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EFFECT OF DOMESTIC FUEL USE IN SONITPUR DISTRICT OF ASSAM ON RURAL WOMEN HEALTH: A *STUDY IN MEDICAL GEOGRAPHY*

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ABSTRACT

The use of biomass fuels in rural households of developing countries generates indoor air pollution that results various health hazards, especially for those actively involved in cooking. This study examines the risk factors responsible for respiratory symptoms among rural women on the basis of socio-economic variables, characteristics of the kitchen, housing condition, cooking practices, fuel used, health symptoms, etc, from a number of sample households of villages of Naduar, Biswanath and Pub-Chaiduar blocks of Sonitpur district, Assam. A poor household has low access to cooking fuel, spends the longest time obtaining it, and puts it to use in stoves which are not only fuel-inefficient, but which also imposing her to various health problems.The study therefore aims to create awareness on the issue of implication on health of rural women who are continuously exposing themselves to the harmful affects of smoke emitted from the use of bio-fuels while cooking. Apart from that focus has been given on the possibilities to make available more efficient stoves and clean fuels at cheaper price and tries to highlight the importance of proper ventilation in the cooking areas.

Key words: Biomass fuel, Indoor air pollution, health risks and proper ventilation

1. Introduction:

Traditional fuel for cooking is being dominantly used 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 pain staking and time consuming task for rural poor. Besides, it is also linked to the degradation of natural resource especially the forest, leading to a situation of massive deforestation and as well as loss of bio-diversity and man-elephant conflict especially in Assam. In addition, there are a number of other adverse consequences of forest degradation, such as inadequate rainfall, release of excess carbon dioxide into atmosphere and soil erosion (Heltberg, et al. 2000). Burning of biomass in open-fire stoves and 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). Studies have shown strong associations between biomass fuel combustion and increased incidence of chronic bronchitis in women and acute respiratory infections in children. The available evidence also suggests that the indoor air pollution (IAP) from biomass fuels and traditional cooking stoves may pose a serious health threat. The smoke from burning solid fuels produces many pollutants, including particulate matter (PM) and carbon monoxide (CO) are highly toxic and is associated with increased rates of infant mortality [Chay and Greenstone 2003a and 2003b]. The emissions rates of pollutants from traditional stoves are extremely high. Smith (2000) reports that mean 24-hour PM_{10} concentration from solid-fuel-using households in India sometimes exceeds 2,000 /µg/m3, where PM_{10} refers to particulate matter with a diameter of less than or equal to 10/µm; these particles are widely believed to pose the greatest health problem. The World Health Organization (WHO) has prescribed 20 micro grams in cubic meter ($\mu g/m_3$) of air for particulate matter as a norm for indoor air pollution. In India, the average indoor air pollution is 375$\mu g/m_3$ and the prime contributor for this is burning of solid fuels, says a study done by Indian Council for Medical Research. High generation of indoor air pollution had caught attention of policy-makers and environmentalists recently. They want the central government to prescribe national indoor air pollution norms on the lines of national ambient air norms. According to the survey conducted by the Energy and Resources Institute (TERI) in a recent study said that 27.5 % of under-five infant mortality in India is because of indoor air pollution. Another study said that about 80 % of women in India are affected by indoor air pollution. Despite the serious threat posed by the consequences of IAP on the health of women and children very less work and survey has been done to find out the causal relationship between the use of traditional cooking fuels and respiratory health syndromes vis-a-vis to the use of cleaner fuels in cooking. Worldwide,

exposure to smoke emissions from the household use of solid fuels is estimated to result in 7 million deaths annually.

Indoor air pollution is main in India resulting high number of deaths annually. This means that, after contaminated water, solid fuels- used by over half of the world's population is the most important cause of disease [Bruce et al. 2006]. Around 1.3 million people died of indoor air pollution in 2010 whereas death because of outdoor air pollution was around 6.20 lakh. Unlike many western countries, India does not have any norm for regulating and controlling indoor air pollution, resulting from the use of home appliances such as refrigerators, air-conditioners and bread toasters etc.

In India, biomass fuels constitute the main 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 mostly preferred by all rural households especially in Assam as it has rich forest coverage. Though these traditional fuels are predominant in rural areas, but the pattern of their use is little different (Viswanathan and Kavi, 2005). In fact willingness of a household to shift towards better quality fuels requires an awareness regarding air pollution and its health consequences. But the economic position of an household however plays a predominant role in determining the current choice of fuels. In the past, there have been various attempts by the government of India to promote cleaner fuels, especially among 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.

The rural population of Assam is significantly more than the population that live in rural India. Similarly, the percentage of population living under below poverty line in Assam is ten points more than all India percentage. As cooking fuel like firewood, crop residue etc., are available for free in nature, so majority of rural households shows more dependency on biomass. To reduce in consumption of biomass, the government should make the distribution system of

Liquefied Petroleum Gas (LPG), kerosene and solar energy more 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. 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, et al. 2000). This paper is designed to increase understanding of what types of households use traditional cooking fuels and to understand the correlations among fuel use pollution levels and respiratory health. In this paper an attempt has been made to discuss the factors guiding rural household choices of cooking fuels and its impact on the health of rural women. This is crucial for policies makers 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 long-term environmental consequences of fuel use.

2. Objectives:

The present study has been undertaken with the following specific objectives:

a) To examine the relationship between biomass fuel combustion and increased incidence of chronic diseases and respiratory infections among women in rural households.
b) To analyze the correlation between socio- economic factors and primary cooking fuel consumption patterns.
c) To suggest measures to reduce indoor air pollution with the adoptation of improved stoves, access to cleaner burning fuels and proper ventilation.\

3. Study region:

The Sonitpur district it located on the North bank of Brahmaputra River; within longitudes $92^0$16′E-$93^0$43′E and latitudes $26^0$30′N-$27^0$01′N. The district is bounded by Arunachal Pradesh in the North, river Brahmaputra in the South, Lakhimpur district in the East and Darrang district in the West. The total Geographical area of the Sonitpur district is 5324sq.km. The district headquarters is Tezpur and there are three sub-divisional-Tezpur, Biswanath Chariali and Gohpur. The present district comprises of 7 Tehsils/circles and 14 community development blocks. There are 1615 no.s of villages (including 19 under BTAD), and 5 towns (Tezpur, Dhekiajuli, Rangapara, Biswanath Chariali and Gohpur).

The Sonitpur district is located between the mighty Brahmaputra and Himalayan foothills of Arunachal Pradesh. The district is largely plains with some hills. The Brahmaputra River forms the South boundary of the district. A number of rivers which originate in the Himalayan foothills flow southward and ultimately fall in Brahmaputra River. There are number of River Island in Brahmaputra River locally known as Chars or Chaporis. They are generally sandy. Some chars are large enough and fit for habitation and cultivation.

According to 2011 census, Sonitpur has the population of 19, 25,975, while according to 2001, total population was 16, 77,874, which indicates a growth rate of 15.67% over the decade. The population density is 365 inhabitants per sq. km. The sex-ratio is estimated as 946 females for every 1000 males. While the literacy rate of the district is 69.96%. The district is populated by people from different religion and communities like Assamese, Bodos, Nepali, Bengali Muslims, Adivasis, Koch-Rajbongshi etc. According to the 2001 census (GoI, 2001), Scheduled Castes (SC) and Scheduled Tribes (ST) comprised 5.23 percent and 11.60 percent of the total population of Sonitpur respectively. The average literacy rate of Sonitpur in 2011 is 69.96 percent with males at 76.98 percent and females at 62.53 percent (GoI, 2011). The district is primarily rural with 91.11 percent people living in villages and the remaining 8.89 percent living in the urban areas (ibid). The economy of Sonitpur is primarily agriculture based with nearly 80 percent of the population engaged in agriculture and allied activities to earn their livelihood. Paddy is the main food crop grown in the region. Apart from paddy tea, pulses, jute, and vegetables are also some of the major crops grown in the district

Fig.1: Location Map of Sonitpur District

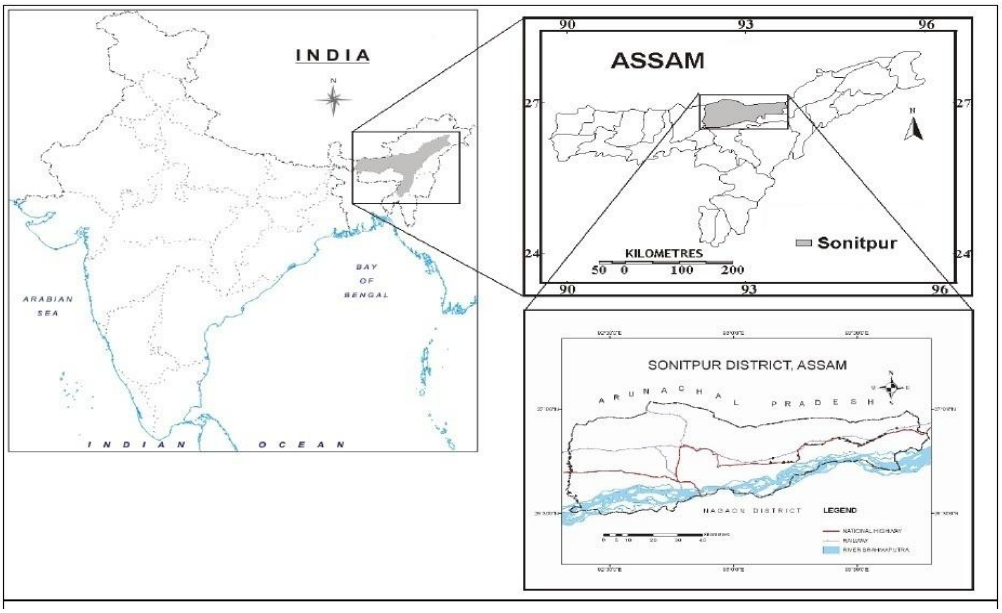
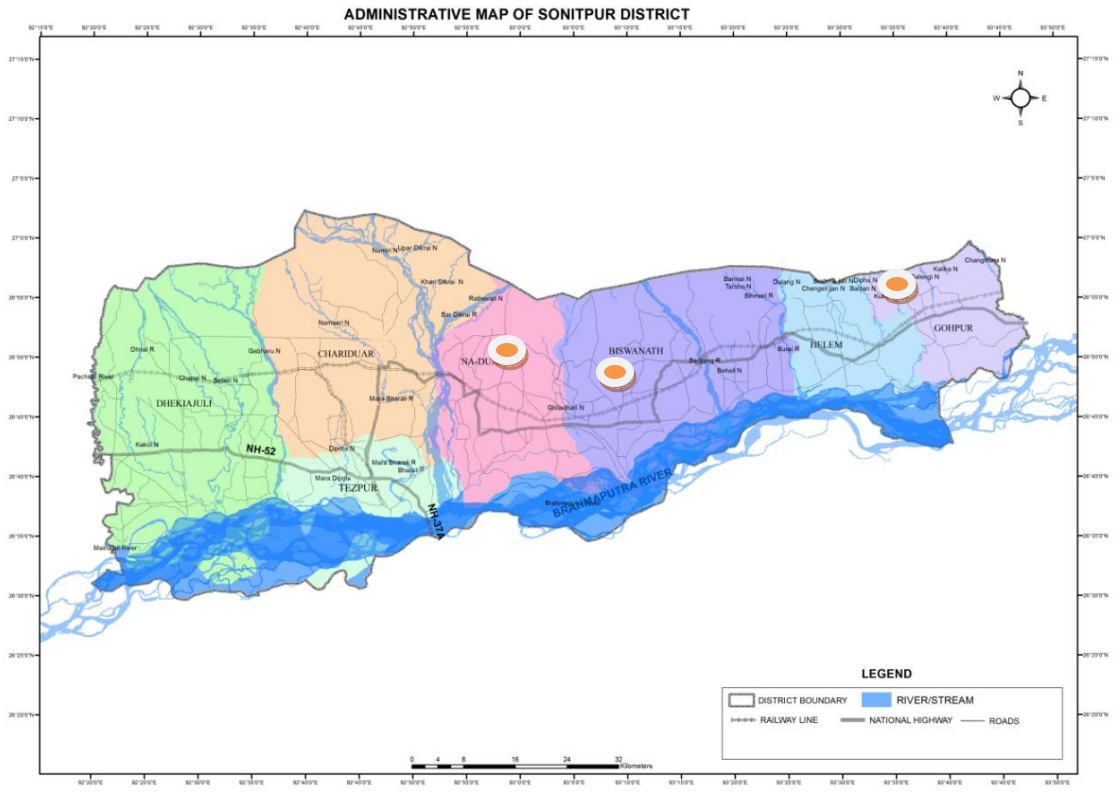


Fig.2: Administrative map (Red spots indicate the sample community development blocks)



4. Database and Methodology:

The data were collected both from primary and secondary sources. Primary data have been collected through extensive field survey. The survey was conducted at three levels viz, household level survey including individual health status, village level survey and survey of nearby public health care centers. For this purpose a questionnaire was designed to collect the relevant information related to socio-economic condition so as to give a complete picture of fuel consumption pattern, cooking behavior, villager's exposures to indoor air pollutants generated during combustion of bio-fuels and health profile of individuals so as to link pollution with health and other related variables. Data from primary sources have been collected through: i) Interview with the chief cook of the house i.e. women members ii) Discussion with the head of the Village Panchayat iii) Discussion with the chief resident doctor of the primary health care center. While secondary sources includes the annual report of Rural Health Mission, District Statistical Handbook, Census report collected from various departments like Directorate of Economics and Statistics, NSSO etc. The surveyed villages are selected from three community

development blocks using systematic stratified random sampling technique. From each block three villages are selected i.e., altogether 9 villages are considered as sample villages for study. As the study area is almost homogeneous in respect to physical conditions, economy and population characteristics, so the sample size is taken to be 30%. Now from every village, 30 households were selected randomly. In this way, 270 rural households were selected from the whole district. In the present analysis a set of indicators of socio-economic development have been taken into account to determine the type of fuel used in the households on one hand and health condition and income on the other hand. These indicators are literacy, employment, income, household condition, infrastructure and household assets. The correlation co-efficient has been computed on the basis of Karl Pearson's correlation co-efficient (r) method. To find out the computed 't' value, student t-test technique is used. Besides, advanced statistical techniques like SPSS has been used for further data analysis and representation.

5. Result and Discussion:

Fuel consumption pattern in Assam:

About 70 percent of India's population resides in rural India (Census of India, 2011) 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, crop residue, dung cake, kerosene and liquefied petroleum gas (LPG) as the sources of energy for cooking. Among these sources, firewood and crop residue is used by almost three-fourths of the rural households. However, less than two percent of rural households use kerosene for cooking. The use of LPG is very low in rural India; only about six percent of the households use it for cooking purposes. However the introduction of LPG will leads to corresponding decrease in the consumption of firewood in rural areas (NSSO, 2011). On the other hand, the use of dung cake decreased slightly at all-India level.

In Assam about 86 percent of total population resides in rural area while the urban areas shares only 14 percent. As per 2011-12 data, 33.89 percent of people in rural areas (92.06 lakhs) of Assam are below poverty line (BPL), while in the urban areas of Assam 20.49 percent of the total population (or 9.21 lakh) people fall in the BPL segment. Assam's position in BPL segment is third highest among the seven North Eastern states. The type of fuel used in rural households is usually determined by the income level and fuel availability. 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. In Assam, about 78 percent of rural household used firewood as primary fuel for cooking; followed by LPG and crop residue. Similarly, share of rural household used cow dung and kerosene is one and two percent respectively (Table.1). This may be due to their rich forest coverage in the state and socioeconomic condition and cultural influences on the rural dwellers.

Table 1: Primary Cooking Energy Sources in Assam (Percentage of households)

	2001-02		2011-12	
Type of Fuel	**Rural**	**Urban**	**Rural**	**Urban**
Firewood & Crop residue	89.2	33.5	83.4	25.2
LPG	1.9	29.7	4.3	44.3
Dung	2.4	1.5	2.0	0.7
Charcoal	0.3	0.5	0.0	0.1
Kerosene	1.7	22.9	2.7	21.3
Electricity	Negligible		0.2	0.8
Others	3.5	2.4	2.6	0.5
No cooking available	0.7	6.7	1.1	4.1

Source: Census of India (2001 & 2011)

From table 1, it is observed that 83.4 percent of the rural households and 25.2 percent of urban households depends exclusively on firewood & crop residue for cooking followed by 4.3 percent of rural and 44.4 percent of urban households use LPG for cooking. Interestingly, the use of dung for cooking appears is very negligible in Assam which is only 2.7 percent for rural and 0.7 percent in urban households.. This may be due to expanse of forest area in Assam; which constitutes 36.37 percent of the State's geographical area. Likewise the use of kerosene and electricity for cooking purpose is also low in rural areas in comparison to urban areas where these energy sources are easily available. Thus it is apparent that income and as well as availability of fuel in both urban and rural areas plays a pre-dominant role in determining the fuels that households adopt for cooking. As most of the rural areas in Assam suffers from poor

infrastructure and are located in the interior areas which are not easily accessible, in such circumstances the rural households has no other option rather than depending upon locally available sources for cooking.

A total number of 270 households in nine villages spread across all the three development blocks of Sonitpur district viz Naduar, Biswanath and Pub Chaiduar are studied. All the respondents belong to the Bellow Poverty Line (BPL) category. From the table 2 it becomes clear that the majority of rural households are dependent on biomass for cooking which is highly hazardous for health as it generates indoor air pollution.

Table 2. Number of Rural Households Used Fuel for Cooking

Type of Fuel	Respondents
Firewood, Crop Residual and Dung	255
Kerosene and Liquefied Petroleum Gas	15
Total Respondents	270

Based on field survey

5.1 Health Impact of Exposure to Emissions from Solid Fuel Use:

The health impacts of Indoor Air Pollution (IAP) due to use of bio-fuels can be attributed to exposure to domestic smoke. Indoor air pollution is indeed a significant health threat in rural areas where households rely on traditional fuels for cooking their meals. In fact high incidence of respiratory illness: about two third of all adults particularly women who are actively involved in cooking and half of all children experiencing symptoms of respiratory illness for more than one month, with 10 percent of adults and 20 percent of children experiencing serious cough in the study area. To obtain overall view of the area, data was collected from the records of 12 health centers servicing the villages covered in the study. The total number of patients treated in a month by these health centers for respiratory diseases and water related problems and average number of patients per public health centers is shown in table 4. The patients suffering from respiratory diseases appear to be quite high especially among females who are directly involved in cooking. The patients suffering from respiratory diseases are 30 percent and from water related diseases are 18 percent of total patients treated at these health centers. It is clear from the table that the prevalence of respiratory diseases is higher in the study area, particularly in the health centers that are located in the char land areas, where majority of rural population (95

percent approx) are below poverty line and illiterate. Bronchitis is seen as most common among respiratory diseases. For eye irritation symptoms observed among the patients, the use of bio-fuels is considered to be the chief culprit.

Table-4: Number of Patients per month in 12 health centers of Sonitpur district, Assam

Diseases Type	Total Patients	Percentage of male patients	Percentage of female patients	Percentage of child patients
Bronchitis	2058	62	74.5	9.0
TB	899	4.3	5.2	0.4
Asthma	575	7.5	8.6	0.2
Pneumonia	35	1.5	2.4	0.3
Cough	90	56	65	17
Phlegm	38	4.4	3.2	1.0
Blood in sputum	12	3.4	5.5	1.7
Eye irritation	1457	56	72	15
Skin infection	51	3.2	9.3	5.3
Diarrhea	450	17	22	45
Typhoid	200	21	17	35
Malaria	49	32	26	18
Others	1756	12	9.8	3.3

Source: Report of Health centers (September, 2014)

As far individual exposure to air pollution associated with the combustion of bio-fuels in rural households are seen more among the members who are chief cooks and also other family members who stay inside the house while cooking i.e. adults and children. The number of meals cooked also determines the total exposure. Each time the fire is started using bio-fuel, it produces a lot of smoke and pollutants. Most households cooked two meals a day (80 percent) and 10 percent of the households cooked once. Remaining 10 percent cooked thrice a day. Mostly female adults of age above 15 years are the chief cooks as shown in table 5. Those who are chief

cooks have greater risk of respiratory ailments. Overall it is found that males are rarely involved in cooking.

Table 5: Cooking Involvement

Sex	Involvement in cooking (percent of person)		
	Chief cook	Partial involvement	Not at all
Male >15 years	3	5	93
Female >15 years	52	17	24*
Female 15-30 Years	45	-	-

Source*: Based on field survey* (Note: * *Female of age above 15 those who are not at all involved in cooking represent those women who had left cooking due to old age or some other reasons*)

5.2 Housing condition and indoor air pollution:

Housing conditions is directly related with health; especially air pollution and sanitation related diseases. If cooking is performed in an enclosed area with bad ventilation and traditional stoves, exposure is much higher than cooking the meal in open air. In fact kitchen type and proper ventilation are indicators of women's health. The type of house, number of rooms, and location of kitchen and adequacy of ventilation determines the extent of indoor air pollution. Persons living in *pucca* house (house constructed using bricks and cement as building material) had a lower risk of respiratory diseases than persons living in *kutcha* house (house constructed using bamboo, dried leaves, thatch, etc) as they are poorly ventilated. Around 74 percent of rural houses are kutcha, while only 29 percent are pucca houses. About 44 percent of houses have only one room. The number of rooms in the house is very important information as far as the indoor air pollution is concerned. In the study it is found that there is a negative correlation is observed between respiratory diseases and number of rooms. It is observed that if there are less number of rooms in the houses the chances of respiratory diseases increase because of less dispersion of the smoke. In the sample households 21 percent (Fig.3) do not have any kitchen or cooking space.

These households cooked their food outside in the open air. In such

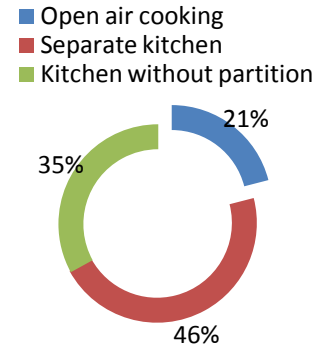


Fig-3: Location of kitchen

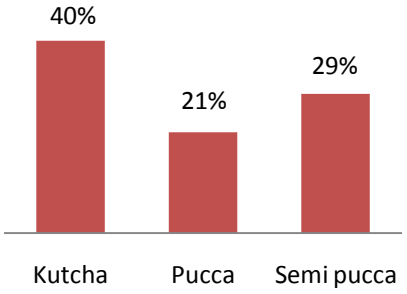


Fig-4: Type of house

type of kitchen exposure is minimal for both cook and other family members, as the pollutant generated dissipate quickly in the air. Around 35 percent households had cooking space inside the living room itself, due to which all other family members who are present during the cooking also get exposed to air pollution. 48 percent have separate kitchen outside the house. Among separate kitchen, 55 percent are very badly ventilated as there is no window or ventilator.

Table 5: Correlation between household income and health:

Variables	Defination of variables	Income (Y1)	Health (Y2)
X_1	Type of fuel used	0.074**	0.173**
X_2	Type of Asset owned	0.039**	1
X_3	Total literacy rate	0.50**	-0.047
X_4	Kitchen location	0.43	0.097*
X_5	Male employment rate	0.76*	-0.30
X_6	Female literacy rate	-0.52	0.202**
X_7	Female employment rate	0.83*	0.066
X_8	Availability of electricity within	0.32	0.44*

	household		
X_9	Number of rooms	0.45*	-0.072*
X_{10}	House type (Kutcha/ Pucca)	0.04**	-0.381*

*** Significant at 1 percent level, * Significant at 5 percent level*

Source: Based on Sample survey

The above table no. 5 shows the analysis of simple correlation of income and health (dependent variables) with selected indicators of socio-economic development (independent variables) to find out the causes of indoor air pollution affecting the health of women and children in the majority of rural households. Among the ten indicators, four indicators (X_1, X_2, X_3 & X_{10}) are significant at 99 percent confidence level which thereby indicates a positive correlation with income. While (X_5, X_7, X_8 and X_9) are also correlated with per capita income at significant at 95 percent confidence level. The result of correlation between health and selected indicators of socio-economic development exhibits that out of ten indicators, the coefficient of correlation of two indicators are positively correlated with health at 99 percent confidence level, while (X_4, X_8, X_9 & X_{10}) are also positively correlated with health status. Other indicators of socio-economic development are also correlated with the per capita income and health. Thus the above analysis clearly shows how per capita income of the households determines the level of poverty which ultimately determines the type of fuel to be used for cooking and health status in the households. 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 and thereby risking their lives to the hazardous gases released from the combustion of bio fuel everyday while cooking. Apart from income, others factors which determines the rate and extent of indoor air pollution are kitchen location, house type, proper ventilation, female literacy and so on.

6. Suggestion and Conclusion:

The use of biomass fuels for cooking and resultant emission of indoor air polluters is the matter of serious concern in today worldwide. Considering the present circumstances, it has becomes indispensible to look for modern fuel for cooking by the poor rural household. The most significant step towards reducing biomass fuel consumption could be by a shift towards adopting a cleaner fuel, i.e., adopting liquefied petroleum gas. This will enable to reduction indoor air

pollution and will save valuable trees. From the entire study, the factors emerging out of the analysis is that the income of the respondent has great influence in the switchover to modern cooking fuel. From the personal interview with the responded it is revealed that the smaller household sizes are prepared to switchover to modern fuel provided the accessibility of the fuel is made easier. Compared to LPG, 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 is more common as they are finally in a better position to afford it. However, making the modern fuel easily available will be beneficial, not only for socio economic development, but will also help in regulating environmental pollution to a greater extent. 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.

From field survey it has been found that, the availability of clean fuel is not sufficient in the study area. The kerosene supplied through public distribution system (PDS) is mostly restricted to a quota of 3 liters per households, four out of nine villages (located in the interior area and char land) do not receive kerosene through PDS and one village out of remaining five reported to have irregular supply of kerosene. Therefore, Government of India should actively involve in providing the supply of improved fuel for cooking to the rural poor at a nominal price more particularly to the economically weaker section as they are more vulnerable to IAP. 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, thus this study could be useful not only to Assam, but to many other economies that are on the threshold of transition; where majority of its population is still living in the rural areas. Various innovative techniques to face the acute shortage of power supply; the making the rural areas free from indoor pollution could be an attractive option in near future to provide a cleaner environment in rural areas which demands a thorough research in near future.

Note:

Particulate matter is a mixture of solid and liquid particles of organic and inorganic substances suspended in air. Particles are classified according to their diameter in micrometers; PM $_{10}$ designates particles with diameters of 10 micro meters or less, while PM_{25} designates diameters of 2.5 micrometers or less. The smaller the diameter, the greater the risk; finer particles can be inhaled deeper into the lungs, causing greater damage to respiratory function. CO (carbon monoxide) is a highly poisonous gas found in combustion fumes, such as those

produced when burning solid fuels. CO can build up in enclosed poorly ventilated spaces. CO compromises the transportation of oxygen by the red blood cells, which can lead to tissue damage and death.

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