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Is Household Electrification Helpful for Environmental Conservation?

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Abstract: *Majority of Bhutanese population lives in rural area where natural forest cover plays significant role in social, cultural and in daily economic activity. Degradation of natural resources often marginalizes poorer sections of the society. According to national accounts of 2011, hydropower generation accounted for 13.9 percent of the total GDP. The making electricity and other forms of clean energy may force households to switch to cheaper energy sources like biomass. This in long run may negatively impact natural resource conservation and income generation from hydropower. We estimated a demand function for firewood using Bhutan Living Standard Survey 2012. Our results suggests that there is strong preference for clean energy by households and household electrification has helped in reducing the consumption of firewood by about 35 percent per month, thus contributing to conservation.*

Keywords - Firewood, Electricity, Environmental Conservation, Natural Resources
Research Area: Population and Development Studies
Paper Type: Research Paper

1. INTRODUCTION

About 70 percent of the Bhutanese population dwells in rural areas and nature plays significant role in day to day economic activity (NSB, 2013). Rural communities are fully dependent on natural products like fodder, fuel wood and other food items like vegetables, medicinal herbs etc. The degradation of these natural resources will further marginalize poorer sections of society. Thus, having understood the coexistence relationship between community and natural environment, constitution of Bhutan requires maintaining 60 percent of forest coverage at all times to come. Currently, about 50 percent of country's geographical area is protected under national parks and its biological corridors (RGoB, 2012).

According to national accounts of 2011, hydropower generation accounted for 13.9 percent of the total GDP and all future development activities are expected to support by revenue generated by hydro power plants. The Department of Energy has also reported that 80 percent of the water flowing in the rivers of Bhutan is contributed by forested watersheds, highlighting the importance of forest cover and its conservation for sustainable hydropower generation (Beldring & VoksØ, 2012; NSB & ADB, 2013). Therefore, the conservation of forest is important not in terms of livelihoods of people but also for the achieving the developmental goals of Government of Bhutan.

Carbon sequestration by the vast forest cover of Bhutan is another ecosystem service, for which Bhutan and global community has benefited. The Watershed Management Division of Forest and Park Services Department claims that Bhutan emits approximately 1.5 million tons of carbon annually and at the same time Bhutan's forests absorb approximately 6.3 million tons. In 2010, Bhutan became an observer to the UN-REDD programme, with hopes for being rewarded for its contribution to mitigating global carbon emissions (WMD, 2012).

According to draft renewable energy policy of Bhutan 2011, Royal Government of Bhutan shall strive to ensure adequate provision and extensive use of modern energy services in rural areas, which in the past have been largely dependent on firewood and kerosene (RGoB, 2011). As of 2012, 92 percent of all households in Bhutan, almost all urban households and 87 percent of rural households have access to electricity. Electricity was found to be the main source of lighting for both urban (98 percent of households) and rural (83 percent households). It is also the main source of cooking energy in urban (98 percent of households) (NSB & ADB, 2013).

Various activities were initiated to achieve the Millennium Development Goal of providing access to clean energy services to at least 50 percent of the population by the year 2015 and national goal of 100 percent electrification by 2020. Rural electrification (RE) master plan for Bhutan was developed to serve as a road map for department of energy and to enhance the socio-economic development and improve living conditions of the Bhutanese (Tshering & Tamang, 2004). As of 2013, all urban (100 percent) households and 87 percent of rural households have access to electricity (BLSS, 2013). With an intensification of rural electrification under various development plans, there has also been drastic reduction in firewood consumption (ADB, 2010). In this study we attempt to quantify how much household electrification has helped in the reduction of firewood consumption in Bhutan.

The main aim of the paper is to test whether household electrification programme in Bhutan has contributed to reduction in fire wood consumption. It is expected to help the policy makers to help them to make informed decision about the tariff of electricity and other substitutes. This paper is arranged as brief review of related studies, data and variables used, basic theory and economic model, results and discussion and conclusion.

2. BRIEF REVIEW OF RELATED STUDIES

Majority of the people in developing countries still rely on firewood to meet their basic energy needs (Greenstone et al, 2008; Edwards, 2005). Firewood is the major source of cooking energy in Bhutan. We expect to remain so for several decades because the shift towards conventional fuels is seems to very slow according to available evidence. Likewise, Laxmi et al (2000) found fuel wood as main source of cooking fuel in rural Tamil Nadu with average consumption 2.5 kg per day. Only 8 percent of the households were using the clean fuels, like kerosene or liquid petroleum gas for cooking purpose. Authors also provide details account of sources, time spent and number of people involved in collection of firewood. It was found that about 73 percent of the household collect firewood from village and government forest located within less than one kilometer, usually one to two persons are engaged gathering and spend on average 2.5 hours per day for the collection. In contrast, according to Bhutan Living Standard Survey, 2012 (BLSS) 91 percent of rural households are connected with electricity and firewood no longer remain as ultimate energy source for cooking, lighting and washing. For instance, 83 percent of rural people in Bhutan utilize electricity for lighting and 12 percent use kerosene or gas lamps for lighting, 84 percent of household use electricity for cooking, while 61 percent of the household use gas an alternative for cooking (NSB & ADB, 2013).

The studies on determinants or factors influencing household choice of fuel indicates that the type of fuel used by household is influenced by a number of demographic, socio-economic, cultural, political and institutional factors (Laxmi et al, 2000; Abebaw, 2007). For example, in Zanzibar the choice of firewood over other energy sources are often dictated to a large extent by poverty, fuel wood is cited to be cheaper compared to other sources of energy (Makame, 2007), while in rural Tamil Nadu, insufficient supply of clean energy sources is

the main reason for remaining the firewood as main source of cooking fuel (for example, kerosene supplied through Public Distribution System (PDS) is mostly restricted to a quota of 3 liters per household) (Laxmi et al, 2000).

Boadi & Kuitunen (2005) statistically validate the socio-demographic factor of household greatly influencing the choice of fuel. Many poor households depends on charcoal and firewood, while the greater majority of high and medium wealth households depend on cleaner energy sources (LPG, electricity). The choice of cooking fuel is significantly affected by respondent's education level. Less educated respondents are more likely to use charcoal and unprocessed wood than those with secondary or higher education. Strong correlation is observed between the choice of cooking fuel and cooking place. Households using solid fuels (firewood) are more likely to cook outdoor. However, Greenstone et al., (2008) pointed out that socio-economic status of households not only determines the choice of cooking fuel but also type of cooking stove. The higher income households' and households' with access to electricity are more likely to use clean stove. Households' in which women are empowered are 2 to 3 percent more likely to use clean stove.

Similarly, Dunkerly et al., (1989) reported that there is strong relationship between household income, fuel choice, energy and consumption in Raipur City, India. Firewood constitutes about 80 percent total household consumption for two lowest income group. The middle and above average income households use of firewood constitute 30 to 45 percent of total energy, only 10 percent or less of total energy is contributed by wood for highest income households. Spending on energy sources is positively correlated with increase in households' income. Equally, total energy consumption per household increases more rapidly with households' income. The possible explanation is, cooking may involve more or larger meals as households' use more efficient types of energy or additional attributes, such as convenience, cleanliness, or taste may be associated with the more efficient forms of energy used by higher income households. Further, study shows that firewood is not only the major source of energy at the household (64 percent) level but also used by commercial and institutional consumers in food preparation, accounting for 54 percent of the total. The popularity of firewood for commercial establishments is due to supply reliability (Dunkerly et al., 1989).

Abebaw (2007) studied the determinants of household choice of fuel wood in urban Ethiopia, taking into the explanatory variable like per-capita income, age and sex of head of household, home and cattle ownership, and distance from the road. The findings of the study demonstrated that per-capita income and age of the household head exerts positive effect on firewood consumption. The sex of the head of the household is negatively associated as women have stronger preferences for cleaner energies. Likewise, home ownership is also negatively correlated meaning that ownership of home increases the opportunities for spending for cleaner fuels.

Shonalipachauri et al., (2007) stated that there are number of factors, other than income, influencing the choice of household cooking fuel in urban India. The ordered profit model shows that LPG and kerosene prices have negative effects, indicating that higher prices can result in lower energy status. The price of wood is statistically insignificant for fuel switching. Variable like size of household, age of the head of the household and female headed household have positive effect on probability of choosing cleaner fuels. For instance, household head without education or only having primary education increases the likelihood of choosing firewood or kerosene as a cooking fuel, whereas, those households where the

head has a higher level of education are more likely to use LPG for cooking (Shonalipachauri et al, 2007).

The study by Edwards et al (2005), reports that 75 percent of households use firewood for cooking in Guatemala. Findings demonstrate that firewood is not exclusively for poor households and rural phenomenon. Furthermore, empirical evidence suggest that firewood consumption and choice of type of cooking stove is also influenced by credit availability, price of wood, age of household head, and household size, price of electricity and place of residence (rural or urban). For example, household who had access to credit are more likely to own stove, and households that own a stoves consume less firewood, while the price of wood has significant negative effect on firewood consumption. Firewood use is positively correlated with age of household head and rural households are more likely to use firewood than urban households (Edwards et al., 2005).

Studies on the determinants of household's willingness to adopt improved cleaner energy sources shows low adoption rate in developing countries. It is influenced by a number of socio-economic, cultural, political and institutional factors (Jan, 2011; Laxmi et al, 2000; Abebaw, 2007). According to Jan (2011), qualification, total monthly income and household level of awareness have significant effects on household adoption of improved and cleaner energy sources in Pakistan. Further, study confirms that age, total land holdings, size of the family is statistically not significant. In addition, much recent literature on fuels switching suggest that fuel switching is a gradual process with many households often using multiple fuels. The reasons for multiple fuel use are varied and not dependent on economic factor alone. In some cases, households choose to use more than one fuel as they want to increase the security of supply. In other cases, choice might be dependent on cultural, social or taste preferences (Shonalipachauri et al., 2007). The demand for firewood is assumed to be function of demographic and socio-economic characteristics of household.

3. DATA AND VARIABLES

We use Bhutan Living Standard Survey 2012, which was collected in collaboration with Asian Development Bank. This is latest household data currently available in Bhutan. It follows the methodology developed for Living Standard Measurement Survey (LSMS) developed by World Bank. The sample was chosen at two-stage stratifications: district and urban/rural stratum. Primary Sampling Unit (PSU) for rural area was chiwogs[11] and blocks for urban areas. Total of 4619 households from rural and 4349 households from urban were randomly chosen (for details, refer BLSS Report 2012), and this translate to total sample size of 8969 households. Information related to education, income and household expenditures were collected. The main objective of this paper is to investigate whether the household electrification has helped in reducing the firewood consumption, we use information about household characteristics, monthly expenditures on firewood and its substitutes and the place of residence. The information about firewood consumption was collected in two different units namely, backload and truckload. Backload is amount of firewood a person can carry on back and it may weigh about 30 to 40 kilogram on an average.

In BLSS 2012, about 91 percent of households have reported as having connected to grid electricity. Among these households, 36 percent had reported as having used electricity as the most often used cooking fuel while 41 percent and 22 percent have reported as using LPG (liquid petroleum gas) and firewood respectively. About one percent had reported as using coal, kerosene, and biogas and dung cake. Firewood is also used for heating purposes, 3

[1]Chiwog is the smallest administrative units, it consist of group of villages

and 44 percent of the sample households have reported as using electricity and wood for heating purposes respectively. The overall mean monthly household expenditure on firewood was reported as about Nu 7 which was the lowest among the four alternative fuels. It was reported that household expenditure on electricity was the highest with mean monthly expenditure of Nu 246. An insignificant number of households have reported as using other fuels like coal and dung cake, and these fuels are ignored in our study.

It was reported that only about 16 percent of head of households completed higher secondary and above years of education and about 27 percent of the total households were headed by female. Our sample is also about equal distribution in terms of place of residence particularly distribution between urban & rural and northern & southern belt.

Table 1: Descriptive Statistics of Variables (N=8969)

Variable	Mean	Std. Dev.
Firewood consumed per month (backload)	5.49	10.40
Household connected to electricity (1 if connected to grid electricity)	0.91	0.28
Monthly expenditure on firewood (Nu)	7.34	35.39
Monthly expenditure on electricity (Nu)	246.49	393.24
Monthly expenditure on LPG (Nu)	220.69	270.40
Monthly expenditure on kerosene (Nu)	190.02	289.92
Level of education of head of household (1 if completed schooling of higher secondary and above)	0.16	0.37
Firewood used for cooking (1 if firewood is used for cooking)	0.11	0.31
LPG used for cooking (1 if LPG is used for cooking)	0.65	0.48
Cattles owned by household (1 if household owns a cattle	0.48	0.81
Female head of household (1 if head of household is female)	0.27	0.44
Household per capita income per month (Nu)	3970.17	18411.46
Distance from the nearest forest (Hours)	1.44	1.81
Northern/southern region (1 if north)	0.49	0.50
Rural/urban (1 if urban)	0.51	0.50

4. BASIC THEORY AND EMPIRICAL MODEL

Following Nepal etal (2010), we assume that the households derive utility from consumption of household goods, energy for cooking & heating and household characteristics. The demand for firewood, which is derived by maximizing the household utility function, subject to household income (Baland etal 2010) is what we are estimating in this study. Therefore, for the household *i* at location *j*, the firewood (FWij) is a function of price of firewood and its substitutes (PWij), household characteristics (HCij) and the place of residence (PRij).

$$FW_{ij} = \beta_0 + \beta_i EF_{ij} + \beta_m HC_{ij} + \beta_n PR_{ij} + U_{ij} \quad (1)$$

The market for firewood is fully developed in urban areas, and it is almost nonexistent in rural areas. However BLSS 2012 has reported household expenditure on firewood and its substitutes such has electricity, LPG and kerosene. We therefore, use monthly household

expenditure on firewood and its substitutes as a proxy for these household energy prices. As per the law of substitution, we expect the coefficient of monthly expenditure on electricity, LPG and kerosene to be positive and we expect negative coefficient for the expenditure on firewood.

Household characteristics indicating whether a household is connected to grid electricity or not is our interest variable of our study and we attempt to understand if electrification is helpful in reducing the demand for firewood, *ceteris paribus*. As mentioned earlier, electrification in Bhutan is expected to help in reduction of firewood consumption thus helping conservation of environment, which is one of the main arms of our development paradigm, Gross National Happiness[2]. Hence, we expect its $\beta<0$.

Demand for firewood is also affected by place of residence (urban or rural) and region (plain and mountainous). The proximity to firewood for rural households is better and rural households are expected to consume more firewood compared to urban households. Similarly, households in plain region are warmer than those located in mountainous region, and we expect its $\beta>0$.The knowledge and awareness about indoor air pollution and impact of collecting firewood on conservation may influence the choice of household fuel. To control for it, we have included the dummy for if head of household had completed schooling of higher secondary and above. It is because, family do respect the view of the highly qualified person in the household.

Different types of cooking fuel used by households are included to check for sensitivity of estimated parameters with the choice of cooking fuel. The types of cooking fuel that we are controlling for in our model are LPG and firewood. Since firewood and LPG are substitute for fuel, we expect $\beta<0$ when LPG is used $\beta>0$ when firewood is used as cooking fuel. In rural Bhutan, firewood is used for the preparing cattle feeds. The presence of cattle in a household may determine the amount of firewood consumed by household. The presences of cattle (cattle) have been included in our model to control for variation in firewood consumption by the households.

5. RESULT AND DISCUSSION

We estimated a demand for firewood function (equation 1) and to ensure positive predicted value of firewood consumed by households, we estimated log-log models. The primary objective of this study is to understand the effect on household electrification on firewood consumption. Table 2 shows the results of log-log regression model. In this model, firewood is measured in terms of backload consumed by a household per month. We also control for other household characteristics, monthly expenditure on firewood and its substitutes and place of residence. One of the problems associated with cross sectional data is heteroskedasticity, where variance of error term is not constant. To hedge against this problem, we estimated robust standard error. The presence of heteroskedasticity does not bias a coefficient; however the standard errors are biased and making coefficients no longer sufficient to draw inferences. The regression results are still significant after estimating robust standard errors, thus indicating our results are robust and sufficient to draw inferences.

The coefficient of household connected to electricity, which is whether a household is connected to electricity, is negative as expected and highly significant. Negative coefficient tells us that the household having connected to grid electricity consumes less firewood compared to those not connected to electricity. Our result suggests that households connected to grid electricity consume 36 percent less backloads of firewood in a month compared to

[2]Gross National Happiness is holistic development paradigm followed by Royal Government of Bhutan

those not connected to electricity. Therefore, conservation of forest strategy of a country or region may be more helpful by supplying electricity for household purposes.

Following the law of demand and price, we did expect the coefficient of monthly expenditure on firewood to be negative, indicating that when the price of firewood increases the demand for firewood would decrease. However, our coefficient is positive indicating that when price of firewood increase, the demand would also increase. However, this result is consistent with Nepal (2012) indicating that firewood is an inferior good. One possible explanation could be firewood is the cheapest source of energy compared to its substitutes. Similarly, the coefficient of monthly expenditure on electricity and LPG is negative which was expected to be positive. The result suggests that households demand for the cleaner energy in Bhutan is still high despite soaring energy prices particularly in urban Bhutan.

We also included the type of cooking fuel used for cooking since firewood is also used for other purposes in Bhutan like heating and rituals. As expected the coefficient is positive while firewood is used for cooking and negative while LPG is used as cooking fuel.

We also controlled for household characteristics such as level of education of head of household and female head of household. Available literature suggest that as the level of education increases, the demand for dirty energy decreases as the household becomes more aware of implications of indoor air pollution and other related health problems. Our results are also consistent with the past studies. Similarly, cooking is mostly done by female in Bhutan and female are more exposed to air pollution and results suggest that female head of household tends to consume less firewood. The number of cattle owned by the households would also determine the amount of firewood consumed as firewood is also used for cooking cattle feed. Our results show that household with more cattle consumes more firewood however it is insignificant at conventional level. We also controlled for distance from the nearest forest as closer to forest increases the proximity to firewood. As expected, coefficient is negative suggesting that as the distance from forest increases, the consumption of firewood decreases. The coefficient of household per capita income also suggests that as the household incomes increases, the consumption of firewood decreases. This result may be telling us that as income increases, households switch to cleaner alternative fuels such as electricity, LPG and kerosene which is also consistent with the many past studies in our region and Africa.

As mentioned above, the place of residence such as southern or northern belt would influence the consumption firewood. Southern belts are warmer than Northern belt and we expect negative coefficient. As expected the coefficient is negative suggesting us that Southern belt tends to consume less compared to its counter-part North. As expected the coefficient of rural or urban-place of residence negative as expected. We did expect negative as urban residents have more alternatives and also the proximity to firewood is very low.

Table2: Log-Log Model Regression Result

Variables	**Firewood (*ln*)**
Household connected to electricity (1 if connected to grid electricity)	-0.352***
	(-0.117)
Monthly expenditure on firewood (Nu) [*ln*]	0.073**
	(-0.029)
Monthly expenditure on electricity (Nu) [*ln*]	-0.028**
	(-0.013)
Monthly expenditure on LPG (Nu) [*ln*]	-0.001***
	(0.000)

Monthly expenditure on kerosene (Nu)[*ln*]	0.000
	(0.000)
Level of education of head of household (1 if completed schooling of higher secondary and above)	-0.271***
	(-0.074)
Firewood used for cooking (1 if firewood is used for cooking)	0.673***
	(-0.112)
LPG used for cooking (1 if LPG is used for cooking)	-1.125***
	(-0.079)
Number of cattles owned by household [*ln*]	0.068
	(-0.047)
Female head of household (1 if head of household is female)	-0.201***
	(-0.063)
Household per capita income per month (Nu) [*ln*]	-0.052***
	(-0.012)
Distance from the nearest forest (Hours) [*ln*]	-0.080**
	(-0.036)
Northern/southern region (1 if south)	-0.252***
	(-0.062)
Rural/urban (1 if urban)	-0.216***
	(-0.081)
Constant	2.105***
	(-0.163)
Observations R-squared	8,969
	0.181

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

6. CONCLUSION

Bhutan had been prioritizing the development of hydropower projects since the inception of its first five year plan and gearing towards development of hydro economy. Towards this end, Bhutan has realized the importance of maintaining forest cover given the importance of watershed services that forest provides for the flowing rivers. At the same time, majority of Bhutanese population lives in rural Bhutan and we want to forest cover provides livelihoods to rural community through various means.

However, if electricity tariff becomes expensive and unaffordable, households are likely to depend more on firewood. It was reported that, switch to clean energy sources only happens, if the shift do no create an additional burden on the households budget (Wickramasinghe, 2011). Higher electricity tariff might trigger switching to cheaper energy sources like firewood; because firewood is freely collected in many parts of Bhutan except in urban areas. Increase in firewood consumption is likely to put more pressure on existing forest cover, which in long run may fail to provide watershed services for the rivers. Reduction of watershed services in long run affect hydropower generation, thus affecting the GDP of the country. Therefore, maintaining affordable electricity tariff all levels of household is crucial for stopping this chain effect.

Our results show that's there is strong preference for the clean energy like electricity and LPG, however in future, the revisions of tariffs for electricity and LPG should be revisited cautiously as results indicate that the household electrification has immensely

contributed in terms of reducing firewood consumption by about 35 percent of backload per month.

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