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The Health Burden of Biomass Energy Consumption: Empirical Insights from Tribal Households

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Abstract
Despite initiatives to promote cleaner energy, tribal households in rural areas still rely heavily on biomass fuels, like firewood, for their daily cooking and heating needs. Focusing on the impact of indoor air pollution on respiratory health and related ailments, this study explored the health burden associated with using biomass fuels. The study was conducted in Nandurbar district in the state of Maharashtra. It covers a sample of 600 households across two blocks and explores the energy sources utilized and the health status of these tribal households. The study revealed prevalent health problems such as respiratory infections, constant coughing, eye irritation, and other difficulties caused by continuous exposure to biomass smoke using empirical data from selected tribal household. The study also examines the socio-economic factors that affect household fuel preferences and the difficulties in switching to cleaner energy sources. Households, the switch to sustainable energy, and respiratory diseases. The findings highlight the urgent need for policies to provide access to cleaner cooking technology, raise knowledge of health risks, and minimize energy costs. By highlighting the need for a cleaner energy transition for the welfare of tribal people, this study contributes to the larger conversation on energy poverty, public health, and sustainable development.

Keywords: Biomass Energy, Health Impact, Indoor Air Pollution, Tribal Households, Respiratory Diseases.

I. Introduction

Access to affordable, reliable, sustainable, and modern energy is critical to achieving sustainable development, as highlighted in Sustainable Development Goal 7 (UNDP, 2015). In developing countries, 2.6 billion people rely on biomass fuels, such as wood, dung cakes, and crop residues for cooking and heating, often in poorly ventilated spaces. This exposure leads to severe health risks, causing approximately 4 million deaths annually (WHO, 2021). Indoor air pollution (IAP) is a significant health risk worldwide, especially because people spend approximately 90% of their time indoors (Leech et al., 2002). By 2020, IAP was responsible for an estimated 3.2 million deaths, including 2,37,000 children under five (WHO, 2022). Indoor smoke can contain fine particles 100 times above the acceptable limits (WHO, 2022). IAP ranks among the top environmental health risks and contributes 2.7% of the global disease burden (WHO, 2010). Studies have linked IAP exposure to asthma in children (Institute of Medicine 2000; Franklin 2007; Hansel et al. 2008; Sousa et al. 2012). Daily IAP exposure is notably higher in households using biomass than in those using LPG or electricity (Hu et al. 2019). Research indicates that Biomass smoke is a primary contributor to chronic obstructive pulmonary disease (COPD), with women accounting for 75% of biomass smoke-related COPD cases (Ramírez-Venegas et al., 2014; Pauwels et al., 2001). COPD is the third leading cause of mortality globally, with a significant burden in low-income regions (WHO, 2021). Access to clean cooking solutions increased by seven percentage points between 2015 and 2021, with projections suggesting that 77% of the global population will have access by 2030 (WHO, 2021).

Despite global efforts, disparities persist, especially in developing countries such as India, where many rely on traditional polluting fuels such as wood, crop waste, animal dung, charcoal, and coal. This dependence leads to indoor air pollution, respiratory diseases, cardiovascular illnesses, and other health complications, particularly in women and children exposed to high levels of smoke in confined indoor spaces. The urban-rural divide intensifies energy access challenges. According to the National Sample Survey (78th Round, 2021), 47% of rural households still rely on traditional fuels for cooking compared to 6.5% in urban areas. This disparity reflects systemic barriers, including limited infrastructure, high costs of clean energy technologies, and a lack of awareness. The prohibitive costs of LPG connections and other clean energy technologies reinforce energy poverty and hinder socioeconomic development in rural areas. Tribal communities in rural and remote areas face significant challenges in accessing modern energy services owing to socio-economic marginalization and geographical isolation. In Maharashtra, 36% of rural households lack access to clean cooking fuels, which is higher in the tribal-dominated districts. In Nandurbar, 74.5 per cent of tribal households lack clean cooking energy (NFHS-5 2021). The lack of infrastructure and socio-economic vulnerabilities hinders the transition to cleaner energy sources, perpetuating their reliance on polluting fuels. This energy deprivation impacts not only health, but also economic and social outcomes. The labor productivity of women who manage household energy needs is affected, contributing to continued poverty and socioeconomic marginalization, particularly for women and children.

1.1 Context

The According to the 2011 Census, Maharashtra has a population of 11.24 crore, with 9.3% being tribal. Nandurbar district, located in northern Maharashtra, has the highest tribal population, with 69.5% of its inhabitants belonging to tribal communities. The district faces challenges in terms of energy access, with 74.5% of tribal households lacking access to clean cooking fuel, contributing to health issues such as indoor air pollution. Nandurbar also had one of the lowest literacy rates in Maharashtra (64.38%), with a gender disparity of 72.98% male and 55.37% female literacy. This hinders the adoption of cleaner energy technology. The district's Human Development Index (HDI) was also the lowest in the state, reflecting limited access to essential services such as education, healthcare, and clean energy. District governance under the Panchayats Extension to Scheduled Areas (PESA) Act, 1996, offers a unique opportunity to study the role of local governance in addressing energy access, health issues, sustainability, and economic development.

II. Literature review

2.1 Overview of Previous Research

Many studies show that household income is positively correlated with the adoption of sustainable energy sources, such as electricity and gas, while poorer households in developing nations rely on unclean energy, such as firewood, agricultural waste, and animal dung (Danlami et al., 2016; Mensah &Adu, 2013; Ozcan et al., 2013; Couture et al., 2012). Liquefied petroleum gas (LPG) is the most widely used clean cooking fuel in rural areas. However, according to data from the 2011 Indian Census, only 11% of rural households use LPG as their primary cooking fuel, and the remaining 89% heat their homes each day by burning solid fuels, including wood, coal, and dung (Tripathi et al., 2015).

According to previous research, tribal women may experience worsening coughing, wheezing, shortness of breath, eye itching, and other symptoms caused by an unprepared housing structure, inadequate ventilation, moisture, and biomass smoke (Chakraborty et al., 2014).

Indoor air pollution (IAP) remains a critical environmental and public health issue, particularly for women and children in developing countries. According to Sehgal et al. (2014), burning biomass fuel is a major contributor to IAP, negatively impacting Indian women's health, as they spend significant time near household fireplaces, leading to prolonged exposure. Oluwole et al. (2017) found that smoke from biomass fuels, including wood, animal dung, and agricultural residues, increases the risk of severe asthma among rural Nigerian children, many of whom remain undiagnosed. Similarly, Maji et al. (2017) highlighted the severe health consequences of air pollution in Indian cities, noting that Delhi and Mumbai experienced high mortality rates due to exposure to PM10 and PM2.5. The study emphasized the importance of local assessments in mitigating health risks and maintaining environmental balance.Agrawal (2012) also found that women in households relying on biomass and solid fuels for cooking face a higher risk of asthma than those using cleaner fuels, and tobacco smoking further exacerbates this risk. According to Smith et al. (2000), cooking with biomass fuels can emit 50 times as many pollutants as cooking with gas stoves.

Addressing the economic dimension, (Ester Duflo, 2008) explored the relationship between financial well-being, respiratory health, and IAP, highlighting the significance of the "Energy Ladder" and suggesting that improved cookstove development and iron supplementation can enhance health outcomes. The Global Indoor Health Network (2017) underscored the global burden of indoor air contaminants, including radon, lead, asbestos, tobacco, and cooking fuels, noting that India alone witnessed significant child mortality due to PM1, PM2.5, and PM10 exposure as per UNICEF reports. Sharma (2015) further emphasized that IAP is the second leading cause of health hazards in India after high blood pressure, contributing to diseases such as bronchitis, lung cancer, and pneumonia.

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Mukkannawar et al. (2014) conducted a comparative study on indoor air quality in rural Pune, revealing higher particulate concentrations in households using traditional chullahs than kerosene and LPG stoves. The U.N. report (2017) noted that indoor pollution accounts for 52% of India's air pollution, advocating for adopting cleaner fuels, improved biomass stoves, and alternative energy sources such as electricity and natural gas. Economic constraints and the high cost of clean fuels limit the adoption of alternative energy sources, particularly among rural tribal communities (Chakraborty and Mondal, 2021a).

Building on previous research, Chakraborty and Mondal (2018) and Chakraborty et al. (2014) highlighted the restricted adoption of LPG in tribal-dominated regions, where households predominantly depend on biomass fuels. This heavy reliance on traditional fuels significantly contributes to the deterioration of indoor air quality, creating an unhealthy microenvironment. However, there is a paucity of comprehensive data on the adverse effects of biomass-derived pollutants on tribal households. In this context, the present study aims to systematically assess the interrelationship between household air pollution and associated health burdens among tribal communities in Nandurbar district, Maharashtra.

2.2 Research Gap

Despite the extensive research on biomass energy consumption and its health effects, significant gaps remain, particularly in the context of tribal households. Existing studies have emphasized the health risks associated with biomass use, such as respiratory diseases, eye infections, and cardiovascular issues. However, empirical evidence on tribal communities that rely on biomass owing to economic constraints, geographic isolation, and cultural preferences is limited. Most studies have analyzed biomass consumption at national or regional levels, overlooking the unique socio-economic and cultural factors influencing fuel use in tribal areas (Chowdhury et al., 2022).

While research links indoor air pollution to respiratory illnesses, few studies have quantified the long-term health burden on tribal populations by considering factors such as malnutrition, healthcare inaccessibility, and occupational exposure (Balakrishnan et al., 2019). Women and children face the highest exposure to biomass smoke; however, studies focusing on their specific health burden in tribal communities are scarce (Dutta et al., 2021). Few studies have focused on the different determining factors of energy use depending on location (i.e., near the city and interior area). The present study attempts the same.

2.3 Research Questions

1. What are the primary sources of energy and consumption patterns in the study region?
2. What are the major health issues caused by biomass fuel use in tribal households?
3. How aware are tribal households about the health risks of biomass fuel?

2.4Research Objectives

1. To identify the types of energy sources used by the Scheduled Tribe population.
2. To analyze the health impact of biomass fuel use, focusing on respiratory diseases, eye irritation, headaches, and other related health issues.

III. Methodology

This study used a mixed-method approach, combining surveys and interviews, to understand how tribal households use energy and how it affects their health. Household surveys have documented the types of energy sources used and common health issues, such as breathing problems, eye irritation, and headaches. This study employed a stratified random sampling technique, dividing the sample into two strata: households near the city and those in interior areas. This approach covered 600 households, evenly split between these strata. The sampling was conducted with a 95% confidence level and a 5% margin of error. Household medical records were reviewed to assess the frequency of biomass-related illnesses. Group discussions with community members explored their experiences with indoor air pollution, whereas interviews with healthcare providers provided insights into available treatments and awareness levels. The collected data were analyzed using statistical methods to identify health trends and links between biomass exposure and illnesses. Moreover, qualitative analysis helped understand community perceptions and challenges. The study focused on tribal villages in the Nandurbar district of Maharashtra.

3.1 Sample Design

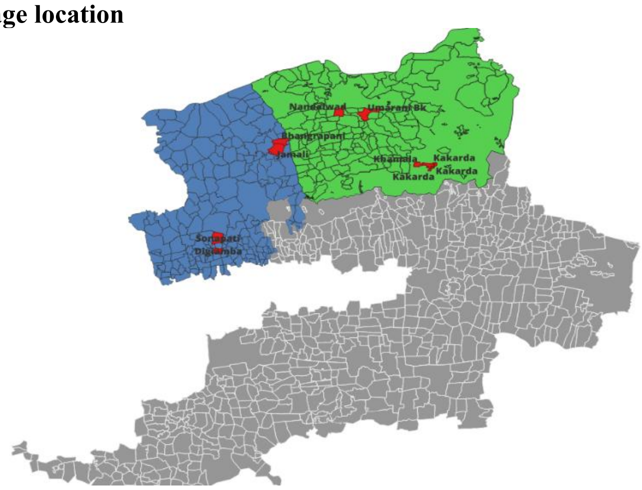
A district with a large tribal population was selected for this study. I then picked two blocks in that district, known for their tribal population and forest areas. Next, we randomly chose eight villages from these blocks, including the interior and nearby city villages. In these blocks, four interior villages were selected that were more than 50 km apart, and four villages were located near the city within a 5 km radius. The Proportion to Population Method was used to select sample households.

The study collected data from 600 sample households out of 2488 households, nearly 24.1 per cent of the total households. The 600 sample households were divided into 300 from interior villages and 300 from nearby city villages.

3.2 Data Collection

The study was conducted in Nandurbar district from January 2022 to March 2022. This study examines household characteristics to understand how tribal households use energy and how it affects their health across selected villages in the Nandurbar district. In urban areas, the villages of Umarani Bk (90 households) and Nandalwad (82 households) in Akrani block, as well as DighiAmba (52 households) and Sonapati (76 households) in Akkalkuwa block, were surveyed. These villages, located within a 0-5 km radius of the tehsil, have tribal populations ranging from 98% to 100%. In rural areas, the villages of Khamala (70 households) and Kakarda (104 households) in Akrani block, along with Jamali (64 households) and Bhangrapani (62 households) in Akkalkuwa block, were included. These villages, situated more than 50 km from the tehsil, also exhibit high tribal populations (98%–100%). The sample comprised 600 households, equally distributed between urban and rural areas.

District map and village location



3.3 Data Analysis Tools

Primary data was systematically collected from tribal households in Nandurbar district. In contrast, secondary data sources, including government reports, energy statistics, and scholarly publications on rural energy policies, were utilized to enhance contextual understanding. The study rigorously examines key variables such as energy access, socio-economic determinants, health implications and the effectiveness of government interventions. Quantitative data from structured surveys was analyzed using STATA for statistical robustness, whereas qualitative insights from interviews and focus group discussions were thematically analyzed to capture nuanced perspectives.

IV. Results and Overview of Findings

4.1 Results

4.1.1 Socio-economic profile of the selected sample households

Descriptive Statistics of the Households for Selected Variable (percentage)			
Variable	***Interior***	***Near to City***	***Total***
Gender of household head			
Female	6.3	4.7	5.5
Male	93.7	95.3	94.5
Age Group of Respondent			
18-35	42.7	33.7	38.2
36-59	46.0	54.7	50.3

60 and above	11.3	11.7	11.5
Type of Family			
Joint	10.3	4.3	7.3
Nuclear	89.7	95.7	92.7
Marital status			
Married	92.7	95.0	93.8
Unmarried	0.7	0.3	0.5
Widowed	6.7	4.7	5.7
Education Level			
No Education	54.7	58.0	56.3
Primary	22.3	15.0	18.7
Secondary	13.0	18.7	15.8
Higher	10.0	8.3	9.2
Occupation of respondent			
AgriLabor	92.3	50.7	71.5
Farmer	7.3	48.7	28
Teacher	0.3	0.7	0.5
Land Holding			
No Land	25.0	22.3	23.7
Less than 1 Acre	74.3	77.3	75.8
1 Acre and above	0.7	0.3	0.5
Income Level			
less than10 K	41.0	22.3	31.7
11k-20k	27.7	11.7	19.7
21k-30k	23.7	58.3	41.0
31k - 40k	3.7	5.3	4.5
41k-50k	1.7	1.0	1.3
51k above	2.3	1.3	1.8
LPG Connection			
Yes	39.3(N-118)	30.3(N-91)	34.8(N-209)
N0	60.6(N-182)	69.6(N-209)	65.1(N-391)
LPG Connection and Family Type (Out of 209)			
Joint	9.3	3.3	6.7
Nuclear	90.7	96.7	93.3

Source: Primary Survey

A total of All study participants are all female. Only 5.5% of households are female-headed, with 94.5% being male-headed. Most respondents (50.3%) fall within the age group of 36-59 years. 92.7% belong to nuclear families, and 93.8% are married. 56.3% had no formal education and 18.7% had completed primary education. The majority (71.5%) are agricultural laborers, with 23.7% lacking land ownership and 75.8% owning less than one acre. The income levels show that 31.7% earn below ₹10,000, while only 1.8% earn over ₹51,000, indicating economic vulnerability. Regarding energy access, 34.8% had an LPG connection, with a notable disparity: 93.3% of nuclear families had LPG, compared to only 6.7% of joint families. This reflects the limited access to clean energy and the economic challenges faced by the respondents.

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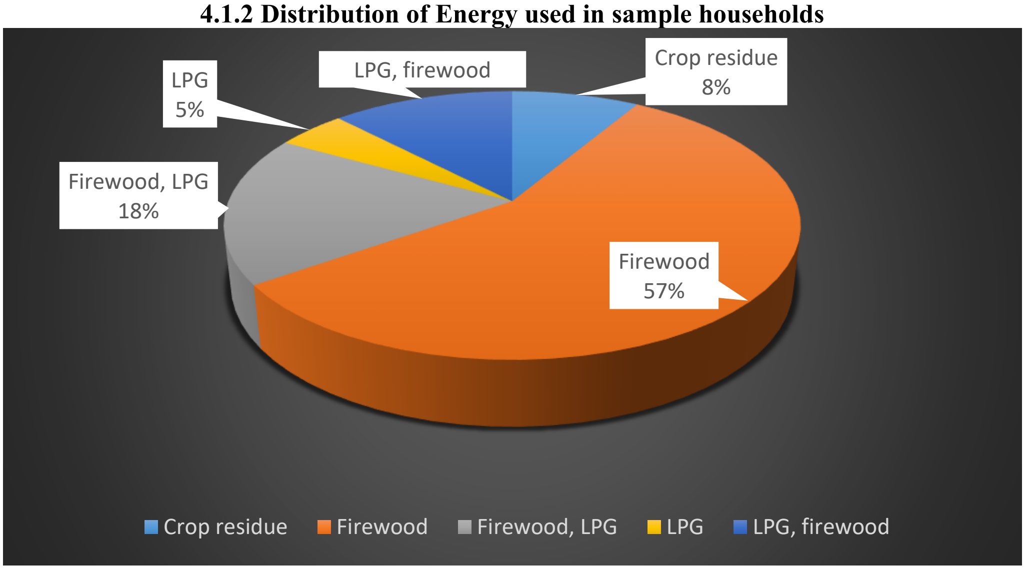
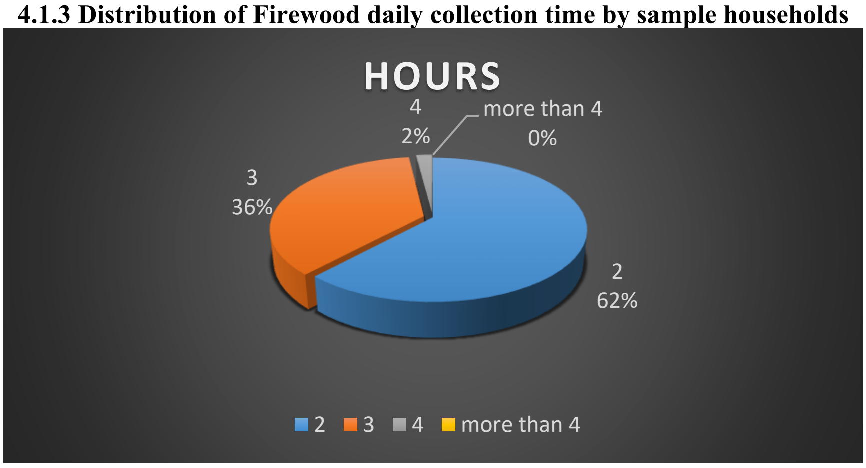
4.1.2 Distribution of Energy used in sample households



Source: Primary Survey

The chart indicates that firewood is the primary fuel source for most households, with 56.7% (340 households) using it, and an additional 30.2% combining it with LPG. LPG is less common as a standalone fuel, but is used alongside firewood by 12.2% (73 households). Crop residue was the least used fuel, with only 8.5% (51 households) relying on it. These patterns suggest that firewood is preferred because of its accessibility, affordability, and cultural factors, with LPG acting as a secondary fuel source. Overall, firewood was the dominant fuel in households.

4.1.3 Distribution of Firewood daily collection time by sample households



The chart presents the daily firewood collection time for the sample households, showing the frequency and percentage distribution across different time intervals. Most households (61.5%) spent two hours collecting firewood daily, whereas 36.2% spent three hours. Only 2% of households spend four hours on this task, with none exceeding four hours. This indicates that firewood collection is a significant but time-efficient activity, with most households completing it within 2 hours.

4.1.4 Distribution of Daily time spent in the kitchen

Sr No	Hours	Frequency	In per cent
1	0-2	68	11.3
2	2-3	218	31.8

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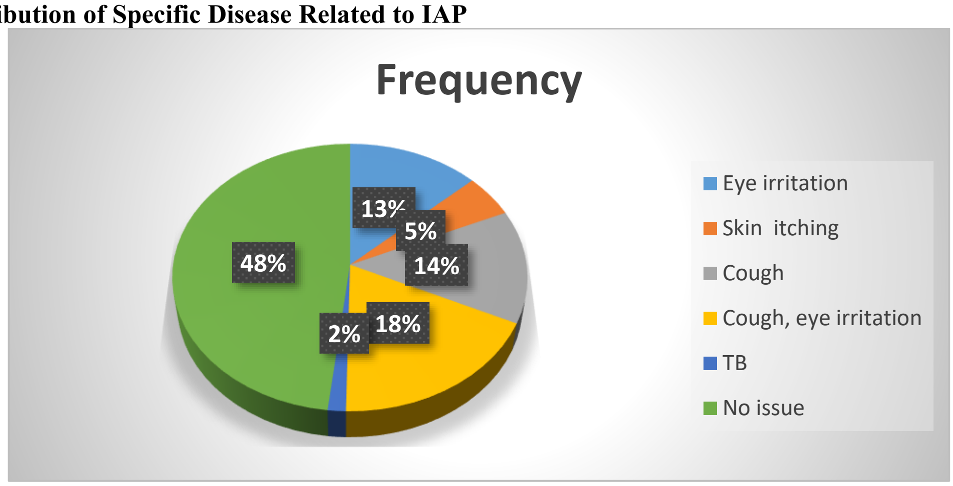
3	3-4	313	52.3
4	4-5	1	0.2
5	More than 5	0	0
Total		600	100

Source: Primary Survey

The table shows the daily time spent in the kitchen by surveyed households, showing the frequency and percentage distribution across various time intervals. Most households (52.3%) spent two to three hours in the kitchen, while 31.8% spent three to four hours. A smaller group (11.3 %) spends 0–2 hours, and only 0.2% spend 4–5 hours. None of the households reported spending more than 5 hours. This suggests that most households have moderate daily kitchen activity, with typical cooking and meal preparation times ranging from two to four hours.

4.1.5 Distribution of Specific Disease Related to IAP



The chart shows the health effects of Indoor Air Pollution (IAP) among the surveyed population. Cough is reported by 13.7%, cough with eye irritation by 18.3%, eye irritation alone by 13.2%, and skin itching by 5.2%. Tuberculosis (TB) is reported by 1.5%, while 48.2% report no IAP-related issues. These findings highlight the range of health impacts, from mild symptoms to more severe conditions like TB, emphasizing the need to address indoor air quality.

4.1.6 Distribution of Major chronic disease related to IAP

Sr No	Disease	Frequency	In per cent
1	Asthma	14	2.3
2	Heart disease	3	0.5
3	Lung issue	7	1.2
4	Pneumonia	14	2.3
5	Stroke	1	0.2
6	No issue	561	93.5
Total		600	100

Source: Primary Survey

The table presents data on major chronic diseases experienced by individuals in the surveyed population over the past year, showing frequency and percentage distribution. Asthma and pneumonia are the most common conditions, affecting 14 individuals each (2.3%). Lung issues are reported by 7 individuals (1.2%), while heart disease and stroke affect 3 individuals (0.5%) and one individual

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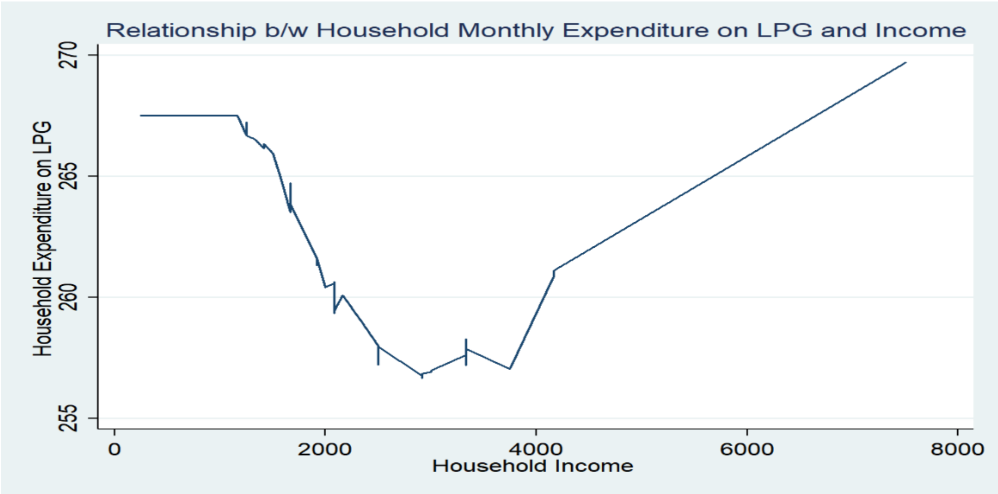
(0.2%), respectively. Most respondents (93.5%, or 561 individuals) report no major chronic diseases in the past year. These findings emphasize the prevalence of respiratory conditions and highlight the need for preventive healthcare and chronic disease management.

4.1.7 Relationship between Household Monthly Expenditure on LPG with Income

We can observe a U-shaped curve. As the household income increases, the LPG expenditure first decreases, bottoms around the monthly Rs. 2500-3000 Income, and then rises sharply again. However, the range of LPG expenditure is only Rs.255-270.

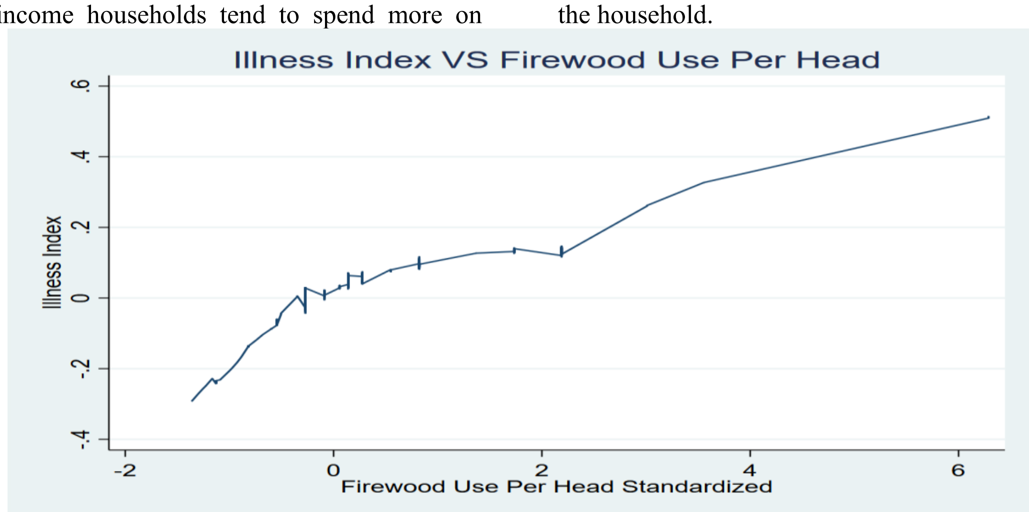


Source: *Primary Survey*

The graph shows the relationship between household monthly expenditure on LPG and household income. Initially, at lower income levels, LPG expenditure remains stable. As household income increases to around 3,000, LPG expenditure decreases. Beyond this point, as income continues to rise, spending on LPG starts to increase significantly. This pattern suggests that lower-income households might be optimizing their expenses or using alternative energy sources, while higher-income households tend to spend more on LPG, possibly due to increased energy consumption and improved living standards.

4.1.8 Firewood Usage VS Illness Index:

Using the family health condition variables from the primary survey, an Illness Index was generated using Principal Component Analysis (PCA). We can observe an upward linear trend indicating traditional fuels may be causing higher instances of respiratory/ IAP medical conditions in the household.



Source: *Primary Survey*

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The graph shows a positive relationship between the Illness Index and standardized Firewood Use Per Head. As firewood use increases, the Illness Index also rises, indicating a potential link between higher firewood consumption and more significant health issues. The relationship starts with a steep increase and then rises more gradually. This suggests that as firewood use exceeds the average, the associated health risks continue to grow, albeit steadily. The graph underscores the potential health impacts of firewood use, suggesting a need for further investigation and possible policy measures to address these risks.

4.1.9 Linear regression: Near to City

Wood per day use In kg	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
LPG connection : b~0	0	.	.	.	.	.	
1	-1.906	.3	-6.36	.008	-2.86	-.953	***
Respondent Age	.01	.007	1.51	.228	-.011	.032	
Occupation : base ~r	0	.	.	.	.	.	
Farmer	.063	.289	0.22	.843	-.858	.983	
Milk Supplier	-.649	.603	-1.08	.361	-2.569	1.271	
Teacher	1.215	.795	1.53	.224	-1.315	3.744	
: base Illiterate	0	.	.	.	.	.	
Primary	.189	.2	0.95	.414	-.447	.825	
Secondary	-.101	.08	-1.27	.294	-.354	.152	
Junior College	-.198	.052	-3.80	.032	-.364	-.032	**
Degree and Above	.294	.205	1.44	.246	-.357	.946	
Family size	.102	.027	3.75	.033	.015	.188	**
: base 0 - 10k	0	.	.	.	.	.	
10K - 20k	-.07	.079	-0.89	.44	-.322	.182	
20k - 30k	.179	.069	2.61	.08	-.04	.397	*
30k -40k	-.154	.428	-0.36	.743	-1.517	1.209	
40k - 50k	.18	.418	0.43	.695	-1.149	1.509	
Wealth index	.155	.036	4.33	.023	.041	.268	**
Livestock index	.147	.047	3.12	.052	-.003	.297	*
Illness index	-.13	.085	-1.53	.223	-.4	.14	
Id proof index	.007	.119	0.06	.956	-.373	.387	
Constant	4.332	.191	22.69	0	3.725	4.94	***

Mean dependent var	4.783	SD dependent var	1.186
R-squared	0.597	Number of obs	300
F-test	.	Prob> F	.
Akaike crit. (AIC)	683.339	Bayesian crit. (BIC)	694.440

**** p<.01, ** p<.05, * p<.1*

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Results shows that several factors significantly influence the dependent variable. There is a negative association with LPG connection (p = 0.008) and Junior College education (p = 0.032). Family size (p = 0.033), income in the 20k-30k range (p = 0.08), wealth index (p = 0.023), and livestock index (p = 0.052) all have positive effects. These results indicate that LPG connection, education level, family size, specific income levels, wealth, and livestock ownership are key determinants.

4.1.10 Linear regression: Interior

Wood per day use In kg	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
LPG connection : b~0	0	.	.	.	.	.	
1	-1.498	.442	-3.39	.043	-2.905	-.091	**
Respondent Age	.004	.002	2.04	.134	-.002	.01	
Occupation : base ~r	0	.	.	.	.	.	
Agri Labor	.663	.172	3.85	.031	.115	1.211	**
Anganwadi	-.155	.235	-0.66	.556	-.904	.593	
Farmer	.494	.215	2.29	.106	-.192	1.179	
: base Illiterate	0	.	.	.	.	.	
Primary	-.044	.052	-0.86	.453	-.208	.12	
Secondary	.057	.091	0.63	.573	-.231	.345	
Junior College	-.172	.148	-1.16	.329	-.644	.299	
Degree and Above	-.069	.334	-0.21	.85	-1.13	.993	
Family size	-.027	.009	-3.16	.051	-.054	0	*
: base 0 - 10k	0	.	.	.	.	.	
10K - 20k	-.154	.092	-1.67	.194	-.448	.14	
20k - 30k	.043	.061	0.71	.527	-.15	.236	
30k -40k	-.125	.092	-1.36	.267	-.417	.167	
40k - 50k	.473	.213	2.22	.113	-.205	1.152	
5o	0	.	.	.	.	.	
Wealth index	.213	.057	3.72	.034	.031	.395	**
Illness index	-.026	.024	-1.07	.363	-.103	.051	
Livestock index	.201	.125	1.61	.205	-.196	.599	
Id proof index	-.113	.113	-1.00	.392	-.474	.248	
Constant	5.187	.409	12.67	.001	3.884	6.489	***

Mean dependent var	4.633	**SD dependent var**	1.018
R-squared	0.698	**Number of obs**	300
F-test	.	**Prob> F**	.
Akaike crit. (AIC)	507.457	**Bayesian crit. (BIC)**	518.568

**** p<.01, ** p<.05, * p<.1*

Key factors significantly influencing the dependent variable include a negative association with LPG connection (p < 0.05), a positive association with agricultural labor occupation (p < 0.05), a marginally significant negative effect of family size (p < 0.10), and a positive association with wealth index (p < 0.05). These results suggest that LPG connection, agricultural labor occupation, family size, and wealth are important determinants.

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4.1.11 Linear Regression Output:

Variable	*Coef*	*St.Err*	*p-value*	*Coef*	*St.Err*	*p-value*
	Near to City			**Interior**		
LPG connection						
1	0.3	0.008	***	0.442	0.043	**
Respondent Age	0.007	0.228		0.002	0.134	
Occupation						
Farmer	0.289	0.843		0.172	0.031	**
Milk Supplier	0.603	0.361		0.235	0.556	
Teacher	0.795	0.224		0.215	0.106	
Education						
Primary	0.2	0.414		0.052	0.453	
Secondary	0.08	0.294		0.091	0.573	
Junior College	0.052	0.032	**	0.148	0.329	
Degree and Above	0.205	0.246		0.334	0.85	
Family size	0.027	0.033	**	0.009	0.051	*
Income						
10K - 20k	0.079	0.44		0.092	0.194	
20k - 30k	0.069	0.08	*	0.061	0.527	
30k - 40k	0.428	0.743		0.092	0.267	
40k - 50k	0.418	0.695		0.213	0.113	
Wealth Index	0.036	0.023	**	0.057	0.034	**
Illness Index	0.085	0.223		0.024	0.363	
Livestock Index	0.047	0.052	*	0.125	0.205	
ID Proof Index	0.119	0.956		0.113	0.392	
Constant	0.191	0.000	***	0.409	0.001	***
Mean dependent var	4.783			4.633		
SD dependent var	1.018					
R-squared	0.597			0.698		
Number of obs	300			300		
Akaike crit. (AIC)	683.339			507.457		
Bayesian crit. (BIC)	518.568					

The results show that people in interior regions are slightly more likely to use LPG (0.442, $p < 0.05$) than those near cities (0.3, $p < 0.01$). Occupation plays a role, with farmers in remote areas more likely to adopt LPG (0.172, $p < 0.05$), while teaching and milk supply jobs don't show significant effects. Education impacts LPG use mainly near cities, where households with someone who completed junior college are more likely to adopt LPG (0.052, $p < 0.05$). Larger families are more likely to use LPG in both areas. Middle-income households (₹20k–30k) in cities are more inclined to adopt LPG (0.069, $p < 0.1$), while wealthier households are more likely to use LPG in both areas (0.036, $p < 0.05$ near cities; 0.057, $p < 0.05$ in remote areas). Livestock ownership slightly influences LPG use near cities (0.047, $p < 0.1$) but not in remote areas. The model explains 59.7% of the variance near the city and 69.8% in interior regions, suggesting it fits better for interior areas. Key factors like household wealth, occupation, education, and family

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size influence LPG adoption, with notable differences between urban and rural areas.

4.2 Overview of Findings

- Education slightly impacts wood use in villages near cities, but does not affect wood consumption in interior areas, suggesting that cultural factors and preferences more influence wood use in these regions.
- The Livestock Index shows that livestock is considered a form of wealth storage, and these households tend to use more traditional fuels like wood, reflecting their economic choices.
- Family size plays a significant role in wood use, with more prominent families in rural interior villages consuming more wood than those in city-adjacent villages, where families tend to be smaller.
- Households with higher per capita wood usage also report a higher incidence of health issues related to indoor air pollution, highlighting the connection between fuel use and respiratory health.
- Tribal households rely heavily on firewood for cooking, with 56.7% using it exclusively. When combined with those using LPG in addition to firewood, 86.8% use firewood, making it the most common fuel source in the region.
- The study shows that all respondents are female, and only 5.5% of households are female-headed, pointing to the male-dominated nature of household decision-making in this area.
- A significant proportion (50.3%) of respondents are aged between 36-59 years, which indicates that middle-aged women are primarily involved in making decisions related to household energy use.
- Most households (92.7%) are nuclear families, and 93.8% of respondents are married, suggesting a dominant family structure in the region.
- The study finds that 56.3% of respondents have no formal education, which limits their access to information and knowledge about alternative energy sources and energy-saving technologies and affects decision-making in household energy use.
- Most respondents (71.5%) are agricultural laborers, signifying that agriculture is the primary livelihood, which may influence energy use practices linked to rural lifestyles.
- A large proportion (75.8%) of households own less than one acre of land, and 23.7% own no land, pointing to their economic vulnerability and limited resources for investing in cleaner energy alternatives.
- Household income data shows that 31.7% of households earn below ₹10,000 monthly, while only 1.8% earn more than ₹51,000. This disparity highlights a significant income disparity that likely impacts access to cleaner energy options.
- Energy access is limited, with 34.8% of households having LPG connections. Households that are nuclear families are more likely to have access to LPG, showing that structural barriers prevent wider access to cleaner cooking fuels.
- Firewood remains the primary fuel for 56.7% of households, while only 12.2% use LPG exclusively. This suggests that firewood remains the most affordable and accessible option for many households.
- The time spent on firewood collection is considerable, with 61.5% of households spending 2 hours daily. This reflects the labour-intensive nature of collecting firewood, which is often time-consuming for rural families.
- Similarly, cooking time is also significant, with 52.3% of households spending 2-3 hours daily cooking. This indicates a high demand for time and labour in preparing meals, mainly using traditional cooking methods.
- Health issues related to indoor air pollution are widespread, with 13.7% of respondents reporting respiratory issues like coughing, while 48.2% of respondents report no health problems related to air pollution.
- Chronic diseases like asthma and pneumonia affect 2.3% of respondents, suggesting a potential link between prolonged exposure to indoor air pollution and respiratory conditions.
- A strong association is observed between firewood use and health conditions, with higher firewood consumption correlating with increased health problems due to indoor air pollution, underlining the health risks of relying on traditional fuels.
- LPG expenditures are influenced by household income. Lower-income households have more stable LPG costs, while higher-income households tend to see an increase due to greater usage.
- Statistical analysis reveals a negative correlation between LPG adoption and education level ($p = 0.032$) and family size ($p = 0.033$), meaning households with lower education levels and larger family sizes are less likely to adopt LPG.
- Households earning between ₹20,000 and ₹30,000, those with a higher wealth index, and those owning livestock are more likely to adopt LPG, suggesting that financial stability and access to resources play a key role in cleaner energy adoption.
- Households in interior regions are more likely to use LPG (0.442, $p < 0.05$) than those near cities (0.3, $p < 0.01$), indicating that rural interventions may support the adoption of cleaner cooking technologies.
- The final model explains 59.7% of the variance in LPG adoption in areas near cities and 69.8% in

interior regions, suggesting that geographic factors significantly influence energy adoption trends.

- Fewer households use LPG in isolation, with only 4.7% using it as their sole cooking fuel. However, 34.8% of households use LPG in combination with firewood, indicating that LPG is primarily used as a secondary fuel source in many households.
- Women, as the main household managers responsible for tasks like cooking, are particularly affected by indoor air pollution. They spend 3 to 5 hours daily in the kitchen, where they are exposed to harmful pollutants emitted from cooking fuels like firewood and the smoke generated by high temperatures.

V. Discussion

The findings highlight the critical role of socio-economic factors in shaping household energy choices in tribal regions. The low rate of female-headed households (5.5%) aligns with existing literature indicating male dominance in decision-making within rural India (Agarwal, 1997). The predominance of nuclear families (92.7%) suggests a shift from traditional joint family structures, which may influence economic stability and energy access (Desai & Dubey, 2011). Education remains a key barrier, as 56.3% of respondents have no formal education. Studies show that education significantly impacts energy transition, with higher educational attainment linked to increased LPG adoption (Pachauri et al., 2013).The economic vulnerability of respondents, reflected in low land ownership (75.8% owning less than one acre) and low incomes (31.7% earning below ₹10,000), is a significant determinant of energy choices. Prior research indicates that households with limited financial resources rely on biomass fuels due to cost constraints (Van der Kroon et al., 2013). This explains the dominant use of firewood (56.7%) and its combination with LPG (30.2%). Similar findings in India highlight that economic hardship leads to fuel stacking rather than complete transition to clean energy (Heltberg, 2004).Time allocation data show that firewood collection remains labour-intensive, with 61.5% of households spending at least 2 hours daily. This aligns with research by (Dutta, 2005), which found that women in rural India spend significant time collecting biomass, limiting education and income generation opportunities. Cooking duration (2-4 hours for most households) suggests a reliance on traditional stoves, which require more time for fuel preparation and cooking.

The health impact of indoor air pollution is evident, as respiratory illnesses such as cough (13.7%), eye irritation (13.2%), and TB (1.5%) are reported. Numerous studies confirm that traditional biomass fuels contribute to respiratory diseases, particularly among women and children (Smith et al., 2011). The upward trend in the Illness Index with increased firewood consumption supports findings from (Bruce et al. 2000), emphasizing the direct link between biomass use and poor respiratory health.Economic and demographic factors significantly influence LPG adoption. The negative correlation between LPG connection and education ($p = 0.032$) is consistent with findings that educated households are more likely to transition to clean energy (Jain et al., 2021). Similarly, wealthier households show higher LPG adoption rates, corroborating research indicating that affordability is a key determinant (Masera et al., 2000). The findings reinforce existing literature on the economic, social, and health-related constraints influencing clean energy adoption. Policy interventions should focus on increasing financial support, education, and accessibility to LPG to improve energy transitions in tribal communities.

VI. Conclusion

The study shows various factors affect energy use and health in tribal households. Education has a negligible effect on wood usage in villages near the city, but cultural habits are the main reason for using wood in rural areas. Families with livestock tend to use more wood, as it is part of their traditional way of storing wealth. Larger families use more wood, and households that rely heavily on wood tend to experience more health problems, such as cough and eye irritation, due to indoor air pollution. Most tribal households rely on firewood, with over half using it as their only fuel. Although some also use LPG, it's mostly a secondary fuel because many families can't afford it. Housing conditions are often essential, with most homes lacking separate kitchens, and people spend a lot of time cooking and collecting firewood daily. This leads to prolonged exposure to smoke, especially for women who spend more time in the kitchen. Health problems linked to indoor air pollution, like cough, eye irritation, and fever, are common. However, chronic diseases are relatively rare. Many people seek medical help for these issues, but the treatment can be costly. Finally, the study shows that the way tribal households use energy is closely tied to their income and job status, with wealthier households more likely to use cleaner fuels. Overall, the findings highlight the need for better, more affordable energy options for tribal communities and the importance of addressing indoor air pollution to improve health and well-being.

References

[1]. Agarwal, B. (1997). "Bargaining"and gender relations: Within and beyond the household. *Feminist economics*, *3*(1), 1-51.

[2]. Agrawal, S. (2012). Effect of indoor air pollution from biomass and solid fuel combustion on prevalence of self-reported asthma among adult men and women in India: findings from a nationwide large-scale cross-sectional survey. *Journal of Asthma*, *49*(4), 355-365.

[3]. Balakrishnan, K., Dey, S., Gupta, T., Dhaliwal, R. S., Brauer, M., Cohen, A. J., ... &Dandona, L. (2019). The impact of air pollution on deaths, disease burden, and life expectancy across the states of India: The Global Burden of Disease Study 2017. *The Lancet Planetary Health*, *3*(1), e26-e39.

[4]. Barron, M., & Torero, M. (2017). Household electrification and indoor air pollution. *Journal of Environmental Economics and Management*, *86*, 81-92.

[5]. Bruce, N., Perez-Padilla, R., &Albalak, R. (2000). Indoor air pollution in developing countries: a major environmental and public health challenge. *Bulletin of the World Health Organization*, *78*(9), 1078-1092.

[6]. Chakraborty, D., &Mondal, N. K. (2018). Hypertensive and toxicological health risk among women exposed to biomass smoke: A rural Indian scenario. *Ecotoxicology and environmental safety*, *161*, 706-714.

[7]. Chakraborty, D., &Mondal, N. K. (2018). Hypertensive and toxicological health risk among women exposed to biomass smoke: A rural Indian scenario. *Ecotoxicology and environmental safety*, *161*, 706-714.

[8]. Chakraborty, D., &Mondal, N. K. (2021). Reduction in household air pollution and associated health risk: a pilot study with an improved cookstove in rural households. *Clean Technologies and Environmental Policy*, *23*(7), 1993-2009.

[9]. Choudhuri, P., & Desai, S. (2021). Lack of access to clean fuel and piped water and children's educational outcomes in rural India. *World Development*, *145*, 105535.

[10]. Chowdhury, S., Pozzer, A., Haines, A., Klingmueller, K., Münzel, T., Paasonen, P., ... &Lelieveld, J. (2022). Global health burden of ambient PM2. 5 and the contribution of anthropogenic black carbon and organic aerosols. *Environment International*, *159*, 107020.

[11]. Couture, S., Garcia, S., & Reynaud, A. (2012). Household energy choices and fuelwood consumption: An econometric approach using French data. *Energy Economics*, *34*(6), 1972-1981.

[12]. Danlami, A. H. (2017). An intensity of household kerosene use in Bauchi state, Nigeria: A tobit analysis. *Nigerian Journal of Management Technology & Development*, *8*(2), 1.

[13]. Duflo, E., Greenstone, M., & Hanna, R. (2008). Indoor air pollution, health and economic well-being. *SAPI EN. S. Surveys and Perspectives Integrating Environment and Society*, (1.1).

[14]. Dutta, S. (2022). Risk factors for child survival among tribal dominated states in India: a pooled cross-sectional analysis. *Journal of Population Research*, *39*(3), 391-416.

[15]. Franklin, P. J. (2007). Indoor air quality and respiratory health of children. *Paediatric respiratory reviews*, *8*(4), 281-286.

[16]. Hansel, N. N., Breysse, P. N., McCormack, M. C., Matsui, E. C., Curtin-Brosnan, J., Williams, D. A. L., ... &Diette, G. B. (2008). A longitudinal study of indoor nitrogen dioxide levels and respiratory symptoms in inner-city children with asthma. *Environmental health perspectives*, *116*(10), 1428-1432.

[17]. Heltberg, R. (2004). Fuel switching: evidence from eight developing countries. *Energy economics*, *26*(5), 869-887.

[18]. Hu, C. Y., Fang, Y., Li, F. L., Dong, B., Hua, X. G., Jiang, W., ... & Zhang, X. J. (2019). Association between ambient air pollution and Parkinson's disease: Systematic review and meta-analysis. *Environmental Research*, *168*, 448-459.

[19]. Jain, T. K., & Jain, N. (2021). Service quality in the energy sector and its impact on sustainability. In *Affordable and Clean Energy* (pp. 1156-1164). Cham: Springer International Publishing.

[20]. Maji, S., Ahmed, S., Siddiqui, W. A., & Ghosh, S. (2017). Short-term effects of criteria air pollutants on daily mortality in Delhi, India. *Atmospheric Environment*, *150*, 210-219.

[21]. Masera, O. R., Saatkamp, B. D., &Kammen, D. M. (2000). From linear fuel switching to multiple cooking strategies: a critique and alternative to the energy ladder model. *World Development*, *28*(12), 2083-2103.

[22]. Mensah, J. T., &Adu, G. (2015). An empirical analysis of household energy choice in Ghana. *Renewable and Sustainable Energy Reviews*, *51*, 1402-1411.
[23]. Mukkannawar, U., Kumar, R., &Ojha, A. (2014). Indoor air quality in rural residential Area-Pune case study. *Int J CurrMicrobiol App Sci*, *3*(11), 683-694.
[24]. Munro, P., Van Der Horst, G., & Healy, S. (2017). Energy justice for all? Rethinking sustainable development goal 7 through struggles over traditional energy practices in Sierra Leone. *Energy Policy*, *105*, 635-641.
[25]. National Family Health Survey (NFHS-5, 2021)
[26]. Oluwole, O., Arinola, G. O., Huo, D., &Olopade, C. O. (2017). Household biomass fuel use, asthma symptoms severity, and asthma underdiagnosis in rural schoolchildren in Nigeria: a cross-sectional observational study. *BMC pulmonary medicine*, *17*, 1-8.
[27]. Ozcan, B. (2013). The nexus between carbon emissions, energy consumption and economic growth in Middle East countries: a panel data analysis. *Energy policy*, *62*, 1138-1147.
[28]. Pachauri, S., van Ruijven, B. J., Nagai, Y., Riahi, K., van Vuuren, D. P., Brew-Hammond, A., &Nakicenovic, N. (2013). Pathways to achieve universal household access to modern energy by 2030. *Environmental Research Letters*, *8*(2), 024015.
[29]. Pauwels, R. A., Buist, A. S., Calverley, P. M., Jenkins, C. R., & Hurd, S. S. (2001). Global strategy for diagnosing, managing, and preventing chronic obstructive pulmonary disease: NHLBI/WHO Global Initiative for Chronic Obstructive Lung Disease (GOLD) Workshop summary. *American journal of respiratory and critical care medicine*, *163*(5), 1256-1276.
[30]. Ramírez-Venegas, A., Velázquez-Uncal, M., Aranda-Chávez, A., Guzmán-Bouilloud, N. E., Mayar-Maya, M. E., Pérez Lara-Albisua, J. L., ... &Sansores, R. H. (2019). Bronchodilators for hyperinflation in COPD associated with biomass smoke: clinical trial. *International journal of chronic obstructive pulmonary disease*, 1753-1762.
[31]. Roser, M. (2021). Data review: how many people die from air pollution? *Our world in data*.
[32]. Sehgal, M., Rizwan, S. A., & Krishnan, A. (2014). Disease burden due to biomass cooking-fuel-related household air pollution among women in India. *Global health action*, *7*(1), 25326.
[33]. Sharma, R. (2015). Indoor air pollution in India and health hazards. *International Journal of research granthaalayah*, *3*(9), 1-3.
[34]. Smith, K. R. (2000). National burden of disease in India from indoor air pollution. *Proceedings of the National Academy of Sciences*, *97*(24), 13286-13293.
[35]. Sousa, S. I. V., Pires, J. C. M., Martins, E. M., Fortes, J. D. N., Alvim-Ferraz, M. C. M., & Martins, F. G. (2012). Short-term effects of air pollution on respiratory morbidity at Rio de Janeiro—Part I: air pollution assessment. *Environment International*, *44*, 18-25.
[36]. Tripathi, A., Sagar, A. D., & Smith, K. R. (2015). Promoting clean and affordable cooking: smarter subsidies for LPG. *Economic and Political Weekly*, 81-84.
[37]. Van der Kroon, B., Brouwer, R., & Van Beukering, P. J. (2013). The energy ladder: Theoretical myth or empirical truth? Results from a meta-analysis. *Renewable and sustainable energy reviews*, *20*, 504-513.
[38]. World Health Organisation Report (2021)
[39]. World Health Organization. (2017). *Beyond the barriers: framing evidence on health system strengthening to improve the health of migrants experiencing poverty and social exclusion*. World Health Organization.