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   OBJECTIVES

   HYPOTHESES

   RESEARCH METHODOLOGY

   RESULTS & DISCUSSION

   FINDINGS

   RECOMMENDATIONS/SUGGESTIONS

   CONCLUSIONS

   SCOPE FOR FURTHER RESEARCH

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BIOFUELS CONSUMPTION IN EASTERN HIMALAYAS HOUSEHOLDS - AN EMPIRICAL ANALYSIS

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ABSTRACT

Arunachal Pradesh, the Eastern Himalayas state, is endowed with rich natural resources like forests; water resources, wild life, and these resources play an important role in the socio-economic life of the tribal peoples. The study reveals that in the rural area all the households use bio-mass fuels and in urban area around 67 per cent of the households use biofuels, either exclusively or in combination with other fuels. On the whole the study shows that biofuels consumption is influenced by collection time, family labour availability, level of education and income and the average distance between the house and forest. . It was also observed that the peoples collect bio-mass resources from common property resources to meet own consumption as well as to meet other needs by selling it in the markets. Moreover, the factors like food habit, livelihood strategy, easy access to the forest resources, poor communication, non- availability of other fuels make the demand for bio-mass fuels indispensable in Arunachal Pradesh. Therefore, excessive pressure on forest may be expected, owing to these factors along with extreme dependency of the people for survival, which may bring about significant changes to the stock of forest resource leading to depletion and degradation of these resources. Energy substitution, though on the rise, is still insignificant in rural eastern Himalayas households. Decentralised renewable energy options (like micro-hydels) can use resources more efficiently, empower local communities, develop indigenous technologies and deliver strong social and environmental benefits. As such, harnessing the non-conventional sources of energy with small-scattered loads and good availability is urgently demanded.

KEYWORDS

Biofuels, Common Property, Degradation, Energy Substitution Household Energy.

INTRODUCTION

Around half of the world population use biofuels[1] for cooking, which provide about thirty five per cent of energy supplies in the developing countries (World Bank Report, 1992). Though the fulfillment of energy gap and modernization of energy sector has been considered as one of the indispensable ingredients of rural development agenda in India, yet the realization was very poor. As per the data provided by UNSD[2], bio-mass provided 77 per cent of the total household energy consumption in India.

Arunachal Pradesh, the Eastern Himalayas state, is endowed with rich natural resources like forests; water resources, wild life, and these resources play an important role in the socio-economic life of the tribal peoples. As per Census Report of India (2001), around 87 per cent of the rural households and 33 per cent of the urban households use bio-mass fuels for cooking. It was also observed that the peoples collect bio-mass resources from common property resources to meet own consumption as well as to meet other needs by selling it in the markets. Moreover, the factors like food habit, livelihood strategy, easy access to the forest resources, poor communication, non- availability of other fuels make the demand for bio-mass fuels indispensable in Arunachal Pradesh. Therefore, excessive pressure on forest may be expected, owing to these factors along with extreme dependency of the people for survival, which may bring about significant changes to the stock of forest resource leading to depletion and degradation of these resources. Energy substitution, though on the rise, is still insignificant in rural Arunachal Pradesh. However till date, no systematic study has been conducted in Arunachal Pradesh on the nature of household energy consumption based on any economic framework. The present study is an attempt in to fill the gap in knowledge.

DATA BASE AND METHODOLOGY OF THE STUDY

The study is basically empirical in nature and designed to test the theoretical model based on primary data[3] in the context of Arunachal Pradesh. The households are the ultimate unit of observation. A multi-stage sampling technique was used for selection of households of the selected villages. The different stages under the technique are as follows:

Stage I : Selection of districts
Stage II : Selection of circles
Stage III : Selection of villages
Stage IV : Selection of households

In the first stage, two districts namely Papum Pape and West Kameng were selected purposively from the Eastern Himalayas State Arunachal Pradesh. The districts were selected to represent two different altitude[4] areas of the State. The Papum Pare district was selected from relatively low altitude areas of the State whereas West Kameng district was selected from high altitude areas of the State. At stage II, two circles namely Doimukh, and Sagalee were selected from Papum Pare district and another two circles namely Bomdila and Dirang were selected from West Kameng District purposively. In the third stage, eight and four villages were selected from Papum Pare and West Kameng district respectively. In the next stage, altogether 238 sample households were selected by a stratified random sampling technique of which 144 numbers of households were selected from Papum Pare district and rest 94 households were selected from West Kameng district. The selection of sample from the selected districts was done on the basis of relative population size. Once villages were selected, the primary data was collected from the household using a structured schedule. Simple and well designed detailed questionnaires, keeping in view of the objectives of the study, were prepared to elicit information from selected households so as to study the nature and consequences of household energy consumption in rural households of Eastern Himalayas.

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[1] Biofuels include the fuelwood and charcoal, and agricultural waste, such as crop residues and dung.
[2] United Nations Statistics Division, quoted from Dzioubinski et.al. 1999.
[3] The primary data were collected during field survey in connection to the Ph. D. programme of the author.
[4] The altitude of the surveyed areas of Papum Pare district ranges from 180 meters to 290 meters. On the other the altitude of West Kameng district ranges from 1497 meters to 2700 meters.

THEORETICAL FRAME WORK AND EMPERICAL SPECIFICATION OF THE MODEL

In rural Arunachal Pradesh, the market of domestic fuels is either absent or ill functioning. The households mainly collect biofuels from common forests. It makes reasonable to assume household energy supply and demand as non-separable in rural Arunachal Pradesh. The allocation of household time in biofuels collection along with other economic activities would go to a great extent determines the nature of demand (supply) for (of) fuel wood.

The theoretical frame work begins with a utility maximizing household. It deals with the household labour allocation to biofuels collection, agriculture and off farm activities. It is assumed that households' biofuels consumption is responsive to fuels prices (in a limited extent), labour cost, fuel substitution from different sources and farm and non farm income.

The household utility U is a function of consumer good, leisure, taste and preference.

$\therefore$ $U= U(C, C_L, \theta)$ ----------- (1)

Here C = Consumer goods.

C_L = Leisure.

θ = Taste and preference.

The household consumer goods again can be decomposed into two parts i.e.

1. consumption goods that required energy input *(C_E)* and
2. other consumption goods *(C_X)*

$\therefore$ $U = U (C_X, C_E, C_L, \theta)$ ------------ *(2)*

Now C_E is produced with fuel input from common forest (biofuels) C_{BF}, private sources of energy (wood from own farm or residues or from the clearance of jungle for shifting cultivation) C_P and commercial sources of energy (LPG, Bio gas, improved stove etc.)C_T, so that

$C_E = f (C_F, C_P, C_T, \beta)$ ---------- (3).

Where, β is a vector technology that affects the co-efficiency of fuels consumption.

The household collects biofuels from forest (Q_{BF}) and sometimes sells a part (BF_S) or some times purchase (BF_P) for domestic use. So the total household consumption of biofuels is

$C_{BF} = Q_{BF} + BF_P - BF_S$----------- (4)

The collection of biofuels can be described as a function of household labour allocation in bio- fuels collection (L^H_{BF}), various local and demographic characteristic (Ω) that are important to household preference and a fixed factor of production *(T).*

$\therefore$ $Q_{BF} = f (L_{BF}, T: \Omega)$ ---------- (5)

The supply of private sources of energy is a function of total agricultural production. Agricultural production *(Y_P)* is assumed to be a function of household labour in agriculture *(L_A)*, farm input*(R)* and a vector of household endowments pertaining to farming *(Z)* i.e., land, livestock etc.

$\therefore$ $Y_P = y_p (L_A, R, Z)$ ---------- (6)

It is assumed that the supply of private energy is a fixed portion of (α) agricultural out put. Again there is a trade off between residue use as energy and use for other purpose like fodder, manure, etc. Supply of residue as energy or private sources of energy is that portion of total available residue which is not used as farm input (R) and fodder (F).

$\therefore$ $Q_P = \alpha .Y_P – R –F$- ---------- (7)

Where Q_P = Supply of private energy.

R = Residue used as farm input.

F = Residue used as fodder.

The supply of commercial sources of energy can not be made available by the household itself. The supply is dependent upon external agencies. So it may be considered as a class of other consumption good. But the consumption is dependent upon the market price. A shadow price is added to the market price due to make it available in the consumption places from the production or supply place.

The budget constrain is as follows:

$P_F.F_S + P_A.Y_P + W.L^H_W = P_X.C_X + P_{BF}.BF_P + P_T.C_T$------ (8).

Where, P_{BF}, P_A and P_X refer to the market prices of biofuels, agricultural output and consumer goods respectively. P_T refers to the price of modern or commercial sources of energy input. W is the exogenous wage rate and L_W is labour time in off farm activities.

It is assumed that the collection and consumption of biofuels may not be equal so that the purchase and sell of biofuels is an observed phenomenon. It implies that the net marketed amount of biofuels is non-negative for those who do not purchase biofuels and it may be negative for them who do purchase.

$Q_{BF} - C_{BF} \geq 0$ for those who do not purchase------ (9.1)

$Q_{BF} - C_{BF} \leq 0$ for those who purchases ---------- (9.1)

The commercial sources of energy are not traded, that is supply is equal to consumption. In addition the non-negativity constraints are:-

$Q_i \geq 0; C_j \geq 0; L_k \geq 0$

Here i = BF, A, P;

j= BF, X, P, T;

k= F, A, W.

The equations (1) to (9) represent a problem of constraint maximization. So maximizing equation (1) subject to the budget constrains a set of reduced form equations can be derived showing the household consumption of biofuels and other energy as a function of all exogenous variables. i.e.

$$\left.\begin{matrix} C_{BF} \\ C_P \\ C_T \end{matrix}\right\} = f (\vartheta, \beta, \Omega, Z, T_M, T_W, P_A, P_X, W, P_F, P_T) \text{ --------------------------- (10)}$$

EMPIRICAL SPECIFICATION OF THE MODEL

Equation (10) gives the basis for the empirical works. The equation (10) does not impose any restrictions on functional form and parameters. The equations are independent and as such it is not necessary to estimate the full system of all endogenous variables (Sadoulet and Janvry, 1995, Heltberg, 2001). Though the theoretical model distinguishes fuelwood collection from CPRs and from own farm, it could not be done due to ill-defined[5]. The estimation is, therefore, confined to two reduced form of equations i.e. (i) biofuels consumption (C_{BF}) and (ii) non-conventional energy consumption (C_T). So the relationship can be represented in the form of following equation.

$$\left.\begin{matrix} \sum_{1}^{N} C_{ij} \\ \\ \sum_{1}^{N} C'_{ij} \end{matrix}\right\} = f\,(\text{FUELTIME}_i, \text{FSIZE}_i, \text{LIVSTOK}_i, \text{WONLAND}_i, \text{PMDENG}_i, \text{EDUCATION}_i, \text{BIOGAS}_i, \text{INCOME}_i, \text{DISTANCE}_i) \text{----------------- (11)}$$

[5] Emergence of property right over land and forests is a recent phenomenon in Arunachal Pradesh and in many cases it appears in an ill-defined form.

Where,

C_{ij}	= Biofuels consumption (C_{BF}) in the i^{th} household in terms of kg and
$C^{/}_{ij}$	= Commercial energy consumption (C_T) in the i^{th} households in terms of Mega Jules.
FUELTIME	= Collection time for per kg. Fuelwood collected. (Hours per kg)
FSIZE	= Total number of household members.
LIVSTOK	= Size of livestock holding by the households (Value in rupees)
WONLAND	= Total land (in acre) owned by the households
PMDENG	= Prices of modern sources of energy (Rupees)
EDUCATION	= Average years of schooling of the households (number of school years)
BIOGAS	= A dummy variable for bio-gas consumption (Yes = 1, No= 0))
INCOME	= Annual household income in Rupees.
DISTANCE	= Distance (km) of forest area from the consumption place
'i'	= (1, 2, 3, ----- N) observations

However, the empirical implementation of the theoretical model gives rise to a number of issues to be discussed. First of all, the commercial fuels are not widespread in the rural area and therefore, non-commercial source of energy dominants households' consumption of energy in rural Arunachal Pradesh. The non-commercials fuels are fuelwood from CPRs and from own land, crop residues, etc. The commercial energy sources like, LPG, electricity and kerosene are predominantly used in the urban area. The joint production and consumption of non-commercial fuels suggest the use of non-separable household model rather than a pure demand model (Singh, Squire and Strauss, 1986). Moreover in many parts of the State markets for domestic fuels are either absent or ill functioning. Therefore it is reasonable to make the model as non-separable (Heltberg, 2000). The absence of labour market in rural Arunachal Pradesh makes household labour supply and demand function non-separable. The non-seperability assumption implies that household resource allocation, including energy supply and energy demand, farm and off farm labour supply is decided simultaneously rather than recursively. It also implies that each household determines energy production and consumption by maximising its utility subject to an unobservable shadow[6] price. Thus, interdependency of production and consumption activities and the absence of market for some goods indicate that households' fuelwood demand and supply cannot be separated.

In the surveyed area fuelwood market is not very effective and many times it is not visible also. A few households have reported selling of fuelwood. The sellers directly supply fuelwood to the customers and sometimes they sell it to the local road-side hotels and restaurants. The market price of fuelwood varies substantially across households and villages and therefore it is unlikely to be entirely exogenous in the model (Heltberg[7]). Instead fuelwood price can be explained by other independent variables, like collection time per kg of fuelwood. The price of agricultural output (P_A) and other goods (P_X) are assumed to be constant across the households in the sample. As such, they are not included in the regression analysis. The price of LPG, which is taken as proxy for the price of modern sources of energy, is a unique one from the distributor's point of view. However, it involves a substantial transportation cost and as a result actual cost[8] of getting LPG is different for the households residing in interior places. Therefore the actual cost of LPG is much higher in interior villages. Thus, the actual cost of LPG is included in the regression analysis. At the same time, the wage market is not clearly defined in rural Arunachal Pradesh. So it is not possible to calculate the actual wage rate. The average years of schooling of the household members are included in the regression model to account for unobservable labour market opportunity (Heltberg). Bio-gas is used in Arunachal Pradesh to a very limited extent. The National Programmed on Bio-gas Development (NPBD) is still on an experimental phase. So, the price of bio-gas installation can not be calculated. However, a dummy variable for bio-gas consumption is incorporated in the model to estimate the impact of the use of bio-gas on the household energy consumption. The variable is expected to reduce fuelwood consumption as well as other sources of fuels consumption. Though the local management institutions of CPRs are expected to determine the access role yet, we found contradictory result regarding the strength of management institutions in regulating the commons. Therefore, the strength of management institution variable is eliminated from the regression analysis. Besides, the model failed to take care of forest stock due to extreme difficulties of getting data about the size of village forests. The variable DISTANCE (Distance to be covered for collecting fuelwood in kilometer) is taken as proxy to estimate forest stock. As the villagers were leaving within vicinity of a forest, therefore, the more the distance to be covered for fuelwood collection implies the lower the stock of forests resources.

RESULT AND DISCUSSION

DETERMINANTS OF HOUSEHOLD ENERGY CONSUMPTION: EMPIRICAL TEST OF THE THEORETICAL MODEL

The model (11) outlined above (Section III) shows that the fuelwood consumption and the modern sources of energy consumption is determined by socio-economic and demographic variables. So, in log linear form, the empirically amenable multiple regression models can be written as:

$$\ln \sum_{1}^{N} C_{ij} = \beta_0 + \beta_1 \text{ In FUELTIME} + \beta_2 \text{ In FSIZE} + \beta_3 \text{InWONLAND} + \beta_4 \text{ In PMDENG} + \beta_5 \text{ In EDUCATION} + \beta_6 \text{ In BIOGAS} + \beta_7 \text{ In INCOME} + \beta_8 \text{ In DISTANCE} \text{ ------------------------------------} \textbf{(12.1)}$$

$$\ln \sum^{N} C^{/}_{ij} = \beta^{/}_0 + \beta^{/}_1 \text{InFUELTIME} + \beta^{/}_2 \text{In FSIZE} + \beta^{/}_3 \text{WONLAND} + \beta^{/}_4 \text{In PMDENG} + \beta^{/}_5 \text{ In EDUCATION} + \beta^{/}_6 \text{ In BIOGAS} + \beta^{/}_7 \text{ In INCOME} + \beta^{/}_8 \text{ In DISTANCE} \text{ ------------------------------------} \textbf{ (12.2)}$$

The corresponding equations are defined as double- log model and it is based on a similar model by Di Falco and Perrings (2003) who developed it to understand the effect of co-operative production on inter-specific crop genetic diversity. The reasons for transforming the equations into double-log model is to pull outlying data from a positively or negatively skewed distribution closer to the bulk of the data in a quest to have the variables be normally distributed.

The results of regression for determinants of household energy consumption on the above explanatory variables in the estimated equations are represented as:

In $\hat{C}_{BF}$ =	6246.492 (2.311)	-0.689* In FUELTIME (-11.434)	+0.326* In FSIZE (5.473)	+0.0069In WONLAND (1.188)	+0.087In LIVSTOCK (1.352)	- 0.033 In PMDENG (-0.654)
	-0.017*In EDUCATION	- 0.071 In BIOGAS (-1.526)	-0.304*In INCOME	-0.0.144*In DISTANCE	---**(13.1)**	

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[6] "Virtual" or "shadow" price of energy which is unobserved and unknown except to the household itself. The price (shadow price) varies between households depending on household and village characteristics (Sadeulet and Janvry, 1995)

[7] Fuelwood markets in the study area are "thin" and largely localized in part due to restrictions on motorized transport which increase transaction costs. Fuelwood market prices, which vary substantially across households and villages, are therefore unlikely to be entirely exogenous: (Heltberg)

[8] Actual cost of LPG includes additional cost for making it available in the consumption point in addition to market price of LPG.

(-0.283) (-5.075 (-2.601)

R^2 = 0.53 **Adj R^2 = 0.51** **F= 28.51** **N= 238**

In $\hat{C}_T$ = 6.175 +0.148* In FUELTIME (2.683) - 0.220* In FSIZE (-4.384) +0.008 In WONLAND (0.148) +0.046 In LIVSTOCK (0.777) -0.164 In PMDENG (-3.554)

+ 0.265*In EDUCATION (4.835) – 0.046 In BIOGAS (1.030) +0.464* In INCOME (8.439) + 0.0.090 In DISTANCE (1.765) ---**(13.2)**

R^2 =0.58 Adj R^2 = 0.56 F= 34.31 N= 238

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The estimated models, (13.1) and (13.2) show that most of the explanatory variables have the expected signs which are statistically significant at different levels. The variables FUELTIME, FSIZE, EDUCATION, INCOME and DISTANCE were found to be significant in determining household energy consumption (C_{BF} and C_T) in rural areas. However, the level of significance varies. The variable DISTANCE is not significant for C_T but it has positive relationship. On the whole the study shows that in the rural areas the household energy consumption is influenced by collection time, family labour availability, level of education and income and the average distance between the house and forest. Scarcity of fuelwood induces substitution of biomass fuels by commercial fuels. The more the members in a household the greater is the demand for bimass fuels. As the level of education and income increases the households start substitution of biomass fuels by modern non-conventional fuels. An increasing distance between forest and households also induce fuel substitution in rural areas. It is to be mentioned here that the variable PMDENG no longer appeared as significant variable in the models fitted for the rural households. The Biogas which was taken as a proxy for renewable energy consumption does not yield any good result for any of the models. This may be due to the fact that the biogas installation programes are still on experimental phase. Hence it may not be possible to make suggestion regarding fuel substitution in relation to bio-gas in the study area.

PER CAPITA BIOMASS FUELS CONSUMPTION

The per capita biomass fuel consumption is calculated to observe regional variation (due to difference in altitude) as well as seasonal variation in the consumption of biofuels among rural households which is given as follows:

BFC/P

Where BFC= biofuels consumption in kg per day and P= adult equivalent members. The per capita per day biofuels consumption, maximum and minimum values, average values, standard deviations and coefficient of variation were computed for a year as well as season wise. The per capita daily consumption of biofuels in two surveyed districts is shown in the Table-1

TABLE-1: PER CAPITA DAILY BIOFUELS CONSUMPTION IN THE SURVEYED DISTRICTS (Based on Demographic Criteria)

Surveyed Districts	Per Capita Fuelwood Consumption				
	Maximum	Minimum	Average	Standard Deviation	Coefficient of Variation
Papum Pare (Low Altitude Area)	8.26	1.52	3.83	1.27	301.57
West Kameng (High Altitude Area)	14.79	4.10	7.13	2.26	315.49
Total	14.79	1.52	5.22	1.66	306.24

Source: Field Survey, 2008.

Data presented in the Table-1 shows that, on an average per capita biofuels consumption in West Kameng (high altitude area) was much higher than that of Papum Pare (low altitude area) district.

The study also attempted to analyse the per capita biofuels consumption based on different economic classes i. e. relatively poor and relatively non-poor. The study revealed that in both the surveyed areas the poor households consumed more biofuels in comparison to that of non-poor households. This may be due to high installation cost involved in commercial sources energy like LPG. As a result the poor households continued to depend upon traditional sources of fuels like fuelwood, crop-residues, etc. The details are shown in Table 2.

TABLE-2: PER CAPITA DAILY BIOFUELS CONSUMPTION IN THE SURVEYED DISTRICTS (Based on Economic Criteria)

Surveyed Districts	Economic Classes	Per capita Biofuels Consumption				
		Maximum	Minimum	Average	Standard Deviation	Coefficient of Variation
Papum Pare (Low Altitude Area)	Poor	8.26	0.52	4.06	1.46	278.08
	Non-poor	6.41	0	2.62	1.36	192.65
	Total	8.26	0	3.20	1.57	208.28
West Kameng (High Altitude Area)	Poor	13.81	3.70	7.37	2.48	297.18
	Non-poor	14.79	2.88	6.40	1.95	328.20
	Total	14.79	2.88	6.38	2.22	305.40

Source: Field Survey, 2008.

So far we have discussed regarding the per capita consumption of biofuels based on climatic, demographic and economic criterions. However, it was observed that the demand for fuels, particularly biofuels increases significantly in the winter seasons. So an attempt was made to estimate the season-wise variations in the consumption of biofuels in the two different altitude areas. It was observed that there were wide variations in the consumption of biofuels between two seasons, i. e. summer and winter and between two surveyed districts i.e. Papum Pare and West Kameng. The details are shown in Table-3

TABLE -3: SEASON WISE BIOFUELS CONSUMPTION

Surveyed Districts	Seasons	Per capita Biofuels Consumption		
		Maximum	Minimum	Average
Papum Pare (Relatively Low Altitude Area)	Summer	7.50	0	2.85
	Winter	12.50	0	4.71
West Kameng (Relatively High Altitude Area)	Summer	9.00	0	3.50
	Winter	22.50	5.00	9.72
Total	Summer	9.0	0	3.11
	Winter	22.50	0	6.68

Source: Field survey, 2008.

Table-3 shows that there were wide variations in per capita daily consumption of biofuels between summer and winter seasons in both the surveyed districts. However, the variation was wider in West Kameng district (3.50 kg per capita in summer season and 9.72 kg per capita in winter season) than that of Papum Pare district (2.85 kg per capita in summer and 4.71 kg per capita in winter). In Papum Pare district not only the seasonal variations in bio-fuel consumption was smaller but also the average consumption of bio-fuel was smaller irrespective of their socio-economic conditions. On an average bio-fuel consumption in West

Kameng district was around two times higher than that of Papum Pare district. It establishes the fact that in winter season bio-fuel is used for heating the room and therefore the per capita consumption in winter season is found to be relatively higher. Again, due to high altitude, the per capita bio-fuel consumption in West Kameng district (high altitude area) was higher then that of Papum Pare (low altitude area) i. e. low temperature prevailing over a considerable part of the year necessities greater use of energy for heating purpose.

CONCLUSIONS AND POLICY IMPLICATIONS

The finding summarized above lead to the following conclusion and policy suggestions of the study.

∗ The theoretical model which was tested using primary survey data supported the theoretical proposition that the bio-fuel consumption and modern sources of fuels consumption were influenced by household labours, fuelwood collection time, price of commercial energy, education and income etc. However, fuelwood collection time was not found to be significant to determine commercial energy consumption. Hence, an increasing collection time or forest scarcity cannot be expected to stop fuelwood collection and substitution of non forest fuels to avoid deforestation. Under such situation it is urgently required to create awareness about the environmental cost and health hazard of fuelwood consumption in order to motivate the people towards the modern fuels. A study conducted by Laxmi, Parikh, Karmarkar and Dabrase observed the health impact due to indoor air pollution in rural Rajasthan. The study showed serious health impact of bio-mass fuels used in the form of, respiratory diseases, eye diseases, bronchitis, pulmonary tuberculosis, chest infection etc. The present study also attempted to collect information regarding certain diseases which are closely related to bio-mass fuels consumption. These were eye irritation, skin diseases, bronchitis and headache. The questions were put to the person who usually cooked food. It was found that out of the 306 respondent around 30.09 per cent suffered from eye irritation, 23.86 per cent from skin diseases, 11.43 per cent from bronchitis and 8.50 per cent from headache. It is to be noted here that one cannot say that all these respiratory diseases are exclusively due to fuelwood consumption, but these can certainly be triggered by it. If the real cost (including health hazards) of bio-mass fuels consumption is take into account fuelwood may not be a cheaper product and the actual cost may be higher.

∗ Another important finding of the study is that in the rural areas people are reluctant to pay for commercial fuels as the fuelwood can be gathered free at cost. As a result, the Government policies of subsidizing commercial fuels sufficiently so as to make people attractive will hardly yield good result. Instead forest policies might seek to induce substitution away from forest fuelwood. Such policy could aim at promoting agroforestry and tree growing in private land. Policy intervention to this end include the provision of subsidized seedling, selection of fuelwood generated tree species, monetary incentive for planting and maintaining trees, sharing knowledge and information with the villagers, creating awareness etc.

∗ The dependency of rural households on fuelwood consumption can not be reduced immediately but it consumption can be reduced by popularizing scientific *Chullhas.* Improved wood stoves not only raise energy efficiency, typically by 30-50 per cent but also reduce indoor pollution by a factor of 20 to 100, to levels well within WHO guidelines (Anderson, 1996). In the rural areas of Arunachal Pradesh, the improved end-use technologies, which reduce the energy requirement for any given level of energy output, have the potential to reduce pressure on CPFRs. However, this type of techniques should be adopted with special care. For example, the households often find difficulties with this type of stove because certain foods cannot be cooked on it. Thus, it implies that the technology dissemination programes need to pay careful intention to local food and cooking habits. Hence, it is suggested that steps may be taken to renovate the scientific *Chullhas* to meet the local needs and popularize it among the rural households inorder to save energy.

∗ It was observed that fuelwood is substantially used for heating purpose in the high altitude area. This is also true that in some parts of the State during winter season the temperature is so cold that it is not possible to survive without any artificial heating. So the Government should explore an alternative to fuelwood for heating purpose in order to reduce substantial deforestation. As the State is having immense potentials for hydro-electric power generation, attempts should make to harnessing full potential for hydro-generation of electricity.

∗ Given the precipitous topography and the sparse spatial distribution of population, the conventional long range generation transmission network may not suit Aruachal Pradesh. Therefore, the provision of stand-alone isolated small generation facilities (50 KW to 4 MW) allowing for limited distribution in the habitation areas, would perhaps be more useful for capacity addition, economy and to contain huge transmission and distribution losses. Thus, microhydel power stations are ideally suited to areas where power demand is relatively low and population is scattered. Thus, the State Government is required to develop a suitable management for the villages and block at the Panchayat level to maintain the plant after setting up the project. Once the villagers particularly in high altitude areas get used to electricity it will go a long way in preventing indiscriminate felling of tree.

Hence in order to preserve forest, the alternative option as suggested above may be implemented seriously by the State Government. The Ministry of Non-conventional Energy sources (MNES) has initiated a number of programmes in associated with Arunachal Pradesh Energy Development Agency (APEDA) in the State for harnessing the non-conventional sources of energy in the State. However, the progress is not found to be satisfactory and it is only an experimental stage. It should be noted that with small-scattered loads and good availability of renewable energy sources like hydro, solar, biofuels etc. the State is ideally suitable

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