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TRADITIONAL WASTE BURNING & ENERGY POVERTY IN WEST BENGAL

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ABSTRACT: In developing countries, providing clean and affordable energy for poor households is an essential prerequisite in the fight against poverty. Even though rural households often have easy access to traditional forms of energy like firewood and agricultural residues to fulfil their daily energy requirements, that adversely affects their health and environment
This paper envisages household energy consumption and related quality of life modelling. It indicates the significant influence of energy consumption on humans. As these two factors correlate, per capita energy consumption is determined by household income. Increasing per capita income leads to the rise of the uses of efficient energy like LPG and electricity. In contrast, poor households still depend on biomass burning, which leads to other health and environmental problems.

1. INTRODUCTION

Energy is necessary for a country's social and economic development (*Sustainable Energy for Developing Countries*, n.d.). In rural Bengal, clean and cost-effective energy is critical to prevent energy poverty, specifically for poor households. Energy poverty and biomass burning are, to some extent, associated with the household's economic structure and family size (Bouzarovski & Petrova, 2015). Few earlier studies have suggested a close interrelationship between waste quantity/quality and the socio-economic status of households in developing countries (Ojeda-Benitez et al., 2003);(Thanh et al., 2010); (Sujauddin et al., 2008). As income rises, the household's consumption pattern changes along with the quality and quantity of waste generation (Bernad-Beltrán et al., 2014). The families with good income have more requirements for energy for their homes and consequently consume more Biomass for cooking and heating purposes in rural areas.

On the other hand, there is a positive correlation between family size and the generation of household waste and biomass burning (Suthar & Singh, 2015). There are several ways in a household to use energy services: cooking, space heating, lighting, education /entertainment (radio, TV, computer), services provided using household appliances (e.g. refrigerator), telecommunication and mechanical power. Rural households depend on traditional energy mainly for cooking and heating purpose. These conventional fuels like firewood, agricultural wastes, and charcoal are essential sources of household energy that have harmful effects on health and the environment. Mostly they use household waste like kitchen waste, plastic, polythene bags, and agriculture waste as cooking fuel. The dependence on solid fuels is very high in rural areas (72.22%) compared to urban areas (21.43%). Among different castes, the reliance on solid fuels for cooking is most elevated among Scheduled Castes (61.79%) and Scheduled Tribes (70.46%) (Faizan & Thakur, 2019). This adversity primarily impacts household women and children as in Indian households. Women are mainly responsible for household chores like collecting fuel, wood and cooking; therefore, they cannot participate in productive work or education.

2. REVIEW OF LITERATURE

In the circular economy, waste to energy is an integral part of the selected countries in Europe. Increasing household waste is a consequence of the rise in population numbers and their living standards, followed by the consumption of more goods and energy. On the other hand, there is a strong correlation between increased wealth and increased energy consumption. "Given that the average heating value of municipal solid waste (MSW) is approximately 10 MJ/kg, it seems logical to use waste as an energy source. Traditionally, waste-to-energy (WtE) has been associated with incineration. Yet, the term is much broader, embracing various waste treatment processes generating energy (for instance, electricity and heat or producing a waste-derived fuel). Turning waste into energy can be one key to a circular economy enabling the value of products, materials, and resources to be maintained on the market for as long as possible, minimizing waste and resource use". (Malinauskaite et al., 2017)

"Biomass has always been the greater source of traditional energy. It contributes around 10-14 percent of the world's energy supply. Traditionally Biomass is utilized through direct combustion. Biomass burning produces pollutants and acid rain gases such as Sulfur dioxide and Nitrogen oxides." (Saxena, 2007)

Clean Energy consumption is the key indicator for improving quality of life and overall economic development as energy poverty is very communion the developing world. "After the published report by the International Energy Agency (IEA) showing that nearly 1.1 billion people still have no access to electricity, anew UN initiative has been launched to coincide with the designation of 2012 as the International Year for Sustainable Energy for All, focusing on reducing energy poverty." (World Energy Outlook, 2017)

According to a report of Duke University, in developing countries, a substantial demand for energy is a common scenario in the household sector, particularly in India. Here 'energy ladder' approach has been used to show the traditional view on fuel choice (e.g. Leach, 1992), according to which households switch to more convenient energy forms as their income increases. 'A partial critique of this approach has been presented by Masera et al. (2000), who observed from data on rural Mexican energy consumption that households do not ascend a 'ladder'but rather follow a 'stacking' procedure, i.e. traditional fuels are not completely discarded with rising income, but rather used in conjunction with modern fuels due to cultural preferences.' (Tommi Ekholam, 2010)

3. OBJECTIVE

To study the availability of different energy carriers and constraints in their utilization.
To find out the reason behind residential biomass burning.
To identify the link between biomass burning and energy poverty.
To study the quality of life modelling in terms of energy consumption.

4. HYPOTHESIS

Energy poverty hinders the socio-economic and cultural enhancement of the study areas.

5. MATERIALS AND METHODS

5.1. Study site

Primary data is collected from two villages in the Birbhum district. Administratively Birbhum district is a unit in the Indian state of West Bengal. Primarily 75% of the population is dependent on agriculture in the district. Latitudinal and longitudinal extension of Birbhum is between 23°32'30" (right above the tropic of cancer) and 24°35'0" north latitude and 87° 5' 25" and 88° 1' 40" east longitudes. This district is triangular, having about 4,545 square kilometres in area. This area lies at the northeastern end of the Chota Nagpur Plateau, as it slopes down and merges with the alluvial plains of the Ganges. There is only a hilly area of natural rock formation near Dubrajpur town called Mama Bhagne *Pahar* (Hill). During summer, the temperature can shoot well above 40 °C (104 °F), and in winters, it can drop to around 8 °C (46 °F). Rainfall is higher in the western areas as compared to the eastern regions.

5.2. Sampling methodology and data collection

Primary data is collected through a complete enumeration of 62 households in two villages in Birbhum district on several household-level parameters through a door-to-door survey (Table 1). The usability of the electricity supply is based on the domestic supply of energy, and it is based on several indicators like capacity, duration, reliability, quality, the legality of connection, the service's affordability, and the installation's safety. A survey schedule is prepared to obtain different sets of information on socio-economic, demographic and housing properties involving the type of fuel, the quantity of fuel usage, household expenditure on fuel resources, cooking practices and cooks preference for particular energy.

The air quality parameter was monitored three times at each sampled household during the cooking time for the period. All the tested family was given a 5kg plastic bag to store all kinds of Household waste for a whole day. The procedure was followed for 7 days, and the garbage bag was collected from each family after the duration for further screening and analysis. In the laboratory, the total weight of the garbage from each household was measured along with the types of waste collected for further analysis. The following kind of garbage collected from the household is found.

- Waste from traditional *chulhas*: Ashes are generated from conventional *chulhas* through waste burning.
- Agricultural waste: crop residues, weeds, leaf litter, sawdust, forest waste, and livestock waste.
- Kitchen waste/food waste – peeling waste, discarded vegetables, food waste, discarded food, seeds, etc.
- Paper – paper scraps, packing papers, discarded papers etc.
- Plastic and polythene bags – bag, jar, container, bottle etc.

Table 1 Demography of the study area

Caste & Community	Name of the village	District	State	Distance from Howrah station	Religion	Total households	Total Population	
							M	F
Scheduled Tribe (Santal)	Pearson Palli & Bali Para	Birbhum	West Bengal	156 Km	Hindu	62	105	134
Total Households = 62								

5.3. Statistical analysis

The correlation coefficient and Gini coefficient were used to find the relation of family size and household income with the quantity of waste generation.

6. RESULTS AND DISCUSSION

Most households surveyed were of low to medium incomes, with the main occupations being either employed in daily labour or farmer. House has been classified based on the material used. 84 percent of the houses were kaccha houses, having no separate kitchens. 80% of the study households reported a combination of indoor kitchens and open-air cooking. Only 20% of households cooked their food in a separate kitchen. The rest cooked in the open even though they had a kitchen. Most households' kitchens were moderately ventilated by having a door and a window. In 32% of the households, the kitchens were not having any windows and hence were poorly ventilated

7.1 Household energy consumption scenario

Indian rural households are still very much dependent on biofuels for cooking purposes, so the study areas for our present research are no exceptions. "Historical trends in household energy consumption for 1980-2000 indicate that many households continue to depend on traditional cooking and water heating fuels. The household sector is responsible for about 45% of total primary energy use in India, a large share of which is through non-commercial fuels such as fuel wood, dung, etc. Primary energy use increased more than 1.5 times between 1980 and 2000, from 4,760 to 6,786 peta joules (PJ)." (Reddy, ECONOMIC AND SOCIAL DIMENSIONS OF HOUSEHOLD ENERGY USE: A CASE STUDY OF INDIA, 2004). In our research about 60 percent of the total household uses biofuels for different domestic activities, followed by 0.77 percent kerosene, 15.6 percent LPG, and 25 percent electricity consumption. (Table 2)

Table 2 Household Energy Consumption (Based on the expenses on energy parameters)

Energy Carriers	% of total
Kerosene	0.77
LPG	15.6
Bio-fuels	59.24
Electricity	25
Total	100

7.2 Household income and energy consumption (with reference to the Pradhan Mantri Ujjwala Yojana scheme)

There is a positive correlation (R=0.59)between household income and household energy consumption (Table 3)[5]. The rise in income level positively impacts their energy consumption and their choices of choosing types of energy. Firstly, with increasing income levels, energy consumption increases due to the changes in the preparation of food items at the house. Secondly, people can afford cleaner and efficient energy carriers such as LPG or electricity with increasing income. Many households use modern and traditional fuels for cooking and heating.

Table 3 Households using energy for cooking & different purposes (After Pradhan Mantri UjjwalaYojana)

Energy Carriers	% of households using various fuels in other income groups	
Low Income	Biofuels	100
	Kerosene	33.33
	LPG	23.80
	Electricity	95.23
Middle Income	Biofuels	90.47
	Kerosene	47.61
	LPG	38.09
	Electricity	90.47
High Income	Biofuels	100
	Kerosene	40
	LPG	60
	Electricity	100

[5] The low income group consists of household s with a per capita income of less than Rs. 7,000, middle income group (Rs. 7000-15000), and high income group (over Rs. 15000) per month at the time of survey i.e., (April 2019)

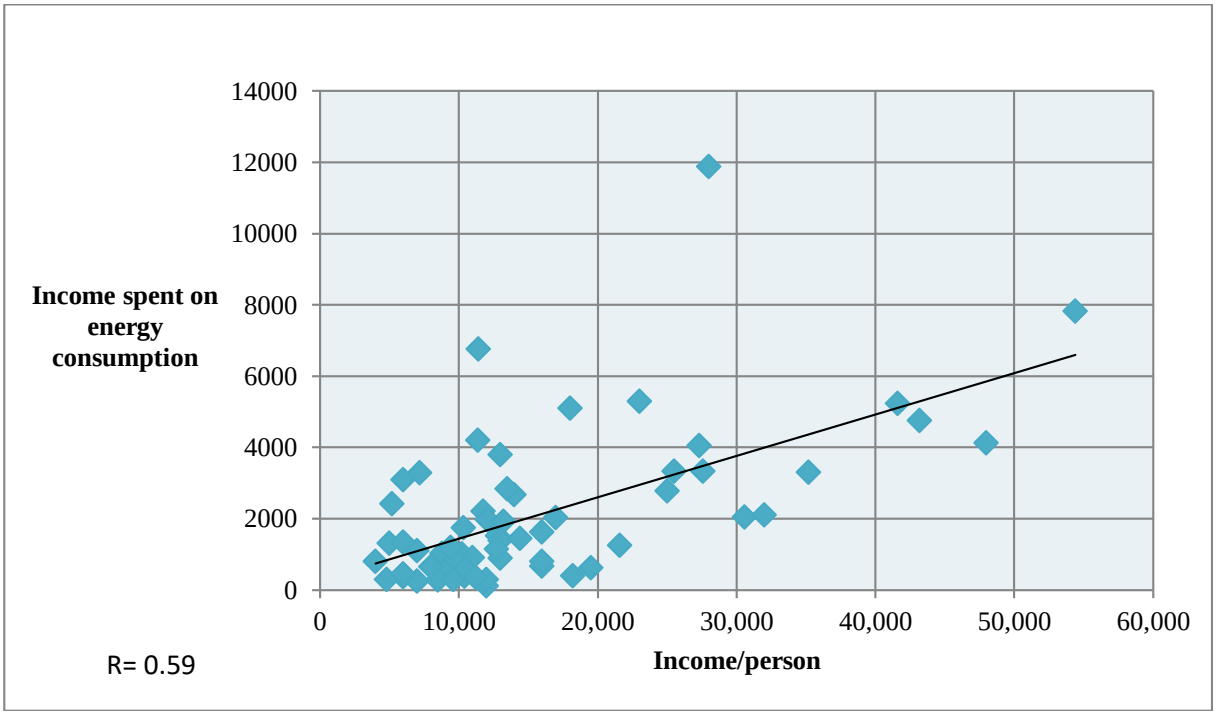

Figure 1 Correlation between Income and Energy Consumption

Increasing per capita income leads to increased use of LPG and electricity for cooking and other purposes. It is shown with the help of the before and after analysis of the Pradhan Mantri Ujjwala Yojana scheme (Table 2, Table 3). Households under the Below Poverty Level category avail electricity facilities free of cost. After launching the Pradhan Mantri Ujjwala Yojana in 2016, most BPL families got free LPG connections, but most of them could not afford the price of cylinders later. Therefore, some of them shifted back to biofuels, and some were found to depend on modern and traditional cooking fuels.

Table 4 Households using fuels for cooking in different income groups (Before Pradhan Mantri Ujjwala Yojana 1983-2000)[Source: Economic and Social Dimensions of Household Energy Use: A Case Study of India]

Energy Carriers	**% of households using various fuels in different income groups**			
		1983	**1993-94**	**1999-2000**
Low Income (Less than Rs. 6000/annum)	Biofuels	96.2	93.8	91.0
	Kerosene	2.1	2.9	3.1
	LPG	0.6	1.1	1.7
	Electricity	1.1	2.2	3.4
	Total	100	100	100
Middle Income (Rs. 6000-10000/annum)	Biofuels	92	90.6	89.8
	Kerosene	3.5	4.2	4.5
	LPG	1.8	2.1	2.2
	Electricity	2.7	3.1	3.5
	Total	100	100	100
High Income (Rs. More than Rs. 10000/ annum)	Biofuels	88.4	80.5	61.0
	Kerosene	4.2	7.2	8.2
	LPG	4.0	8.5	22.6
	Electricity	3.4	3.8	8.2
	Total	100	100	100

7.3 Energy use by Occupation:

The Occupation of the household members also plays a vital role in determining the energy carrier type. Manual labours in our study areas mainly depend on biofuels and LPG usage by high-income groups. With increasing income, energy consumption for refrigeration, audio/Video appliances and other modern uses grows (Table 5, Table 6).

Table 5 Energy-use by Occupation

Occupation	**Kerosene**	**Biofuels**	**LPG**	**Electricity**	**Total**
Daily labour	19.09	34.54	12.72	33.63	100
Self-employed	13.51	32.43	16.21	37.83	100
Service	5	25	30	40	100

Table 6 Income-wise distribution of Household Assets

Electrified Assets	Refrigerator	Television	Mobile phone	Fan	Light	Motorbike
Low Income	0 (0)	16.66 (7)	16.27 (7)	12.5 (7)	11.29 (7)	10 (1)
Middle Income	50(1)	47.61 (20)	48.83 (21)	53.57 (30)	51.61 (32)	30 (3)
High Income	50 (1)	35.71 (15)	34.88 (15)	33.92 (19)	37.09 (23)	60 (6)
Total	100	100	100	100	100	100

Occupation and income of the villagers jointly define the types of assets used by them. These factors are positively correlated to each other. In some cases, the percentage figure is more because more households are present in the middle-income group than in the high-income group. With increasing income, people are using more assets like television, mobile phone, fan light, etc.

7.4 Household Income &Waste Disposal

Households with good income sources are responsible for generating more household waste. As the family earns more, homes tend to spend more on daily items like food, fuel, wood, and so on, which lead to disposable and non-disposable household waste (Figure 2). Likewise, household income and family size also contribute to generating household waste. Households with many members create more garbage than small families (Figure 3). In the urban area, there are many ways to combat waste disposal. Still, in rural areas, people either dump household waste on the ground or burn the garbage due to the unavailability of proper infrastructure for waste management.

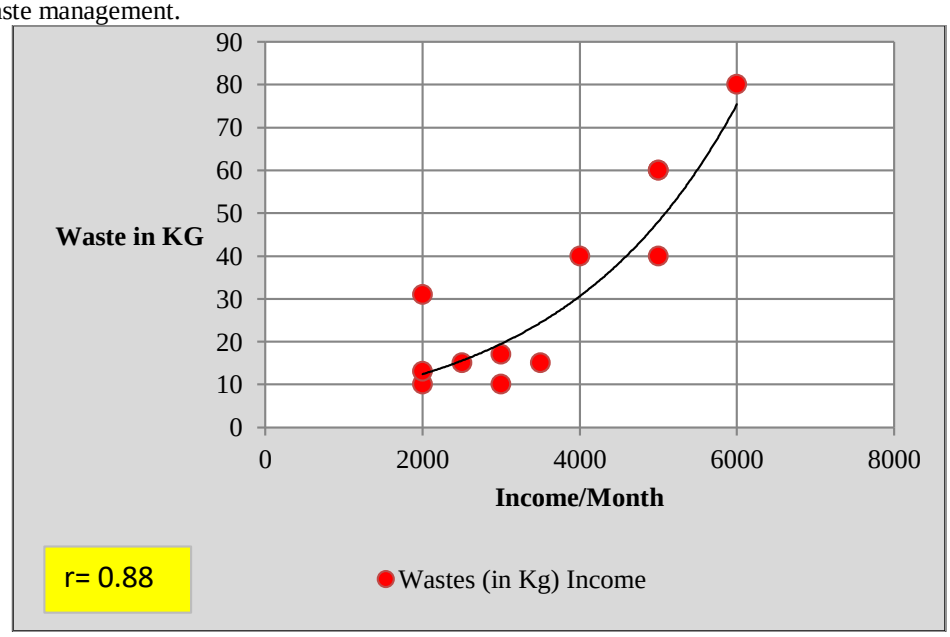

Figure 2 Correlation between Household Income & Waste Disposal

Showing Waste Disposal Gap of the Study Areas

Descriptive Statistics

	Waste	Population
Valid	12	12
Missing	0	0
Mean	1.629	4.500
Std. Deviation	1.180	1.508
Minimum	0.500	2.000
Maximum	4.000	7.000

Pearson Correlations

		Waste	Population
Waste	Pearson's r	—	—
	p-value	—	—
Population	Pearson's r	0.724	—
	p-value	0.008	—

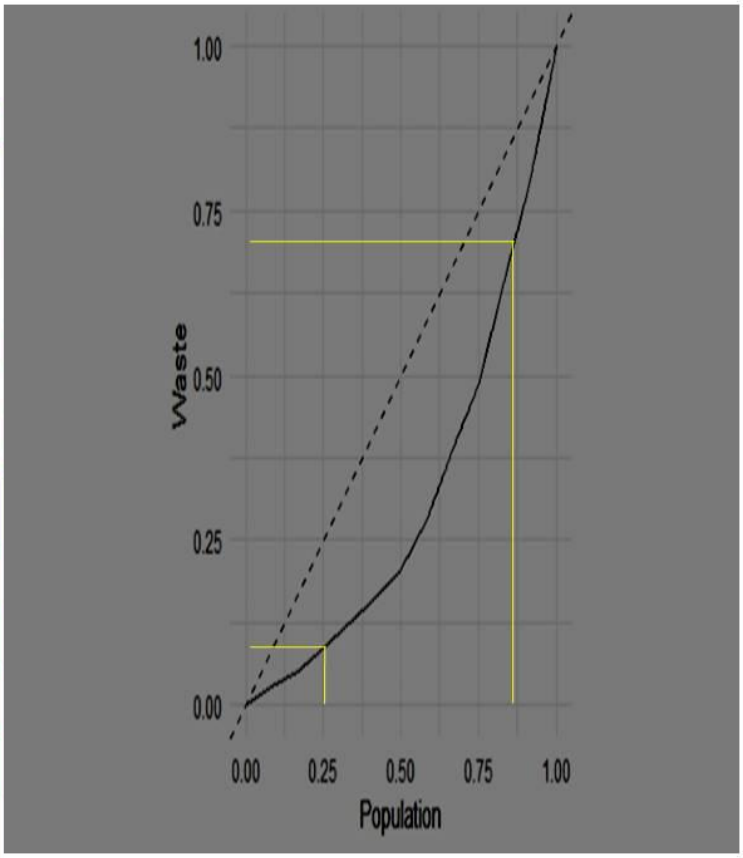

Figure 3 Family size and household waste generation

7.5 Implications of Household energy consumption

Increasing uses of biofuels (Wood, Petrol, Coal) by rural households lead to deforestation rapidly. The present research finds 8440 kg of biofuels (Table 7) per month, followed by an average per capita of 68.61biofuel consumption. This indicates an alarming rate of deforestation each day to keep the continued supply of firewood demand for the community at large. Poor people invest a lot of time in their daily life in firewood collection that they can use in any productive activity. Similarly, Kerosene usages also have a significant environmental impact by increasing residential sectors' carbon emissions. It directly affects the health of people working and cooking in one-room homes.

Table 7 Quality of fuels used in the study areas

Type of energy	Average Per capita consumption	Total
Biofuels	68.61	8440 kg
Kerosene	286.66	17.2 kg
Electricity	14	56 kWh
LPG	9.64	588.14 kg

7.6 Energy-poverty analysis

In the study areas, 92 percent of the household is found with regular electricity supply; 3 percent of the family is electrified with irregular supply, and the rest is not. Essential electrified assets like lights, fans, and mobile phones are present in most houses. The study areas are not agriculturally developed; therefore, uses of electrical agricultural machinery are absent.

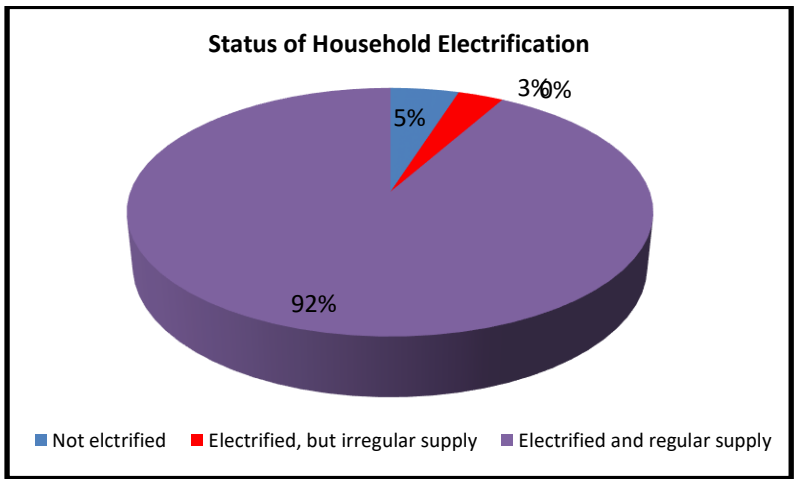

Figure 4 Status of Household Electrification

"Electricity consumption in Indian homes has tripled since 2000. The percentage of households with access to electricity has increased from 55% in 2001 to more than 80% in 2017. In 2014, an electrified Indian household consumed about 90 units (kWh) of electricity per month. This is three-fourths of the average monthly household consumption in China, a tenth of that in the USA, and a third of the world average. There is a significant inequity at the micro level of electricity consumption. According to National Sample Survey Office (NSSO) 's surveys, in rural areas, 90% of the electrified households consume less than 100 units." (CENTRE FOR POLICY RESEARCH (CPR) AND PRAYAS, 2017).

This energy gap between India and the study area can be plotted with the help of the Lorenz curve, where the straight line shows energy consumption by Indian households (90 kWh) and below two lines show the electricity consumption by two study areas. The total electricity consumption by the two villages is 56 kWh, and the average per capita consumption is 14 kWh.

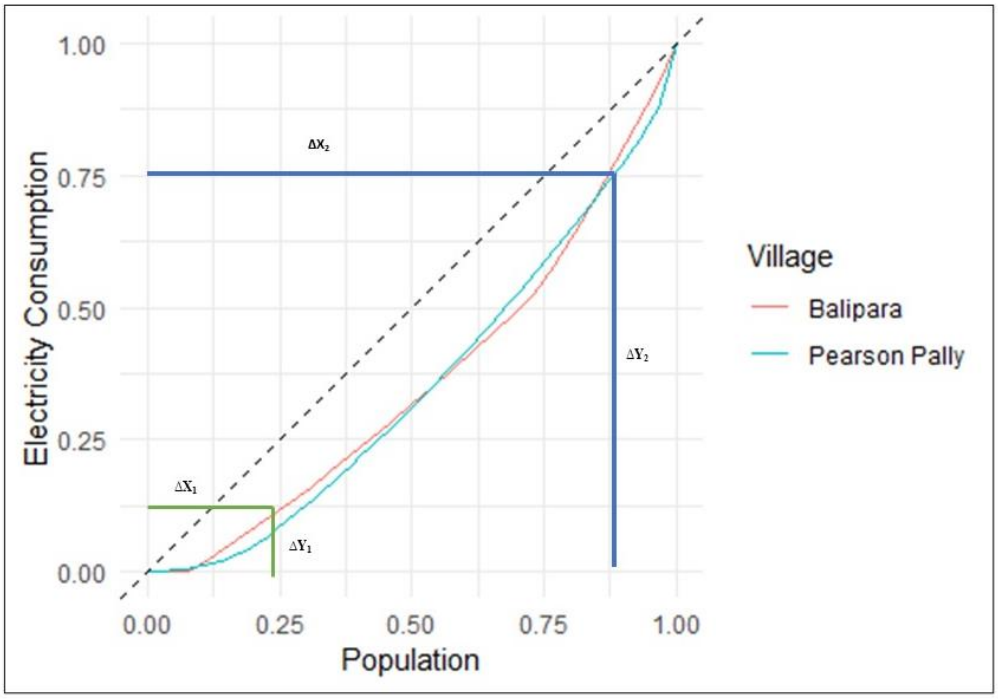

Figure 5 Showing Energy Gap of the Study Area Using Lorenz Curve

The above curve shows the unequal distribution of electricity between the economically rich and poor populations. The estimation below indicates that the per capita electricity consumption is half (1:2)for the poorest section of the people. In contrast, it is the opposite in the case of the rich section of people as their per capita energy consumption is double (2:1).

$12.5/25=\Delta Y_1 \div \Delta X_1$ ($\Delta Y_1:\Delta X_1 = 1:2$) , $25/12.5=\Delta Y_2 \div \Delta X_2$ ($\Delta Y_2:\Delta X_2) = 2:1$)

25 percent of the population, whose average monthly income is Rs 7000, consumes approximately 12.5 percent of the energy (electricity); that is, the bottom 25 percent of the population can access just 12.5 percent of the total electrical energy. On the other hand, from the right end, we could see thus, the upper 12.5 percent of the population whose average monthly income is Rs 15000correspond to the approximately 25 percent of the electricity, that is, the top 12.5 percent of the population own as much as 25 percent of the total electricity. This is not any surprising finding; rather, it is a common phenomenon worldwide. But unequal consumption pattern has been shown through the Lorenz curve, becoming a distinctive characteristic in low-income countries like India.

CONCLUSION

The primary energy services in rural India, such as lighting, cooking, mobility and communication, are very common to maintain their welfare goals. Energy poverty shows that people do not consume energy directly. Still, they need it in their daily lives to alleviate the struggle of poverty and for the cause of their socio-economic development. Access to energy services demands a source of energy like fuel or electricity and the availability of energy when needed depending on the household's affordability to

avail energy producing/procuring technology that provides a service. Several factors are symbiotically associated with energy consumption, income, occupation, family size, education, health and sanitation of the household. The household's income and occupation determine the energy consumption rate and the use of different energy types. People with higher incomes consume more energy than the poor section. Non-manual occupation and increasing income result in people shifting to the efficient energy consumption mode, like using LPG and electricity for cooking and heating. The level of education determines the pattern of energy consumption. During the household survey period, the households with educated members or members going to schools and colleges are seen to consume a more efficient form of energy. They have regular electricity connections at their houses, use technical devices like mobile phones and audio/video players, and depend on LPG for cooking. The pattern of energy consumption determines the health condition of the households. People cooking with biofuels have breathing problems more than those using LPG connections.

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