Cite this article
Tiwari, V., Jana, A., Bandyopadhyay, S. (2024). Choice of Cooking and Lighting Energy Sources in Households: Empirical Evidence from Urban India. In Proceedings of Energise 2023- Lifestyle, Energy Efficiency, and Climate Action, pp 234-241, Alliance for an Energy Efficient Economy.
https://doi.org/10.62576/FVNJ6197

Choice of Cooking and Lighting Energy Sources in Households: Empirical Evidence from Urban India

Vidhulekha Tiwari
Centre for Urban Science and Engineering, Indian Institute of Technology Bombay, India
(Corresponding Author: 204420004@iitb.ac.in)

Arnab Jana
Centre for Urban Science and Engineering, Indian Institute of Technology Bombay, India

Santanu Bandyopadhyay
Department of Energy Science and Engineering, Indian Institute of Technology Bombay, India

Highlights

- This research highlights the effect of the household economy on the fuel choice for cooking and lighting fuels in urban India.
- The population working as casual labour tends to use the most polluting fuels like kerosene, coal or charcoal due to the lack of disposable income and, thus, the inability to pay for the initial cost of using cleaner fuels.
- The low-income households have a higher monthly expenditure on fuels than others, as they are using less efficient fuels, which are also the more polluting ones.
- Electric cooking is energy and cost-efficient; it must be promoted among middle and lower-income households through policy measures.

Abstract

Household energy consumption constitutes approximately 30% of India's total energy usage. Since the fuel choice for cooking and lighting includes unclean fuels like kerosene, coal, dung cakes and firewood, studying it becomes imperative. This study examines the fuel choice for cooking and lighting in urban Indian households through Multinomial Logistic Regression Analysis. The analysis incorporates variables depicting household economy, such as land ownership, expenditure, employment type, housing ownership, meals served, and access to the public distribution system. It is assumed that households make choices based on their specific household characteristics to maximise fuel utility. This study utilises data from the Household Consumer Expenditure Survey (2011-12) conducted by the National Sample Survey Office (NSSO) of India. Results show that employment type, amount of food cooked, fuel availability, and household expenditure capacity significantly influence fuel choices. Additionally, households using cleaner fuels experience lower expenses for cooking and lighting due to improved fuel efficiency.

Keywords: Energy Mix, Household Energy, Cooking Energy, Lighting Energy

Introduction

India is the third-largest contributor to anthropogenic carbon emissions [1]. Out of the net energy consumption in India, more than 80% of the total demand is still being met by coal, oil and solid biomass [2]. If the conveyance is excluded, approximately 30% of the total energy consumption in India is in households [3], [4]. In households, cooking is the highest energy-consuming service, accounting for a share of 66% in urban and 78% in rural of the net energy consumed. With increasing urbanisation, the transition to clean and energy-efficient fuels for cooking and lighting services is observed [5].

In India, approximately 68.7% of the urban population uses Liquified Petroleum Gas (LPG) for cooking, and 95.6% uses electricity for lighting, which accounts for approximately 115 million still using polluting fuels for cooking and 16 million for lighting [6]. India's urban population is supposed to increase up to 35% in 2020 [7]. With the high rate of urbanisation and changing lifestyles, the urban energy demand can increase multi-fold in the next few decades. However, few research works focus on urban fuel consumption patterns in India. In this study, we have focused on the factors affecting the choice of cooking and lighting fuels in urban India. For the analysis, the data from the survey done by the National Sample Survey Office, Ministry of Statistics & Programme Implementation (MOSPI), Government of India has been used [6].

This research also aligns with national and global policy developments. During the UNFCCC's 26th Conference of Parties (COP26) in Glasgow, the Prime Minister of India announced that the country aims to reduce one billion-tonne emission from now until 2030. India aims to develop its renewable energy capacity by 2030 from 450GW to 500GW while ensuring that 50% of the total energy is generated through renewable sources. In the speech on India's 75th Independence Day, the Prime Minister also announced the country's plan to become a net-zero carbon emitter by 2050. The 2030 Agenda for Sustainable Development [8], adopted by all United Nations Member States in 2015, talks about the 17 Sustainable Development Goals. A few of these goals discuss energy efficiency, sustainability and climate action.

Literature Review

According to Stoner et al. [9], almost 53% of the global population was using polluting cooking fuels in 1990, which dropped to 36% in 2020. They suggest that 31% of people will still mainly use polluting fuels in 2030, “the global community is far off track from reaching universal access to clean cooking by 2030”, and the business-as-usual scenario will lead to approximately 2.7 billion people using polluting fuel by then. Thus, it becomes necessary to study the household characteristics that influence household fuel choices.

The most commonly studied cooking fuels are biomass, charcoal, coal, kerosene, gas, and electricity [9]. These fuels have been classified and studied in numerous ways. Katutsi et al. [10] define fuels as traditional fuels (firewood), transitional fuels (charcoal), and modern fuels (LPG & electricity). Earlier, the classification was based on whether the fuels were solid fuels or other fuels, but now they are most often also classified as polluting fuels consisting of unprocessed biomass (wood, crop residues, and dung), charcoal, coal, and kerosene, and clean fuels consisting of gaseous fuels (liquified petroleum gas or LPG, natural gas, biogas), electricity, alcohol, and solar energy [9]. "Besides cooking, lighting is one of the most vital household energy needs", highlights Danlami et al. [11]. In the case of lighting fuels, electricity and solar energy are studied as clean fuels, while kerosene, candles, and solid fuels are considered polluting fuels.

In India, disparities exist in energy consumption by urban and rural regions and among various socio-economic groups [3]. Stoner et al. [9] mention that the urban population is mostly using gaseous fuels, and they are gradually moving towards using electricity, whereas the rural population is still highly dependent on biomass-based fuels. The clean break with the more probable use of traditional fuels in rural areas than their urban counterparts has also been observed by Kuo and Azam [12]. However, given the population size of the country, and the economic disparity in the urban regions, a study on urban areas is also required.

Other phenomena observed with the use of cooking fuels are fuel stacking behaviour and the energy ladder concept. The use of more than one fuel is known as fuel stacking behaviour [13], whereas the energy ladder [14] concept hypothesises that fuel types follow an order. Kuo and Azam [12] observe that the household characteristics which promote the use of clean fuels might also promote fuel stacking in rural households, but it is not the same in urban households. Kapsalyamova et al. [15] observe that the availability of a fuel such as electricity does not necessarily lead to a complete transition, but it might lead to fuel stacking. Cheng and Urpelainen [16] used the NSS (National Sample Survey) data of India from 1987 to 2010 and observed that in the case of lighting, the fuel stacking is decreasing as households are becoming completely dependent on electricity, while in the case of cooking fuels, LPG is being used in addition to biomass-based fuels. They highlight their most important finding that high household income reduces fuel stacking for lighting but not for cooking.

Various variables have been used to study the choice of fuels in households. Demographic variables are one of the widely used set of variables [17], which contain household size, age of household/head [10], [18], [19], gender of household head [10], marital status [10], and level of education [10], [20].

The next widely studied factor is the household economy [21]. The economic variables which have been observed to influence fuel choice are employment status, income [10], [12], [22], expenditure, land ownership, number employed, type of employment [23], credit access [20], ownership of ICT [24]. The factors which can be considered as proxy variables of economic status such as housing characteristics, namely: ownership of housing [24], [25], housing type [18], [25], housing area, and number of rooms in the housing, have also been used widely.

Critical factors like the price of fuel [21] and its availability [15], [24] directly influence fuel choice; these have been significantly studied in the case of rural areas but not in their urban counterparts. Additionally, road connectivity to housing [12], location of household [10], and neighbourhood properties [26], type of food cooked [23], [25], energy saving awareness [18], technological advancements [26], and in-home time-use [27] have also been used for the study of cooking fuel choice.

In the case of lighting fuels, household demography and economic status have been observed to affect fuel choice in the same way as in the case of cooking fuels. The factors are household size [28], [29], age of household/head [11], [30], [31], gender of household head [28], [29], [30], marital status [29], and level of education [28], [29], [31], household income [11], [28], [29], [30], [31], ownership of housing, housing type [31], and housing area [11], [31], location of household [11], [28], [29], [31], [32], neighbourhood properties [28], and availability of fuel [11], [16], [29].

It is observed that researchers have extensively focused on household demography, while the critical factors related to the household economy, such as employment characteristics, have been overlooked. Research shows that after controlling the economic factors, the demographic factors might not show a significant influence on fuel choice [23]. This creates a need to specifically study the economic variables. In the case of India, PDS, which ensures the availability of fuels like kerosene, is vital to understanding the fuel choice in the case of polluting fuels. Additionally, the amount of food being cooked, specifically in agricultural or industrial households, are important in defining fuel choice. In this study, these factors have been the focal point of analysis.

Methodology

Researchers have studied the choice of cooking and lighting fuels in households using methods like Multinomial Logistic Regression [10], [11], [15], [20], [29], [31], Ordered Probit Model [30], and Multiple Discrete-Continuous Extreme Value [24], [26], [27]. According to Liao et al. [23], some clean fuel types might not have advantages over others, the fuels can be ordered on the basis of their properties, and households might use two or more fuels. Hence ordered logit and binary logit cannot be used for such analysis. There is a clear predominance of Multinomial Logistic Regression for such analyses; hence, this study uses Multinomial Logistic Regression to analyse the household fuel choice for lighting and cooking in urban India. Since multinomial logistic regression is effective when the dependent variables are polychotomous categorical [15], and there is a dominant choice, which in our case is LPG for cooking and electricity for lighting. Since we have considered multiple independent variables, the multinomial logistic regression supports our analysis.

The available choices for cooking fuels are LPG (base category), coke/coal/charcoal, firewood/ chips, cow dung, kerosene and electricity. The available choices for lighting fuels are electricity (base category), kerosene, gas and candle. The independent variables were selected on the basis of a literature review and are detailed in Appendix 1. A few new variables were chosen, namely: (a) Accessibility to the Public Distribution System (PDS), as it leads to the accessibility of fuels like kerosene in India, and (b) 'Meals served to non-household members' as the amount of food to be cooked also influences the fuel choice. It must be noted that the households which have performed ceremonies have been removed from the study to avoid errors occurring from out-of-routine activities.

This research studies the data from the survey of Household Consumption of Various Goods and Services in India, conducted in 2011-12 (National sample Survey 68th Round, Schedule-1, Type-2), which is representative of the whole country[6]. For the survey, 7,469 villages and 5,268 urban blocks were surveyed, comprising 119,378 households in rural areas and 83,935 in urban areas of India. However, after removing households which organised ceremonies and extreme values, 40739 datasets were selected. The survey was conducted by the National Statistical Office (NSO) under the Ministry of Statistics and Program Implementation (MoSPI), Government of India. The survey contains information about household characteristics like household size, land holdings, type of income, housing characteristics and type of main fuel used for cooking and lighting. The data description for the selected variables is shown in Appendix 1.

Results and Discussion

Analysis of Choice of Cooking Fuels

For analysing cooking fuels, LPG was taken as a base category, as 68.7% of the Urban Population uses LPG for cooking. The results are shown in Table 1.

Table 1 Results of Multinomial Logistic Regression Analysis for Cooking Fuels with LPG as Base Fuel

Variables		**Cooking Fuels (LPG as base)**				
		Coke, Coal, Charcoal	Firewood, Chips	Cow dung	Kerosene	Electricity
Household Size		-0.069** (0.022)	-0.109*** (0.010)	0.017 (0.025)	-0.285*** (0.022)	0.298*** (0.041)
Land Owned (in Ha)		-0.258* (0.102)	0.186*** (0.017)	0.157*** (0.034)	-0.752*** (0.162)	-0.669* (0.320)
Monthly Expenditure on Fuel (in Rs)		-2.509*** (0.212)	-2.634*** (0.097)	-1.047*** (0.251)	-1.505*** (0.148)	-4.074*** (0.400)
Total Monthly Expenditure (in Rs)		-0.520*** (0.071)	-0.455*** (0.030)	-0.618*** (0.116)	-0.268*** (0.032)	0.034 (0.039)
Fraction of Total Expenditure on Fuel Expenditure		2.849*** (0.224)	3.065*** (0.118)	1.931*** (0.308)	1.787*** (0.210)	-0.342 (0.545)
Employment Type	**Salaried**	-0.005 (0.131)	-0.196** (0.067)	0.212 (0.251)	-0.490*** (0.088)	0.202 (0.211)
	Self-Employed	0.221 (0.152)	-0.366*** (0.060)	-0.348 (0.234)	0.350*** (0.101)	0.062 (0.227)

	Casual Labour	0.534*** (0.148)	0.134* (0.058)	0.421 (0.216)	0.400*** (0.105)	-0.190 (0.245)
Housing Ownership	**Owned**	1.058*** (0.157)	1.243*** (0.062)	1.516*** (0.223)	1.335*** (0.108)	-0.038 (0.293)
	Hired	-0.477** (0.174)	-0.386*** (0.088)	0.719 (0.419)	-0.726*** (0.131)	-0.211 (0.381)
Number of Meals Served to Non-household members in One Month	**0**	-0.576*** (0.156)	-1.074*** (0.080)	-0.109 (0.412)	-0.010 (0.109)	0.102 (0.353)
	1-5	-0.103 (0.366)	-0.830*** (0.129)	-1.072** (0.355)	-0.009 (0.249)	-0.570 (0.466)
	6-10	-0.562 (0.374)	-0.757*** (0.132)	-0.882* (0.365)	-0.266 (0.256)	-0.561 (0.484)
	11-30	-0.920* (0.385)	-0.637*** (0.133)	-0.712 (0.365)	-0.297 (0.259)	-0.771 (0.497)
Availability of PDS		-0.730 (0.403)	-0.514*** (0.138)	-0.560 (0.379)	-0.231 (0.269)	-1.014 (0.546)
Intercept		-0.910* (0.434)	1.550*** (0.169)	-3.114*** (0.600)	-0.163 (0.296)	-2.434*** (0.625)
Log Likelihood		-55053.2				
Pseudo R-square		0.190				
Observations		40739				
Note: LPG is base category; ***p < 0.01, **p < 0.05, *p < 0.1						

Firewood/Chips and Kerosene have a negative coefficient for household size, while other fuels are not. This might indicate that the population with small household sizes prefers these fuels. Firewood/Chips and Cow Dung have a positive coefficient for with land owned, while other fuels are not. Firewood and cow dung are generally used by households involved in agricultural practices, giving them accessibility to cow dung through cattle reared and firewood through the plantation. The prevalence of such data in urban households is there because the 'urban areas' here refer to administrative classification, and urban fringes are thus included in the dataset. The coefficient of monthly expenditure on fuel is extremely low in the case of electricity, which indicates that people using electricity are spending considerably less on cooking fuel, whereas the coefficient of total monthly expenditure is negative for electricity. This indicates that the households spending more are using electricity as fuel.

The population working as casual labour is most likely to use polluting fuels as all of its coefficients are positive and significant. In case the casual labours are migrants, they might not possess a local permanent address, and the absence of a certificate of residence would mean that they will not have access to PDS. As mentioned by Gangopadhyay et al. [33], the migrants might get access to kerosene through illegal diversions in case of unavailability to PDS. However, all the coefficients for accessibility to PDS are negative, indicating that people with accessibility to PDS are more likely to use LPG. With the increase in the number of meals served to non-household members in one month, households prefer LPG over other fuels.

Analysis of Choice of Lighting Fuels

For analysing lighting fuels, Electricity was taken as a base category, as 95.6% of the Urban Population uses electricity for lighting. The results are shown in Table 2.

Table 2 Results of Multinomial Logistic Regression Analysis for Lighting Fuels with Electricity as Base Fuel

Variables		**Lighting Fuels (Electricity as base)**		
		Kerosene	Gas	Candle
Household Size		0.019 (0.018)	-0.254* (0.129)	-0.128 (0.071)
Monthly Expenditure on Fuel (in Rs)		-5.004*** (0.212)	0.408 (0.256)	-0.689 (0.391)
Total Monthly Expenditure (in Rs)		-0.441*** (0.054)	-0.036 (0.118)	-0.017 (0.078)
Fraction of Total Expenditure on Fuel Expenditure		2.296*** (0.174)	1.448 (0.841)	1.856*** (0.490)
Employment type	**Salaried**	-0.033 (0.118)	0.357 (0.648)	-1.121** (0.345)
	Self-Employed	0.541*** (0.110)	0.240 (0.681)	-0.001 (0.309)
	Casual Labour	0.882***	0.271	0.237

		(0.109)	(0.786)	(0.333)
Housing Ownership	**Owned Housing**	-0.145 (0.103)	-1.050 (0.657)	-1.132*** (0.319)
	Hired Housing	-0.919*** (0.119)	-0.396 (0.651)	-0.780* (0.318)
Availability of PDS		0.043 (0.069)	-0.267 (0.392)	-1.170*** (0.219)
Intercept		-1.062*** (0.148)	-6.213*** (0.874)	-3.824*** (0.386)
Log Likelihood		-12204.4		
Pseudo R-square		0.181		
Observations		40739		
Note: Electricity is base category; ***p < 0.01, **p < 0.05, *p < 0.1				

Most of the coefficients are highly negative or insignificant, depicting that all the households are highly likely to use electricity for lighting. The only different case is with casual labour because its coefficient is highly significant and highly positive, indicating they might use illegally diverted kerosene as fuel [33].

Discussion

In this study, the respectively cheaper fuels, such as Firewood/Chips and Kerosene for cooking, and gas or candle for lighting, are found to have a negative coefficient for household size, which signifies that an increase in household size will lead to a decrease in the use of these fuels. At the same time, households that have better employment status do not seem to use these fuels. This result might indicate that economically weaker social groups, who are not living with families, such as casual labours, might frequently use polluting fuels for both cooking and lighting. Cooking a larger amount of food and lighting a bigger housing might be difficult with these fuels, and hence, people might shift to better alternatives in case the household size increases. Research points out that household size might positively influence the energy-saving potential, which aligns with previous studies [22].

The frequency of using kerosene is higher in casual labours. But, it is lower in the population which has access to Ration Card (Public Distribution System). Gupta and Ravindranath mention that the "subsidised kerosene option is cheaper than wood in the traditional stove" in India. After the Government of India eliminated subsidies on kerosene [34] in 2021, the population using kerosene is bound to decrease.

In the case of expenditure patterns, the observation is the population which is using polluting fuels has higher monthly expenditure on fuels than the ones that are using LPG or Electricity for cooking and Electricity for lighting. Moreover, the households using cleaner fuels are spending lower fraction of their expenditure on the fuel. The households with higher net monthly expenditure tend to use electricity for cooking, which is one of the most efficient forms of fuel for cooking. Since the initial investment cost for cleaner fuel is higher, the population having lower expenditure power is using fuel forms with lower energy efficiency of utilisation [3], [4]. This pattern emphasises the limited access to cleaner fuels to economically weaker households. The initial investment cost such as price of buying LPG or electric cookstoves and LPG cylinders might be too high for them. Along with the initial investment costs, lack of distribution networks [3], the habit of using polluting fuels like dung cake or firewood [35], availability of solid biomass fuel in neighbourhoods [35], and the taste of cooked food [35] are a few hindrances in the population moving towards cleaner fuel alternatives.

Our results show that an increase in the economic status of the household, through steady income and better ownership of assets, tends to shift them towards using cleaner fuels. This pattern has also been observed in other research works [3], [4], which signify that increase in income causes the population to shift from cheaper and less convenient fuels to more expensive and more convenient ones.

We also observe that households with higher land ownership are tended to use Solid Biomass Fuels (SBF) like firewood and dung. Previous research [4], [35] suggests that in regions with the availability of solid biomass fuel through home production or collection, LPG usage is low, and this usage remains unaffected by income as opportunity cost comes into effect [36]. The SBFs are present at no inherent costs to such households, and this also leads to fuel stacking in households [37]. Given the huge availability of SBF in India and the efficiency of biogas being six times that of SBF [38], policies supporting initial investment costs for the setup of biogas plants can be proposed. Biogas is a cleaner fuel and also promotes efficient utilisation of SBFs [4].

Our results show that with the increase in the number of guests eating at the household, they prefer LPG over other fuels, including electricity. This aligns with previous research works showing that approximately 69.2% of households prefer to use LPG for cooking if guests are present [35].

LPG turns out to be the most popular choice of fuel in Indian urban households. Previous research also suggests that LPG is used mainly by the middle and high-income groups in India, and given its high initial cost, it remains inaccessible to the poor [4]. LPG is convenient, clean and efficient, and hence the government has been pushing towards increasing its use through various policies such as Pradhan Mantri Ujjwala Yojana (PMUY), which ensures its better distribution and higher subsidies. However, some studies suggest that PMUY needs policy review as a significant amount of its beneficiaries purchased no refills during the first year of implementation [39], [40]. Several households which were previously using SBF have shifted back to it, and even though LPG could have been a preferred choice of the households, they are not being able to use it because of habitual and economic constraints, and higher fuel stacking can be expected.

The samples representing the population using electricity were low. However, we can observe that stability in employment status has a positive coefficient for the use of electricity for cooking, which signifies that stable employment leads to more use of electricity for cooking. Researchers mention that electric cooking advantages like cleanliness, ease to use, high standard of living, no drudgery, and high conversion efficiency [4]. But, the use of electric cooking appliances is limited to high-income groups due to high initial costs of equipment [4].

However, the recent increase in LPG prices has made electric cooking the cheaper option, and electric cooking is more efficient than LPG [41]. About 17% of the households in a few cities have switched to electric cooking, and a greater percentage of people who have switched believe that it is cheaper, faster and can meet all kinds of cooking demands [42]. Consequently, electric cooking has entered the households of middle-income groups, and push-through policy measures can further increase its frequency in lower-income groups as well.

In the case of lighting, almost all households show a tendency to use electricity except those working as casual labours. This can be attributed to the fact that their housing might not even have an electricity supply. However, recent studies show that more than 97 per cent of households are electrified in India [43], and hence we can see the improvements in future studies.

Conclusions

This study reinforces the well-known fact that the economy plays a key role in the fuel choice of households. The research emphasises that the type of employment is critical in determining fuel choice, with casual labours tending to use the most polluting fuels, like coal or charcoal, due to the lack of disposable income and inability to pay for the initial cost of using cleaner fuels. The concerning part here is that low-income households have a higher net expenditure on fuels than others as they are using less efficient fuels.

Another finding suggests that the availability of any fuel, polluting or not, highly influences fuel choice. The access to kerosene has been controlled through de-subsidising it. However, households that have free access to SBF still prefer it over cleaner fuels. Fuels like biogas have much higher efficiency than SBF, and financial support, combined with awareness among SBF-using households, might lead them to shift their fuel choices. Although government policies have managed to increase access to LPG, careful planning and policy implementation can help in penetrating lower-income households. Popularising electric cooking in middle and lower-income households should be the future target, and policies should be framed accordingly. Given the fact that electric cooking is energy and cost-efficient, it is much easier to shift to it once the households are acquainted with it.

The way to ensure that 100% of the households in the country use electricity for lighting is to ensure uninterrupted power supply to them. Un-notified residential areas in cities mostly face this problem, and hence the policies should focus on housing supplies first.

Acknowledgements

The authors would like to thank the lab-mates, colleagues and peers who have helped through suggestions and reviews in the completion of this study.

References

[1] M. Crippa et al., "Fossil CO2 and GHG emissions of all world countries- 2020 Report," Publication office of the European Union, Luxembourg, 2020.[Online]. Available: https://dx.doi.org/10.2760/143674

[2] IEA, "India Energy Outlook 2021," 2021. [Online]. Available: https://www.iea.org/reports/india-energy-outlook-2021

[3] B. S. Reddy and P. Balachandra, "Dynamics of technology shifts in the household sector-implications for clean development mechanism," Energy Policy, vol. 34, no. 16, 2006. https://doi.org/10.1016/j.enpol.2004.08.019

[4] S. D. Pohekar, D. Kumar, and M. Ramachandran, "Dissemination of cooking energy alternatives in India-a review," Renew. Sustain. Energy Rev., vol. 9, no. 4, pp. 379-393, Aug. 2005. https://doi.org/10.1016/j.rser.2004.05.001

[5] S. K. Yawale, T. Hanaoka, and M. Kapshe, "Development of energy balance table for rural and urban households and evaluation of energy consumption in Indian states," Renew. Sustain. Energy Rev., vol. 136, 2021. https://doi.org/10.1016/j.rser.2020.110392

[6] MoSPI, "Household Consumption of Various Goods and Services in India, 2011-12," Jun. 2014. [Online]. Available: http://microdata.gov.in/nada43/index.php/catalog/126

[7] National Commission on Population, "Census of India 2011: Population Projections for India and States 2011-2036," 2020. [Online]. Available: https://main.mohfw.gov.in/sites/default/files/Population%20Projection%20Report%202011-2036%20-%20upload_compressed_0.pdf

[8] U. N. Department of Economic and Social Affairs, "THE 17 GOALS | Sustainable Development," Department of Economic and Social Affairs, United Nations. [Online]. Available: https://sdgs.un.org/goals

[9] O. Stoner, J. Lewis, I. L. Martínez, S. Gumy, T. Economou, and H. Adair-Rohani, "Household cooking fuel estimates at global and country level for 1990 to 2030," Nat. Commun., vol. 12, no. 1, pp. 1-8, Oct. 2021. https://doi.org/10.1038/s41467-021-26036-x

[10] V. Katutsi, T. Dickson, and A. G. Migisha, "Drivers of Fuel Choice for Cooking among Uganda's Households," Open J. Energy Effic., vol. 09, no. 03, 2020, doi: 10.4236/ojee.2020.93008. https://doi.org/10.4236/ojee.2020.93008

[11] A. H. Danlami, S. D. Applanaidu, and R. Islam, "Movement towards the adoption of non-traditional household lighting fuel energy in developing areas," Biofuels, vol. 10, no. 5, 2019. https://doi.org/10.1080/17597269.2017.1338125
[12] Y.-M. Kuo and M. Azam, "Household Cooking Fuel Choice in India, 2004-2012: A Panel Multinomial Analysis," SSRN Electronic Journal, 2019. https://doi.org/10.2139/ssrn.3303404
[13] O. R. Masera, B. D. Saatkamp, and D. M. Kammen, "From Linear Fuel Switching to Multiple Cooking Strategies: A Critique and Alternative to the Energy Ladder Model," World Dev., vol. 28, no. 12, pp. 2083-2103, Dec. 2000. https://doi.org/10.1016/S0305-750X(00)00076-0
[14] R. H. Hosier and J. Dowd, "Household fuel choice in Zimbabwe: An empirical test of the energy ladder hypothesis," Resources and Energy, vol. 9, no. 4, pp. 347-361, Dec. 1987. https://doi.org/10.1016/0165-0572(87)90003-X
[15] Z. Kapsalyamova, R. Mishra, A. Kerimray, K. Karymshakov, and D. Azhgaliyeva, "Why energy access is not enough for choosing clean cooking fuels? Evidence from the multinomial logit model," J. Environ. Manage., vol. 290, 2021. https://doi.org/10.1016/j.jenvman.2021.112539
[16] C.-Y. Cheng and J. Urpelainen, "Fuel stacking in India: Changes in the cooking and lighting mix, 1987-2010," Energy, vol. 76, pp. 306-317, 2014. https://doi.org/10.1016/j.energy.2014.08.023
[17] I. Kastner and P. C. Stern, "Examining the decision-making processes behind household energy investments: A review," Energy Res. Soc. Sci., vol. 10. 2015. https://doi.org/10.1016/j.erss.2015.07.008
[18] B. Yu, J. Zhang, and A. Fujiwara, "Representing in-home and out-of-home energy consumption behavior in Beijing," Energy Policy, vol. 39, no. 7, 2011. https://doi.org/10.1016/j.enpol.2011.04.024
[19] M. Aslam and E. Ahmad, "Impact of ageing and generational effects on household energy consumption behavior: Evidence from Pakistan," Energies (Basel), vol. 11, no. 8, 2018. https://doi.org/10.3390/en11082003
[20] P. Mperejekumana et al., "Determinants of Household Energy Choice for Cooking in Northern Sudan: A Multinomial Logit Estimation," Int. J. Environ. Res. Public Health, vol. 18, no. 21, Nov. 2021. https://doi.org/10.3390/ijerph182111480
[21] Y. Alem, A. D. Beyene, G. Köhlin, and A. Mekonnen, "Modeling household cooking fuel choice: A panel multinomial logit approach," Energy Econ, vol. 59, 2016. https://doi.org/10.1016/j.eneco.2016.06.025
[22] E. Acuner and M. Özgür Kayalica, "A review on household energy consumption behavior: how about migrated consumers?," Environmental Economics, vol. 9, no. 4, 2018. https://doi.org/10.21511/ee.09(4).2018.02
[23] H. Liao, T. Chen, X. Tang, and J. Wu, "Fuel choices for cooking in China: Analysis based on multinomial logit model," J. Clean. Prod., vol. 225, 2019. https://doi.org/10.1016/j.jclepro.2019.03.302
[24] B. Acharya and K. Marhold, "Determinants of household energy use and fuel switching behavior in Nepal," Energy, vol. 169, 2019. https://doi.org/10.1016/j.energy.2018.12.109
[25] M. O. Pundo and G. C. G. Fraser, "Multinomial logit analysis of household cooking fuel choice in rural Kenya: The case of Kisumu district," Agrekon, vol. 45, no. 1, 2006. https://doi.org/10.1080/03031853.2006.9523731
[26] Y. Biying, J. Zhang, and A. Fujiwara, "Analysis of the residential location choice and household energy consumption behavior by incorporating multiple self-selection effects," Energy Policy, vol. 46, 2012. https://doi.org/10.1016/j.enpol.2012.03.067
[27] B. Yu, J. Zhang, and A. Fujiwara, "A household time-use and energy-consumption model with multiple behavioral interactions and zero consumption," Environ Plann B Plann Des, vol. 40, no. 2, pp. 330-349, 2013. https://doi.org/10.1068/b38213
[28] M. Giri and B. Goswami, "Determinants of households' choice of energy for lighting in Nepal," Economics and Business Letters, vol. 6, no. 2, 2017. https://doi.org/10.17811/ebl.6.2.2017.42-47
[29] Y. J. Baek, T. Y. Jung, and S. J. Kang, "Analysis of Residential Lighting Fuel Choice in Kenya: Application of Multinomial Probability Models," Front Energy Res, vol. 8, 2020. https://doi.org/10.3389/fenrg.2020.00070
[30] D. B. Rahut, B. Behera, and A. Ali, "Factors determining household use of clean and renewable energy sources for lighting in Sub-Saharan Africa," Renewable and Sustainable Energy Reviews, vol. 72. 2017. https://doi.org/10.1016/j.rser.2017.01.080
[31] E. Niyonshuti, "Analysis of Household Lighting Fuel Choice in Rwanda, Africa: Using the Multinomial Logit Model," Journal of Business and Social Sciences Research, vol. 6, no. 2, pp. 87-97, Dec. 2021. https://doi.org/10.3126/jbssr.v6i2.44714
[32] B. O. K. Lokonon, "Household cooking fuel choice: Evidence from the Republic of Benin," African Development Review, vol. 32, no. 4, pp. 686-698, Dec. 2020. https://doi.org/10.1111/1467-8268.12471
[33] S. Gangopadhyay, B. Ramaswami, and W. Wadhwa, "Reducing subsidies on household fuels in India: how will it affect the poor?," Energy Policy, vol. 33, no. 18, pp. 2326-2336, Dec. 2005. https://doi.org/10.1016/j.enpol.2004.04.024
[34] MoPNG, Allocation of Kerosene for distribution under the Public Distribution System (PDS) for the 4th Quarter of 2021-22 (January-March, 2022). India, 2021.
[35] A. Sharma, J. Parikh, and C. Singh, "Transition to LPG for cooking: A case study from two states of India," Energy for Sustainable Development, vol. 51, pp. 63-72, Aug. 201, doi: 10.1016/J.ESD.2019.06.001. https://doi.org/10.1016/j.esd.2019.06.001
[36] R. Heltberg, "Factors determining household fuel choice in Guatemala," Environ Dev Econ, vol. 10, no. 3, pp. 337-361, Jun. 2005. https://doi.org/10.1017/S1355770X04001858
[37] E. and W. Council on Energy, "Which is the Primary Cooking Fuel in Indian Households? CEEW Study," Council on Energy, Environment and Water. [Online]. Available: https://www.ceew.in/press-releases/more-70-indian-households-use-lpg-primary-cooking-fuel-ceew
[38] K. S. Jagadish, "Bioenergy for India: prospects, problems and tasks," Energy Sustain. Dev., vol. 7, no. 1, pp. 28-34, Mar. 2003. https://doi.org/10.1016/S0973-0826(08)60346-4
[39] A. Kar, S. Pachauri, R. Bailis, and H. Zerriffi, "Using sales data to assess cooking gas adoption and the impact of India's Ujjwala programme in rural Karnataka," Nature Energy 2019 4:9, vol. 4, no. 9, pp. 806-814, Jul. 2019. https://doi.org/10.1038/s41560-019-0429-8
[40] R. Ranjan and S. Singh, "Household Cooking Fuel Patterns in Rural India: Pre- and Post-Pradhan Mantri Ujjwala Yojana,". 14, no. 3, pp. 518-526, Dec. 2020. https://doi.org/10.1177/0973703020975045
[41] D. Palit, "Transition to electric cooking in India," ET EnergyWorld, 2021. [Online]. Available: https://energy.economictimes.indiatimes.com/energy-speak/transition-to-electric-cooking-in-india/5041
[42] S. Agrawal, S. Mani, A. Jain, and K. Ganesan, "Are Indian Homes Ready for Electric Cooking Transition? : Insights from the India Residential Energy Survey (IRES) 2020," 2021. [Online]. Available: https://www.ceew.in/publications/are-indian-homes-ready-for-electric-cooking-transition
[43] S. Agrawal, S. Mani, A. Jain, and K. Ganesan, "State of Electricity Access in India: Insights from the India Residential Energy consumption Survey (IRES) 2020," 2021. [Online]. Available: https://www.ceew.in/publications/access-to-electricity-availability-and-electrification-percentage-in-india

Appendix 1: Data Description and Statistics

Variable	Description	Mean	Standard Deviation	Frequencies
Household Demography				
Household Size	Number of members in Household	4.27	2.19	-
Household Economy				
Land Owned (in Ha)	Total land possessed as on the date of survey (in hectares) (owned + leased-in + otherwise possessed + leased-out)	0.17	0.89	-
Monthly Expenditure on Fuel (in Thousands of Rs)	Total value (in Rs) spent on fuels in last 30 days	0.73	0.49	-
Total Monthly Expenditure (in Thousands of Rs)	Total Monthly Expenditure in the last 30 days (in Rs)	2.49	2.15	-
Employment Type	Categorised as: self-employed; salaried; casual labour; others	-	-	self-employed =15258; salaried =15874; casual labour =5263; others =4344
Housing Ownership	Categorised as: owned; hired; no housing; others	-	-	owned =27592; hired =11371; no housing =37; others =1739
New variables				
Number of Meals Served to Non-household Members in One Month	Number of meals served to non-household members during the last 30 days. Categorised as (in numbers): 0; 1 to 5; 6 to 10; 11 to 30; more than 30	-	-	0 =24020; 1to5 =6870; 6to10 =5819; 11to30 =3362; more than 30 =668
Accessibility to PDS	Possession of ration card (yes; no)	-	-	yes =29259; no =11480
Dependent Variables				
Main Cooking Fuel	Categorised as: coke, coal and charcoal; firewood and chips; LPG; cow dung; kerosene; electricity; others	-	-	coke, coal and charcoal =997; firewood and chips =7394; LPG =27989; cow dung =493; kerosene =1788; electricity =228; others =345
Main Lighting Fuel	Categorised as: kerosene; gas; candle; electricity; others	-	-	kerosene =1515; gas =33; candle =104; electricity =38950; others =53