Time allocation model for fuelwood collection in rural Nepal: An Empirical Analysis

Introduction

Forest area covers 38% of the total land area of Nepal. Nepalese households living in the rural sector of Nepal depend on the forest for fuel, fodder and non-timber forest products (NTFP). Forest resources are the most prominent source of fuelwood in Nepal with around 70% of residential energy coming from this sector (MOF, 2015). Fuelwood consumption by Nepali households was reported to be 32,784,000 cubic meters in 2013 as compared to 12,097,000 cubic meters in 1990 (UN data, 2016). The data clearly depict the importance of fuelwood as a major energy source in Nepal.

Nepalese society is agrarian in nature where agriculture contributes around one-third of the total GDP of the country (MOA, 2015). Subsistence agriculture is the norm, small landholder farmers accounting for about two-thirds of the total farming community (MOA, 2015). Subsistence agriculture coupled with forestry activities forms the basis of rural people's lives in Nepal. As subsistence users of forest products, the survival of rural households in Nepal is directly linked to forest resources (FAO, 2009). Fuelwood collection may occur from a variety of sources, including community forest, private land and other forest land. Household labor forms the basic input for fuelwood collection in rural Nepal. Female members of the family are the active participants involved in fuelwood collection while male members are also involved in fuelwood collection. The laws and rules formed by community forest, type of forest area prevalent in the local area and household characteristics determine the extent of time spend by a household on community forest/local forest/private land for fuelwood collection.

The major source of income of rural Nepalese household is agriculture and many households are dependent on forest products as well for sustaining day to day life. But, the scenario has been changing in recent times. Foreign employment has become a prominent source of income for Nepali households which contributes 29.1% of GDP (MoLE, 2014). The out-migration of Nepali youth leaves dearth of labor force in Nepalese communities. The out-migration of male population is in surge while female population are also bound to out-migration. A total of 1921494 population were absent during the year 2011 which is around 7.35 percent of the total Nepalese population (MoLE, 2014). Meanwhile, remittance earned from foreign employment has helped to increase household income in Nepal. How households allocate time for agricultural and forest activities in these changed socio-economic conditions is an intriguing question. Labor allocation to agricultural and forest-related activities remains a challenge to rural people in these changed socio-economic conditions.

The present study analyzes the time allocated by individual households for fuelwood collection in rural Nepal. Time spent for fuelwood collection by the household members forms the dependent variable which were collected based on recall by the household members over the past one year period. The findings of the study can give a brief look into the pattern of time spent by Nepalese household members i.e., by males and females in forest sources for energy i.e., fuelwood. Moreover, household reliance over forest fuelwood can be analyzed. . Independent variables for the study are educational attainment of family members, household income, number of private trees planted, number of active members in household (between 16 and 60 years of age), distance to the nearest forest resource, use of other energy sources (dummy variable, 1 if only fuelwood is used), resource type (dummy variable, 1 if timber forest), gender (dummy variable, 1 if female) and private land holdings.

Review of Literature

McDonald et al. (1998) examined behavior related to fuelwood collection to assess the tradeoffs implicit in the choice of fuelwood collection site and developed a model that can assess the impact of changes in the quality and quantity of fuelwood collection sites. They examined the use of calories as a measure of the opportunity cost of collecting fuelwood. This provided the opportunity to value the services with a metric that is relevant to the local community and, by making assumptions on the monetary value of calories, the ability to convert this measure into monetary terms. The results showed standard economic models of choice can be adapted to model the decision making processes of the subsistence agricultural household. Domestic energy supply and demand in rural India was discussed in Heltberg et al. (2000). A non-separable household model was used to analyze the link between forest scarcity and household fuel collection, focusing on substitution of non-commercial fuels from the commons and the private domain. A novel maximum entropy approach was used for estimation based on the study location. Households in the study area were found to be responding to forest scarcity and increased fuelwood collection time by substituting fuels from private sources for forest fuelwood. The energy consumption and fuel substitution were linked to household endowments of land, labor, trees, and stoves, fuelwood collection time, forest stock, forest access, and management institution. One major implication of this study was that interventions seeking to increase the stock of forest such as reforestation and plantation works may have little impact unless the factors underlying forest degradation are addressed. Increasing forest stock and decreasing collection time will induce substitution of fuelwood for energy with institutional management. Thus, proper management institutions should be enforced to insure lesser degradation of forest resource.

Household survey data from Madagascar were used to examine water supply choice and time spent in water collection (Glick and Sahn, 2011). The choice of water source was found to be strongly influenced by a number of household characteristics, as well as distance to sources. Strong substitution effects were observed across different water sources. With regard to time spent gathering water, the study focused on the effects of gender, age, and distance to water. Women and girls were found to be spending most of the time gathering water. The response to reducing distance to different water sources differed a lot in rural and urban areas, as well as by gender and age of household members.

Sapkota et al. (2008) examine household socio-economic characteristics and fuelwood collection patterns from local common property forests in a highly heterogeneouscommunity of Nepal (Sapkota et. al., 2008). The study provided evidence in favor of the hypothesis that socio-economic inequalities within the group are inexorably associated with the ability of the households in resource appropriation from forest resource Household wealth status, proximity to the forest, and the number of forest visits were found to exert a strong influence on fuelwood appropriation from the forest. Income status of households was found to be a key determinant of household fuel-wood collection from the forest. Poor households were found to be highly dependent on the forests for fuelwood for sustaining their day-to-day livelihood. Higher dependence of poor people who represented a larger population size in the region were viewed as a prime reason for forest degradation in the future. Socio-economic heterogeneity and household's dependency must be considered prior to devolution of management rights to local level was the broader policy implication of the study.

Household survey data was used to empirically investigate how rural economies depend on tropical forests use on Siberut, Indonesia (Pattanayak et. al., 2003). Household production theory was used to build a model of forest products collected as a function of labor, tools, forest condition and household classes. Five different forest products were all combined into a composite forest product using market prices of those respective products as weights. Similarly, households were also classified into four different classes based on the possession of assets, i.e., land, livestock, productive equipment and consumer durables. Labor allocation to forest related activities was found to be significantly influenced by household composition and socio-economic factors. Meanwhile, forest quality was found to be negatively correlated with forest product collection. Similarly, the wealthiest households were found to be collecting the least amount of forest products while the mid-wealthiest families were found to be investing the most labor for forest product collection.

Cooke, 2016, investigated how forest user group (FUG) management and household characteristics influenced household allocation of male and female labor to fuelwood collection using household data from rural Nepal. The study primarily investigated how the level of FUG restrictions on fuelwood collection in the FUG forest and the share of women on FUG committees influenced fuelwood collection by males and females. It also investigated the time spent by households and the place used for fuelwood collection too. Male and female fuelwood collection labor allocation was found to be influenced by gender-specific opportunity costs of time, fuelwood scarcity and household demographics. Similarly, FUG management was found to significantly influence gender allocation of labor choices by households. Banning fuelwood collection in the FUG decreases the likelihood that men and women collect in the FUG forest and encourages women to collect fuelwood in other, less protected forest areas. Thus, women were propelled to travel to less protected areas for fuelwood collection. Similarly, results suggested that a higher share of women on the FUG executive committee and more FUG forest area per FUG household work could counter the effects of tight restrictions. A larger female executive committee share encourages male collection in the FUG forest and decreases the likelihood females collect in other forests. More FUG forest availability increases the likelihood that men and women collect in the FUG forest and decreases the likelihood that they collect from either private property or from other forest lands.

A household model was used to examine the adoption and efficient use of improved stoves in Nepal (Amacher et al, 1992). Improved stoves are a technological substitute for fuelwood and are supposed to reduce deforestation. Both adoption of improved stoves and efficient use were regarded as uncertain events in the study as well as future household income. Fuelwood and fuelwood substitute prices, the level of stove efficiency, household income, and demographic characteristics and wealth were found to be important indicators of adoption and efficiency.

Deforestation behavior of smallholder agriculturalists in relation to changing condition of off-farm labor market was examined by Bluffstone, 2004. A model representing a village situation was proposed which incorporated dependence of villagers on open access forests for fuelwood and animal raising. Dynamic simulations were performed which compared time paths of forest stocks, deforestation levels, and household labor supply under a variety of conditions. Despite the open access regime assumed in the model, with a perfect low-wage off-farm labor market, the agro-forestry system in Nepal was found to be stable. Similarly, an alternative model was examined where there was no off-farm labor market. The alternative model eliminated the important feature i.e., adjustment to deforestation which generated forest stability. The alternative model suggested that the availability of off-farm opportunities was an important determinant of deforestation behavior and equilibrium forest stock levels

Scheurlen , 2016 estimated the time allocation to energy resource collection in rural Ethiopia using two step regression analysis and focal group discussion. The paper examined the rural Ethiopian households' time allocation to different activities, especially fuelwood collection, and also examined the effect of changes in the availability of firewood resources on households' time allocation to fuelwood collection and on and off-farm income generation. Women were found to be involved in more time-consuming and simultaneous work activities then men in the study area and were primarily responsible for fuelwood collection. Similarly, the households located in areas with lower fuelwood availability were found to be spending more time per week for fuelwood collection which had a negative effect on time allocation for off-farm work but did not have a statistically significant negative effect on on-farm labor time and total income.

Heltberg (2004) has studied household fuel use and fuel switching behavior in eight diverse developing countries including Brazil, Ghana, Guatemala, India, Nepal, Nicaragua, South Africa, and Vietnam. Fuel switching was found to be quite happening in the urban areas of the study countries, with the exception of Ghana. In rural areas, however, modern fuels i.e., LPG and electrification was found to play a relatively modest role, and were often confined to the top income brackets. Biomass was used almost universally in rural areas. Moreover, once rural households start using modern fuels, solid fuels i.e., biomass were far from always displaced. Similarly, larger households were found to be using both modern fuel i.e., LPG and electrification in combination of solid fuels i.e., biomass. Increasing level of education was found to be associated with higher probability of using modern fuel and lower incidence of use of solid fuel.

Hosier and Dowd (1987) applied a multinomial logit formulation of the energy ladder to household energy-use data from Zimbabwe. The 'energy ladder' is a concept used to describe the way in which households will move to more sophisticated fuels as their economic status improves. The results showed that as economic status of household improves, households will move away from wood to kerosene and electricity but a large number of other factors were found important in determining household fuel choice. The policies which could be used to encourage fuel substitutions were found limited, and would prove more effective in the urban areas where higher incomes provide greater flexibility for fuel substitution. Contrary, rural households would face less stress for fuelwood due to fuel substitution in urban area and can make them better off using available fuelwood.

Macht et al (2007) examined the impact of community context on households' use of fuels other than wood for cooking. They emphasized the importance of local community contextual characteristics as determinants of the transition from fuelwood to the use of alternative fuels. They used longitudinal multilevel data on household fuel choice and community context from the Nepalese Himalayas to provide empirical estimates of their theoretical model. The results of their empirical investigation revealed that increased exposure of household to nonfamily organizations in the local community increases the use of alternative fuels in the household.

``Energy ladder'' model explains the transition from traditional to modern fuels and devices that suggests that with increasing affluence, a progression is expected from traditional biomass fuels to more advanced and less polluting fuels. Kammen et al (2000) evaluated the energy ladder model utilizing data from a four-year (1992- 96) case study of a village in Mexico and from a large-scale survey from four states of Mexico. They showed that an alternate ``multiple fuel'' model of stove and fuel management based on the observed pattern of household accumulation of energy options, rather than the simple progression depicted in the traditional energy ladder scenario, more accurately depicted the cooking fuel use patterns in rural households.
The proposed model integrated four factors demonstrated to be essential in household decision making under conditions of resource scarcity or uncertainty i.e., economics of fuel and stove type and access conditions to fuels; technical characteristics of cook stoves and cooking practices; cultural preferences; and health impacts. They found that fuel switching is actually a step toward ``multiple fuel cooking'' or ``fuel stacking'' of both fuelwood and LPG. Examination of the different dimensions of the adoption of modern cooking fuels showed that it was a complex process well beyond a simple change in the end use efficiency of cooking-where economic aspects are interlinked with social and cultural issues. The rate and pace of inter-fuel substitution, rather being a smooth process driven by increasing household income, was found to be the result of the interplay between structural macroeconomic conditions and the local cultural and economic circumstances of households. At the village level, fuelwood scarcity, the increasing monetization of the household economy, and the influence from urban centers were found to be motivating households to look for other cooking options.

Mishra (2008) examined household behavior related to fuelwood collection and use in rural Orissa focused on identifying the behavioral transition of fuelwood-using households from collection to purchase. The study examined the theory linking households' labor allocation decisions to choice of fuel and modeled household decision using a three-stage least squares probit specification. Household fuelwood choice (purchase/collection) was predicted based on an endogenously determined wage income which in turn was found to depend on the opportunity cost of fuelwood collection. Economic ability and availability of fuel alternatives were found to have significant positive marginal effects on household choice for fuelwood purchases. There was also the possibility that at very high levels of income, and in the absence of alternatives, households may revert back to collecting fuelwood using either their own labor or hired workers. Economic ability alone might not be sufficient to bring about energy transition in rural areas; there might be a need of price subsidies on alternative fuels and creation of effective institutions for conserving forest commons.

Sengupta and Kuri (2016) addressed the problems associated with fuelwood production and consumption in the rural areas of Purulia district of West Bengal using. They analyzed household responses to forest scarcity using a non-separable household model focusing on the prospects of fuel substitution based on primary data from six villages located on the Ajodhya Hills of Purulia. They used OLS technique and probit model to fit the estimation. It was observed that instead of reducing fuelwood collection from the forest, households respond to the scarcity by increasing its consumption. Substitution of forest fuelwood was noted only when number of trees on private land increases although the result turns out to be insignificant. This indicated that there were not any alternatives to forest fuelwood in the rural areas especially when the forest resources are available for free to the inhabitants residing in the vicinity of the forests.

Methodology

A non-separable agricultural household model is used to describe a rural household engaged in agricultural and forest activities. Household consumption model was a modified form of model used by Heltberg et. al., 2000. Apart, some may be involved in business activities, services and work for wage/salary earning purpose.

$$U = U(L, X, M, D)$$

Where L is leisure, X is market good, M is consumption of home produced goods which require energy in their production, and

D is vector of household demographic variables upon which utility is conditioned.

$$M = M\ (FW_C(L_M^M\ , L_M^F), BG_{own}(L_M^M\ , L_M^F), OE_C(X))$$

where FW_C is the fuelwood collected, L_M^M and L_M^F are male and female labor used for fuelwood collection, BG_{own} is bio-gas own by family and OE_C is the other energy sources purchased in market such as LP gas, kerosene etc.

Households produce M with the combination of fuelwood and other energy sources consumed. Fuelwood consumed is related to male and female labor. Similarly, bio-gas produced by household needs animal dung and household labor for the production process. Other energy sources can be kerosene stove and LPG gas which are purchased in markets. The socio-economic status of an individual household is related to the use of other energy sources which are included as market goods in our original model. Households can only use fuelwood or other energy sources or a combination of both. Households can collect fuelwood from different sources i.e., their own property, CFUG forest, or another forest area.

A concave production function describes the collection of fuelwood Q^j_{FWk} from site *k* by gender *j* as a function of male or female collection labor at the site, L^j_{FWk} , and of a vector of site characteristics, Z_k , that reflects resource endowment, resource type, and access conditions.

$Q^j_{FWk} = FW^j_k$ (L^j_{FWk} , Z_k , BG_{own}, OE_c)   *k* = own, CFUG, other   *j* = male, female

The individual households were found to be collecting fuelwood for their own use. No respondents reported fuelwood sales. Thus, net consumption of fuelwood is expressed as non-negativity constraint:

$$FW_c - \sum_{kj} Q^j_{FWk} \geq 0$$

Household agricultural production is given by

$Q_G = (L^j_G, A, Z_{own})$ where j = male, female

where L^j_G is the male and female labor allocated for agricultural production, *A* is livestock which contribute to agriculture in the form of draft animal and source of animal manure for agricultural production. Z_{own} is own land characteristics, i.e., total land area and number of trees planted.

Household labor is allocated for fuelwood collection, agricultural production, production of home-produced goods *M*, off-farm , leisure and production of bio-gas. Leisure may be written as

$$L^j_L = L^j_T - L^j_M - L^j_G - \sum_K L^j_{FWk} - L^j_{off} - L^j_{BG}$$

L^j_T is the total family endowment of labor, L^j_{off} is the male and female labor allocated to off-farm labor, L^j_L is leisure L^j_G is labor allocated for agricultural activity and L^j_{BG} is labor allocated for bio-gas production.

A household faces a budget constraint given by

$$Y + P_g Q_G + w^m L^M_{off} + w^f L^F_{off} + S^j + P^j = P_x X + P_{oe} OE_c$$

For simplicity, we assume that each household sells all of the output from agricultural production in the market. The other income sources include non-earned income Y, salary from job (S^j), profit from agribusiness/business (P^j) , male off-own-farm labor and female off-own-farm labor. Income is spent on the market goods (X) and purchase of other energy sources (OE_c).

Additionally, non-negativity constraints also apply to Q_G , Q^j_{FWk} , X and all labor variables. The lagrangian for an internal solution to the households' maximization problem may be formulated as

$$\mathcal{L} = U\Big[X, M\left(L^M_M, L^F_M, \left(OE_c + \sum_{kj} Q^j_{FWk} + BG_{own}\right)\right), \left(L^M_T - L^M_{off} - L^M_G - L^M_M - \sum_k L^M_{FWk} - L^M_{BG}\right), \left(L^F_T - L^F_{off} - L^F_G - L^F_M - \sum_k L^F_{FWk} - L^F_{BG}\right)\Big] + \lambda\left[Y + w^M L^M_{off} + w^F L^F_{off} + P_G Q_G + \right.$$

$S^j + P^j - P_X X - P_{oe} OE_c] - \eta_G [Q_G - G(L_G^M, L_G^F, A, Z_{own})] - \eta_{FW} \sum_{kj} [Q_{FWk}^j - FW_k^j (L_{FWk}^j, Z_k, BG_{own}, OE_c)] - \mu [\sum_{kj} Q_{FWk}^j - FW_c]$

The choice variable in our study are labor allocated for various household activities, quantity of fuelwood collected,, other energy sources bought and the market goods.

The first order conditions can be rearranged to show that

$$\frac{\partial \mathcal{L}}{\partial L_L^j} = \frac{\partial U}{\partial M} \frac{\partial M}{\partial L_L^j} = \eta_G \frac{\partial G}{\partial L_L^j} = \eta_{FW} \frac{\partial FW_k^j}{\partial L_L^j} = \lambda w^j$$

Where j = male, female; k = own, neighbor, FUG, other.

The household allocates male and female labor in such a way that the marginal utility of leisure for males and females is equalized to the marginal value products of male and female labor in each of the productive activities. Using the first order conditions, we can derive reduced form equations of the labor allocated by male and female for fuelwood collection through various sources and the respective quantities of fuelwood collected from each source.

The labor allocated and the amount of fuelwood collected are functions of exogenous variables in the model i.e., household demographics D, male and female wage rate w^j , site specific resource characteristics, Z_k.

The amount of time each individual household spend for fuelwood collection and the amount of fuelwood collected varies with extreme values. Similarly, the independent exogenous variables in our study have extreme values. Conditional median analysis can give a clear picture how it is related to socio-economic and other factors.

Quantile regression was introduced by Koenker and Bassett(1978) for modeling conditional quantiles as the functions of the predictors. It is a natural extension of the linear regression model. Since, it specifies changes in the conditional quantile, it is possible to model any predetermined position of the distribution.

For any random variable Y with probability distribution

$F(y) = \text{Prob}(Y \leq y)$

The τth quantile of Y^* is defined as the inverse function

$Q(\tau) = \inf \{y: F(y) \geq \tau \}$

Where $0 < \tau < 1$.

For a random sample $\{ y_1 \ldots \ldots y_n \}$ of Y, the sample median is the minimizer of the sum of absolute deviations

$$\min_{\xi \in R} \sum_{i=1}^{n} |y_i - \xi|$$

Likewise, the general τth sample quantile ξ(τ), which is analogous to *Q(τ)* , may be formulated as solution to optimization problem.

$$\min_{\xi \in R} \sum_{i=1}^{n} \rho_\tau (y_i - \xi)$$

Where $\rho_\tau (z) = z(\tau - I(z < 0)), 0 < \tau < 1$. Here, I(.) indicates the indicator function.

The linear conditional quantile function, Q (τ|X = *x*) = $x'(\beta\tau)$, can be estimated by solving

$$\hat{\beta}(\tau) = \underset{\beta \in R^P}{argmin} \sum_{i=1}^{n} \rho_\tau (y_i - x_i' \beta)$$

Results and Discussion

A total of 390 households were interviewed in CFUGs representing Terai and Hilly region of Nepal. The dependent variable in our analysis i.e., time spent by household for fuelwood collection was found to be heteroskedastic in both the regions. Similarly, family education was found to be heteroskedastic in the CFUGs representing hilly region i.e., non-timber forest.

The number of samples households where only female were involved in fuelwood collection were found to be 328 whereas the number of household where either female or male were involved and were not collecting the fuelwood were found to be 62 in the CFUGs representing timber forest in Table 1. The total family education attainment mean value was 28.64 for the household where females were predominantly involved in fuelwood collection as compared to 33.5 for the other households. The difference in the mean values for family education was found to be statistically significant for the two groups i.e., only female involved in fuelwood collection vs either female or male or no involvement in fuelwood collection.

Similarly, the mean household income (NRS) of the household where females predominantly does fuelwood collection was found to be lower than the household income of the rest of the households in CFUGs representing timber forest. Mean total household income was found to be 257739.2 for the households where women are the only ones involved in fuelwood collection.

Whereas, the mean household income for the other households where male, female are involved in fuelwood collection or are not involved in fuelwood collection was found to be 332661.3. The difference in the mean values of the household income was found to be statistically significant for timber forest.

The mean time spent by individual household where females are the primary labor force involved in fuelwood collection was found to be 89.8 hours as compared to the other households where the average time spent was found to be 53.04 hours in the timber forest. The difference in mean values was found to be statistically significant. Schurlen, 2016 too found in his study that women were more involved in fuelwood collection in rural Ethiopia. Thus, women were the primary labor force engaged in fuelwood collection in our study too.

Meanwhile, the wood collected (in bhari) was also found to be more for the households where only women were involved in fuelwood collection as compared to the other households in CFUGs representing timber forest in the Terai region of Nepal . The mean wood collected (in bhari) was found to be 27.06 for the other household categories as compared to the 38.27 for the households where only female were involved. The difference in mean value of wood collected was also found to be statistically significant.

The household where female are the major labor force involved in fuelwood collection were found to be spending more time as well as collecting more wood as compared to the other household categories in the CFUGs representing timber forest in Nepal. Similarly, the mean household income and total family educational attainment were also less for the household where female were the major labor force involved in fuelwood collection as compared to the other in the CFGUs representing timber forest of Nepal. Thus, fuelwood collection was predominantly done by females in the CFUGs representing timber forest of Nepal and were spending more time and collecting more fuelwood.

Among the households representing non-timber/mixed forest i.e., CFUGs in the hilly region of Nepal; women were the sole labor force involved in fuelwood collection in 352 households whereas in the 38 households, either female or male or were not involved in fuelwood collection.

The mean family education was found to be lesser for the households where female were the predominant labor force involved in fuelwood collection as compared to either female or male or no involvement in the CFUGs representing non-timber/mixed forest. The mean value of household educational attainment was found to be 31.77 for those households where female were the major labor force for fuelwood collection as compared to the other households where the mean value was found to be 36.68. The difference in mean value was found to be statistically significant too.

Similarly, the mean household income was also found to be lesser for the household where only female were involved in fuelwood collection as compared to the other households where either female or male or were not involved in fuelwood collection. The difference in mean value of household income was not found statistically significant across the two groups.

The mean time spent for fuelwood collection was found to be 68.55 hours where only female members were involved in fuelwood collection as compared to the mean time value of 42.52 for the other households where either male, female or were not involved in fuelwood collection. Similarly, the households were collecting mean amount of 30.74 (bhari) fuelwood where female were only involved in fuelwood collection as compared to the mean value of 19.65 (bhari) for other households where either male or female or were not involved in fuelwood collection. There was difference in mean values for time spent and the amount of wood collected for these two groups which was found to be statistically significant.

A total of 43 sampled households were found to be totally reliant on fuelwood for energy source in the CFUGs representing timber forest in Terai region and 347 sampled household were found to be reliant in combination of energy sources i.e., fuelwood, bio-gas and other sources as shown in Table 3.

The mean value of family educational attainment and household income was found to be statistically different across sample households where fuelwood was the major source of energy as compared to the rest of the sample households who were using combination of energy sources. Both family educational attainment and household income were found to be lesser for the sample households who were mostly reliant on fuelwood as energy source. Thus, households with lesser family educational attainment and lesser household income were more reliant in forest for fuelwood in the CFGUs representing timber forest of Nepal. As, the household income goes up, households prefer other cleaner fuel sources as compared to fuelwood. Households' preference for purchased fuel source in combination with collected fuelwood somewhat justifies the "energy ladder" hypothesis in our study. As most of the surveyed households were found to be reliant on combination of energy sources in our study, our findings are in accordance with the findings of Kammen et al (2000).

Similarly, a total of 68 sampled households were found to be totally reliant on fuelwood for energy source in the CFUGs representing non-timber/mixed forest in Hilly region and 322 sampled household were found to be reliant in combination of energy sources i.e., fuelwood, bio-gas and other sources as shown in Table 4.

The mean value of family educational attainment and household income was found to be statistically different across sample households where fuelwood was the major source of energy as compared to the rest of the sample households who were using combination of energy sources. Both family educational attainment and household income were found to be lesser for the sample households who were mostly reliant on fuelwood as energy source. Thus, households with lesser family educational attainment and lesser household income were more reliant in forest for fuelwood in the CFGUs representing non-timber forest of Nepal.

Moreover, the sample households were found to be spending more time and collecting more quantities of wood who were fully reliant in fuelwood for energy sources. The difference in mean values across the sample households where fuelwood is the major energy source as compared to the sample households who were using combination of energy source was found to be statistically significant. Thus, the sample households who were completely reliant on fuelwood as energy source were less educated, having lesser household income and were spending more time to collect fuelwood in the CFUGs representing non-timber/mixed forest in the Hilly region of Nepal .

Time spent in fuelwood collection forms the dependent variable in our study. The multiple regression results as well as quantile regression results are presented in Table 5 for the CFUGs representing timber forest of Nepal. The variable time to reach the Community forest (CF) in minutes was found to be positively increasing the dependent variable time spent for fuelwood collection. As time to reach the destination increases, obviously the time spent for fuelwood collection will increase too. Surprisingly, the variable was negatively related to the 10th quantile whereas it was positively related to the rest of the quantiles of time spent in fuelwood collection.

As the number of private trees planted were found to be increasing, the dependent variable i.e., the quantiles of time spent for fuelwood collection was decreasing. The lower quantile i.e., the 10th quantile and the highest quantile i.e., 90th quantile of time spent were decreasing more than the others with a unit change in the independent variable. The lowest time spent quantile may represent the sample households with near to enough private trees planted for fuelwood purpose so increase in number of private trees will significantly decrease the time spent for fuelwood collection from the CFUGs. A unit change in number of private trees would made those households self-reliant and would not depend on CF for fuelwood. Similarly, for the highest quantiles of the dependent variable time spent in fuelwood collection are highly dependent in the forest for fuelwood. Increase in the number of private tress planted would significantly decrease the dependence of those households on forest resource for fuelwood collection.

A unit increase in the variable family member will decrease the dependent variable for the lowest and the highest quantile i.e., 10th and 90th whereas will increase the dependent variable in the rest of the quantiles of the dependent variable. Surprisingly, the variable family education was found to be positively related with the different quantiles of the dependent variable i.e., time spent. The independent variable household income was found to be weakly negatively associated with the different quantiles of time spent on fuelwood collection. Similarly, the variable land holding would decrease the fuel wood collection time for the 25th, 50th and 75th quantiles of the dependent variable time spent for fuelwood collection. Although, the 10th and 90th quantiles would positively increase with a unit increase in the value of the same variable.

Quantile regression and multiple regression results are presented in Table 6 for the CFUGs representing non-timber/mixed forest in the Hilly region of Nepal. The independent variable family education was found to be negative and significantly decreasing the value of time spent for fuelwood collection by 0.28 units per unit increase in its own value. 10th and 25th quantiles of the dependent variable i.e., time spent for fuelwood collection were positively increasing 0.47 and 0.22 units per unit increase in the value of independent variable family education. Whereas, the rest of the quantiles i.e., 50th, 75th and 90th were found to be decreasing with a unit increase in the value of this variable. Increase in educational attainment might be associated with better jobs, better income and less dependent on forest sources for fuelwood collection.

The OLS results predict that one unit increase in the variable family member will increase the time spent on fuelwood collection by 5.17 units. The OLS results are in accordance with the higher quantiles of the dependent variable i.e., time spent on fuelwood collection. The variable will have positive but lesser effects on the lower quantile i.e., 10^{th} quantile. The sample households who are spending lesser time for fuelwood collection would not benefit more as compared to the sample households who are spending more time in fuelwood collection by a unit increase in the family members. Lower income households with lesser education were found to be spending much time for fuelwood collection in the CFUGs representing non-timber households. Thus, a unit increase in family member will increase the time spent by those households for fuelwood collection.

A unit increase in variable private trees planted will decrease the time spent on fuelwood collection by 0.19 units as predicted by OLS. As found earlier in the case of timber forest, a unit increase in the variable number of private tress planted will decrease time spent on fuelwood collection for the lower quantiles of the dependent variable. Similarly, the variable mean household income, time to reach CF and land holdings will all decrease the time spent on fuelwood collection but were not found statistically significant in our study.

Conclusion

The surveyed households in our study representing timber and non-timber/mixed forest in the Terai and Hilly region of Nepal respectively were mostly reliant on women labor for fuelwood collection purposes. The households where mostly women were involved in fuelwood collection were found to be less educated with low mean household income. Similarly, the household with women as the primary labor force engaged in fuelwood collection were spending more time and were collecting more amount of fuelwood as compared to other households. Majority of the surveyed households were found to be using combination of fuel resources in our study. The households reliant on combination of energy sources are found to be have more mean household educational attainment and mean household income as compared to the households completely reliant on fuelwood. Our study findings somehow supports the “energy ladder hypothesis”. As we find in our findings that the rural households opt for energy stacking i.e., use of fuelwood in combination of cleaner energy source as their income level goes up.

As the time to reach the nearest forest goes up, households were spending more time for fuelwood collection in our study area. Similarly, as the number of private trees planted for fuelwood and fodder goes up, households were found to be spending lesser time for fuelwood collection from the forests in both the CFUGs representing timber forest and non-timber/mixed forest. Similarly, with an increase in family member will increase the total time spent for fuelwood collection. Family education is related to better jobs and better employment opportunities which was found to be negatively related to fuel wood collection time except for the CFUGs representing timber forest in the Terai region of Nepal.

[Initial working paper, needs a lot of correction and re-writing]

References

Amacher, G. S., W. F. Hyde, and Joshee. B. R. (1992). The Adoption of Consumption Technologies under Uncertainty: A Case of Improved Stoves in Nepal. *Journal of Economic Development* 17 (2), 93-105.

Bluffstone, R. A. (1995). The Effect of Labour Market Performance on Deforestation in Developing Countries under Open Access: An Example from Rural Nepal. *Journal of Environmental Economics and Management* 29, 42-63.

Boone, C., Glick, P., &Sahn, D. E. (2011). Household water supply choice and time allocated to water collection: Evidence from Madagascar. Retrieved [12/21/2016], from Cornell University, School of Hotel Administration site: http://scholarship.sha.cornell.edu/articles/811

Cooke, P. (2016). Community forest management, gender and fuelwood collection in rural Nepal. *Journal of Forest Economics* 24, 52–71.

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

Heltberg, R., Arndt, T, C., and UdayaSekhar, N. (2000). Fuelwood Consumption and Forest Degradation: A Household Model for Domestic Energy Substitution in Rural India . *Land Economics* 76 (2), 213-232.

Hosier, R. H., and Dowd, J. (1997). Household Fuel Choice In Zimbabwe: An Empirical Test of the Energy Ladder Hypothesis. *Resources and Energy 9*, 347-361.

MacDonald, D.H., Adamowicz, W.L., & and Luckert, M. K.(1998). A Microeconometric Analysis of Choice of Fuelwood Collection Sites in Zimbabwe: Valuation through Behavior and Caloric Expenditure. *Paper Presented at the World Congress of Environmental and Resource Economics June 25-27, 1998 Venice, Italy.*

Macht, C., Axinn, W. G., and Ghimire, D. (2007). Household Energy Consumption: Community Context and the Fuelwood Transition. *Population Studies Center Research Report 07-629.*

Masera, O. R., Saatkamp, D. B., and 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.

Mishra, A. (2008). Determinants of Fuelwood Use in Rural Orissa: Implications for Energy Transition. South Asian Network for Development and Environmental Economics (SANDEE) Working Paper No. 37-08.

Pattanayak, S, K., Sills, E. O., Mehta, A. D., Kramer, R. A. (2003). Local Uses of Parks: Uncovering Patterns of Household Production from Forests of Siberut, Indonesia . *Conservation and Society*, 1, 2 . SAGE Publications New Delhi/Thousand Oaks/London.

Sapkota, I. P., and Odén, P. (2008). Household characteristics and dependency on community forests in terai of Nepal. *International Journal of Social Forestry*. 1(2), 123-144.

Scheurlen, E. (2015). Time Allocation to Energy Resource Collection in Rural Ethiopia : Gender- Disaggregated Household Responses to Changes in Firewood Availability. IFPRI Discussion Paper 01419.

Sengupta, C., and Kuri, P.K. (2016). Energy Consumption And Labour Allocation In Rural Purulia: A Model For Household Responses To Fuelwood Scarcity. *International Journal of Current Research* 8(09), 39203-39209.

Table 1: Socio-economic demographics for timber forest (Classified based on labor allocation for fuelwood collection)

	Female or male or not collecting fuelwood			Female involved in fuelwood collection		
Variable	**N**	**Mean**	**Std Dev**	**N**	**Mean**	**Std Dev**
Family education	62	33.58065*	16.41126	328	28.64024*	15.18183
Family members		2.806452	1.502334		3	1.282677
land holdings(ha)		0.226281	0.202642		0.191378	0.173602
Household income (NRS)		332661.3*	246863.2		257739.2*	222905.5
Time (hrs)		53.04839*	48.0022		89.85061*	58.52984
Wood (in bhari)		27.06452*	22.78975		38.27439*	19.98144
Time to reach CF(minutes)		35	17.48536		30.07622	24.6144
Number of private trees		3.854839	5.759801		3.240854	6.447618

Note: * = the difference in mean values statistically significant at 5% level of significance (two sample t-test)

Table 2: Socio-economic demographics for non-timber/mixed forest (Classified based on labor allocation for fuelwood collection)

	Female or male or not involved in fuelwood collection			Female involved in fuelwood collection		
Variable	**N**	**Mean**	**Std Dev**	**N**	**Mean**	**Std Dev**
Family education	38	36.68421*	18.96384	352	31.77557*	16.13858
Family members		2.552632	1.223583		2.423296	1.109309
Land holding		0.328489	0.246626		0.300366	0.268095
Household income (NRS)		309765.8	226544.7		294784.1	204850.8
Time (Hrs)		42.52632*	31.98035		68.55398*	45.44829
Wood (in bhari)		19.65789*	14.95268		30.74148*	18.1842
Time to reach CF (minutes)		24.55263	13.63758		22.13352	11.25852
Number of private trees		28.42105	33.41842		26.50284	43.18819

Note: * = the difference in mean values statistically significant at 5% level of significance (two sample t-test)

Table 3: Socio-economic demographics of people in timber forest (classified based on fuelwood consumption)

	Combination of fuelwood, bio-gas and other sources			Totally fuelwood reliant		
Variable	**N**	**Mean**	**Std Dev**	**N**	**Mean**	**Std Dev**
Family education	347	30.23343*	15.67094	43	22.90698*	11.99963
Family members		2.951009	1.314841		3.116279	1.366422
Land holding (ha)		0.206711	0.18038		0.117969	0.143457
Household income (NRS)		284537.3*	235997.1		149511.6*	83073.3
Time (hrs)		82.0634	58.25176		99.62791	58.86305
Wood (in bhari)		36.33718	20.99419		37.74419	19.64821
Time to reach CF(minutes)		31.7464	24.50903		23.69767	13.55331
Number of private trees		3.642651	6.597356		0.883721	2.611415

Note: * = the difference in mean values statistically significant at 5% level of significance (two sample t-test)

Table 4: Socio-economic demographics of people in non-timber forest/mixed (classified based on fuelwood consumption)

	Combination of fuelwood, bio-gas and other sources			Totally fuelwood reliant		
Variable	**N**	**Mean**	**Std Dev**	**N**	**Mean**	**Std Dev**
Family education	322	33.15*	16.29	68	28.03*	16.76
Family members		2.45	1.16		2.37	0.88
Land holding(ha)		0.30	0.26		0.31	0.27
Household income(NRS)		309550*	200516.9		233235.3*	225352.5
Time (hrs)		63.20*	40.89		79.35*	59.16
Wood (in bhari)		28.51*	17.00		35.13*	22.30
Time to reach CF (minutes)		23.28	11.55		18.04	10.39
Number of private trees		27.29	45.09		23.84	25.33

Note: * = the difference in mean values statistically significant at 5% level of significance (two sample t-test)

Table 5: Quantile estimates for time spent in fuelwood collection in timber forest

Parameters	Quantiles					OLS
	0.1	**0.25**	**0.5**	**0.75**	**0.9**	
Intercept	50.74	53.75	53.73	70.63	95.43	69.35
Family education	0.29	0.33	0.18	0.16	1.59	0.35**
Family members	-2.71	1.60	-0.14	1.94	-2.06	1.25
Land holding (ha)	9.58	-31.63	-12.50	-23.32	35.76	-15.83
Household income (NRS)	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00001
Time to reach CF (minutes)	-0.30	0.15	0.82	0.85	0.59	0.38*
Number of private trees	-1.62	-1.15	-1.42	-1.29	-1.69	-1.09*

Note: * & ** = significant at 5% and 10% level of significance respectively

Table 6: Quantile estimates for time spent in fuelwood collection in non-timber/mixed forest

	Quantiles					OLS
Parameters	**0.1**	**0.25**	**0.5**	**0.75**	**0.9**	
Intercept	43.82	63.44	79.20	90.19	89.10	77.65
Family education	0.47	0.22	-0.04	-0.14	-0.23	-0.28**
Family members	1.08	2.53	2.91	1.68	5.53	5.17*
Land holding (ha)	-11.42	-2.80	-2.57	-7.69	-10.25	-2.43
Household income (NRS)	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00
Time to reach CF (minutes)	-0.56	-0.66	-0.60	-0.28	0.34	-0.26
Number of private trees	-0.50	-0.36	-0.16	-0.10	-0.10	-0.19*

Note: * & ** = significant at 5% and 10% level of significance respectively

Figure 1: Quantile plots for timber forest

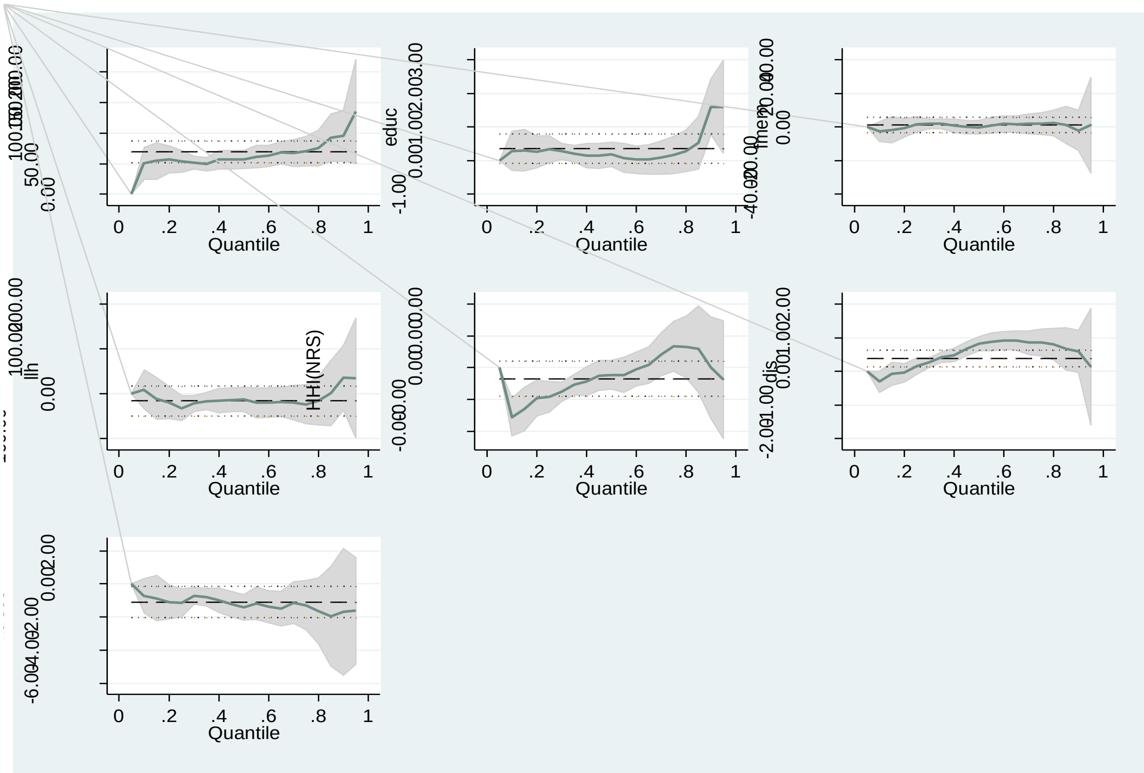

Figure 2: Quantile plots for non-timber/mixed forest