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Household energy transition to clean fuel in rural India: Role of LPG subsidy

N. Brahmanandam[1]

Abstract

The present article seeks to assess the household energy use pattern, per-capita real spending on clean energy and LPG subsidy usage in association with the intersection of different social groups of BPL card holders and social groups with different economic statuses based on data from two rounds of the National Sample Survey of Consumption Expenditure (2011-12 and 2022-23). Results show overall increment in real per-capita spending, and the percentage use of clean fuel is higher among lower- and middle-income social groups and social groups with BPL cards from 2011 to 2022. However, significant social disparities are prevalent in the use of clean energy, and most rural households are more likely to use biomass fuel compared to clean fuel. Results from pooled multivariate logistic regression show that compared to 2011-12, in 2022-23, there is a more likely use of clean energy for cooking, and results from pooled multivariate linear regression show that per-capita spending on clean fuel is higher in 2022-23 compared to 2011- 12. *Furthermore, results from multivariate logistic regression shows that BPL card holding SC, ST and OBC households are more likely to use LPG subsidy compared to 'Others' group without ration card and surprisingly lower- and middle-income SC, ST and OBC households are less likely to receive LPG subsidy compared to 'Other rich' group in 2022-23 after controlling other factors. Overall results suggest that current PMUY subsidy may not be enough for sustained transition to clean fuel.*

Keywords: Household Energy, Clean Fuel, LPG Subsidy.

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I Introduction

The use of solid fuel sources such as coal, firewood, and dung cakes for cooking remains widespread in developing countries, including India, primarily due to their low cost and accessibility. The United Nations Sustainable Development Goal (SDG) 7 emphasizes the importance of ensuring access to affordable, reliable, sustainable, and modern energy for all by 2030, which is crucial for the development of these nations. Despite this, solid fuel continues to be used in more than half of rural households in India (57%) and in a smaller proportion, in urban households (10%), according to the latest National Family Health Survey (NFHS-5) (IIPS, 2021). This widespread use is largely due to the unwillingness and inability of many households to afford cleaner alternatives.

The reliance on solid fuel significantly contributes to indoor air pollution, which has significant socio-economic and health impacts, particularly for women and children, who often spend considerable time indoors. In India, women are primarily responsible for cooking and collecting cooking fuel, including firewood, dung cakes, and water. These duties not only increase the opportunity cost for women in terms of time and energy but also affect household economies and the well-being of children. According to the World Health Organisation (WHO, 2016), the use of solid fuels leads to indoor air pollution, which is responsible for approximately 4.6 million premature deaths annually worldwide.

In India, children under the age of five, who often spend significant time (56%) with their mothers during cooking activities, are especially vulnerable to the adverse effects of indoor air pollution (Gordon et al., 2014). A study by Basu et al. (2020) found a 4.9% higher probability of under-five mortality associated with indoor air pollution due to solid fuel use. Additionally, solid fuel use and indoor air pollution contribute to 3.5% of the total burden of disease in India, with 20% of under-five deaths being attributed to these factors (Bonjour et al., 2013).

Transition in Clean Energy Use in India

The transition to cleaner energy sources has been notably faster in urban India compared to rural areas, with nearly 90% of urban households now using clean fuels. This shift is primarily attributed to increased incomes, government subsidies, and broader efforts to promote clean fuel adoption. In rural India, the proportion of households using clean fuels has risen from just 3% in 1993 to 23% in 2015 and 41% in 2019–2021 (IIPS, 2021). Although the pace of clean fuel adoption has accelerated in rural areas, particularly between 2019 and 2021, this shift remains slower compared to urban areas.

Several factors, including the implementation of flagship programmes such as Pratyaksh Hanstantrit Labh (PAHAL) and the Pradhan Mantri Ujjwala Yojana (PMUY), might have contributed to this increase. These programmes have made clean fuels more accessible through subsidies, targeting lower socio-economic groups, and improving access to LPG (Liquefied Petroleum Gas) in rural areas.

Policy context for Promoting Clean Fuel Use

To mitigate household air pollution and its adverse health effects due to use of solid fuel, various policy interventions have been introduced. These initiatives aim to encourage the adoption of clean fuels, particularly among lower-income households that traditionally rely on fuels like firewood, dung cakes, and coal. A brief review of these programmes, along with studies examining the impact of socio-economic and demographic factors on clean fuel adoption, is presented below.

The PAHAL (Pratyaksh Hanstantrit Labh) scheme, launched in 2015, was designed to identify beneficiaries and ensure the direct transfer of LPG subsidies to bank accounts, thus reducing fraud and leakage. Another key initiative, the Pradhan Mantri Ujjwala Yojana (PMUY), was introduced in 2016 to provide cash assistance (₹1,600) to Below Poverty Line (BPL) women in both rural and urban households. This assistance covers the cost of an LPG connection, including the security deposit, pressure regulator, domestic gas consumer card, and installation charges. As of May 31, 2023, over 112 million LPG connections had been distributed under PMUY (PMUY, 2023). While PMUY has played a significant role in increasing access to clean fuel, recent reviews suggest that it is a necessary but not sufficient condition for a sustained transition to cleaner energy (Gupta, 2006; Sharma & Dash, 2022).

A study assessing the impact of PMUY in Karnataka, based on connection and refill rates, found that PMUY had not led to a significant increase in LPG adoption, as indicated by low refill rates (Kar et al., 2019). Similar findings were reported by Sharma and Dash (2022), suggesting that while PMUY has made LPG more accessible, it has not ensured widespread and sustained usage.

Another study using the ACCESS-2018[2] data assessed the effectiveness of PMUY in reducing disparities in access to clean fuel among different social groups. The findings showed that the percentage of Scheduled Caste (SC) households with access to LPG increased from 7% to 32% between 2015 and 2018, and for Scheduled Tribe (ST) households, it rose from 6% to 21%. However, the increase was even more substantial for general category households, rising from 23% to 49% between 2015 and 2018. This suggests that while PMUY has improved access to clean fuel for marginalised groups, it has not sufficiently reduced disparities in fuel access (Patnaik & Jha, 2020).

Socio-economic and Demographic differences in Clean Fuel Use

A study by Gill-Wiehl et al. (2022) found that households classified as Below Poverty Line (BPL) were 40–45% more likely to adopt LPG compared to non-BPL households. However, the study also concluded that the magnitude of change for non-BPL households was not significant, suggesting that the Pradhan Mantri Ujjwala Yojana (PMUY) alone is not sufficient for achieving a complete transition to clean fuel across all socio-economic groups.

In addition to programme and policy interventions, various socioeconomic and demographic factors—such as education, income, and household composition—play a crucial role in the adoption of clean fuels. The 'Energy Ladder Hypothesis' posits that income is the most significant factor influencing the transition from traditional fuels, such as firewood and dung cakes, to cleaner energy sources like LPG and electricity for cooking (Barnes & Floor, 1999; Hosier & Dowd, 1987). Income levels are often closely linked to education, which can further drive the adoption of clean energy due to the increased opportunity cost of time spent collecting traditional fuel sources (Puzzolo et al., 2016). For example, higher income and educational levels reduce the time spent on tasks like fuel collection, encouraging the switch to cleaner energy alternatives.

In India, a number of studies have analysed the influence of socio-economic and demographic factors on clean fuel adoption using data from sources such as the National Family Health Survey (NFHS), the Indian Human Development Survey (IHDS), and other primary surveys. These studies indicate that smaller household sizes and female-headed households are more likely to adopt clean fuels (Farsi et al., 2007; Gould & Urpelainen, 2018; Gupta & Kohlin, 2006; Rao & Reddy, 2007). Other social

2 The Access to Clean Cooking Energy and Electricity-Survey of States (ACESS) is India's largest multidimensional survey on energy access. The largest panel data on energy access in India, The survey is conducted across the six of major energy access deprived states in the country -Bihar ,Jharkhand, Madhya Pradesh , Odisha ,Uttar Pradesh and West Bengal.

factors, such as caste, also play a role: Scheduled Caste (SC) and Scheduled Tribe (ST) households are less likely to adopt clean fuels compared to General Caste households (Rao & Reddy, 2007; Pandey & Chaubal, 2011; Saxena & Bhattacharya, 2018). The use of traditional fuels has a particularly significant impact on women, who are primarily responsible for collecting, transporting, and processing these fuels. On an average, Indian women spend around 20 hours per week on fuel collection, while Sri Lankan women spend about 10 hours (Bhide & Monroy, 2011). The transition to clean fuels, therefore, reduces the opportunity cost of time spent on fuel collection, freeing up women to pursue economic and social opportunities.

The key determinant of household adoption of clean fuel is the price of the energy source (Farsi et al., 2007). Other important factors include the availability of fuel, the cost of appliances needed to use cleaner fuels, and household incomes. Despite government subsidies, many households continue to rely on biomass energy due to the higher costs associated with LPG (Liquefied Petroleum Gas) and kerosene, including the cost of LPG cylinders and equipment. An important supply-side constraint is supplying security; the absence of a reliable supply of LPG and poor distribution networks often force households to depend on biomass energy (Choudhuri & Desai, 2020).

While many previous studies have assessed the influence of socio-economic and demographic parameters on the adoption of clean fuels using data from the NFHS, IHDS, and other small-scale surveys (Farsi et al., 2007; Gould & Urpelainen, 2018; Gupta & Kohlin, 2006; Rao & Reddy, 2007; Saxena & Bhattacharya, 2018), few have specifically evaluated the impact of policy programs like PMUY on the adoption of clean energy.

This study contrasts with the previous literature in many ways and contributes significantly to the existing literature. Previous studies ignored the trend and expenditure patterns of clean energy and the percentage use of clean energy for cooking by the intersectionality of social groups with different economic statuses and BPL card holders. Hence, understanding the intersectionality of social groups with different economic status and BPL card holders provides an in-depth analysis of the status of clean energy uses and per capita expenditure on clean energy. Furthermore, this study assesses the performance of policy programme in terms of whether household LPG subsidy was received or not for three months preceding the survey date by BPL card household and intersectionality of social groups with different economic status, using the latest large-scale survey of National Sample Survey of Household consumer expenditure 2022-23.

II Data and Methodology

Sample design and study population:

The study data is obtained from two rounds of survey of the National Sample Survey Organisation (NSSO) Household Consumption and Expenditure: 2011-12 and 2022-23. Both surveys are conducted by the Ministry of Statistics and Program Implementation (MOSPI), Government of India. Both surveys adopted a multistage stratified random sampling design to collect the data on household consumption and expenditure. The First Stage Unit (FSU) in a rural area village and in the urban area urban blocks are considered, while the Second Stage Unit (SSU) or ultimate unit households are drawn randomly with simple random sampling without replacement from the first units, namely, the village, and urban blocks. The detailed sampling design is seen in survey methodology and estimation procedure (NSSO-survey methodology and estimation procedure, 2022-23). Both the surveys cover sample information across the states and union territories. The latest round of the survey, 2022-23, collected information from a sample of 8,723 villages and 6,115 urban blocks, from which 155,014 rural and 106,732 urban households were interviewed. The 2011-12 round gathered information from a sample of 7469 villages and 5268 urban blocks, from which 59,695 rural and 41,967 urban households were interviewed. The final sample for this study thus, consisted of 59,695 and 155,014 rural households in 2011-12 and 2022-23 respectively.

Variables

There are three main outcome variables in this study. The first is per-capita expenditure on clean fuel (such as LPG and biogas) during the month preceding the survey. Real per-capita expenditure on clean fuel was estimated after adjusting for inflation using a price deflator with 2011–12 as the base year. The second outcome is the use of clean fuel, as a binary variable: households using electricity, LPG, or biogas are coded as clean fuel 1, while those relying on unclean fuels—including firewood, kerosene, coal, charcoal, and dung cake—are coded as 0. The classification of the two types of fuel followed the World Health Organization definition of clean and unclean fuels. According to WHO definition electricity, LPG, biogas are classified as clean fuels, and kerosene is classified as an unclean fuel (WHO, 2014). The third outcome is whether the household received an LPG subsidy during the three months preceding the survey, measured as a binary variable (1 = received; 0 = not received).

The main predictor variables are based on the intersectionality of social group with economic status and the intersection of social group with BPL card ownership. For

social group–economic status intersections, categories include ST-poor, ST-middle, ST-rich; SC-poor, SC-middle, SC-rich; OBC-poor, OBC-middle, OBC-rich; and Other-poor, Other-middle, Other-rich. For social group–BPL intersections, categories include ST-BPL, SC-BPL, OBC-BPL, and Other-BPL households, compared against households without ration cards. Additional control variables include economic status (poor, middle, rich), household members' education, household type, religion, and region. Economic status was derived from consumption deciles, where the population was ranked by monthly per-capita consumption expenditure and divided into ten equal groups. The bottom three deciles were classified as poor, the middle four as middle, and the top three as rich. A detailed description of the socio-economic variables used in the study is provided in Appendix Table A1.

III Econometric Analysis

The study used cross-tabulation to examine the association between the percentage use of clean fuel for cooking and per capita real expenditure on clean fuel with the intersectionality of social groups with economic status and social groups who are BPL card holders and different socio-economic variables. The focus is on the intersectionality of social groups with Below Poverty Line (BPL) cards and with different economic statuses, allowing us to identify trends and patterns over time (2011-12 to 2022-23). Furthermore, the study used cross tabulation to examine association between the intersectionality of social groups with economic status and social groups who are BPL card holders receiving LPG subsidy. To analyses the change in clean energy from 2011-12 to 2022-23, the pooled multivariate binary logistic regression model has been used. This model assesses the change in clean fuel use from 2011 to 2022 by incorporating a year, with 2011 as the base category and 2022 as the coefficient. In this model, clean energy use is treated as a binary variable: **1** for clean energy use and **0** for unclean fuel use. Additionally, a pooled multivariate linear regression model is employed to evaluate the change in per capita expenditure on clean energy from 2011-12 to 2022-23. This regression assesses the change in per capita expenditure from 2011 to 2022, using the year 2011 as a base year as a dummy variable and 2023 as a coefficient, the per capita expenditure is treated as a continuous variable.

Details of pooled binary multivariate logistic regression are as follows:

$$log\left[\frac{p(y_{it})}{1-p(y_{it})}\right] = a + b_1x_{1it} + b_2x_{2it} + b_3x_{3it} \dots\dots\dots \gamma D2011 - 12. + \epsilon_{it}$$

$log\left[\frac{p(y_{it})}{1-p(y_{it})}\right]$ log of odds event occurring y =1 is clean fuel usage, 0 is otherwise,

where X_{1it} …X_{2it}…X_{3it} are predicator variables (X_{1it} intersectionality social groups with economic status, X_{2it} intersectionality of BPL card holders and X_{3it} other socio-economic variables…. γD is 2011-12-year dummy and γ is cofficient)

b_1+b_2+b_3……are coefficient of predictor variables

if γ > 0 the odds of outcome increase in the year 2022-23 represented by the dummy variable compared to base year 2011-12

if γ < 0 the odds of outcome decrease in the year 2022-23 represent by the dummy variable compared to base year 2011-12

ϵ error term

Both the multivariate binary logistic regression and multivariate linear regression models are applied to the base period (2011-12) and end period (2022-23) to assess the effects of the intersectionality of different social groups who are BPL cardholders and intersectionality of social groups with different economic statuses, on clean energy use and per capita expenditure on clean fuel. Furthermore, the multivariate binary logistic model is applied to assess the effects of the intersectionality of different social groups who are BPL cardholders and intersectionality of social groups with different economic statuses, on LPG subsidy usage in 2022-23.

Table 1: Per-capita expenditure (in INR) by different type of cooking fuel

Monthly per-capita expenditure on different type of energy for cooking						
Source of cooking fuel	**Rural**		**Urban**		**Total**	
	2011-12	**2022-23**	**2011-12**	**2022-23**	**2011-12**	**2022-23**
Electricity (in kwh)	27	42	85	85	42	54
Clean energy						
LPG (in Kg)	12	51	56	81	24	57
Gobar Gas	0	0	0	0	0	0
Total MPCE on clean energy	**12**	**51**	**56**	**81**	**24**	**57**
Unclean energy						
Kerosene	10	1	11	0	10	1
Firewood (in Kg)	50	37	16	5	41	25
Coal	1	0	2	0	1	0
Charcoal	0	0	0	0	0	0
Dung Cake	13	4	3	0	10	3
Total MPCE on unclean energy	**74**	**42**	**32**	**5**	**62**	**29**
Total MPCE on energy for cooking	113	135	173	171	128	140
N	59,695	154,869	41,967	106,444	101,662	261,313

Source: Author's computation from NSSO Household consumption expenditure survey, 2011-12 and 2022-23

Table 2: Percentage distribution of households by different type of cooking fuel use

Type of cooking fuel	**Rural**		**Urban**		**Total**	
	2011-12	**2022-23**	**2011-12**	**2022-23**	**2011-12**	**2022-23**
Gobar Gas	0.2	0.1	0	0	0.1	0.1
Electricity	0.1	0.1	0.4	0.3	0.2	0.1
LPG	15.1	43	67.8	84.8	31.5	56.2
Clean energy	**15.4**	**43.2**	**68.2**	**85.1**	**31.8**	**56.4**
Firewood and Chips	67.2	51.9	14.3	6.5	50.6	37.6
Kerosene	0.8	0	5.7	0.2	2.3	0.1
Dung Cake	9.9	3.5	1.3	0.3	7.2	2.5
Charcoal	0	0	0.1	0	0	0
Others	4.6	0.3	1.2	0.4	3.5	0.3
Coke, Coal	1.1	0.3	2.1	0.5	1.4	0.4
No Cooking Arrangement	1.2	0.7	7.2	4.3	3.1	1.9
Unclean energy	**84.2**	**56.8**	**26.2**	**12**	**65.9**	**42.8**

Source: Author's computation from NSSO Household consumption expenditure survey, 2011-12 and 2022-23

***Per-capita Expenditure on Household Energy and Percentage Usage of Household Energy for Cooking*:**

Table 1 presents the per-capita expenditure on different cooking fuels in rural and urban India. In rural areas, there was a significant decline in real per-capita expenditure on firewood, from 50 rupees to 37 rupees, while expenditure on LPG increased from 12 rupees to 51 rupees between 2011–12 and 2022–23. A similar trend was observed in urban areas, where real per-capita expenditure on LPG rose from 56 rupees to 81 rupees, while spending on firewood declined from 16 rupees to 5 rupees over the same period (2011–12 to 2022–23).

Table 2 illustrates the pattern of percentage usage of different types of cooking fuels in rural and urban areas. The percentage of LPG usage in rural areas increased from 15.1% to 43%, while the usage of firewood and chips declined from 67.2% to 51.9% between 2011–12 and 2022–23. In urban areas, the percentage of LPG usage rose from 68% to 85%, while firewood usage decreased from 14.4% to 6.5% during the same period. This indicates a clear trend towards increased adoption of cleaner cooking fuels such as LPG.

Despite the rise in LPG adoption, firewood use remains predominant in rural areas at 52% as of 2022–23, with widespread usage across rural India. Recent evidence suggests that households using LPG significantly reduce their firewood consumption compared to their non-LPG counterparts. However, solid fuel use persists in all parts of rural India (Gould & Urpelainen, 2020). This reliance on solid fuel places a substantial burden on women, who bear the majority of cooking responsibilities while also collecting firewood, cleaning, and taking care of children (Gould & Urpelainen, 2020).

***Percentage share of total expenditure on clean fuel consumption (LPG) in 2022-23*:**

Table 3 above, presents the percentage share of total Monthly Per Capita Expenditure (MPCE) on LPG across different socio-economic categories of households. The share of MPCE spent on LPG is lower among rural households (2.4%) compared to urban households (2.9%), while the national average stands at 2.6%. Among social groups, Scheduled Tribe (ST) households report the lowest share of MPCE on LPG (1.5%), in contrast to Scheduled Caste (SC) households (2.3%), Other Backward Classes (OBC) (2.5%), and 'Others' (2.7%). When examining the intersection of social groups and economic status, ST households across all economic classes—poor (0.9%), middle (1.7%), and rich (1.9%)—consistently spend a lower share of MPCE on LPG compared to their counterparts from 'Other' social groups.

Table 3: Percentage share of total expenditure on clean fuel consumption (LPG) by socio-economic characteristics of households in 2022-23

Background Characteristics	MPCE	PCE_LPG	Percentage share of MPCE on LPG
Place of Residence			
Rural	3761	91	2.4
Urban	6450	186	2.9
Total	4523	118	2.6
Social Groups			
Scheduled Tribes	3015	45	1.5
Scheduled Castes	3473	79	2.3
Other Backward Caste	3836	96	2.5
Others	4361	118	2.7
Economic status			
Bottom	2047	40	2.0
Middle	3300	84	2.6
Top	6097	150	2.5
Social groups with Economic status			
Poor & ST	1898	18	0.9
Poor & SC	2057	37	1.8
Poor & OBC	2085	48	2.3
Other & poor	2138	57	2.7
Middle & ST	3249	54	1.7
SC & Middle	3271	76	2.3
Middle & OBC	3309	89	2.7
Middle & Other	3339	98	2.9
Rich & ST	5779	107	1.9
Rich & SC	5767	144	2.5
Rich & OBC	6042	148	2.4
Rich & Other	6491	168	2.6
Social groups with BPL card holders			
ST & BPL	2876	43	1.5
SC & BPL	3388	76	2.3
OBC & BPL	3656	90	2.5
Other & BPL	4024	109	2.7
Other-no-ration-card	4208	104	2.5

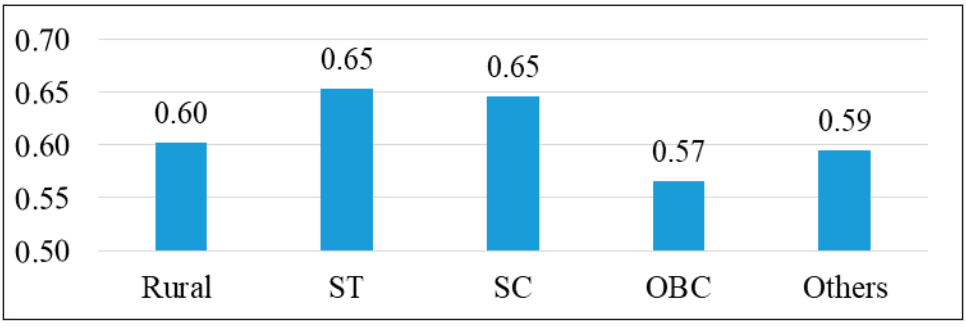
Source: Author's computation from NSSO Household Consumption Expenditure Survey, 2022-23, MPCE stands for Monthly Per-capita Expenditure, PCE_LPG stands for Per-capita expenditure on Liquified Petroliam Gas

Similarly, poor SC households allocate a lower share (1.8%) compared to poor households from the 'Other' group (2.7%), which are relatively better positioned socially despite being economically disadvantaged. Among BPL cardholder households, ST-BPL households exhibit the lowest expenditure share on LPG (1.5%), compared to SC, OBC, and Other BPL households. This significantly lower expenditure among ST-BPL households highlights potential barriers beyond subsidy eligibility, such as issues related to availability, accessibility, and infrastructural limitations, which may be impeding the effective use of LPG.

Elasticity coefficient with respect to monthly per-capita expenditure

Figure 1 presents the elasticity coefficient of monthly per capita expenditure on LPG by social groups in rural India. The income elasticity of demand for LPG in rural India is 0.60, indicating inelastic demand. This implies that a one percent increase in household income leads to an approximate 0.60 percent increase in LPG consumption. Since the increase in demand is proportionally smaller than the increase in income, LPG may be classified as a necessity good for rural households. Among social groups, ST and SC households exhibit relatively higher income elasticity of demand for LPG compared to the rural average. This suggests that as their income rises, their LPG consumption responds more strongly, reflecting a faster increase in usage relative to other groups. In contrast, OBC households show the lowest elasticity, indicating that their demand for LPG is less responsive to income growth. For these households, additional income leads to only a modest increase in LPG expenditure. The elasticity of demand among households classified as 'Other' social groups is similar to the rural average.

Figure 1: Elasticity coefficient with respect to monthly per-capita expenditure by Social Group and Rural India in 2022-23



Source: Author's computation from NSSO Household Consumption Expenditure Survey, 2022-23

Usage and Per-capita Expenditure on Clean Energy by Different Socio-economic Variables

Table 4 shows the per-capita real expenditure on clean energy and the percentage use of clean fuel by various socio-economic categories of households in India from 2011-12 to 2022-23. Both per-capita expenditure on clean energy and the percentage usage of clean fuel have increased across all socio-economic groups during this period. Real per-capita spending on clean energy ranged from 25 rupees for Scheduled Tribes (ST) to 66 rupees for 'Other castes' in 2022-23. However, the increase in real per-capita spending on clean energy was higher among SCs (from 6 to 44 rupees), Other Backward Classes (OBCs) (from 10 to 54 rupees), and Scheduled Tribes (STs) (from 4 to 25 rupees) compared to other groups (from 17 to 66 rupees) between 2011-12 and 2022-23. The most notable increment in spending on clean energy was observed among SCs.

A similar pattern is observed in the percentage usage of clean energy among caste groups. The highest improvement in clean energy usage occurred among SCs, with usage rising from 8.3% to 35.4% between 2011-12 and 2022-23. A similar increase was seen in STs (from 6% to 22%) and OBCs (from 15% to 45.4%). Overall, clean energy usage increased from 14% to 42 % of households over the last decade (2011-12 to 2022-23). Despite these improvements, significant caste disparities persist, with lower caste groups such as SCs (35%) and STs (22%) having significantly lower usage rates compared to other castes (53%). These disparities are deeply rooted in caste identity and household economic status, as income distribution among caste groups reveals that SCs and STs earn significantly lesser than the national average. Data from 1961 to 2012 show that earnings of SCs and STs are 21% and 34% lower, respectively, compared to the national average (Bharti, 2018).

In terms of religion, Christians tend to have higher real per-capita expenditure on clean energy compared to other religious groups, and this is reflected in the higher percentage of clean energy usage within this group. Additionally, real per-capita spending and the percentage use of clean energy are positively associated with increasing education levels. In 2022-23, highly educated households spent 37 rupees on clean energy, while illiterate households spent only 8 rupees. Similarly, the percentage use of clean fuel was 33% among illiterate households, compared to 59% among those with higher levels of education. Although illiterate households have a larger percentage of solid fuel usage, they also saw the highest increase in both spending and clean fuel usage between 2011-12 and 2022-23.

Economic status is also positively correlated with the usage of clean fuel and real per-capita spending on clean fuel. In 2022-23, poor households spent 22 rupees on clean fuel, while wealthier households spent 84 rupees. The percentage usage of clean fuel was 21% among poor households and 64% among rich households. This highlights significant economic disparities in clean fuel adoption and expenditure. The rural poor, in particular, face significant barriers to adopting clean fuels due to high installation costs and LPG cylinder expenses.

Furthermore, there are notable differences in the percentage use of clean energy and real per-capita spending on clean energy based on employment status. Regular wage/salary earners had a usage rate of 55% and a real per-capita spending of 67 rupees in 2022, whereas casual labourers in non-agriculture sectors had the lowest usage (30%) and the lowest per-capita spending (40 rupees) during the same period.

Regional disparities are also evident in clean energy usage. The Southern (80%) and Western (61%) regions have higher usage of clean fuel compared to other regions. In contrast, the Central (32%) and Eastern (21%) regions have the lowest usage of clean energy in 2022-23. A similar pattern is seen in per-capita spending. However, the greatest increase in clean energy usage was observed in the Central (6% to 32%) and Eastern regions (5% to 21%) between 2011-12 and 2022-23. These regions also have the highest percentage of households covered by the Pradhan Mantri Ujjwala Yojana (PMUY) (Controller and Auditor General of India, 2019). A similar trend was seen in per-capita spending in these regions. The Central and Eastern regions, with 4 to 39 rupees and 4 to 58 rupees respectively, experienced significant increases in spending from 2011-12 to 2022-23. Despite this, these regions are still more dependent on solid fuel. Geographic heterogeneity plays a crucial role in LPG adoption, particularly in the Central region. Evidence suggests that states like Jharkhand and Madhya Pradesh report the high cost of LPG cylinder as a reason for non-adoption (Gould & Urpelainen, 2020). Additionally, states in the Eastern (Bihar, Jharkhand) and Central (Madhya Pradesh, Chhattisgarh) regions use more solid fuel compared to other regions. These states also have the lowest socio-demographic indices and the highest burden of disease from household air pollution (Balakrishnan et al., 2019).

Table 4: Usage and Per-capita expenditure on clean energy by household background characteristics

Background Characteristics	2011-12	2022-23	2011-12	2022-23
	Per-Capita Expenditure on clean energy (LPG & Biogas)		Use of clean fuel (%) (LPG, Bio-gas, Electricity, Gober gas, Other natural gas)	
Social Group				
Scheduled Tribes	4	25	5.5	21.7
Scheduled Castes	6	44	8.3	35.4
Other Backward Caste	10	54	14.7	45.4
Others	17	66	22.7	53.2
Religion				
Hindu	9	50	14.0	41.3
Islam	8	47	11.4	37.8
Christian	20	58	25.4	48.4
Other	27	85	25.7	70.1
Education of Household Members				
Illiterate	6	41	7.8	33.4
Primary	8	46	11.6	38.5
Middle	12	50	16.3	39.6
Secondary	18	60	24.8	50.6
Higher	26	70	37.0	58.8
Economic Status				
Poor	1	22	1.6	20.8
Middle	6	47	9.2	40.9
Rich	27	84	33.4	64.1
Household Type				
Self-Employed in Agriculture	8	46	10.8	40.6
Self-Employed Non-Agriculture	15	64	23.0	54.3
Regular Wage/Salary Earning	28	67	40.2	55.2
Casual Labour in Agriculture	3	38	4.7	32.1
Casual Labour Non-Agriculture	5	40	7.7	29.9
Others	20	75	22.3	49.1
Regions				
North	17	60	17.9	41.6
Central	4	39	5.5	31.6
East	4	35	5.0	21.0
Northeast	14	45	18.7	38.6
West	15	60	22.7	60.5
South	19	83	29.6	79.6
Total	12	51	14.2	41.8

Source: Author's computation from NSSO Household Consumption Expenditure Survey, 2011-12 and 2022-23

Percent usage and Per-capita expenditure on Clean Fuel by the Intersectionality of Social and Economic Groups:

Table 5 presents the per-capita expenditure on clean fuel and the percentage use of clean fuel by the intersectionality of social and economic groups in rural areas for the periods 2011–12 and 2022–23. In 2022–23, the highest real per-capita spending on clean fuel (61 rupees) and the highest percentage use of clean fuel (52%) were observed among the "Others" group with Below Poverty Line (BPL) card and others without BPL card households (58 rupees vs 47%) compared to other social groups with a BPL card. Between 2011–12 and 2022–23, the highest increase in real per-capita spending was observed among households having BPL card such as Scheduled Tribes (ST)(2 rupees to 24 rupees), Scheduled Castes (SC) (4 rupees to 43) and Other Backward Classes (OBC) (8 to 50 rupees), compared to "Others" without a BPL card(9 to 58 rupees). A similar trend was seen in the increase of the percentage use of clean fuel between 2011 and 2022 among social groups with BPL cards, such as Scheduled Tribes (ST) (from 3% to 21%), SC (from 7% to 36%), and OBC (from 13% to 45%), compared to "Others" without a ration card (from 13% to 47%).

The higher increment in both the percentage usage of clean fuel and real per-capita spending among BPL card household of social groups, compared to "Others" without a ration card, may be attributed to the Pradhan Mantri Ujjwala Yojana (PMUY). Despite these increases, social disparities persist. The "Others" group without ration cards continued to have a higher percentage of clean fuel usage (47%) and higher spending (58 rupees) compared to SC (36%) and ST (21%) BPL card households in 2022–23. Similarly, "Others" with BPL cards exhibited the highest percentage usage (52%), further highlighting the disparities between different social groups.

Significant disparities exist among social groups with different economic statuses in both the percentage usage of clean fuel and real per-capita spending on clean fuel. In 2022–23, the percentage usage of clean fuel was notably lower among poor households, such as Scheduled Castes (SC) [17%], Scheduled Tribes (ST) [9%], and Other Backward Classes (OBC) [26%], compared to wealthier households, including "Others" (71%), OBC (64%), SC (60%), and ST (49%). Similarly, middle-income households among SC (35%), ST (27%), and OBC (44%) had lower clean fuel usage compared to rich households, such as "Others" (71%), SC (60%), ST (49%), and OBC (64%) in 2022–23.

The increment in the percentage use of clean fuel was slightly higher among lower-income households. For instance, clean fuel usage among poor SC households increased from 0.8% to 17%, poor ST households from 0.7% to 8%, and poor OBC households from 2% to 26% during 2011–12 to 2022–23. Similarly, middle-income households, such as SC (7% to 35%), ST (4% to 27%), and OBC (10% to 44%), experienced higher increases in the percentage use of clean fuel compared to higher-income households, including "Others" (40% to 71%), OBC (33% to 64%), and SC (24% to 60%). There is a higher increment in clean fuel usage and real per-capita spending among lower-income households, such as SC, ST, and OBC. However, compared to wealthier households their use of clean fuel and expenditure on real per-capita spending on clean fuel is significantly lesser.

Table 5: Per capita expenditure on clean fuel and percent use of clean fuel by intersectionality of social and economic groups in rural areas

Background Characteristics	20011-12	2022-23	20011-12	2022-23
	Per Capita Expenditure clean fuel (Rupees)		Use of clean fuel (%)	
Social groups with BPL Card				
ST & BPL	2	24	3.1	21.2
SC & BPL	4	43	6.5	35.7
OBC & BPL	8	50	12.7	45.3
Other & BPL	10	61	15.7	51.6
Other-No-Ration-Card	9	58	13.0	47.0
Social Group with Economic Status				
Poor & ST	0.3	10	0.7	8.6
Poor & SC	0.5	21	0.8	17.4
Poor & OBC	1.1	27	2.0	26.1
Other & Poor	2.0	32	2.9	29.4
Middle & ST	3.0	30	4.0	27.2
Middle & SC	4.0	42	6.5	35.4
Middle & OBC	6.0	50	9.6	44.0
Middle & Other	9.0	55	13.3	47.0
Rich & ST	19.0	60	22.9	48.9
Rich & SC	21.0	80	24.0	60.1
Rich & OBC	26.0	82	33.2	63.7
Rich & Other	34.0	94	40.0	71.2
Total	12.0	51	14.2	41.8

Source: Author's computation from NSSO Household Consumption Expenditure Survey, 2011-12 and 2022-23

The distribution of household expenditure on different energy sources for cooking in India:

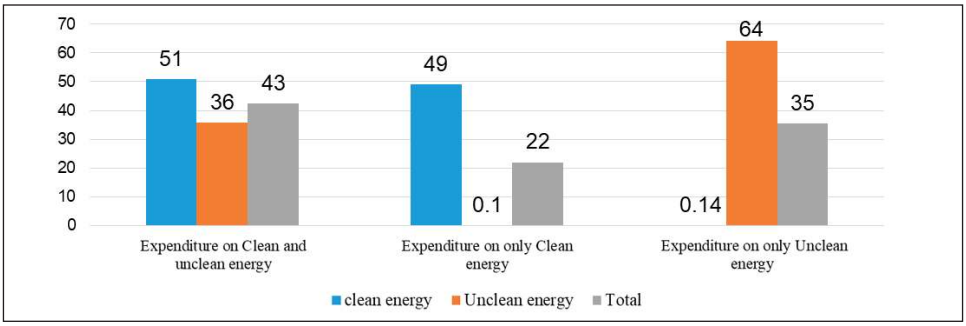
Table 6 and **Figure 2** present the distribution of household expenditure on different cooking energy sources in India for 2022–23. Among households whose primary source of energy is clean fuel, 51% reported expenditure on both clean and unclean fuels, 49% reported spending on only clean fuels, and 0.14% reported expenditure on only unclean fuels. In contrast, households primarily dependent on unclean fuels allocated 36% of their expenditure to both clean and unclean fuels, 0.1% to only clean fuels, and 64% to only unclean fuels. Overall, across all households, 43% of expenditure is reported on both clean and unclean fuels, 22% on only clean fuels, and 35% on only unclean fuels. Other evidence shows that despite having LPG connections, more than half of the households in rural India from lower- and middle-income social groups continue to use biomass fuels (Mani et al., 2021). Biomass fuels, such as firewood, often benefit non-cooking tasks (e.g., heating living spaces during colder months), which clean burning fuels cannot replicate as efficiently or safely, and they are often available for free (Gould et al., 2022)

Table 6: Distribution of household expenditure on different energy sources for cooking in India 2022-23

Primary source of Energy for cooking	Expenditure on Clean and unclean energy	Expenditure on only Clean energy	Expenditure on only Unclean energy	Total
HH using Clean energy	51	49	0.14	100
HH using Unclean energy	36	0.1	64	100
Total	43	22	35	100

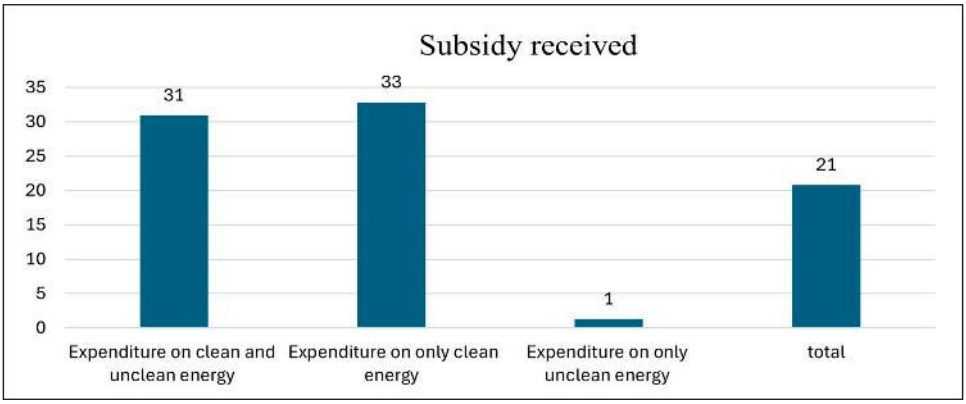
Author's computation from NSSO Household Consumption Expenditure Survey, 2022-23

Figure 2: Household expenditure on different energy source for cooking in India 2022-23



Author's computation from NSSO Household Consumption Expenditure Survey, 2022-23

Figure 3: Percentage of LPG subsidy received by households according to expenditure pattern on household energy use for cooking



Author's computation from NSSO Household Consumption Expenditure Survey, 2022-23

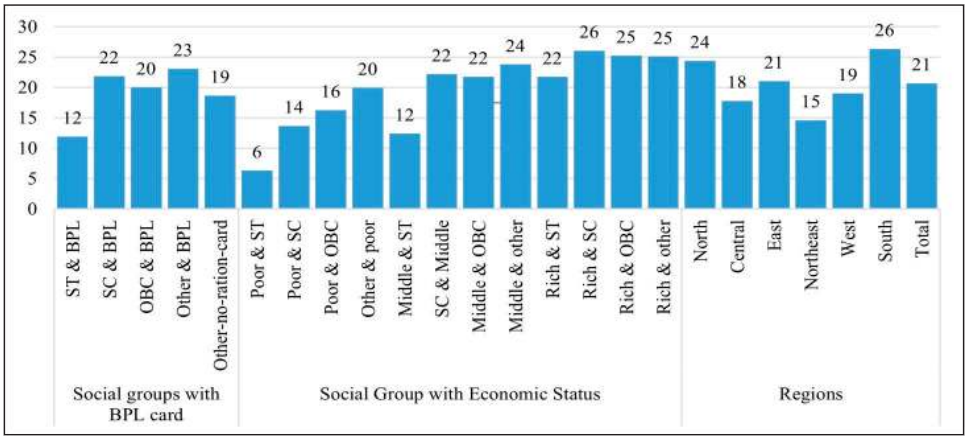
Figure 3 above illustrates the percentage share of households receiving LPG subsidies in India, classified by expenditure patterns on cooking energy. Among households that spend on both clean and unclean fuels, 31% reported receiving an LPG subsidy. For households spending exclusively on clean energy, the proportion was slightly higher at 33%, whereas only 1% of households relying solely on unclean fuels received the subsidy. Overall, 21% of rural households in India reported receiving the LPG subsidy.

Percentage of LPG subsidy received by Intersectionality of social groups with different economic status and social groups with BPL card holders:

Figure 4 above, presents the percentage distribution of LPG subsidy receipt by the intersectionality of social groups with economic status and BPL card ownership in rural India for 2022-23. The results indicate that subsidy coverage is lowest among Scheduled Tribe (ST) households who have BPL card (12%), while it is highest among households from the "Other" social category possessing a BPL card (23%). Scheduled Caste (SC) and Other Backward Class (OBC) households with BPL cards report higher rates of subsidy receipt (22% and 20%, respectively) than ST households with BPL cards. Surprisingly, households from the "Other" social category without a ration card also report a higher rate of subsidy receipt (19%) than ST households with BPL cards. An analysis based on economic status reveals that subsidy coverage is lowest among poorer households, particularly those from SC (6%), followed by ST (14%) and OBC (16%) backgrounds. In contrast, coverage is slightly higher among middle-income households, ranging from 12% for ST to 24% for the "Other" social group. Among

wealthy households, SC households have the highest rate of subsidy receipt (26%), followed by OBC and "Other" households (both, with 25%). This pattern suggests that wealthier households, regardless of social group, are more likely to receive the subsidy than poorer households**,** with poor ST households being the most disadvantaged. Regionally, the data show that households in the South (26%) and North (24%) have the highest subsidy coverage, while those in the Central (18%) and Northeast (15%) regions report the lowest.

Figure 4: Percentage of LPG subsidy by Intersectionality of social groups with different economic status and social groups with BPL card holders in rural India in 2022-23



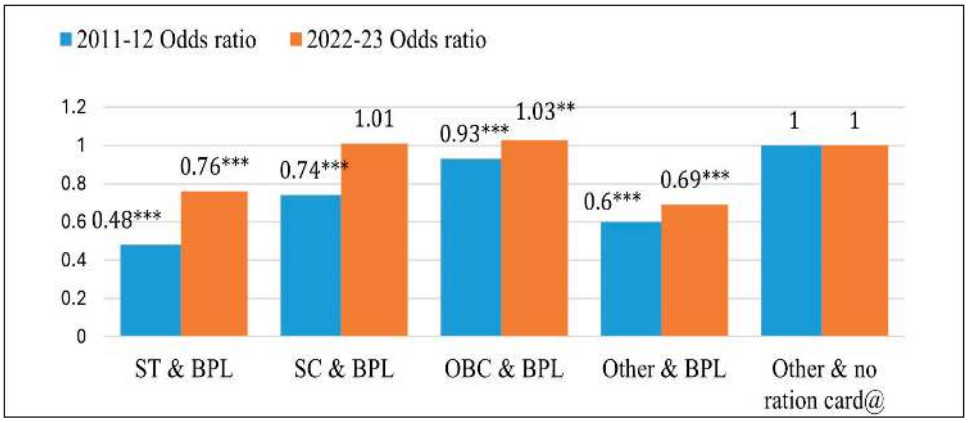
Author's computation from NSSO Household Consumption Expenditure Survey, 2022-23

Intersectional Effects of Social Group, Economic Status, and BPL Card Ownership on Clean Fuel and per-capita expenditure on clean fuel:

Figure 5 above shows the Odds Ratios for clean fuel usage among different social groups with BPL cardholders in 2011–12 and 2022–23 (before and after the implementation of the Pradhan Mantri Ujjwala Yojana (PMUY), without controlling for other socio-economic variables. The figure indicates that, in 2011–12, the odds ratios for clean fuel usage among social groups with BPL cards were significantly lower compared to Other Castes (OC) without ration cards. Specifically, Scheduled Tribes (ST) with BPL cards (OR = 0.48; P < 0.01), Scheduled Castes (SC) with BPL cards (OR = 0.74; P < 0.01), Other Backward Classes (OBC) with BPL cards (OR = 0.93; P < 0.01), and 'Other groups' with BPL cards (OR = 0.60; P < 0.01) were all significantly less likely to use clean fuel. After the implementation of PMUY, between 2011–12 and 2022–23, OBC with BPL cardholders became significantly more likely to use clean fuel (OR = 1.03; P <

0.01), and SC with BPL cardholders also showed an increased likelihood of using clean fuel (OR = 1.01), although this change was not statistically significant. Other social groups, such as Scheduled Tribes (ST), were still less likely to use clean fuel compared to Other Castes without ration cards. However, the odds of clean fuel usage among ST groups significantly improved in 2022–23 compared to 2011–12.

Figure 5: Odds ratio estimates of clean fuel usage by social groups having BPL card holders

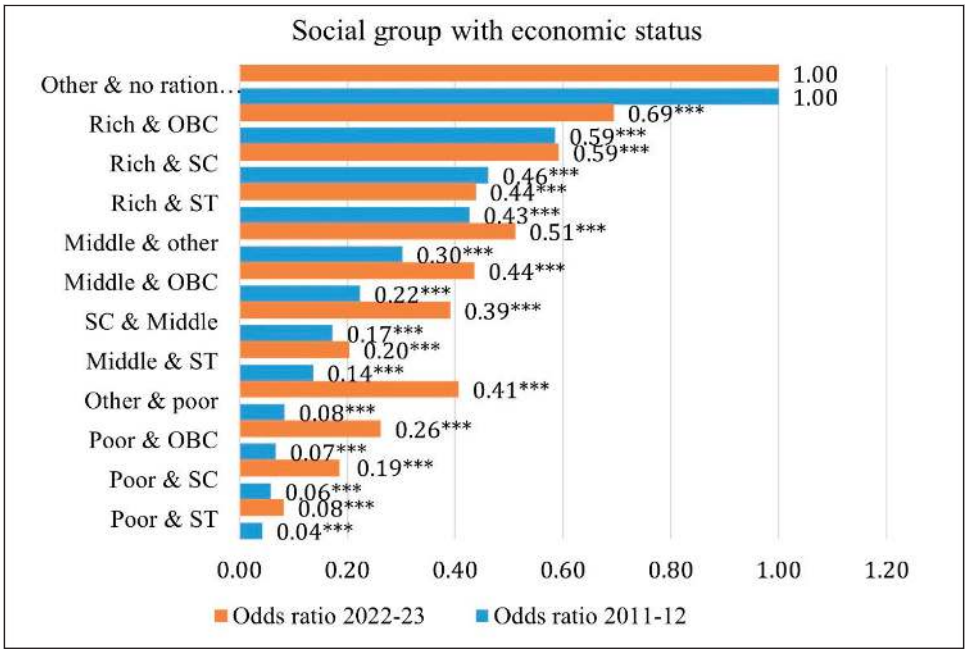


Note: ***less than 0.01 (P<0.01) **less than 0.05 (P<0.05), Other & no ration card @ is reference category

Source: Author's computation from NSSO Household Consumption Expenditure Survey, 2011-12 and 2022-23

Figure 6 illustrates the Odds Ratios for clean fuel usage by social groups with different economic statuses in 2011–12 and 2022–23, before and after the program implementation, controlling for other socio-economic characteristics. The Odds Ratios for clean fuel usage significantly improved from 2011 to 2022 after the implementation of the program, particularly among poor and middle-income households in the SC, ST, and OBC social groups. Additionally, the improvement in odds ratios from 2011 to 2022 for clean fuel usage was greater among poor and middle-income households in these social groups. However, both in 2011–12 and 2022–23, poor and middle-income social groups, such as SC, ST, and OBC, were still less likely to use clean fuel, and significant disparities in clean fuel usage persist among them.

Figure 6: Odds ratio estimates of clean fuel usage by social group and economic status in 2011–12 and 2022–23 controlling other socio-economic variables



Note: ***less than 0.01 (P<0.01), Source: Author's computation from NSSO Household Consumption Expenditure Survey, 2011-12 and 2022-23

Table 7 presents the multiple linear regression coefficients for log of Per-Capita expenditure on clean fuel usage, after controlling for other socio-economic variables in 2011–12 and 2022–23. The mean regression coefficients for social groups with BPL cards and Lower- to Middle-Income households improved over time, indicating coefficients became less negative over the time from 2011–12 to 2022–23. This suggests that per-capita spending on clean fuel was more likely to increase in 2022–23 compared to 2011–12. However, Poor and Middle-Income social groups such as SC, ST, and OBC were incurring less per-capita expenditure on clean fuel compared to wealthy households in the "Other" category without a ration card, in both 2011 and 2022.

Households belonging to social groups with BPL cards, such as Scheduled Castes (SC), Scheduled Tribes (ST), Other Backward Classes (OBC), and "Other" households with BPL cards, were incurring less per-capita expenditure on clean fuel in both 2011–12 and 2022–23, compared to those without ration cards.

Table 7: Multiple Linear Regression Coefficients for Per-Capita expenditure on clean fuel in 2011–12 and 2022–23, after controlling for other variables.

Dependent variable: log of Per-Capita expenditure on clean fuel				
Predictor variables	**2011-12**	**P<0.01**	**2022-23**	**P<0.01**
Social group having BPL card				
Other & no ration card@				
ST & BPL	-0.24(0.01)	0.00	-0.08(0.01)	0.00
SC & BPL	-0.25(0.01)	0.00	-0.15(0.01)	0.00
OBC & BPL	-0.18(0.01)	0.00	-0.19(0.01)	0.00
Other & BPL	-0.24(0.01)	0.00	-0.18(0.01)	0.00
Social group with economic status		0.00		0.00
Others & Rich@				
Poor & ST	-1.17(0.02)	0.00	-1.11(0.01)	0.00
Poor & SC	-1.14(0.02)	0.00	-0.78(0.01)	0.00
Poor & OBC	-1.22(0.02)	0.00	-0.69(0.01)	0.00
Other & Poor	-1.19(0.02)	0.00	-0.65(0.01)	0.00
Middle & ST	-0.95(0.02)	0.00	-0.60(0.01)	0.00
SC & Middle	-0.93(0.02)	0.00	-0.39(0.01)	0.00
Middle & OBC	-0.89(0.01)	0.00	-0.35(0.01)	0.00
Middle & Others	-0.77(0.01)	0.00	-0.33(0.01)	0.00
Rich & ST	-0.33(0.02)	0.00	-0.14(0.01)	0.00
Rich & SC	-0.34(0.02)	0.00	-0.13(0.01)	0.00
Rich & OBC	-0.25(0.01)	0.00	-0.06(0.01)	0.00

Note @ Reference Category; Parenthesis refers to standard error, Source: Author's computation from NSSO Household Consumption Expenditure Survey, 2011-12 and 2022-23

Appendix Table A2 findings show that households in 2022 were significantly more likely to use clean fuel (OR = 5.8, P < 0.01) compared to 2011. Social groups with BPL cardholders, such as SC (OR = 0.68, P < 0.01), ST (OR = 0.57, P < 0.01), and OBC (OR = 0.61, P < 0.01), were less likely to use clean fuel compared to others without a ration card, after controlling for other variables. Similarly, Poorer households were less likely to adopt clean fuel. Poor-Income households—SC (OR = 0.16, P < 0.01), ST (OR = 0.09, P < 0.01), and OBC (OR = 0.22, P < 0.01)—and Middle-Income households—SC (OR = 0.32, P < 0.01), ST (OR = 0.22, P < 0.01), and OBC (OR = 0.38, P < 0.01)—were significantly less likely to use clean fuel compared to wealthier households in the "Other" category.

The persistence of biomass fuel use (e.g., firewood) alongside clean fuel is notable, especially among Poor and Middle-Income households. Since biomass is often freely

available and not purchased, affordability plays a critical role in fuel stacking, whereas clean fuels such as LPG involve recurring costs. Key drivers of fuel stacking include: (1) remote geographic location, (2) marginalized socio-economic status (e.g., SC and ST), (3) intra-household gender dynamics where women have limited bargaining power in patriarchal households, (4) irregular or uncertain income due to dependence on agriculture, and (5) the lump-sum cost of LPG refills (Gill-Wiehl et al., 2021; Kowsari & Zerriffi, 2011; Kumar et al., 2016; Patnaik & Jha, 2020).

Education is positively associated with clean fuel adoption: households with primary (OR = 1.19, P < 0.01), middle (OR = 1.23, P < 0.01), and higher education (OR = 2.29, P < 0.01) are significantly more likely to use clean fuel compared to illiterate households. Employment type also matters. Households with members self-employed in non-agricultural activities (OR = 1.88, P < 0.01) and those with regular wage or salaried earners (OR = 2.15, P < 0.01) are more likely to use clean fuel compared to those self-employed in agriculture. Regional variation is evident. Households in Southern (OR = 3.51, P < 0.01) and Western states (OR = 1.54, P < 0.01) are significantly more likely to adopt clean fuel compared to those in Northern states. Additionally, Muslim households (OR = 0.94, P < 0.01) are significantly less likely to use clean fuel compared to Hindu households.

Appendix Table A3 presents the results of pooled multivariate linear regression on per-capita spending on clean energy for cooking. The findings indicate that household spending on clean energy was significantly higher in 2022 compared to 2011 (β = 1.802, P < 0.01). Regional analysis shows that households in the Southern (β = 0.060, p < 0.01) and Western states (β = 0.044, P < 0.01) spend significantly more on clean fuel compared to households in the Northern states. Education is positively associated with per-capita spending on clean energy. Compared to households with illiterate members, those with Primary (β = 0.018, P < 0.01), Middle (β = 0.059, P < 0.01), Secondary (β = 0.141, P < 0.01), and Higher education levels (β = 0.209, P < 0.01) spend significantly more on clean energy. Employment type also matters. Households with members self-employed in non-agriculture (β = 0.160, P < 0.01) and those with regular wage or salaried earners (β = 0.266, P < 0.01) spend significantly more on clean fuel compared to households self-employed in agriculture. According to social groups with different economic status, Lower-Income households in SC (β = –0.89, P < 0.01), ST (β = –0.993, P < 0.01), and OBC (β = –0.853, P < 0.01) social groups spend significantly less on clean fuel relative to wealthy households in the "Rich-Other" category.

Determinants of Receiving LPG Cooking Subsidies by Social Group, Economic Status, and BPL Card Ownership, 2022–23:

Table 8 above, presents the results of a Logistic Regression analysis, examining the factors associated with receiving LPG cooking subsidies, focusing on the intersectionality of social groups with economic status and BPL card ownership in 2022-23.The results indicate that, compared to the reference group of households without a ration card, all social groups possessing a Below Poverty Line (BPL) card were significantly more likely to receive the LPG subsidy: Scheduled Tribes (ST) (OR = 1.28, P < 0.01), Scheduled Castes (SC) (OR = 1.59, P < 0.01), Other Backward Classes (OBC) (OR = 1.19, P < 0.01), and the "Other" social group (OR = 1.10, P < 0.01). Among BPL cardholders, SC households had the highest odds of receiving the subsidy.

Table 8: Logistic Regression on subsidy assistance on LPG for cooking by intersectionality of social groups based on Economic Status and Social Groups with BPL card holding households in 2022-23

Predictors variables	Odds Ratio	Std. Err.	P-value
Social groups with BPL card holders			
Other with no-ration card@			
ST & BPL	1.28	0.04	0.00
SC & BPL	1.59	0.05	0.00
OBC & BPL	1.19	0.02	0.00
Other & BPL	1.10	0.02	0.00
Social Group with Economic Status			
Rich & Other @			
Poor & ST	0.22	0.01	0.00
Poor & SC	0.43	0.02	0.00
Poor & OBC	0.59	0.02	0.00
Other & poor	1.02	0.03	0.46
Middle & ST	0.46	0.02	0.00
SC & Middle	0.72	0.03	0.00
Middle & OBC	0.79	0.02	0.00
Middle & other	1.01	0.02	0.80
Rich & ST	0.87	0.04	0.00
Rich & SC	0.87	0.03	0.00

Predictors variables	Odds Ratio	Std. Err.	P-value
Rich & OBC	1.01	0.03	0.68
Religion			
Hindu @			
Muslim	1.08	0.02	0.00
Christian	1.46	0.04	0.00
Others	1.99	0.04	0.00
Education			
Not literate @			
Primary	1.11	0.02	0.00
Middle	1.15	0.02	0.00
Secondary	1.29	0.02	0.00
Higher	1.54	0.02	0.00
Household type			
Self-employment in agriculture@			
Self-employment in non-agriculture	1.18	0.02	0.00
Regular wage/salary earning	1.12	0.02	0.00
Casual labour in agriculture	0.71	0.01	0.00
Casual labour in non-agriculture	0.65	0.01	0.00
Others	0.71	0.02	0.00
Regions			
North @			
Central	0.83	0.01	0.00
East	1.08	0.02	0.00
Northeast	0.31	0.01	0.00
West	0.96	0.02	0.02
South	0.61	0.01	0.00
_cons	0.32	0.01	0.00
Number of obs = 282,062	LR chi2(32) = 15223.79		
Prob > chi2 = 0.0000	Pseudo R2 = 0.0550		

Note: @ indicates reference category, Source: Author's computation from NSSO Household Consumption Expenditure Survey, 2022-23

When examining the intersection of social groups and economic status, a different pattern emerges. Compared to the reference group of affluent households from the "Other" social category, Poorer Households from marginalized social groups were significantly less likely to receive the subsidy: SC (OR = 0.43, P < 0.01), ST (OR = 0.22, P < 0.01), and OBC (OR = 0.59, P < 0.01). This suggests that Wealthier Upper-Caste households are more likely to receive subsidies than Poorer Households from marginalized groups, indicating a potential exclusion error in the welfare system where the neediest are not effectively reached. Middle-income households from marginalized groups (SC: OR = 0.72, P < 0.01; ST: OR = 0.46, P < 0.01; OBC: OR = 0.79, P < 0.01) were also significantly less likely to receive the subsidy than the wealthy "Other" reference group, although this disparity was less pronounced than for their poorer counterparts.

Significant regional disparities were also observed. Households in the Northeast (OR = 0.31, P < 0.01) and South (OR = 0.61, P < 0.01) were much less likely to receive the subsidy compared to households in the North. In contrast, households in the East were slightly more likely to receive it (OR = 1.08, P < 0.01).

Finally, the likelihood of receiving the LPG subsidy increased with educational attainment. Compared to illiterate households, those with higher education (OR = 1.54, P < 0.01) were significantly more likely to receive the subsidy.

IV Discussion

The transition from solid fuels to clean energy for cooking has contributed to reducing indoor air pollution and saving time for women who would otherwise spend considerable effort collecting firewood. This shift has improved quality of life and contributed to reductions in child mortality (WHO, 2016; Bonjour, 2013). Sustainable Development Goal (SDG) 7 emphasizes universal access to affordable, reliable, sustainable, and modern energy by 2030.

This study comprehensively assessed changes in clean fuel usage and real per-capita spending on clean energy for cooking across different socio-economic groups, focusing on BPL cardholder households and the intersection of social groups with varying economic statuses between 2011–12 and 2022–23. Furthermore, it examined the effect of social group and BPL card ownership on LPG subsidy usage. Over the past decade, several clean fuel subsidy programs, such as the Pradhan Mantri Ujjwala Yojana (PMUY), were launched to promote clean energy adoption among lower socio-economic strata.

Our findings reflect the outcomes of PMUY, as we compared changes in clean energy adoption and per-capita spending before and after the program.

The results show that the use of unclean fuels has declined, while the share of households using clean energy increased from 14% in 2011–12 to 43.3% in 2022–23 in rural India. Real per-capita spending on clean energy (LPG) also rose significantly, from ₹12 to ₹51. Results from pooled multivariate logistic regression further show that, compared to 2011–12, households were significantly more likely to use clean energy in 2022–23 after controlling for other variables. Per-capita spending on clean energy was also higher in 2022–23, reflecting the positive impact of the PMUY scheme. However, despite these gains, large social disparities persist in clean fuel usage.

The increase in real Per-capita spending and clean fuel usage was more pronounced among socially disadvantaged groups. For example, between 2011–12 and 2022–23, real Per-Capita spending on clean energy rose from ₹6 to ₹44 for SC households, ₹10 to ₹54 for OBC households, and ₹4 to ₹25 for ST households. Among these, SC households experienced the largest relative increase in both per-capita spending and clean fuel usage, with adoption rising from 8% to 35%. Despite such improvements, SC and ST households continue to lag behind other groups in clean fuel use.

The study also examined the intersection of social group, BPL card ownership, and economic status. The findings indicate that real Per-capita spending, and clean fuel usage were significantly lower among SC, ST, and OBC households with BPL cards compared to "Other" households without ration cards. Interestingly, "Other" households with BPL cards spent more on and used more clean fuel compared to "Other" households without ration cards. Nonetheless, the growth in spending and clean fuel usage between 2011–12 and 2022–23 was greater among SC, ST, and OBC households than among "Other" households.

BPL cardholder households from SC, ST, and OBC groups were also more likely to receive LPG subsidies in 2022–23 compared to "Other" households without ration cards. Similarly, lower- and middle-income households within SC, ST, and OBC groups recorded slight improvements in clean fuel spending and usage compared to wealthier households in the "Other" category. However, these disadvantaged groups continued to use less clean fuel along with spending less on clean fuel relative to wealthier households, and they were also less likely to receive LPG subsidies than households in the Rich category. Many of these households continue to rely on biomass as their primary cooking fuel, supplementing it with limited use of LPG.

A critical insight from this study is the near-universal practice of fuel stacking, i.e., the simultaneous use of clean and unclean fuels. Figure 2 and Table 6 show that even among households whose primary fuel is clean, 51% continue to spend on unclean fuels such as firewood and dung cakes. This behaviour reflects a rational household response to economic and practical constraints. The estimated income elasticity of demand for LPG is 0.60, confirming that LPG is a necessity good, but it remains costly for rural households. In particular, lower- and middle-income households with irregular incomes from agriculture or casual labour cannot afford exclusive reliance on LPG and thus continue to depend on biomass fuels. The free availability of biomass, coupled with the recurring cost of LPG refills, remains a major determinant of fuel choices. Other barriers, including remote locations and income uncertainty linked to agricultural dependence, also shape household fuel use.

V Conclusion

Our findings suggest modest improvements in clean fuel usage and real per-capita spending among BPL cardholders and Lower- and Middle-Income households in rural India. However, significant disparities persist. Current subsidy levels are insufficient to ensure a sustained transition to clean fuels. On average, household monthly Per-capita expenditure on clean fuel remains less than 3% of total household expenditure in rural areas. Policies that reduce the effective cost of LPG refills could encourage greater adoption.

Achieving sustained convergence in clean fuel use will require disadvantaged socio-economic groups—particularly SC, ST, OBC, BPL cardholders, and lower-income households—to progress at a faster rate than their more privileged counterparts. Without stronger policy support, these groups will remain locked in fuel stacking practices, limiting the potential health, environmental, and gender-equity benefits of clean energy transitions.

References

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. https://doi.org/10.1016/S2542-5196(18)30261-4

Barnes, D. F., & Floor, W. (1999). Biomass energy and the poor in the developing world. *Journal of International Affairs*, *53*(1), 237–259. http://www.jstor.org/stable/24357794

Basu, A. K., Byambasuren, T., Chau, N. H., & Khanna, N. (2020). *Cooking fuel choice, indoor air quality, and child mortality in India* (No. 13295). IZA Discussion Papers.

Bharti, N. K. (2018). Wealth inequality, class and caste in India. *WID. world Working Paper*, *2018/14*, 1961–2012.

Bhide, A., & Monroy, C. R. (2011). Energy poverty: A special focus on energy poverty in India and renewable energy technologies. *Renewable and Sustainable Energy Reviews*, *15*(2), 1057–1066.

Bonjour, S., Adair-Rohani, H., Wolf, J., Bruce, N. G., Mehta, S., Prüss-Ustün, A., ... & Smith, K. R. (2013). Solid fuel use for household cooking: Country and regional estimates for 1980–2010. *Environmental Health Perspectives*, *121*(7), 784–790. https://doi.org/10.1289/ehp.1205987

Choudhuri, P., & Desai, S. (2020). Gender inequalities and household fuel choice in India. *Journal of Cleaner Production*, *265*, Article 121487. https://doi.org/10.1016/j.jclepro.2020.121487

Comptroller and Auditor General of India. (2019). *Report of the Comptroller and Auditor General of India on Pradhan Mantri Ujjwala Yojana* (No. 14; Audit Report). https://cag.gov.in/sites/default/files/audit_report_files/Report_No_14_of_2019_Performance_Audit_of_Pradhan_Mantri_Ujjwala_Yojana_Ministry_of_Petroleum_and_Natural_Gas.pdf

Farsi, M., Filippini, M., & Pachauri, S. (2007). Fuel choices in urban Indian households. *Environment and Development Economics*, *12*(6), 757–774. http://www.jstor.org/stable/44379432

Gill-Wiehl, A., Brown, T., & Smith, K. (2022). The need to prioritize consumption: A difference-in-differences approach to analyze the total effect of India's below-the-poverty-line policies on LPG use. *Energy Policy*, *164*, Article 112915. https://doi.org/10.1016/j.enpol.2022.112915

Gill-Wiehl, A., Ray, I., & Kammen, D. (2021). Is clean cooking affordable? A review. *Renewable and Sustainable Energy Reviews*, *151*, 111537. https://doi.org/10.1016/j.rser.2021.111537

Gordon, S. B., Bruce, N. G., Grigg, J., Hibberd, P. L., Kurmi, O. P., Lam, K. B. H., ... & Martin, W. J. (2014). Respiratory risks from household air pollution in low- and middle-income countries. *The Lancet Respiratory Medicine*, *2*(10), 823–860.

Gould, C. F., & Urpelainen, J. (2018). LPG as a clean cooking fuel: Adoption, use, and impact in rural India. *Energy Policy*, *122*, 395–408.

Gould, C. F., & Urpelainen, J. (2020). The gendered nature of liquefied petroleum gas stove adoption and use in rural India. *The Journal of Development Studies*, *56*(7), 1309–1329.

Gupta, G., & Köhlin, G. (2006). Preferences for domestic fuel: Analysis with socio-economic factors and rankings in Kolkata, India. *Ecological Economics*, *57*, 107–121. https://doi.org/10.1016/j.ecolecon.2005.03.010

Hosier, R. H., & Dowd, J. (1987). Household fuel choice in Zimbabwe: An empirical test of the energy ladder. *Resources and Energy*, *9*, 347–361.

International Institute for Population Sciences (IIPS), & Ministry of Health and Family Welfare, Government of India. (2021). *National Family Health Survey (NFHS-5) 2019-21, India fact sheet*.

International Institute for Population Sciences (IIPS). (2021). *National Family Health Survey-5 India report*.

Jha, S., Patnaik, S., & Warrier, R. (2021). *Are India's urban poor using clean cooking fuels?* [Issue brief]. Council on Energy, Environment and Water. https://www.ceew.in/publications/are-indias-urban-poor-using-clean-cooking-fuels

Johnson, M. A., & Chiang, R. A. (2015). Quantitative guidance for stove usage and performance to achieve health and environmental targets. *Environmental Health Perspectives*, *123*(8), 820–826.

Kowsari, R., & Zerriffi, H. (2011). Three dimensional energy profile. *Energy Policy*, *39*(12), 7505–7517. https://doi.org/10.1016/j.enpol.2011.06.030

Kumar, P., Rao, K., & Reddy, N. H. (2016). Sustained uptake of LPG as cleaner cooking fuel in rural India: Role of affordability, accessibility, and awareness. *World Development Perspectives*, *4*, 33–37. https://doi.org/10.1016/j.wdp.2016.12.001

Mani, S., Agrawal, S., Jain, A., & Ganesan, K. (2021). *State of clean cooking energy access in India: Insights from the India Residential Energy Survey (IRES) 2020*. Council on Energy, Environment and Water. https://www.ceew.in/publications/state-of-clean-cooking-energy-access-in-india-ires-2020-report

Pandey, V. L., & Chaubal, A. (2011). Comprehending household cooking energy choice in rural India. *Biomass and Bioenergy*, *35*, 4724–4731.

Puzzolo, E., Pope, D., Stanistreet, D., Rehfuess, E. A., & Bruce, N. G. (2016). Clean fuels for resource-poor settings: A systematic review of barriers and enablers to adoption and sustained use. *Environmental Research*, *146*, 218–234.

Rao, M. N., & Reddy, B. S. (2007). Variations in energy use by Indian households: An analysis of micro-level data. *Energy*, *32*(2), 143–153.

Santosh, H., & Smith, K. R. (2019). *Ujjwala 2.0 from access to sustained usage* [Policy brief]. https://static1.squarespace.com/static/53856e1ee4b00c6f1fc1f602/t/5d77fa14d48c3c428580b5fc/1568143894592/CCAPC-Ujjwala+V2.0-Aug+2019+%28002%29.pdf

Saxena, V., & Bhattacharya, P. C. (2018). Inequalities in LPG and electricity consumption in India: The role of caste, tribe, and religion. *Energy for Sustainable Development*, *42*, 44–53. https://doi.org/10.1016/j.esd.2017.09.009

Sharma, V., & Dash, M. (2022). Household energy use pattern in rural India: A path towards sustainable development. *Environmental Challenges*, *6*, Article 100404. https://doi.org/10.1016/j.envc.2021.100404

Thomas, L., Balakrishna, R., Chaturvedi, R., Mukhopadhyay, P., & Ghate, R. (2022). What influences rural poor in India to refill their LPG? In *Climate change and community resilience: Insights from South Asia* (pp. 191–203).

World Health Organization. (2016). *Burning opportunity: Clean household energy for health, sustainable development, and well-being of women and children*. https://apps.who.int/iris/handle/10665/204717

World Health Organization. (2014). Defining clean fuels and technologies. https://www.who.int/tools/clean-household-energy-solutions-toolkit/module-7-defining- clean

Appendix

Table A1. Summary Statistics: Socio-Economic variables used in the study

Background Characteristics	2011-12		2022-23	
	Frequency	N	Frequency	N
Type of Cooking Fuel				
Clean energy	15.4	46332	43.2	69,166
Un-clean energy	84.6	55325	56.8	85,703
Social Group				
Scheduled Tribes	11.4	10,001	12.4	28,752
Scheduled Castes	21.2	10,194	22	30,470
Other Backward Caste	44.2	23,757	44.2	62,812
Others	23.2	15,734	21.3	32,835
Religion				
Hindu	84.4	45,603	83.9	120,952
Islam	11	7,043	11	16,856
Christian	2.2	4,295	2.5	10,728
Other	2.4	2,751	2.7	6,333
Education level of Household Members				
Illiterate	35.7	83,215	29.4	192,643
Primary	33.7	91,394	30.1	212,043
Middle	13.7	43,883	13.4	99,720
Secondary	8.7	31,316	11.1	82,205
Higher	8.2	35,956	16	116,376
Economic Status				
Poor	25.3	10,603	24.4	35,351
Middle	38.8	21,145	38.7	57,944
Rich	35.9	27,947	37	61,574
Household Type				
Self-Employed in Agriculture	34.4	16,788	32.3	51,178
Self-Employed Non-Agriculture	16.1	15,295	13.2	21,072
Regular Wage/Salary Earning	8.9	10,705	14.4	23,050
Casual Labour In Agriculture	21.4	4,889	15	21,969
Casual Labour Non-Agriculture	13.1	8,758	17.5	26,638
Others	6	3,248	7.7	10,962
Region				
North	11.3	9,373	12	20,469
Central	23.7	10,087	24.2	31,008
East	25.2	11,610	27.1	34,987
Northeast	4.1	9,144	4.5	21,391
West	12.9	7,112	11.7	17,998
South	22.9	12,369	20.6	29,016
Total	100	59,695	100	154,869

Source: Author's computation from NSSO Household Consumption Expenditure Survey, 2011-12 and 2022-23

Table A2: Pooled multivariate logistic regression model on clean fuel usage by different socio- economic variables

Dependent variable: Clean fuel consumption

Predictors variables	Odds-Ratio	Std. Err.	P<0.01
social groups with BPL card			
Other & No-ration card@			
ST & BPL	0.57	0.01	0.00
SC & BPL	0.68	0.01	0.00
OBC & BPL	0.61	0.01	0.00
Other & BPL	0.51	0.01	0.00
Social-groups-with-economic status			
Social group &Rich other@			
Poor & ST	0.09	0.01	0.00
Poor & SC	0.16	0.01	0.00
Poor & OBC	0.22	0.01	0.00
Other & Poor	0.32	0.01	0.00
Middle & ST	0.22	0.01	0.00
SC & Middle	0.32	0.01	0.00
Middle & OBC	0.38	0.01	0.00
Middle & Other	0.45	0.01	0.00
Rich & ST	0.56	0.02	0.00
Rich & SC	0.53	0.02	0.00
Rich & OBC	0.67	0.01	0.00
Education			
Illiterate @			
Primary	1.19	0.01	0.00
Middle	1.23	0.02	0.00
Secondary	1.75	0.02	0.00
Higher	2.29	0.03	0.00
Religion			
Hindu_@			
Islam	0.94	0.01	0.00
Christian	1.12	0.02	0.00
Other	1.98	0.04	0.00
Household type of employment			
Self-employed in agriculture @			
Non-agriculture	1.88	0.02	0.00

Predictors variables	Odds-Ratio	Std. Err.	P<0.01
Regular wage/salary earning	2.15	0.03	0.00
Casual labour in: agriculture	0.71	0.01	0.00
Causal labour non-agriculture	0.72	0.01	0.00
Others	1.3	0.03	0.00
Regions			
North			
Central	0.55	0.01	0.00
East	0.44	0.01	0.00
Northeast	0.97	0.02	0.05
West	1.54	0.02	0.00
South	3.51	0.05	0.00
Year			
2011@			
2022	5.88	0.06	0.00
_cons	0.35	0.01	0.00
Number of obs = 408,046			
Pseudo R2 = 0.1533			
Prob > chi2 = 0.0000			

@ Stand for Reference category, Std. Err: Standard error; Source: Author's computation from NSSO Household Consumption Expenditure Survey, 2011-12 and 2022-23

Table A3: Pooled multiple linear regression on per-capita expenditure on clean energy usage by different socioeconomic variable

Dependent Variable: log of Per-capita expenditure

Predictors variables	β coefficient	Std. Err.	P<0.01
Social groups with BPL			
Other & No-ration card@			
ST & BPL	-0.22	0.01	0.00
SC & BPL	-0.19	0.01	0.00
OBC & BPL	-0.19	0.01	0.00
Other & BPL	-0.2	0.01	0.00
Social groups with economic status			
Social Group &Rich Other@			
Poor & ST	-0.99	0.01	0.00
Poor & SC	-0.89	0.01	0.00
Poor & OBC	-0.85	0.01	0.00
Other & Poor	-0.8	0.01	0.00
Middle & ST	-0.62	0.01	0.00
SC & Middle	-0.56	0.01	0.00
Middle & OBC	-0.5	0.01	0.00
Middle & Other	-0.45	0.01	0.00
Rich & ST	-0.12	0.01	0.00
Rich & SC	-0.19	0.01	0.00
Rich & OBC	-0.1	0.01	0.00
Education			
Illiterate @			
Primary	0.02	0	0.00
Middle	0.06	0	0.00
Secondary	0.14	0.01	0.00
Higher	0.21	0.01	0.00
Religion			
Hindu_@			
Islam	-0.05	0.01	0.00
Christian	0.03	0.01	0.00
Other	0.16	0.01	0.00
Household type-of employment			
Self-employed in agriculture @			
Non-agriculture	0.16	0.01	0.00
Regular Wage/Salary Earning	0.27	0.01	0.00

Predictors variables	β coefficient	Std. Err.	P<0.01
Casual Labour in: Agriculture	0.03	0.01	0.00
Non-Agriculture	0	0.01	0.41
Others	0.41	0.01	0.00
Regions			
North			
Central	-0.13	0.01	0.00
East	-0.16	0.01	0.00
Northeast	-0.09	0.01	0.00
West	0.04	0.01	0.00
South	0.06	0.01	0.00
Year			
2011@			
2022	1.8	0.01	0.00
_cons	3.27	0.01	0.00
Number of observations = 310,711	R-squared = 0.6264		
Adj R-squared = 0.6264			

@ Stands for reference category: Std. Err. Stand for standard error; Source: Author's computation from NSSO Household Consumption Expenditure Survey, 2011-12 and 2022-23.

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Venkateswarlu, ***A. Economic theory: Crossing the barriers.*** Aakar Books. 2024

Venkateswarlu, A. ***Political economy of controversies over the origin of COVID-19 and its impact on the world and India.*** Aakar Books. 2023

Revathi, E and Reddy, Suresh B. ***Economics and Technology of Soybean Cultivation in Central India.*** New Delhi: Academic Foundation, 2022

Ch, Bala Ramulu. Marginalised ***Communities and Decentralized Institutions India: An Exclusion and Inclusion Perspective.*** U K: Routledge, 2021

Rao, Hanumantha CH. ***Rising Inequalities in Income in India: Key Role of Socio-Political Factors, Research Paper.*** Hyderabad: CESS, 2021

Indrakant, S. ***A Confused Professor and His Students.*** Paramount Publishing House, ISBN 978-93-88808-34-7, 2020

Reddy, Srinivasa M. ***Climate-Drought Resilience in Extreme Environments.*** Switzerland AG Basel: Springer Nature, 2020, (with V R Reddy and Y V M Reddy)

Saleth Maria, Galab.S, and Revathi, E.(Eds). ***Issues and Challenges of Inclusive Development: Essays in Honour of Prof. R. Radhakrishna.*** Springer, 2020

Korra, Vijay. ***Forgotten Communities of Telangana and Andhra Pradesh: A Story of De-notified Tribes.*** Singapore: Palgrave Macmillan, 2019

Radhakrishna R. ***Essays on Agriculture, Food Security and Nutrition, New Delhi,*** Academic Foundation, 2019

Radhakrishna R. ***Essays on Growth, Poverty and Wellbeing.*** New Delhi: Academic Foundation, 2019

Radhakrishna R. ***Essays on the Econometrics of Consumer Behaviour.*** New Delhi: Academic Foundation, 2019

Radhakrishna R. ***Essays on the Econometrics of Inflation, Consumption and Welfare.*** New Delhi: Academic Foundation., 2019

Radhakrishna R. ***Essays on Indian Economy,*** New Delhi: Academic Foundation, 2019

Reddy, Gopinath M and Walter Fernandes, NafisaGoga, D'Souza and Palla Thrinadha Rao. ***Displacement and Marginalisation in Andhra Pradesh and Telangana.*** *1951-2010.2019.* Vishakhapatnam: Social Research Centre, Guwahati & Laya Resource Centre, 2019

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