International Journal of Economics, Commerce and Management
United Kingdom Vol. II, Issue 3, 2014
http://ijecm.co.uk/ ISSN 2348 0386

TRANSITION OF COOKING FUEL: A CASE STUDY OF ASSAM IN INDIA

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Abstract

The rural population of Assam is significantly more than the population that live in rural India. Similarly, the percentage of population below poverty line in Assam is ten points more than all India percentage. Since, the rural populations are more close to natural sources, so cooking fuel like firewood, crop residue etc., are available for free. This shows more dependency on biomass as a cooking fuel. However, burning of these could cause health hazards due to the indoor pollution. To reduce in consumption of biomass, the government should make the distribution system of Liquefied Petroleum Gas (LPG), efficient. This study was undertaken with the objective of analyzing the socio-economic conditions of rural poor of Assam with respect to their primary cooking fuel consumption patterns. The questionnaire based survey on demographic, economic, and perceptible parameters of the respondents was used to identify the important variables with the help of Logit model. The income of the respondent has great influence in the decision making of rural poor to switchover to modern cooking fuel. The study further reveals that the smaller household size respondents are prepared to switchover to modern fuel provided the accessibility of the fuel is made easier.

Keywords: Logit Model, Kerosene, LPG, Twigs, Cow dung, Biomass fuel

INTRODUCTION

Fuel for cooking is one of the basic and dominant end uses in developing countries. In many developing countries, biomass fuels namely animal dung, crop residues and firewood are used mostly by very poor people in rural area (Kanagowa and Nakata, 2007). The gathering of firewood and other biomass fuel is a strenuous and time consuming task for rural poor. Besides, it is also intricately linked to the degradation of natural resource especially the forest, leading to a situation of firewood scarcity. In addition, there are a number of other adverse consequences of forest degradation, including loss of biodiversity, release of carbon dioxide into atmosphere and soil erosion (Heltberg, et al. 2000). Similarly, burning biomass in open-fire stoves and often with little ventilation, emits smoke containing large quantities of harmful pollutants, with serious health consequences for those exposed, particularly women involved in cooking and young

children spending time around their mothers (Kumar, et al. 2007). Several recent studies have shown strong associations between biomass fuel combustion and increased incidence of chronic bronchitis in women and acute respiratory infections in children. In addition, evidence is now emerging of links with a number of other conditions, including asthma, tuberculosis, low birth weight, cataracts, and cancer of upper airways (Mathur, 2001). Worldwide, exposure to smoke emissions from the household use of solid fuels is estimated to result in 1.6 million deaths annually (Balakrishnan, 2004).

In India, biomass fuels constitute the predominant sources of energy, especially for cooking (Ravindranath and Ramakrishna, 1997). The most important biomass in rural India are firewood, collected from forests, common lands, roadsides, and private fields; crops residues from farm; and dung, gathered from domestic animals. Firewood is used in almost all rural households. Though these traditional fuels are predominant in rural areas, but the pattern of their use is little different (Viswanathan and Kavi, 2005). Any attempt to shift households to better quality fuels requires an understanding of the factors determining the current choice of fuels. In the past, there have been various attempts by the government of India to promote cleaner fuels. The standard approach was to change the relative fuel prices by providing subsidies but the approach has not been very successful in bringing transition of fuel uses, especially in the lower income groups. The poor delivery infrastructure; high cost of connection and refilling; and availability of competing fuel choices in the form of fuel wood and other biomass fuels at zero cost remain as obstacles to quick diffusion of modern fuels in the rural household (The Energy and Research Institute, 2004). In Assam, which is situated in the north eastern part of India, majority of rural people rely primarily on fuel wood collected from nearby forests or fields as cooking fuel. The semi-urban people use fuel wood, kerosene and LPG (liquefied petroleum gas) as cooking fuel; however urban people mainly use LPG and kerosene.

In Assam heavy reliance on fuel wood has raised pressing concerns over the health impacts of indoor air pollution, as well as over environmental consequences such as deforestation and soil erosion (Sarma, etal. 2000). Therefore the objective of this paper is to discuss the factors guiding rural household choices of cooking fuels. This is crucial for policies to combat indoor air pollution and environmental degradation. It is also important for energy planners who must anticipate future demand for different types of fuels, as well as for those concerned with the longer-term environmental consequences of fuels use. Here the paper undertake the first analysis of a nationally representative survey of rural households in India particularly Assam to describe patterns of rural cooking fuels used, in the context of the conceptual framework of the energy transition. In the next section we describe the dataset. Following that we present a descriptive analysis, focusing on patterns of fuel use; by income, as well as a multinomial logit analysis of the determinants of cooking fuels use and the proportion derived from biomass. Finally, it provides a discussion and summarizes conclusion.

METHODOLOGY

The data used in this paper was collected from primary sources based on fieldwork conducted during 2003-2004. The study covered one state of India. In the first stage of the multi-stage sampling used, one district of the state was chosen. The district was selected through purposive sampling to ensure that these districts were adequately representative of the state with respect to geographical distribution and special conditions of the state, if any. After the district was chosen, four blocks were identified in the second stage through circular systematic sampling using Directory of Blocks as the frame of reference. From each of the selected block ten gram panchayats was chosen using convenience sampling.

A gram panchayat is the lowest administrative unit in India. In some cases a gram panchayat may consist of only one village, while in other, it may have a number of villages, hamlets or padas. The selection of villages/gram panchayats was done carefully so that these would properly represent the blocks. Individual respondents were the final sampling units. From each of the selected village or gram panchayat, fifteen respondents were selected randomly. Special care was taken to ensure that respondents were covered under Below Poverty Line (BPL) category. Finally, the schedule for respondents filled up for each of them. A total of 600 were covered in the entire study.

Fuel Used for Cooking in Rural Area of Assam, India

As per provisional figures released, about sixty-nine percent of India's population resides in rural India (Censuss of India, 2001) and it also has a high concentration of people living under abject poverty. Of the total rural population, nearly thirty percent lives below the poverty line (Rao, 2009). In the rural areas, the households used mainly firewood and chips, dung cake, kerosene and liquefied petroleum gas (LPG) as the sources of energy for cooking. Among these sources, firewood and chips was used by almost three-fourths of the rural households. However, less than two percent of rural households use kerosene for cooking. The penetration of LPG is very low in rural India; only about six percent of the households use it for cooking purposes. The introduction of LPG leads to corresponding decrease in the consumption of firewood in rural areas reflects the shifts in cooking fuel (National Sample Survey Organization, 2001). On the other hand, the use of dung cake decreased slightly at all-India level.

The total number of households residing in rural India was 138.3 million, out of which, the share of Assam was three percent only. The share of firewood consumption as a fuel for cooking in Assam is significantly higher than all India level. However, in case of crop residual and cow dung, it is found to be reverse. The percentage households use LPG as a cooking fuel at all India level is marginally higher than Assam. In Assam, about 78 percent of rural household used firewood as primary fuel for cooking; followed by LPG and crop residue. Similarly, the

share of rural household used cow dung and kerosene is one and two percent respectively (Table.1). This may be due to their geographical location of the rural households and socioeconomic condition.

Table.1: Number of Rural Household Using Different Cooking Fuel

Type of Fuel	India	Assam
Firewood	100842651	3746938
Crop residue	19254851	348302
Cowdung cake	18758885	47952
Coal, Lignite, Charcoal	3932730	9100
Kerosene	12528916	86126
LPG	33596798	652306
Electricity	338054	5225
Biogas	849098	2645
Any other	1231727	23036
No cooking	630225	13728

Source: Census of India (2001)

Table 2. Number of Respondents Used Fuel For Cooking

Type of Fuel	Respondents
Firewood, Crop Residual and Dung	529
Kerosene and Liquefied Petroleum Gas	70
Total Respondents	600

A total number of 600 respondents spread across 40 Gram Panchayat of Nagoan district was studied. All the respondents belong to the Bellow Poverty Line (BPL) category. From table 2, it is observed that 87 percent of the respondents exclusively used firewood, crop residue and dung for cooking; and the remaining 13 percent used kerosene, LPG and electricity. Interestingly, the use of dung is very negligible in Assam. This may be due to expanse of forest area in Assam; which constitutes 36.37 percent of the State's geographical area. One of the important features observed in rural area is that, the poor households are dependent on locally available biomass resources, because they are collected at zero cost, but the household above poverty line are seen to be used LPG as a cooking fuel. Therefore, the importance of income as a factor affecting fuel use is however, apparent even in the case where the switch to modern fuel is not complete. In India, some studies (Ekholm, et al. 2010, Gundimeda and kohlin, 2008, and Pachauri and Jiang, 2008) found that the most significant factors determining fuel consumption for cooking were income and location, whether rural and urban. Table 3 reveals that the average income per annum among the rural poor in Assam is a little over INR 20,000.

The low income levels of rural households, could be the main reason for higher dependence on traditional fuels, which is available free of cost.

Table 3. Socioeconomic Characteristics of Assam

Socioeconomic Parameters	Average
Annual Income (Rupees)	24827
Household Size (No)	5
Market Accessibility Distance (Km)	4.5

Development of Model

For econometric analysis, the authors have adopted probabilistic logit model for fuel choice (Heltberg, 2003, and Das and Srinivasan, 2012). The dependent variable Y can have only binary values, for representing whether the respondent will switch to modern cooking fuel i.e. kerosene/gas or not (Onyekuru and Eboh, 2011). Probability of the occurrence of an event is determined by (Stock and Watson, 2005):

$$\text{Prob}(Y = 1 \mid X_i) = F(\alpha + \beta_i X_i) = \frac{e^{(\alpha+\beta_i X_i)}}{1 + e^{(\alpha+\beta_i X_i)}} = \frac{1}{1 + e^{-(\alpha+\beta_i X_i)}}$$

where, F is the cumulative standard logistic distribution function, which has specific functional form, defined in terms of exponential function and X_1, X_2,….., etc., are independent variables.

For the logit model the interpretation of coefficient β_0, β_1, etc., is transparent, considering the log odds ratio.

The logit model can be written as $\log_e\left[\frac{\text{Prob}(Y_i = 1)}{1 - \text{Prob}(Y_i = 1)}\right] = \alpha + \beta_i X_i$.

The effect of a unit change in X on the log odds ratio of the event occurring is given by the corresponding β coefficient. Taking the log odds ratio into consideration is very useful since the interpretation of the coefficient is immediate.

As logit model is not linear in parameters, they are estimated by using maximum likelihood techniques. The maximum likelihood estimator is consistent and normally distributed in large samples, so that t-statistics and confidence intervals for the coefficients can be constructed in the usual way.

Table 4. Variables in the Model

Dependent Variables	
FUEL	Switch to modern cooking fuel
	1, if yes
=	0, Otherwise
Independent Variable	
INCOME	Yearly Income and Expenditure of the respondent (in INR)
	0: upto 10000
	1: 10001 – 20000
	2: 20001 – 30000
	3: 30001 – 40000
	4: 40001 – 50000
=	5: 50001 – 60000
	6: 60001 – 70000
	7: 70001 – 80000
	8: 80001 – 90000
	9: 90001 – 100000
	10: Above 100000
MARKET	Access to Market (in Kilometer)
	1: upto 1
	2: 1.1 – 5
=	3: 5.1 – 10
	4: 10.1 – 15
	5: Above 15
HHS	Household Size (In Number)

Table 4 defines the variables used in the model. The dependent variable FUEL again can take only binary values for $Y_{i,}$ with value 1 representing that the respondent switch to modern fuel for cooking and 0 indicating otherwise. In the independent variables INCOME, the respondents are classified into eleven categories, with 0 indicating that the respondent has income up to INR 10000 per year; similarly 1, 2, 3, 4, etc. with each representing the respondent household's income per year pertaining to a particular interval. Using this variable, we try to measure the ability of the respondents to switch to the modern cooking fuel, at a given significance level. The switch to modern fuel has been made, in part, a function of income; because of the fact that we are dealing with spending on modern fuel which increases the household cost; and that the capacity to spend has direct relationship with income (Mishra, 2008). Further, it is hypothesized that persons with larger income will expense more, ceteris paribus. Next variable MARKET represents the distance of the respondent household from the nearest market place, where the modern fuel is available (Arntzen and Kgathi, 1984). Finally, the variable HHS represents the number of household the respondent has.

MODEL OUTPUT ANALYSIS

Table 5 presents the parameter estimates of the logit regression of the binary dependent variable (FUEL) for a selection of three independent variables as detailed above. The estimation, using the SPSS software package, was performed on the dataset consisting of 600 observations (respondents). Data set from 2 observations could not be used because of some missing data. Thus only 598 observations were considered for the purpose of analysis.

Table 5. Logit estimates of respondents switch to modern fuel on selected variables

Variable	Coefficient estimate
Constant	0.197 (0.50)
INCOME	0.55 (0.12)
MARKET	-0.64 (0.16)
HHS	-0.47 (0.09)
Total number of observation (A)	600
Number of rejected because of mission data	2
Number of cases included in the analysis (B)	598
Percentage B/A	99.67
Log likelihood for logit	340.68
Wald	252.34

Note: Standard errors are in the parenthesis

The estimated coefficients of the independent variable INCOME of the respondent households is positive and strongly significant, implying that with everything else held constant, the respondent having higher income, is more likely to switch over to modern fuel (Gupta and Ravindranathan, 1997, and Peng, et al. 2010). This is a very significant finding of this study. The reason could be that the households having more income are probably economically stronger than those having lesser income. Therefore, these households have financial resources to pay for purchasing cooking fuel. This is found to have significant relationship with the switching decision of the respondent. The variable MARKET exhibits a negative and high level of significance on switching decision of the respondent. It means that the proximity of the MARKET and accessibility of the commercial fuel, by the respondent household, also play a significant role in the switchover decision. Other things being equal a respondent is more likely to adopt modern fuel, if the MARKET is close-by to the residence of the respondent (Jiang and Brain, 2004, and Njang and Jnhannos, 2011). The variable HHS shows a negative and high level of significance on switching decision of the respondent, indicating smaller household size prefer switching to modern fuel.

$$\text{Prob}(\text{FUEL}=1 \mid \text{INCOME},\text{MARKET},\text{HHS}) = \frac{1}{1+e^{-(0.197+0.55\text{INCOME}-0.636\text{MARKET}-0.47\text{HHS})}}$$

Table 6. Probability of switching to modern fuel in different scenario

Scenarios	Income (Rupees)	Household Size (No)	Market (Kilometers)	Switch to Modern Fuel (Probability)
One	80001-90000	7	10.1-15	0.22
Two	60001-70000	5	0-1	0.74
Three	50001-60000	3	1.1-5	0.57
Four	30001-40000	4	5.1-10	0.13
Five	20001-30000	3	0-1	0.32

Using the above model, five different scenarios are constructed and the probability of switching to modern fuel, under these five scenarios, are computed and shown in Table 6. A look at scenario one reveals that even if the respondent household has a good income and large family size, the household is less likely to switchover, if the market is at far away distance from her residence. In scenario two, under similar conditions as that of scenario one, except that when the respondent's residence is at a close proximity to the market, the switchover possibility to the modern fuel increases dramatically to seventy-four percent. Scenario three explains that even a household with moderate income levels with small family size has a fifty-fifty chance of switchover, if the market where modern fuel is available is not far off. These two scenarios seem to be the best case for adoption of modern fuel. However, the chance of switchover diminishes drastically, in scenarios four and five, where the respondents belong to poor income. In the last two cases, irrespective of market accessibility the switchover probabilities are very less. From the analysis of the five scenarios given above, it can be observed that only income has positive impact; whereas household size and market accessibility have a negative impact in determining the likelihood of switching over to modern fuel. Hence, the families having relatively higher income and the size of household is small; and living close to the market, have a very high probability of adopting modern fuel as the cooking medium, than the big families living far away from the market.

CONCLUSION

According to some of the existing studies, the biomass fuels for cooking are the major indoor air polluters in the world today. In the prevailing circumstances, it becomes essential to look for modern fuel for cooking by the poor rural household. The most significant step towards reducing biomass fuel consumption could be by adopting liquefied petroleum gas. This enables reduction in indoor air pollution and saves forests. Data collected through the field study and subsequent data analysis, revealed that there is a reasonable amount of awareness and acceptability of modern fuel by the rural poor. About twelve percent of the poor household respondents that took the survey have kept kerosene and LPG as an additional fuel for cooking, which is a very less proportion, considering the lack presence and penetration of modern fuel in rural are. The

factors emerging out of the analysis is that the income of the respondent has great influence in the switchover to modern cooking fuel. The study further reveals that the smaller household size respondents are prepared to switchover to modern fuel provided the accessibility of the fuel is made easier. The biomass fuel is available free of cost, as it can be collected from the nearby forest land. As regards the affluent rural households, the use of modern cooking fuel over traditional fuel seems to be more of a social need, rather than choice. Making the modern fuel easily available will be beneficial, not only for socio economic development, but will also help in containing environmental pollution. By adopting cleaner fuel, government will be in a position to reduce the rural health hazards, which would ultimately help in reducing the government spending on public health for rural poor. Therefore, Government of India should actively consider providing incentives, duty cuts, etc., and encourage supplying improved fuel for cooking to the rural poor. Since, the study is undertaken with the objective of analyzing the socio-economic conditions of rural poor in Assam with respect to their primary energy consumption viz. cooking fuel. The study conducts a questionnaire based survey on demographic, economic, and perceptible parameters on cooking fuel such as firewood, crop residual, kerosene, LPG, etc.; using logit model to identifying variables useful for the study. This study could be useful not only to Assam a state of India, but to many other economies that are on the threshold of transition; where majority of its population is still living in the rural areas. However there are certain limitations of the study as the data was collected from only one district of the state. Being a primary survey most of the extraneous factor was difficult to control which depicts that there might be some degree of biasness.

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