption (Mirsa & Kemp, 2009; Jan et al., 2012). Household energy use, however, is not uniform across rural communities. The choice of energy sources varies according to household characteristics and local conditions, with many households simultaneously using both traditional and modern fuels to satisfy different domestic energy needs. Factors such as household income, education, employment, household size, access to electricity, ownership of agricultural land and livestock, and housing conditions are expected to influence these energy choices.

Despite the importance of household energy consumption for rural livelihoods, relatively little empirical evidence exists on the patterns of household energy use and the socio-economic factors determining these patterns in rural Pakistan, particularly in remote districts such as Chitral. Understanding how rural households combine different energy sources and the factors influencing their choices is essential for designing effective energy, environmental, and rural development policies. Therefore, this study examines the patterns of household energy sources used by rural households in District Chitral, Pakistan, and investigates the socio-economic and demographic factors that determine households' choice of different energy sources.

2: Literature Review

Arfin et al. (2014) focused their attention on fuel wood consumption. They find that in some third-world countries, rural areas landowners can gather crop residues and firewood from their property, while the poor and landless people depend on wood from public and common lands, or they may be allowed to collect the wood and residues in exchange for their labor. Arabatzis et al. (2012) used the McFadden (1972) model to estimate the fuel wood demand and estimated the probability of households using fuelwood and then modified the selection bias in the fuel wood demand estimation. They derived a negative relationship between wood consumption and price (price elasticity -0.08), and between wood consumption and income. As the authors assimilated the decision to prefer fuel wood in studying the consumption of fuel wood. They did not make a distinction or differentiate between the various available options relating to the use of such energy. Fuel wood can be seen as the primary or secondary source of heating energy used purely for pleasure. i.e., Households use wood in their fireplace for comfort and pleasure. Various factors, both observable and unobservable, determine the choice to use fuel wood.

Traditional sources of energy are easily accessible and affordable for most rural households. Their use, however, has serious implications for health, the environment, and biodiversity. A higher demand for firewood can result in deforestation, loss of biodiversity, land erosion, and other types of harm to the environment (Specht et al., 2015; Orioogunje & Asifat, 2015; . In addition, burning animal/plant residue creates indoor pollution that can cause several respiratory and lung diseases (Moeen et al., 2016).

Van der Kroon et al (2013) describes energy preference using a framework that revolves around three categories, i.e., decision context like government policies, external environment like climate and geographical location, and household opportunity set like characteristics and factor endowments. Failing to take this preference into account can result in selection bias.

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Wu et al. (2019) argued that more than 1.4 billion people worldwide lack access to clean energy such as electricity, while 2.7 billion people rely on dirty energy such as biomass and fuel wood for cooking. Miah et al. (2010); and Yawale et al. (2021) also state that most households, particularly in rural areas in developing economies, lack access to clean energy sources such as electricity, even though demand for clean energy consistently increases in line with rising household incomes in these economies. Inadequate supply, the consequent high costs, and a lack of purchasing power are the major barriers to a household's conversion to clean energy sources in developing economies.

According to the "energy ladder" model that originated some decades ago (Masera et al., 2000) found that the households which have low income depend on biomass fuels, while those household which have higher incomes consume more efficient and more expensive types of energy, such as fuel oil, natural gas, or electricity.

The energy ladder hypothesis proposes that as household income and awareness increase, families gradually shift from traditional biomass fuels to cleaner and more efficient energy sources such as kerosene, liquefied petroleum gas (LPG), natural gas, and electricity (Leach, 1992; Heltberg, 2004). However, empirical evidence suggests that this transition is rarely complete, as many households continue to use multiple fuels simultaneously because of differences in fuel prices, accessibility, reliability, and cultural preferences (Hosier & Dowd, 1987; Masera et al., 2000; Van der Kroon et al., 2013).

Heltberg, R. (2004) examined the determinants of household energy demand and found that energy consumption and fuel choice are influenced by household income, energy prices, education, infrastructure, and access to modern energy sources. While higher income encourages households to adopt cleaner and more efficient fuels, actual energy consumption is also affected by household characteristics and the ownership of energy-using appliances. Similarly, Pachauri, S. and Jiang, L. (2008) reported that household energy demand depends on appliance ownership, income, urbanization, and demographic factors, whereas energy prices significantly influence consumption decisions. Furthermore, Barnes, D. F. and Floor, W. M. (1996) concluded that education is an important determinant of the transition from traditional biomass fuels to cleaner modern fuels because educated households are generally more aware of the health, economic, and environmental benefits of modern energy technologies.

Kaygusuz (2011) found that the population who are living in rural areas and whose needs are often basic, therefore they depend to a large extent on fuel wood as a main traditional source of energy. Further, it was noted that when fuel prices increase, each family had to devote more of its income, time, and labor to buying and searching for firewood (Malla & Timilsnia, 2014). Puzzolo et al. (2019) also argued based on the empirical test of this claim by examining the effects of restricted access to credit and start-up cost on the decision to switch from an unclean energy source, i.e., fuel wood, to gas using Guatemalan data. By using a probit model, their results show that access to credit, through its effect on the ability of the household to buy a gas stove, implies a substantial influence on the household's consumption levels of fuelwood. Their conclusion also shows that high start-up costs are indeed a limiting factor for the households in Guatemala in the switch from firewood to LPG. Hence, subsidies toward lowering gas stove costs will give desired results.

Households in Timor-Leste spend $14.3 on average per month on energy, which is the equivalent of 20 percent of a typical rural household's monthly income, and on average, members of a household devote 3.5 hours daily to cooking and spend 6 hours weekly for collecting fuelwood (Mercy Corps 2011). An average household uses 9.3 kg of fuelwood per day and three tons per

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year (Mercy Corps 2011). In addition to being the primary source of deforestation, this massive use of fuelwood negatively affects the agricultural systems of Timor-Leste (World Bank 2010). There is a vast reserve of natural gas in the Timor Sea, and thus it has great potential for generating electricity cheaply (Strategic Development Plan 2011).

The forest literature shows that in many developing countries, the current level of biomass consumption is threatening the long-term sustainability of natural forests (see, e.g., Zein-Elabdin, 1997; Ouedraogo, 2006; Bhattacharya and Abdul Salam, 2002). The usage of this biomass energy is self-motivated and dynamic, as it responds to various factors such as changes in prices and access to the origin and sources of other fuel types. As deforestation and forest degradation are of global concern, people who use biomass energy locally generally do not fully internalize forest loss externalities. In developing countries like Ghana, in addition to charcoal and firewood, households commonly use liquefied petroleum gas (LPG) and kerosene as cooking fuels, which are more efficient and have less negative health and environmental impacts (Kumar and Viswanathan, 2007)

Farhar BC (1998) found that when the household income level increases, or if the head of the household is a woman, then women's preferences are more likely to be understood. Female household members concern themselves with the obtaining of energy in developing countries, and households are the main users of energy. Reddy BS (2009) found that when the income level of a female household member is low, they collect firewood, and when the income level is high, they are making decision maker on the choice of fuel. Israel D. (2002) concluded that with the use of modern and clean sources of energy like LPG and electricity, female members have improved health and additional time for leisure and family, so when the head of the household and the principal decision-making agent is female, then she will give a high priority to the goods that are useful to the female members of the household. In the urban areas, women have a stronger preference than men for an efficient and clean energy source, given their greater involvement in cooking.

3: Research Methodology

The methodological choice refers to the overall research method adopted to collect and analyze data. The current study adopts a mono-method quantitative research design because the research objectives require numerical measurement of household characteristics and statistical analysis of their association. Quantitative research design allows the collection of standardized data from a relatively large number of households, improves reliability and consistency of responses, minimizes interviewer bias, and supports advanced econometric analysis (Masera et al., 2000). The current study employed a survey research strategy to collect primary data from rural households in District Chitral. The survey approach is particularly suitable for studies involving household behavior, socioeconomic characteristics, and decision-making processes (Moeen et al., 2016). The survey questionnaire consists of closed-ended questions covering demographic characteristics, educational attainment, occupation, household income, family size, agricultural assets, etc., and the primary household energy sources used for cooking, heating, and lighting.

The target population comprises all rural households residing in District Chitral. Researchers employed a multi-stage sampling technique. During the first stage, rural areas were selected from Upper and Lower Chitral to ensure geographical representation. During the second stage, villages were selected using simple random sampling from identified rural areas. Finally, households in

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each selected village were chosen using systematic random sampling, which provides every eligible household with a known and non-zero probability of selection while minimizing sampling bias. Researchers employed Robert V. Krejcie and Daryle W. Morgan (1970) (Ahmad & Halima, 2017) method for selecting sample size through below equation;

$$\text{Sample size} = \frac{\chi 2\text{NP}\,(1-\text{P})}{\text{d2}\,(\text{N}-1) + \chi 2\text{P}(1-\text{P})}$$

N = Population size

χ^2= the table value of chi-square for one degree of freedom at the desired confidence level.

P = Population proportion (assumed to be .50 since this would provide the maximum sample size)

d = Degree of accuracy expressed as a proportion (.05)

A total of 381 households out of 54556 (2017 Population Census) rural area household selected for data collection. Analysis was conducted in two stages. The first stage involved descriptive statistical analysis using the frequency distribution of the sampled households and their energy use patterns. Frequency distribution tables and charts were used to present the findings. The second stage involved inferential statistical analysis using the Chi-Square Test of Independence. The Chi-Square test was employed to determine whether there was a statistically significant association between household energy choice and each of the selected explanatory variables. The Chi-Square test compares the observed frequencies with those expected under the assumption that no association exists between the variables.

Ethical considerations were observed throughout the study. Before data collection, respondents were informed about the objectives of the study, the purpose of the study, and the intended use of the collected data. Participation was entirely voluntary, and respondents were free to decline participation or withdraw from the interview at any stage without any negative consequences.

4: Data Analysis and Key Findings

Table 4.1 presents the socio-demographic characteristics of the sampled households in rural District Chitral. The results indicate that a slightly higher proportion of the respondents were from Upper Chitral (220 households, 57.74%), while 159 households (41.73%) belonged to Lower Chitral. Regarding monthly household income, the largest proportion of households (164, 43.04%) earned between Rs. 15,000 and Rs. 35,000, followed by 95 households (24.93%) with an income ranging from Rs. 35,001 to Rs. 55,000. In contrast, 42 households (11.02%) earned below Rs. 15,000, another 42 households (11.02%) earned between Rs. 55,001 and Rs. 75,000, while only 38 households (9.97%) reported a monthly income above Rs. 75,000. In terms of educational attainment, matriculation was the most common qualification, with 161 household heads (42.26%), followed by graduates (82, 21.52%) and postgraduates (71, 18.64%), whereas 67 respondents (17.59%) had no formal education. Occupationally, government service constituted the largest employment category, accounting for 130 respondents (34.38%), followed by employment in non-governmental organizations (88, 23.36%), self-employment (71, 18.90%), unemployment (57, 14.96%), and other occupations (32, 8.40%).

Table 4.1: Socio-Demographic Features of Participants

Variable	Category	Frequency	Percentage
Region	Upper Chitral	220	57.74%
	Lower Chitral	159	41.73%
Monthly Income	Below 15000	42	11.02%

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	15000-35000	164	43.04%
	35001-55000	95	24.93%
	55001-75000	42	11.02%
	Above 75000	38	9.97%
Education	Illiterate	67	17.59%
	Matriculation	161	42.26%
	Graduate	82	21.52%
	Post-Graduate	71	18.64%
Occupation	Government Servant	130	34.38%
	Working in NGO	88	23.36%
	Self-Employed	71	18.90%
	Unemployed	57	14.96%
	Others	32	8.40%

Table 4.2 presents the economic characteristics of the sampled households in rural District Chitral. The findings reveal that livestock ownership was widespread, with 356 households (93.44%) owning livestock, while only 25 households (6.56%) reported having no livestock. The high prevalence of livestock ownership reflects the importance of livestock rearing as a supplementary livelihood activity in the mountainous rural economy. Regarding dung making, 101 households (26.51%) reported producing dung cakes from animal waste for domestic fuel use, whereas many households (280, 73.49%) did not prepare dung cakes. The results further indicate diverse patterns of firewood procurement among the surveyed households. About 80 households (21.02%) relied entirely on collecting firewood from nearby forests or their own woodlots, while 36 households (9.43%) collected approximately 80% of their firewood requirements and purchased the remaining 20% from the market. Similarly, 63 households (16.44%) collected 60% and purchased 40%, whereas another 63 households (16.44%) collected 40% and purchased 60% of their firewood needs. The largest proportion of households (92, 24.26%) collected only 20% of their firewood and purchased the remaining 80% from local markets, while 47 households (12.40%) depended entirely on market purchases.

Table 4.2: Economic Characteristics

Variable	Category	Frequency	Percentage
Livestock Owned	Yes	356	93.44%
	No	25	6.56%
Dung Making	Yes	101	26.51%
	No	280	73.49%
Firewood Collection/Bought	100% Collect	80	21.02%
	80% Collect and 20% Buy	36	9.43%
	60% Collect and 40% Buy	63	16.44%
	40% Collect and 60% Buy	63	16.44%
	20% Collect and 80% Buy	92	24.26%
	100% Buy from Market	47	12.40%

Table 4.3 presents the monthly expenditure incurred by rural households in District Chitral on major household energy sources, namely firewood, liquefied petroleum gas (LPG), and electricity. The findings indicate that firewood remained the most commonly used traditional fuel, with more

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than half of the households (204, 53.54%) spending below Rs. 5,000 per month on firewood. Additionally, 85 households (22.31%) reported monthly firewood expenditures ranging from Rs. 5,000 to Rs. 12,000, while 27 households (7.09%) spent between Rs. 12,001 and Rs. 19,000. Only a very small proportion of households (3, 0.79%) incurred monthly firewood costs exceeding Rs. 19,000, whereas 53 households (13.91%) obtained firewood free of cost from their own forests, orchards, or nearby natural resources. Regarding LPG consumption, the largest proportion of households (159, 41.73%) reported zero monthly expenditure, indicating that they did not use LPG or had no access to it. Among LPG users, 78 households (20.60%) spent between Rs. 701 and Rs. 1,100 per month, followed by 52 households (13.55%) spending Rs. 1,101 to Rs. 1,500. Furthermore, 36 households (9.49%) each spent below Rs. 700 and between Rs. 1,501 and Rs. 1,900, while only 20 households (5.15%) incurred monthly LPG expenditures exceeding Rs. 1,900. Electricity expenditure showed a relatively even distribution, with the highest proportion of households (119, 31.20%) paying between Rs. 200 and Rs. 500 per month. This was followed by 79 households (20.80%) spending Rs. 501 to Rs. 800, 62 households (16.27%) spending Rs. 801 to Rs. 1,100, 55 households (14.40%) paying more than Rs. 1,100, and 54 households (14.13%) paying less than Rs. 200 per month. Only 12 households (3.20%) reported no expenditure on electricity.

Table 4.3: Monthly Household Expenditures on Energy

Variable	Category	Frequency	Percentage
Cost of Firewood Per Month	Below Rs.5000	204	53.54%
	Rs.5000 to Rs.12000	85	22.31%
	Rs.12001 to Rs.19000	27	7.09%
	Above Rs.19000	3	0.79%
	Freely available	53	13.91%
Cost of LPG Per Month	Below Rs.700	36	9.49%
	Rs. 701 to Rs.1100	78	20.60%
	Rs. 1101 to Rs.1500	52	13.55%
	Rs. 1501 to Rs. 1900	36	9.49%
	Above Rs. 1900	20	5.15%
	Zero Cost	159	41.73%
Cost of Electricity Per Month	Below Rs. 200	54	14.13%
	Rs. 200 to Rs. 500	119	31.20%
	Rs.501 to Rs. 800	79	20.80%
	Rs. 801 to Rs. 1100	62	16.27%
	Above Rs. 1100	55	14.40%
	Zero Cost	12	3.20%

Table 4.4 presents the association between the primary source of energy for cooking and selected household characteristics in rural District Chitral. Overall, wood was the dominant primary cooking fuel, being used by 332 of the 381 sampled households (87.1%), followed by LPG (32 households, 8.4%), electricity (8 households, 2.1%), and agricultural residue (9 households, 2.4%). The Chi-square results indicate that the choice of primary cooking energy source was significantly associated with most household characteristics. Regional differences were statistically significant ($\chi^2 = 0.029$), with wood being used by 193 households in Upper Chitral and 139 households in Lower Chitral, while LPG was comparatively more common in Lower Chitral (18 households)

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than in Upper Chitral (14 households). Age also showed a significant association ($\chi^2 = 0.002$), where households headed by respondents aged 36–50 years accounted for the largest number of wood users (148), followed by those aged 51–65 years (129). Education exhibited a highly significant relationship with cooking energy choice ($\chi^2 = 0.000$). Among illiterate household heads, 62 of the 67 respondents relied on wood, whereas LPG use increased among more educated households, reaching 11 users among postgraduates. Occupation was also significantly associated with cooking energy choice ($\chi^2 = 0.000$), with wood being predominantly used by government servants (118), NGO employees (75), unemployed respondents (53), and those in other occupations (29). Electricity availability further influenced cooking energy selection ($\chi^2 = 0.015$), as 287 of the 368 households with electricity still relied primarily on wood, while only 18 primarily used LPG and 33 relied on electricity for cooking.

Household economic and accessibility characteristics also demonstrated statistically significant associations with the primary cooking energy source. Although household size was not significantly associated with cooking fuel choice ($\chi^2 = 0.30$), wood remained the principal cooking fuel across all household-size categories, particularly among households with five to seven members (166) and eight to ten members (105). In contrast, the number of earning members was significantly associated with cooking energy choice ($\chi^2 = 0.000$), with households having one earning member (153) and two earning members (130) relying predominantly on wood. Household income likewise showed a significant association ($\chi^2 = 0.000$), as wood remained the dominant cooking fuel across all income groups, although LPG use increased among higher-income households, particularly those earning above Rs. 75,000 per month, where 11 households primarily used LPG. Agricultural land ownership ($\chi^2 = 0.000$), livestock ownership ($\chi^2 = 0.000$), house ownership ($\chi^2 = 0.000$), distance from the market ($\chi^2 = 0.000$), and distance from fuelwood sources ($\chi^2 = 0.000$) were all significantly associated with the primary cooking energy source. Households owning agricultural land, livestock, and their own houses overwhelmingly depended on wood for cooking. Similarly, households located farther from markets continued to rely mainly on wood, while those living close to fuelwood sources exhibited the greatest dependence on wood. Conversely, households with no nearby fuelwood source showed comparatively greater use of alternative fuels, with 23 households using wood, 5 using LPG, 8 using electricity, and 9 using agricultural residues.

Table 4,4: Association Between Primary Energy Source for Cooking and Household Characteristics

Demographic	Categories	Wood	LPG	Electricity	Residue	Total
Region (Chi-Square=0.029)	Upper Chitral	193	14	7	8	222
	Lower Chitral	139	18	1	1	159
	21-35	42	6	1	5	54
Age Group (Chi-Square=0.002)	36-50	148	17	0	2	167
	51-65	129	8	6	1	144
	Above 65	13	1	1	1	16
Level of Education (Chi-Square=0.000)	Illiterate	62	0	1	4	67
	Matriculate	143	15	0	3	161
	Graduate	67	6	7	2	82
	Post Graduate	60	11	0	0	71
Occupation (Chi-Square=0.000)	Government Servant	118	13	0	0	131

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	Working in NGO	75	14	0	0	89
	Unemployed	53	0	0	4	57
	Other	29	3	0	0	32
Electricity Available (Chi-Square=0.015)	Yes	287	18	33	20	368
	No	7	2	0	3	13
Household Members (Chi-Square=0.30)	2 to 4	26	2	0	0	28
	5 to 7	166	19	2	5	192
	8 to 10	105	9	6	2	122
	Above 10	35	2	0	2	39
Earning Members (Chi-Square=0.000)	One	153	6	1	1	161
	Two	130	16	0	4	150
	Three	32	6	6	0	44
	More than 4	2	2	0	0	4
	No Earning Member	4	0	0	4	8
Household Income (Chi-Square=0.000)	Below 15000	38	0	0	4	42
	15000-35000	150	8	1	5	164
	35001-55000	81	9	5	0	95
	55001 -75000	38	4	0	0	42
	Above 75000	25	11	2	0	38
Agriculture Landownership (Chi-Square=0.000)	No agricultural Land	28	6	0	0	34
	1-3 hectares	184	16	0	5	205
	4-6 hectares	85	4	7	1	97
	Above 7 hectares	35	6	1	3	45
Livestock Owned (Chi-Square=0.000)	Yes	316	24	7	9	356
	No	16	8	1	0	25
Nature of House (Chi-Square=0.000)	Own House	330	29	7	9	375
	Rental House	2	3	1	0	6
House Distance from Market (Chi-Square=0.000)	< 1 KM	66	17	0	0	83
	1-2 KM	65	9	0	0	74
	3-4 KM	96	6	7	0	109
	>4 KM	105	0	1	9	115
Distance from Fuel Wood (Chi-Square=0.000)	< 1KM	35	6	0	0	41
	1-2KM	48	9	0	0	57
	3-4 KM	39	11	0	0	50
	>4 KM	187	1	0	0	188
	No Fuelwood	23	5	8	9	45

Table 4.5 presents the association between the primary source of energy for lighting and selected household characteristics in rural District Chitral. The findings reveal that electricity was the dominant primary source of lighting, being used by 367 households (96.3%), whereas only 14 households (3.7%) relied primarily on solar energy. The Chi-square analysis indicates that region was not significantly associated with the choice of lighting energy source ($\chi^2 = 0.233$). Electricity remained the principal lighting source in both Upper Chitral, where 216 of the 222 households

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used electricity and only 6 used solar energy, and Lower Chitral, where 151 of the 159 households relied on electricity while 8 used solar energy. Similarly, age group was not significantly associated with lighting energy choice (χ^2 = 0.635). Across all age categories, electricity remained the predominant lighting source, including 51 households aged 21–35 years, 163 households aged 36–50 years, 138 households aged 51–65 years, and 15 households above 65 years. In contrast, education exhibited a statistically significant association with the primary source of lighting (χ^2 = 0.001). All 161 matriculate households relied exclusively on electricity, while solar energy was used by 7 illiterate households, 2 graduate households, and 5 postgraduate households. Occupation was also significantly associated with lighting energy choice (χ^2 = 0.000), with almost all government servants (130), NGO employees (89), and self-employed respondents (71) using electricity, whereas solar energy use was comparatively higher among unemployed households, where 11 of the 57 respondents relied on solar energy. Electricity availability demonstrated the strongest association with lighting energy choice (χ^2 = 0.000), as all 367 households with electricity access used electricity for lighting, whereas all 13 households without electricity depended on solar energy.

Household economic and accessibility characteristics further influenced the primary source of lighting. Household size showed a statistically significant association with lighting energy choice (χ^2 = 0.000), although electricity remained the dominant source across all household-size categories, including 28 households with two to four members, 189 households with five to seven members, 119 households with eight to ten members, and 31 households with more than ten members. The number of earning members was likewise significantly associated with lighting energy choice (χ^2 = 0.000), with electricity serving as the principal source among households having one earning member (158), two earning members (150), three earning members (42), and more than four earning members (4), whereas 6 of the 8 households with no earning member relied on solar energy. Household income also exhibited a significant association (χ^2 = 0.000), with electricity dominating across all income groups; however, solar energy was relatively more common among households earning below Rs. 15,000 per month, where 9 of the 42 households used solar energy as their primary lighting source. Agricultural land ownership (χ^2 = 0.000) and distance from fuelwood sources (χ^2 = 0.000) were also significantly associated with lighting energy choice. Households owning one to three hectares of agricultural land largely depended on electricity (199 households), while 7 of the 45 households owning more than seven hectares used solar energy. Likewise, 11 of the 45 households with no nearby fuelwood source relied on solar energy, compared with only one or two households in the remaining distance categories. In contrast, livestock ownership (χ^2 = 0.312), nature of house (χ^2 = 0.088), and distance from the market (χ^2 = 0.067) were not significantly associated with the primary source of lighting.

Table 45: Association between Primary Energy Source for Lighting and Demographic Features

Demographic	Categories	Electricity	Solar	Total
Region (Chi-Square=0.233)	Upper Chitral	216	6	222
	Lower Chitral	151	8	159
	21-35	51	3	54
Age Group (Chi-Square=0.635)	36-50	163	4	167
	51-65	138	6	144
	Above 65	15	1	16
Level of Education (Chi-Square=0.001)	Illiterate	60	7	67
	Matriculate	161	0	161
	Graduate	80	2	82

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	Postgraduate	66	5	71
Occupation (Chi-Square=0.000)	Government Servant	130	1	131
	Working in NGO	89	0	89
	Self Employed	71	1	72
	Unemployed	46	11	57
	Other	31	1	32
Electricity Available (Chi-Square=0.000)	Yes	367	1	368
	No	0	13	13
Household Members (Chi-Square=0.000)	2 to 4	28	0	28
	5 to 7	189	3	192
	8 to 10	119	3	122
	Above 10	31	8	39
Earning Members (Chi-Square=0.000)	One	158	3	161
	Two	150	0	150
	Three	42	2	44
	More than 4	4	0	4
	No Earning Members	2	6	8
Household Income (Chi-Square=0.000)	Below 15000	33	9	42
	15000-35000	164	0	164
	35001-55000	95	0	95
	55001 -75000	39	3	42
	Above 75000	36	2	38
Agriculture Landownership (Chi-Square=0.000)	No agricultural Land	33	1	34
	1-3 hectares	199	6	205
	4-6 hectares	97	0	97
	Above 7 hectares	38	7	45
Livestock Owned (Chi-Square=0.312)	Yes	342	14	356
	No	25	0	25
Nature of House (Chi-Square=0.088)	Own House	362	13	375
	Rental House	5	1	6
House Distance from Market (Chi-Square=0.067)	< 1 KM	82	1	83
	1-2 KM	74	0	74
	3-4 KM	103	6	109
	>4 KM	108	7	115
Distance from Fuel Wood (Chi-Square=0.000)	< 1KM	41	0	41
	1-2KM	57	0	57
	3-4 KM	48	2	50
	>4 KM	187	1	188
	No Fuelwood	34	11	45

Table 4.6 presents the association between the primary source of energy for heating and selected household characteristics in rural District Chitral. Overall, wood remained the dominant primary heating fuel, being used by 294 of the 381 surveyed households (77.2%), followed by electricity (33 households, 8.7%), residue (23 households, 6.0%), LPG (20 households, 5.2%), and other sources (11 households, 2.9%). The Chi-square analysis indicates that region was significantly associated with the choice of primary heating fuel ($\chi^2 = 0.001$). In Upper Chitral, 177 of the 222 households relied on wood for heating compared with 117 of the 159 households in Lower Chitral, while electricity was more frequently used in Lower Chitral (21 households) than in Upper Chitral (12 households). Age group also showed a significant association ($\chi^2 = 0.001$), with wood being the predominant heating source among households headed by respondents aged 36–50 years (123

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households) and 51–65 years (119 households). Educational attainment was significantly associated with heating fuel choice (χ^2 = 0.000). Among illiterate respondents, 52 of the 67 households depended on wood and 13 relied on agricultural residues, whereas graduates exhibited relatively greater use of LPG (12 households) and electricity (13 households). Occupation likewise demonstrated a significant relationship (χ^2 = 0.000), with government servants predominantly using wood (116 households), while households working in NGOs showed comparatively higher use of electricity (19 households), LPG (9 households), and other heating sources (8 households). Electricity availability was also significantly associated with heating fuel choice (χ^2 = 0.015), as 287 of the 368 households with electricity still relied primarily on wood for heating, whereas only 33 households used electricity as their main heating source.

Household economic and accessibility characteristics also had significant associations with the primary source of heating. Household size was significantly related to heating fuel choice (χ^2 = 0.035), with wood remaining the principal heating source among households comprising five to seven members (146 households), eight to ten members (93 households), and more than ten members (32 households). Similarly, the number of earning members showed a highly significant association (χ^2 = 0.000), with households having one earning member (137) and two earning members (121) relying predominantly on wood, while electricity use was relatively higher among households with three earning members (13 households). Household income also significantly influenced heating energy choice (χ^2 = 0.000). Although wood remained the dominant heating fuel across all income groups, the use of LPG and electricity increased with income, particularly among households earning above Rs. 75,000 per month, where 10 households primarily used electricity and 4 households used LPG for heating. Accessibility factors further demonstrated significant relationships with heating fuel selection. Distance from the market was significantly associated with heating energy choice (χ^2 = 0.000), with wood being the dominant fuel among households located more than 4 km from the market (102 households), whereas electricity was relatively more common among households residing within 1–2 km of the market (16 households). Likewise, distance from fuelwood sources significantly influenced heating fuel choice (χ^2 = 0.000). Households located more than 4 km from fuelwood sources continued to depend mainly on wood (183 households), while those with no nearby fuelwood source showed comparatively greater reliance on LPG (10 households), electricity (4 households), agricultural residues (7 households), and other heating sources (3 households).

Table 4.6: Association between Primary Source for Heating and Demographic Features

Demographic	Categories	Wood	LPG	Electricity	Residue	Other	Total
Region (Chi-Square=0.001)	Upper Chitral	177	16	12	15	2	222
	Lower Chitral	117	4	21	8	9	159
Age Group (Chi-Square=0.001)	21-35	37	2	3	10	2	54
	36-50	123	8	17	12	7	167
	51-65	119	10	13	0	2	144
	Above 65	15	0	0	1	0	16
Level of Education (Chi-Square=0.000)	Illiterate	52	0	0	13	2	67
	Matriculate	124	8	14	8	7	161
	Graduate	53	12	13	2	2	82
	Post Graduate	65	0	6	0	0	71
Occupation (Chi-Square=0.000)	Government Servant	116	1.048	6	7	1	131

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	Working in NGO	45	9	19	8	8	89
	Self Employed	51	9	6	5	1	72
	Unemployed	49	1	2	4	1	57
	Other	0	0	0	0	0	0
Electricity Available (Chi-Square=0.015)	Yes	287	18	33	20	10	368
	No	7	2	0	3	1	13
Household Members (Chi-Square=0.035)	2 to 4	23	4	0	0	1	28
	5 to 7	146	5	18	15	8	192
	8 to 10	93	14	7	6	2	122
	Above 10	32	1	4	2	0	39
Earning Members (Chi-Square=0.000)	One	137	0	4	15	5	161
	Two	121	8	13	5	3	150
	Three	20	9	13	0	2	44
	More than 4	2	0	2	0	0	4
	No.E Member	3	1	0	3	1	8
Household Income (Chi-Square=0.000)	Below 15000	31	1	0	7	3	42
	15000-35000	135	6	11	9	3	164
	35001-55000	69	11	9	0	6	95
	55001 -75000	26	5	8	3	0	42
	Above 75000	21	4	10	2	1	38
House Distance from Market (Chi-Square=0.000)	< 1 KM	59	1	10	12	1	83
	1-2 KM	44	4	16	3	7	74
	3-4 KM	99	0	2	7	1	109
	>4 KM	102	0	6	7	0	115
Distance from Fuel Wood (Chi-Square=0.000)	< 1KM	33	2	0	5	1	41
	1-2KM	35	0	7	13	2	57
	3-4 KM	32	8	9	1	0	50
	>4 KM	183	0	5	0	0	188
	No Fuelwood	21	10	4	7	3	45

Overall, the findings indicate that household demographic and socioeconomic characteristics have a significant influence on the primary sources of energy used for cooking, heating, and lighting in rural District Chitral. For cooking, wood was the dominant primary fuel, being used by 332 out of 381 households (87.1%), while LPG (8.4%), electricity (2.1%), and agricultural residues (2.4%) accounted for only a small proportion of households. Similarly, wood remained the principal source of heating, with 294 households (77.2%) relying on it, followed by electricity (33 households, 8.7%), agricultural residues (23 households, 6.0%), LPG (20 households, 5.2%), and other sources (11 households, 2.9%). In contrast, electricity was the predominant source of lighting, being used by 367 households (96.3%), whereas only 14 households (3.7%) depended on solar energy. The Chi-square analysis further revealed that most demographic and socioeconomic variables—including education, occupation, electricity availability, number of earning members, household income, and accessibility factors—were significantly associated ($p < 0.05$) with the primary sources of cooking, heating, and lighting. For example, education was significantly

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associated with cooking (χ^2 = 0.000), heating (χ^2 = 0.000), and lighting (χ^2 = 0.001), while occupation was also significant for all three energy uses (χ^2 = 0.000). Household income exhibited a highly significant relationship with cooking (χ^2 = 0.000), heating (χ^2 = 0.000), and lighting (χ^2 = 0.000), indicating that higher-income households were relatively more likely to adopt modern fuels such as LPG and electricity. Conversely, region and age were significantly associated with cooking and heating energy choices but showed no significant association with lighting (χ^2 = 0.233 and χ^2 = 0.635, respectively). Likewise, household size was not significantly associated with cooking energy choice (χ^2 = 0.300) but was significantly related to heating (χ^2 = 0.035) and lighting (χ^2 = 0.000). These findings suggest that although electricity has become the universal source of household lighting due to its widespread availability, traditional biomass—particularly wood—continues to dominate cooking and heating practices. The transition towards cleaner household energy sources therefore depends largely on improvements in education, income, employment opportunities, electricity access, and infrastructure rather than demographic characteristics alone.

Table 4.7 shows the association between secondary energy source for cooking and the explanatory variables. Rural households in Chitral mostly (42.8 percent) rely on LPG and 23.6 percent on animal/plant residue as a secondary/backup source for cooking. Out of this 37.8 percent households in upper Chitral while 49.7 percent households in lower Chitral are using LPG and 27.9 percent households in upper Chitral and 17.6 percent household in lower Chitral are using animal/plant residue. The households located at lower Chitral are preferring LPG because of the easily availability in the market at lower price as compare to upper Chitral. The household' head educations affecting the choice of energy source like as the education of the head of the household increases, the preferences changes from firewood to LPG and electricity, similarly private/NGO employed mostly using LPG and electricity and 45.6 percent unemployed' household heads are using animal/plant residual as a back-up source for cooking. Further, as the number of earning hands increases from 1-4, the household switched to LPG (from 37.9 percent to 64.3 percent), while 50 percent of households which has no earning hands are using other sources for cooking, like plastic, garbage etc.

Similarly, as the income of the household increases their preferences shift from animal/plant residue to LPG and electricity, as 35.7 percent household which has income below Rs.15000 are using animal/plant residue while 56.8 percent of the household whose income is 35000 to 55000 are using LPG as a backup source for cooking. Furthermore, 44.1 percent of the household which have no agricultural land are using LPG and 20.6 percent of that are using electricity as a backup source for cooking and among the households who own livestock are using ,9.8 ,41.9,17.7 and 25.3 percent firewood, LPG, electricity and animal/plant residual respectively as a back-up source while the households who do not owned livestock mostly (56 percent) rely on LPG for cooking, Theses are mostly the households where women are doing jobs in government or private sector. Among the household living in rental houses, 66.7 percent of them are using LPG and 33.3 are using electricity as a back-up source for cooking.

Table 47: Association between Secondary Source for Cooking and Explanatory Variables

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Variables	Secondary Source of energy for Cooking						
	Total	**Firewood N (%)**	**LPG N (%)**	**Electricity N (%)**	**Solar Energy N (%)**	**Animal/Plant Residual N (%)**	**Other N (%)**
	381(100)	**44(11.5)**	**163(42.8)**	**65(17.1)**	**0(0.0)**	**90(23.6)**	**19(5.0)**
Region	Chi Square = 0.003						
Upper Chitral	222	22(9.9)	84(37.8)	37(16.7)	--	62(27.9)	17(17.7)
Lower Chitral	159	22(13.8)	79(49.7)	28(17.6)	--	28(17.6)	2(1.3)
Education	Chi Square=0.001						
Illiterate	67	5(7.5)	21(31.3)	13(19.4)	--	24(35.8)	4(6.0)
Matric	161	17(10.6)	59(36.6)	22(13.7)	--	52(32.3)	11(6.8)
Graduate	82	12(14.6)	39(47.6)	16(19.5)	--	11(13.4)	4(4.9)
Post Graduate	71	10(14.1)	44(62.0)	14(19.7)	--	3(4.2)	0(0.0)
Occupation	Chi Square=0.000						
Government	131	15(11.5)	61(46.6)	30(22.9)	--	23(17.6)	2(1.5)
Private/NGO	89	15(16.9)	50(56.2)	14(15.7)	--	9(10.1)	1(1.1)
Self Employed	72	10(13.9)	25(34.7)	15(20.8)	--	16(22.2)	6(8.3)
Unemployed	57	1(1.8)	16(28.1)	6(10.5)	--	26(45.6)	8(14.0)
Other	32	3(9.4)	11(34.4)	0(0.0)	--	16(50.0)	2(6.3)
Elec Availability	Chi Square=0.000						
Yes	368	42(11.4)	158(42.9)	65(17.7)	--	88(23.9)	15(4.1)
No	13	2(15.4)	5(38.5)	0(0.0)	--	2(15.4)	4(30.8)
No. of Earning Members	Chi Square=0.000						
One	161	10(6.2)	61(37.9)	26(16.1)	--	58(36.0)	6(3.7)
Two	150	17(11.3)	73(48.7)	28(18.7)	--	23(15.3)	9(6.0)
Four	14	3(21.4)	9(64.3)	2(14.3)	--	0(0.0)	0(0.0)
More than four	4	2(50.0)	1(25.0)	0(0.0)		1(25.0)	0(0.0)
No. earning member	8	1(12.5)	1(12.5)	0(0.0)	--	2(25.0)	4(50.0)
Household Income	Chi Square=0.000						
Below 15000	42	5(11.9)	6(14.3)	8(19.0)	--	15(35.7)	8(19.0)
15001-35000	164	9(5.5)	60(36.6)	24(14.6)	--	60(36.6)	11(6.7)
55001-75000	42	4(9.5)	24(57.1)	13(31.0)	--	1(2.4)	0(0.0)
Above 75000	38	13(34.2)	19(50.0)	6(15.8)	--	0(0.0)	0(0.0)
Agricultural Land owned	Chi Square=0.139						
No. agricultural Land owned	34	9(26.5)	15(44.1)	7(20.6)	--	3(8.8)	0(0.0)
1-3	205	17(8.3)	91(44.4)	32(15.6)	--	52(25.4)	13(6.3)
4-7	97	11(11.3)	41(42.3)	19(19.6)	--	22(22.7)	4(4.1)
Above 7	45	7(15.6)	16(35.6)	7(15.6)	--	13(28.9)	2(4.4)
Livestock Owned	Chi Square=0.000						

Rural households in Chitral mostly (34.9 percent) rely on electricity and 21.3 percent on LPG and 13.9 percent on animal/plant residue as a secondary/backup source for heating. Out of this the percentage of residue users are greater (19.4 percent) in upper Chitral as compared to lower Chitral (6.3 percent). This is because of the reason that in rural areas of upper Chitral there are mostly

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barren land and peoples have livestock so they are using peats (partially carbonized vegetable matter saturated with water; can be used as a fuel when dried) and dung for heating. The household' head educations affecting the choice of back-up source for heating like,50 percent of the household whose head are postgraduate are using electricity and 26.9 percent of the household whose head are illiterate are using residue as a back-up source for heating, similarly government employee mostly (51.1 percent) using electricity and 24.6 percent unemployed household' head are using animal/plant residual as a back-up source for heating. Further, as the income of the household increases their preferences shift from animal/plant residue to electricity and LPG, as 26.2 percent household which has income below Rs.15000 are using animal/plant residue and 28.6 are using other back-up sources for heating, while 34 to 37 percent household are using electricity as their income increases from Rs.15000. As the distance of house from the market increases to above four kilometers the use of animal/plant residual to 28.7. This is due to the reason that the household which are located at hilly areas and which are away from the market and don't have access to electricity and LPG they are using animal/plant residual.

Table 4.8: Association between Secondary Source for Heating and Affecting Variables

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Variables	Secondary Source of energy for Heating						
	Total	**Firewood N (%)**	**LPG N (%)**	**Electricity N (%)**	**Solar Energy N (%)**	**Animal/Plant Residual N (%)**	**Other N (%)**
	381	**78(20.5)**	**81(21.3)**	**133(34.9)**	**0(0.0)**	**53(13.9)**	**36(9.4)**
Region	Chi Square = 0.005						
Upper Chitral	222	39(17.6)	42(18.9)	78(35.1)	--	43(19.4)	20(9.0)
Lower Chitral	159	39(24.5)	39(24.5)	55(34.6)	--	10(6.3)	16(10.1)
Education	Chi Square=0.000						
Illiterate	67	12(17.9)	8(11.9)	21(31.3)	--	18(26.9)	8(11.9)
Matric	161	37(23.0)	28(17.4)	53(32.9)	--	26(16.1)	17(10.6)
Graduate	82	23(28.0)	22(26.8)	23(28.0)	--	6(7.3)	8(9.8)
Post Graduate	71	6(8.5)	23(32.4)	36(50.7)	--	3(4.2)	3(4.2)
Occupation	Chi Square=0.000						
Government	131	17(13.0)	28(21.4)	67(51.1)	--	14(10.7)	5(3.8)
Private/NGO	89	43(48.3)	21(23.6)	19(21.3)	--	4(4.5)	2(2.2)
Self Employed	72	16(22.2)	13(18.1)	19(26.4)	--	13(18.1)	11(15.3)
Unemployed	57	2(3.5)	14(24.6)	18(31.6)	--	14(24.6)	9(15.8)
Other	32	0(0.0)	5(15.6)	10(31.3)	--	8(25.0)	9(28.1)
Elec Availability	Chi Square=0.009						
Yes	368	75(20.4)	76(20.7)	133(36.1)	--	52(14.1)	32(8.7)
No	13	3(23.1)	5(38.5)	0(0.0)	--	1(7.7)	4(30.8)
No. of Earning Members	Chi Square=0.000						
One	161	20(12.4)	24(14.9)	59(36.6)	--	35(21.7)	23(14.3)
Two	150	27(18.0)	40(26.7)	62(41.3)	--	13(8.7)	8(5.3)
Three	44	24(54.5)	10(22.7)	8(18.2)	--	2(4.5)	0(0.0)
Four	14	3(21.4)	6(42.9)	4(28.6)	--	0(0.0)	1(7.1)
More than four	4	2(50.0)	0(0.0)	0(0.0)		2(50.0)	0(0.0)
No. earning member	8	2(25.0)	1(12.5)	0(0.0)	--	1(12.5)	4(50.0)
Household Income	Chi Square=0.000						
Below 15000	42	11(26.0)	1(2.4)	7(16.7)	--	11(26.2)	12(28.6)
15001-35000	164	22(13.4)	28(17.1)	60(36.6)	--	34(20.7)	20(12.2)
35001-55000	95	23(24.2)	29(30.5)	37(38.9)	--	5(5.3)	1(1.1)
55001-75000	42	10(23.8)	11(26.2)	16(38.1)	--	3(7.1)	2(4.8)
Above 75000	38	12(31.6)	12(31.6)	13(34.2)	--	0(0.0)	1(2.6)
Livestock Owned	Chi Square=0.008						
Yes	356	75(21.1)	69(19.4)	125(35.1)	--	53(14.9)	34(9.6)
No	25	3(12.0)	12(48.0)	8(32.0)	--	0(0.0)	2(8.0)
Distance of House from the market	Chi Square=0.000						
Less than 1KM	83	24(28.9)	19(22.9)	33(39.8)	--	6(7.2)	1(1.2)
1-2 KM	74	30(40.5)	9(12.2)	22(29.7)	--	7(9.5)	6(8.1)
3-4 KM	109	20(18.3)	29(26.6)	44(40.4)	--	7(6.4)	9(8.3)
Above 4	115	4(3.5)	24(20.9)	34(29.6)	--	33(28.7)	20(17.4)

Table 49: Association between Secondary Energy Source for Lighting and Affecting Variables

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Variables	Total	Secondary Source of energy for Lighting					
		Firewood N (%)	LPG N (%)	Electricity N (%)	Solar Energy N (%)	Animal/Plant Residual N (%)	Other N (%)
	313	0(0.0)	29(7.6)	0(0.0)	313(82.2)	0(0.0)	39(10.2)
Region	Chi Square = 0.144						
Upper Chitral	222	--	12(5.4)	--	188(84.7)	--	22(9.9)
Lower Chitral	159	--	17(10.7)	--	125(78.6)	--	17(10.7)
Education	Chi Square=0.000						
Illiterate	67	--	2(3.0)	--	53(79.1)	--	12(17.9)
Matric	161	--	3(1.9)	--	144(89.4)	--	14(8.7)
Graduate	82	--	10(12.2)	--	62(75.6)	--	10(12.2)
Post Graduate	71	--	14(19.7)	--	54(76.1)	--	3(4.2)
Occupation	Chi Square=0.006						
Government	131	--	9(6.9)	--	114(87.0)	--	8(6.1)
Private/NGO	89	--	3(3.4)	--	80(89.9)	--	6(6.7)
Self Employed	72	--	6(8.3)	--	57(79.2)	--	9(12.5)
Unemployed	57	--	8(14.0)	--	36(63.2)	--	13(22.8)
Other	32	--	3(9.4)	--	26(81.3)	--	3(9.4)
Elec Availability	Chi Square=0.000						
Yes	368	--	24(6.5)	--	313(85.1)	--	31(8.4)
No	13	--	5(38.5)	--	0(0.0)	--	8(61.5)
Household Size	Chi Square=0.000						
2-4	28	--	5(17.9)	--	22(78.6)	--	1(3.6)
5-7	192	--	7(3.6)	--	169(88.0)	--	16(8.3)
8-10	122	--	10(10.2)	--	103(84.4)	--	9(7.4)
Above 10	39	--	7(17.9)	--	19(48.7)	--	13(33.3)
No. of Earning Members	Chi Square=0.000						
One	161	--	6(3.7)	--	137(85.1)	--	18(11.2)
Two	150	--	4(2.7)	--	140(93.3)	--	6(4.0)
Three	44	--	12(27.3)	--	28(63.6)	--	4(9.1)
Four	14	--	5(35.7)	--	8(57.1)	--	1(7.1)
More than four	4	--	0(0.0)	--	0(0.0)	--	4(100)
No. earning member	8	--	2(25.0)	--	0(0.0)	--	6(75.0)
Household Income	Chi Square=0.000						
Below 15000	42	--	2(4.8)	--	29(69.0)	--	11(26.2)
15001-35000	164	--	9(5.5)	--	145(88.4)	--	10(6.1)
35001-55000	95	--	5(5.3)	--	83(87.4)	--	7(7.4)
55001-75000	42	--	6(14.3)	--	31(73.8)	--	5(11.9)
Above 75000	38	--	7(18.4)	--	25(65.8)	--	6(15.8)
House Ownership	Chi Square=0.000						
Own house	375	--	27(7.2)	--	312(83.2)	--	36(9.6)

Overall, solar energy was the most common secondary source of lighting, being used by 313 of the 381 households (82.2%), followed by other energy sources (39 households, 10.2%) and LPG (29 households, 7.6%), while no household reported using firewood, electricity, or animal/plant residues as secondary lighting sources. The Chi-square analysis indicates that region was not significantly associated with the choice of secondary lighting energy ($\chi^2 = 0.144$), as households in both Upper Chitral (188 households, 84.7%) and Lower Chitral (125 households, 78.6%) predominantly relied on solar energy. In contrast, education was significantly associated with the secondary lighting source ($\chi^2 = 0.000$), with solar energy being used by 144 matriculate households (89.4%), 62 graduate households (75.6%), 54 postgraduate households (76.1%), and 53 illiterate households (79.1%), while LPG use increased among postgraduates (14 households, 19.7%). Occupation also showed a significant association ($\chi^2 = 0.006$), with solar energy serving as the principal secondary lighting source among government servants (114 households, 87.0%), private/NGO employees (80 households, 89.9%), self-employed respondents (57 households,

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79.2%), and unemployed households (36 households, 63.2%). Electricity availability exhibited a highly significant relationship ($\chi^2 = 0.000$), as 313 of the 368 households with electricity used solar energy as their secondary lighting source, whereas none of the households without electricity used solar energy; instead, 8 of the 13 households (61.5%) relied on other lighting sources. Household size ($\chi^2 = 0.000$), number of earning members ($\chi^2 = 0.000$), household income ($\chi^2 = 0.000$), and house ownership ($\chi^2 = 0.000$) were also significantly associated with the secondary source of lighting. Solar energy was most common among households with five to seven members (169 households, 88.0%), households having two earning members (140 households, 93.3%), and households earning Rs. 15,001–35,000 per month (145 households, 88.4%). Similarly, 312 of the 375 households (83.2%) living in their own houses used solar energy as a secondary lighting source, whereas half of the rental households (3 out of 6) relied on other sources.

The findings of the study reveal that rural households in District Chitral continue to depend predominantly on traditional biomass, particularly wood, as their primary source of energy for cooking and heating, whereas electricity is the dominant primary source for lighting (Kamal et al., 2021). Specifically, wood was used as the primary cooking fuel by 332 of the 381 households (87.1%) and as the primary heating fuel by 294 households (77.2%), highlighting its continued importance due to its local availability and relatively low cost. In contrast, electricity served as the primary source of lighting for 367 households (96.3%), while only 14 households (3.7%) primarily relied on solar energy. The Chi-square analysis further demonstrated that most demographic, socioeconomic, and accessibility variables—including education, occupation, electricity availability, number of earning members, household income, agricultural land ownership, livestock ownership, house ownership, and distance from markets and fuelwood sources—were significantly associated ($p < 0.05$) with the primary energy choices of households. However, a few variables, such as household size for cooking ($\chi^2 = 0.300$), and region ($\chi^2 = 0.233$) and age ($\chi^2 = 0.635$) for lighting, were not statistically significant (Bhattacharjee & Reichard, 2011; Mrowczynska et al., 2020).

With respect to secondary energy sources, the results indicate that households frequently adopt multiple energy sources to satisfy different domestic energy requirements, reflecting an energy-stacking behavior rather than complete substitution of traditional fuels. LPG emerged as the most common secondary source for cooking, being used by 163 households (42.8%), followed by animal/plant residues (90 households, 23.6%), electricity (65 households, 17.1%), firewood (44 households, 11.5%), and other sources (19 households, 5.0%). Similarly, solar energy constituted the principal secondary source for lighting, with 313 households (82.2%) using it as a backup source, while LPG (29 households, 7.6%) and other sources (39 households, 10.2%) accounted for relatively smaller shares. Across the secondary energy analyses, education, occupation, electricity availability, household size, number of earning members, household income, and house ownership exhibited statistically significant associations with household energy choices, whereas variables such as region showed no significant association with secondary lighting energy ($\chi^2 = 0.144$). Collectively, these findings indicate that households in rural Chitral do not rely on a single energy source but instead combine traditional and modern fuels according to affordability, accessibility, and seasonal requirements, and the reliability of energy supply (Kamal et al., 2021; Asefon & Adepoju, 2015; Wu et al., 2019).

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5: Conclusion and Implications

Household energy plays a fundamental role in improving living standards, health, and socioeconomic development, particularly in rural areas where access to modern energy remains limited. Understanding the patterns of household energy consumption is essential for designing effective energy policies that promote energy security, environmental sustainability, and improved quality of life (Moeen et al., 2016). In rural District Chitral, households continue to depend on a combination of traditional and modern energy sources for cooking, heating, and lighting due to differences in income, education, infrastructure, and resource availability (Jan & Lohano, 2021). Identifying the factors that influence these energy choices is therefore important for promoting cleaner energy adoption and reducing dependence on biomass fuels. Against this background, the present study aimed to examine the patterns of primary and secondary household energy sources used for cooking, heating, and lighting in rural District Chitral and to investigate the demographic, socioeconomic, and accessibility factors associated with household energy choices using Chi-square analysis.

Empirical investigation shows that the majority of the household in the rural areas of Chitral are using firewood for cooking (87.1 Percent) and heating (77.2 percent) as a primary source of energy due to availability of firewood in their houses, garden, orchards (14.2 percent), nearby source (21 percent) and in the market. 16.4 percent households are collecting 40 percent of the required firewood from nearby sources and buying the remaining 60 percent firewood from the market while this ratio is 20 (Collection) and 80 (Buying) for the 24.3 percent households. In this way rural household are spending substantial amount of their income on firewood i.e. 54.8 percent household are spending up to Rs.5000 and 22.8 percent are spending Rs.5000 to Rs.12000 monthly.

Some portion of rural household are preferring other sources of energy as a primary source for cooking and heating, i.e. LPG, electricity, animal/Plant residual and other sources depending on various socio-economic characteristics like employment, household income, number of earning members etc. And when these socio-economic characteristics are improved the household switched to cleaner energy sources like LPG and electricity and vice versa. The 7.3 % household where the head is graduate are using LPG ,8.5 % electricity and 2 % animal/plant residue for cooking while for heating 14.6 % are using LPG and 15.9 % electricity and 2.4 % are using animal/plant for heating as compared to 92.5 percent of the illiterate household using firewood and 6 percent using animal/plant residue for cooking and for heating 17.6 percent firewood, 19.4 percent animal/plant residue and 3 percent are using other sources.

Similarly, the number of earning members in a household increase to two, three, four and above four. The percentage of use of electricity and LPG increases while percentage of animal/plant residual decreases. 95 percent of the household which have only one earning member are using firewood,3.7 percent household are using LPG and,0.6 % electricity and animal/plant residue each. When the number of earnings, member increases to three, then 72.7 % of that household are using firewood,13.6 % LPG and electricity each, and not using animal/plant residual.

For lighting purpose, as electricity is used by almost all the 96 percent of the household, where there is available, whether they have more or less earning member, low or high income and employed or unemployed etc., while as back-up almost all (82.2 percent) of the households are using solar energy.

Due to the excessive uses of inefficient energy sources like firewood (87.1 percent) and animal/plant residue (26.5 percent) for cooking and heating, the smoke from open fires and

traditional stoves leading indoor air pollution causing several diseases in rural areas specially in women. So, the government should play their role in overcoming this issuen (Jan & Lohano, 2021). Almost 80 percent households of rural areas of Chitral are purchasing firewood from the market at various percentages of their consumption by spending a huge portion (54.8 % household are spending up to Rs.5000 and 22.8 % are spending Rs.5000 to Rs.12000) of their income. So, when Government provide them with a natural gas facility, the rural household can spend this huge amount on other necessary expenditures. The dependence on firewood for cooking (87.1 percent) and heating (77.2 percent) in the study area has wide-ranging consequences on the environment: Climate change, deforestation, soil erosion, and flooding. Due to climate change, flooding has been increased and glacier are melting due to high temperatures, resulting damage of infrastructure, supply of clean water, electricity, communication, transport and schools. So, the government besides providing alternate source of energy for cooking and heating should control the excessive cutting of forest (Moeen et al., 2016).

The current study has several limitations that should be considered when interpreting the findings. First, the research was confined to rural households in District Chitral; therefore, the results may not be generalizable to urban areas or other regions of Pakistan with different socioeconomic and geographical conditions. Second, the study relied on cross-sectional survey data, which captured household energy use at a single point in time and could not account for seasonal or long-term changes in energy consumption patterns. Finally, the analysis was limited to descriptive statistics and Chi-square tests to identify associations between household characteristics and energy choices and thus did not estimate the magnitude or causal effects of the determinants influencing household energy selection.

References

Ahmad, H., & Halim, H. (2017). Determining sample size for research activities: the case of organizational research. *Selangor Business Review*, 20-34.

Amer, M., & Daim, T. U. (2011). Selection of renewable energy technologies for a developing country: A case of Pakistan. *Energy for Sustainable Development, 15*(4), 420–435.

Arabatzis, G., Kitikidou, K., Tampakis, S., & Soutsas, K. (2012). The fuelwood consumption in a rural area of Greece. Renewable and sustainable energy reviews, 16(9), 6489-6496.

Arfin, T., Mohammad, F., & Yusof, N. (2014). Biomass resources in environmental and socio-economic analysis of fuel-wood consumption. In *Biomass and bioenergy: processing and properties* (pp. 191-206). Cham: Springer International Publishing.

Barnes D.F., Floor W. M. (1996) Rural energy in developing countries: a challenge for economic development. Annu. Rev. Energ. Env. 21, (1), 497.Bhattacharjee, S., & Reichard, G. (2011). Socio-economic factors affecting individual household energy consumption: A systematic review. *Energy Sustainability*, *54686*, 891-901.

Bhutto, A. W., Bazmi, A. A., & Zahedi, G. (2011). Greener energy: Issues and challenges for Pakistan—Biomass energy prospective. *Renewable and Sustainable Energy Reviews*, *15*(6), 3207-3219.

Ekholmt T., Krey V., Pachauri S., Riahi K.(2010) Determinants of household energy consumption in India. Ener. Poli. 38, (10), 5696.

Goldstein, B., Gounaridis, D., & Newell, J. P. (2020). The carbon footprint of household energy use in the United States. *Proceedings of the National Academy of Sciences*, *117*(32), 19122-19130.

ISSN Online: 2709-7625
ISSN Print: 2709-7615

Government of Pakistan. (2008). *Pakistan Economic Survey 2007–08*. Finance Division, Economic Adviser's Wing.

Hasan, S.A., M. Imtiaz Subhani, and A. Osman (2012). The energy short fall and its after effects(a case study for Karachi city in context to Karachi Electric Supply Corporation). ScienceSeries Data Report, vol. 4, No. 2, pp. 42-49.

Heltberg, R. (2004). Fuel switching: Evidence from eight developing countries. *Energy Economics, 26*(5), 869–887

Hosier, R. H., & Dowd, J. (1987). Household fuel choice in Zimbabwe: An empirical test of the energy ladder hypothesis. *Resources and Energy, 9*(4), 347–361

International Energy Agency. (2006). *World Energy Outlook 2006*. OECD/IEA.

Jan, I., & Lohano, H. D. (2021). Uptake of energy efficient cookstoves in Pakistan. *Renewable and Sustainable Energy Reviews*, *137*, 110466.

Jan, I., Khan, H., & Hayat, S. (2012). Determinants of rural household energy choices: An example from Pakistan. *Polish Journal of Environmental Studies, 21*(3), 635–641.

Kamal, S., Jan, A., Ullah, M., Ali, A., & Khan, S. (2021). Impact of Affordable and Clean Energy (SDG 7) on Signifcant SDGs. *International Journal of Engineering Works*, *8*, 103-111.

Kaygusuz, K. (2011). Energy services and energy poverty for sustainable rural development. *Renewable and sustainable energy reviews*, *15*(2), 936-947.

Khalil, M. S. (2012). Renewable energy in Pakistan: opportunities and challenges. *Journal of Renewable and Sustainable Energy*, *16*(0), 13-20.

Kucukali, S., & Baris, K. (2010). *Turkey's short-term gross annual electricity demand forecast by fuzzy logic approach*. **Energy Policy, 38**(5), 2438–2445.

Kuhe, A., & Bisu, D. Y. (2020). Influence of situational factors on household's energy consumption behaviour: towards an effective energy policy. *International Journal of Energy Sector Management*, *14*(2), 389-407.

Leach, G. (1992). *The energy transition*. **Energy Policy, 20**(2), 116–123.

Malla, S., & Timilsina, G. R. (2014). Household cooking fuel choice and adoption of improved cookstoves in developing countries: a review. *World Bank Policy Research Working Paper*, (6903).

Masera, O. R., Bailis, R., Drigo, R., Ghilardi, A., & Ruiz-Mercado, I. (2015). Environmental burden of traditional bioenergy use. *Annual Review of Environment and Resources*, *40*, 121-150.

Masera, O. R., Saatkamp, B. D., & Kammen, D. M. (2000). From linear fuel switching to multiple cooking strategies: a critique and alternative to the energy ladder model. *World development*, *28*(12), 2083-2103.

McFadden, D. (1972). Conditional logit analysis of qualitative choice behavior.

Miah, M. D., Kabir, R. R. M. S., Koike, M., Akther, S., & Shin, M. Y. (2010). Rural household energy consumption pattern in the disregarded villages of Bangladesh. *Energy Policy*, *38*(2), 997-1003.

Mirza, B., & Kemp, R. (2009). *Why rural rich remain energy poor* (Working Paper No. 2009-024). United Nations University – Maastricht Economic and Social Research Institute on Innovation and Technology (UNU-MERIT).

Moeen, M. S., Sheikh, A. T., Saleem, M. S. S., & Rashid, S. (2016). Factors influencing choice of energy sources in rural Pakistan. *The Pakistan Development Review*, 905-920.

Mrówczyńska, M., Skiba, M., Bazan-Krzywoszańska, A., & Sztubecka, M. (2020). Household standards and socio-economic aspects as a factor determining energy consumption in the city. *Applied Energy*, *264*, 114680.

ISSN Online: 2709-7625
ISSN Print: 2709-7615

Orimoogunje, O. O., & Asifat, J. (2015). Fuel wood consumption and species degradation in south-western Nigeria: the ecological relevance. *J. Landsc. Ecol*, *8*, 56-68.

Pachauri, S., & Jiang, L. (2008). The household energy transition in India and China. *Energy Policy, 36*(11), 4022–4035.

Puzzolo, E., Zerriffi, H., Carter, E., Clemens, H., Stokes, H., Jagger, P., ... & Petach, H. (2019). Supply considerations for scaling up clean cooking fuels for household energy in low-and middle-income countries. *GeoHealth*, *3*(12), 370-390.

Raza, M. Y., Wasim, M., & Sarwar, M. S. (2020). Development of Renewable Energy Technologies in rural areas of Pakistan. *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, *42*(6), 740-760.

Specht, M. J., Pinto, S. R. R., Albuquerque, U. P., Tabarelli, M., & Melo, F. P. (2015). Burning biodiversity: Fuelwood harvesting causes forest degradation in human-dominated tropical landscapes. *Global Ecology and Conservation*, *3*, 200-209.

Van der Kroon, B., Brouwer, R., & Van Beukering, P. J. (2013). The energy ladder: Theoretical myth or empirical truth? Results from a meta-analysis. *Renewable and sustainable energy reviews*, *20*, 504-513.

Wu, S., Zheng, X., You, C., & Wei, C. (2019). Household energy consumption in rural China: Historical development, present pattern and policy implication. *Journal of Cleaner Production*, *211*, 981-991.

Yawale, S. K., Hanaoka, T., & Kapshe, M. (2021). Development of energy balance table for rural and urban households and evaluation of energy consumption in Indian states. *Renewable and Sustainable Energy Reviews*, *136*, 110392.