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Towards Sustainable Energy Access: Descriptive Insights on Clean Fuel Adoption in Rajasthan Using NFHS-5 (2019-21)

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Abstract - Access to clean cooking fuel is a cornerstone of India's energy transition, with strong implications for health, gender equality, and sustainable development (SDG 7). While national-level studies highlight progress through initiatives such as the *Pradhan Mantri Ujjwala Yojana (PMUY)*, micro-level variations remain underexplored. This paper provides a district-wise descriptive analysis of clean cooking fuel adoption in Rajasthan using data from the National Family Health Survey (NFHS-5, 2019–21)

The adoption of clean cooking fuel is a pivotal aspect of India's energy transformation, carrying significant implications for public health, gender equity, and sustainable development. While national studies indicate progress driven by initiatives like the Pradhan Mantri Ujjwala Yojana (PMUY), a granular understanding of micro-level variations remains limited. This paper presents a district-specific analysis of clean cooking fuel adoption patterns within Rajasthan, utilizing data from the National Family Health Survey.

The analysis indicates that expanding connections alone, as accomplished through PMUY, is insufficient for a sustainable transition. Rajasthan necessitates interventions tailored to specific districts, integrating financial assistance for affordability, enhancing LPG distribution infrastructure, and aligning with gender and tribal welfare programs. For districts facing geographical challenges, renewable energy sources such as solar and biogas present viable alternatives. By establishing the inaugural district-level descriptive baseline for clean fuel adoption in Rajasthan, this research contributes to the existing body of literature on household energy transitions within India. It strongly advocates the implementation of localized, multifaceted policies to achieve universal access to clean cooking fuel, ensuring equitable progress for all communities.

Keywords: Clean cooking fuel, Energy transition, Household energy choice, Rajasthan, NFHS-5(2019-21).

Introduction - "Access to clean and affordable energy by 2030" is a key objective for developing nations within the UN Sustainable Development Agenda. This ambitious goal, articulated in Sustainable Development Goal 7, highlights the critical role of sustainable energy in fostering economic development, improving public health, and mitigating climate change (Narula & Raj, 2023). Energy transitions in the household sector have become a cornerstone of sustainable development debates. This is particularly relevant for India, where a substantial portion of the population still relies on traditional biomass for cooking and heating, posing significant health and environmental challenges (Waleed & Mirza, 2022). Globally, around 2.1 billion people use solid fuels and other unclean fuel sources in inefficient stoves and open fires, with most belonging to poor households in low- and middle-income nations (World Health Organization, 2024).

India has made significant strides in promoting clean cooking energy access over the past decade, most notably through the Pradhan Mantri Ujjwala Yojana launched in 2016, which aimed to provide subsidized LPG connections to women in economically vulnerable households. Subsequent policies have sought to expand LPG penetration, improve refill affordability, and complement the infrastructure with improved distribution networks. These interventions have contributed to a rapid increase in LPG ownership across the country, as demonstrated in national household surveys like the National Family Health Survey. While impressive, these efforts still contend with challenges such as consistent refill rates and the persistence of fuel stacking behaviors, where households use both clean and traditional fuels concurrently (Bajpayee et al., 2024). The ongoing reliance on biomass, despite increased access to modern fuels, highlights complex interactions between affordability, cultural practices, and fuel accessibility, particularly in rural areas where biomass remains a cost-

effective option for some households (Davi-Arderius et al., 2023).

This persistence necessitates a deeper examination of socioeconomic factors influencing fuel choice, especially in regions like Rajasthan, which exhibits diverse demographic and economic characteristics (Gould et al., 2019). Rajasthan provides a critical case for examining these dynamics. The state is marked by significant socio-economic and ecological diversity, which substantially impacts patterns of household energy use. On one hand, Rajasthan shares India's broader developmental challenges, with nearly three-quarters of its population residing in rural areas and a considerable proportion of households belonging to marginalized Scheduled Castes and Scheduled Tribes. These groups often face heightened energy poverty, characterized by limited access to clean, affordable, and reliable energy sources, which subsequently impacts health, education, and economic well-being. Furthermore, the arid and semi-arid climate, coupled with a high dependence on agriculture, directly influences the availability and cost of traditional biomass fuels, thereby shaping household energy choices and amplifying the challenges associated with energy transition in the state.

Although national surveys and reports provide valuable overviews of LPG adoption and clean energy transitions at the state and country level, they often overlook the fine-grained spatial heterogeneity that shapes adoption patterns. Rajasthan, with its 33 districts, encompasses wide variations in socio-economic profiles, tribal concentration, agricultural practices, and fuel markets. This heterogeneity necessitates a district-level analysis to uncover the specific barriers and facilitators of clean fuel adoption, thereby informing targeted policy interventions.

This research aims to analyze the current state of clean fuel adoption in Rajasthan, leveraging data from the National Family Health Survey, and identifying the key socio-economic determinants influencing household energy choices within the region.The objective is not to establish causality but to provide a systematic and nuanced description that can inform district-focused policy interventions. Such a granular approach is crucial for identifying pockets of energy poverty, tailoring interventions to local realities, and ultimately advancing the broader agenda of sustainable and inclusive development.

Literature Review

Global Perspectives on Clean Cooking Energy Adoption: The transition from traditional biomass fuels to modern cooking energy has been a focal point of global development research for several decades. Scholars have highlighted that energy poverty is not only a technical issue of supply but also a socio-economic and behavioral challenge (Kumar et al., 2017). This transition is critical for alleviating household air pollution, which disproportionately affects women and children and contributes significantly to respiratory and other chronic diseases (Gould et al., 2019). Furthermore, the persistence of fuel stacking, where households concurrently utilize traditional and clean fuels, underscores the complex interplay of economic constraints, cultural practices, and availability of resources, which collectively impedes a complete transition to modern energy sources (Farah et al., 2023).

At the global level, reliance on solid fuels remains widespread, particularly in Sub-Saharan Africa and South Asia, where access to modern energy services has lagged despite rapid economic growth. The health consequences of household air pollution from burning solid fuels are profound, contributing to millions of premature deaths annually, primarily from respiratory infections, heart disease, stroke, and lung cancer.

The drivers of clean fuel adoption globally encompass three main categories: economic, infrastructure, and socio-cultural. Economic elements, such as household income, prevailing fuel prices, and the affordability of clean energy technologies, play a significant role in shaping domestic energy choices (Farah et al., 2023). For instance, Waweru et al. highlights the "energy ladder hypothesis", which posits that households tend to transition to cleaner fuels as their income increases. However, in practice, many households adopt a "fuel stacking" approach, using both clean and traditional fuels simultaneously, indicating that the adoption of clean fuels is rarely a straightforward or uniform process.

Indian Context: Energy Transition and Policy Interventions: India has historically been a global hotspot for traditional fuel use, with large rural populations dependent on firewood, dung, and crop residues. The health burden of indoor air pollution has been severe, with studies linking biomass use to respiratory illnesses, low birth weights, and child mortality (Gupta et al., 2020). Despite this, the country has made significant strides in promoting clean energy, notably through initiatives like the Pradhan Mantri Ujjwala Yojana, which aims to provide liquefied petroleum gas connections to rural and deprived households (Malakar, 2018). Evaluations of PMUY find significant improvements in LPG penetration but also highlight constraints such as affordability of refills, irregular supply, and persistence of traditional cooking practices (Vyas et al., 2021). These challenges suggest that sustained use of clean cooking fuels requires more than just initial adoption, emphasizing the need for broader rural development and targeted interventions beyond initial provision (Mani et al., 2020).

Rajasthan-Specific Studies and Regional Context: Compared to national-level research, the evidence base on Rajasthan remains limited and scattered. Government reports and program documents indicate improvements in LPG connections under PMUY, yet adoption and sustained use vary significantly across the state's districts. Existing studies often focus on macro-level policy evaluations or micro-level case studies in specific villages, leaving a gap in comprehensive, district-level analyses that account for

Rajasthan's unique socio-cultural and environmental context (Kelkar & Nathan, 2021) (Yadav et al., 2024). Studies on tribal communities suggest that traditional cooking practices persist due to cultural preferences and the free availability of fuelwood, especially in forested areas (Gould & Urpelainen, 2018). This persistence necessitates a deeper investigation into the specific drivers and barriers influencing clean fuel adoption within Rajasthan's diverse socio-economic landscape.

The Research Gap: Synthesizing the existing literature reveals three clear gaps. First, while global and Indian studies have firmly established the health, gender, and environmental benefits of clean cooking energy, district-level disparities within states remain underexplored. Second, in Rajasthan, available insights are fragmented, often based on program reports rather than systematic household survey data. Third, the NFHS-5 dataset provides a unique opportunity to conduct a spatially disaggregated, district-wise analysis of clean fuel adoption across Rajasthan's 33 districts, yet this potential remains underutilized.

Thus, the present study fills an important gap by providing a comprehensive, district-level descriptive analysis of clean fuel adoption in Rajasthan using NFHS-5 data. By focusing on intra-state variation, the study contributes to both academic literature and policy practice, offering evidence that can guide more localized, context-specific interventions.

Data and Methodology

Data Source: National Family Health Survey-5 (NFHS-5, 2019–21) : The current research utilizes the National Family Health Survey, which represents the latest iteration of India's Demographic and Health Survey program. This survey, managed by the Ministry of Health and Family Welfare and overseen by the International Institute for Population Sciences in Mumbai, encompasses all Indian states and union territories. Employing a stratified two-stage sampling methodology to ensure robust representation at national, state, and district levels, NFHS-5 conducted interviews in over 31,000 households across Rajasthan's 33 districts. This extensive data collection provides a comprehensive dataset for examining household demographics, health metrics, and living standards, inclusive of cooking fuel usage patterns.

The National Family Health Survey-5 is exceptionally well-suited for investigating the adoption of clean cooking fuels, as it includes direct inquiries about households' primary cooking fuel sources, encompassing both traditional and modern types. The NFHS-5's district-level representativeness offers a distinct advantage for analysing spatial variations within Rajasthan, a granularity not achievable with datasets such as NSSO consumption surveys, which primarily focus on expenditure patterns.

Defining Clean Cooking Fuel: Following the classification adopted by both NFHS and the World Health Organization (WHO), clean cooking fuels in this study include:

1. Liquefied Petroleum Gas (LPG)
2. Piped Natural Gas (PNG)
3. Biogas
4. Electricity

Conversely, polluting fuels encompass firewood, crop residues, dung cakes, coal, lignite, and kerosene. The primary outcome indicator for this analysis is the proportion of households within each district that report clean fuel as their main source of cooking energy. While NFHS-5 also gathers data on secondary fuel sources, this research concentrates solely on the principal fuel utilized to ensure consistency across districts and to emphasize the predominant cooking energy source.

Methodological Approach: The paper employs a descriptive statistical approach to map patterns and disparities in clean fuel adoption.

Key presentation methods include:

1. Summary Statistics: This involves presenting the proportions of households using clean fuel, broken down by district, residence type, and socio-economic groups.

2. Ranking and Classification: Districts are ranked by their clean fuel adoption rates to identify high and low performing areas. Districts are also categorized to facilitate comparison.

3. Visualization:

i. Choropleth maps illustrate the spatial distribution of clean fuel adoption across Rajasthan's districts.
ii. Bar and column charts highlight differences between rural and urban areas, as well as socio-economic disparities.
iii. Tables offer detailed figures for reference.

This multi-faceted descriptive approach ensures a thorough examination of both the extent of adoption and its distribution across space and socio-economic strata.

4. Descriptive Profile of Clean Fuel Adoption in Rajasthan: This section delineates the empirical findings regarding the adoption of clean cooking fuels within Rajasthan, drawing upon data from the National Family Health Survey-5. The examination commences with a statewide perspective, subsequently delving into district-specific trends, disparities between rural and urban populations, and variations attributable to socio-economic factors. Collectively, these analyses illuminate the intra-state heterogeneity in access to clean fuels. Despite significant differentials in household income, the energy mixes across various income strata often shows no substantial difference, suggesting that affordability alone is not the sole determinant of clean fuel adoption.

Table1: Rural vs. Urban Cooking Fuel Usage

Residence	Unclean	Clean	Total
Urban	12.08	87.92	100
Rural	73.79	26.21	100
Total	58.58	41.42	100

Source: Author's calculations using NFHS-5 unit-level data,

2019–21

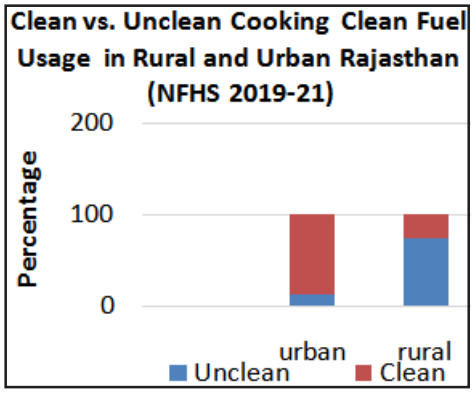


Figure1: Rural vs. Urban Cooking Fuel Usage
Source: Author's calculations using NFHS-5 unit-level data, 2019–21

1. State-Level Overview: Analysis of the National Family Health Survey-5 data for Rajasthan indicates that a mere 41.42% of households utilize clean cooking fuels, such as liquefied petroleum gas, piped natural gas, biogas, or electricity. The remaining 58.58% predominantly rely on traditional, polluting fuels like firewood, dung cakes, and crop residues. As table 4.2 shows This disparity is exacerbated by a significant urban-rural divide: 87.92% of urban households have adopted clean fuels, whereas only 26.21% of rural households have done so, with the latter largely dependent on unclean alternatives. Given that Rajasthan's population is predominantly rural, this imbalance substantially impacts the state average, resulting in a clean fuel penetration rate below 50%. Consequently, while urban centers are largely part of the clean energy transition, rural areas of Rajasthan face considerable energy poverty, underscoring the necessity for targeted policy interventions tailored to these specific contexts.

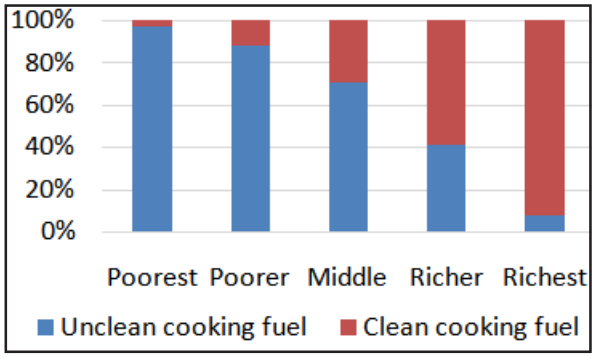
Table 2 as well as Figure 2 illustrate the distribution of clean and unclean cooking fuel usage across different wealth quintiles, as determined by the NFHS-5 wealth index. This index, a composite measure of household living standards based on asset ownership, housing characteristics, and essential amenities, categorizes households into five groupspoorest, poorer, middle, richer, and richestto reflect their relative economic standing within Rajasthan. A significant and consistent correlation is evident between wealth status and energy source selection. The poorest households exhibit a near-total dependence on unclean fuels, with 96.99% utilizing them and only 3.01% reporting clean fuel use. Clean fuel adoption progressively increases with wealth, reaching 11.88% in the poorer quintile and 29.71% among middle-income households. This trend becomes more pronounced in the richer quintile, where 58.96% use clean fuels, outnumbering unclean fuel users. Finally, clean fuel adoption is almost universal at 92.07% in the richest group, with only 7.93% continuing to use unclean fuels. This socio-economic gradient clearly indicates a diminishing reliance on unclean fuels as household wealth increases, visually supporting the "**energy ladder hypothesis"**, whereby households ascend from traditional biomass to cleaner cooking fuels with rising economic status. The data further underscores the critical role of affordability and economic capacity in shaping household energy choices in Rajasthan, suggesting that financial ability, alongside infrastructure and access, is the most influential factor in clean fuel adoption across districts.

Table 2: Clean vs. Unclean Cooking Fuel Usage by Wealth Index

Clean fuel	Poorest	Poorer	Middle	Richer	Richest	Total
Unclean	96.99	88.12	70.29	41.04	7.93	58.58
Clean	3.01	11.88	29.71	58.96	92.07	41.42
Total	100	100	100	100	100	100

Source: Author's calculations using NFHS-5 unit-level data, 2019–21

Figure 2: Clean vs. Unclean Cooking Fuel Usage by Wealth Index



Source: Author's calculations using NFHS-5 unit-level data, 2019–21

The link between financial means and energy choices, as previously discussed, is further supported by considering household education levels (Table 3). Education, much like wealth, shows a strong positive connection to clean fuel adoption. Households with no formal education use clean fuels at a rate of only 25.13%, with the majority (74.87%) still relying on unclean sources. As education levels increase, so does clean fuel use: 34.7% for primary education, 48.84% for secondary education, and a notable 76.22% for higher education. Even among those who reported "don't know," clean fuel use (40.59%) was higher than the state average.

Collectively, the findings from wealth and education profiles indicate a dual trend in the energy transition. The wealth index highlights the importance of affordability and economic status, while the education gradient emphasizes awareness and the ability to adopt modern energy sources. Both suggest that barriers to clean fuel adoption in Rajasthan are not just economic but also socio-cultural. This means the energy ladder hypothesis is influenced not only by income but also by knowledge and awareness, as better-educated households are more likely to recognize

the health, convenience, and efficiency benefits of clean fuels. Consequently, future policies must address both affordability and behavioral aspects to speed up the clean energy transition for rural and disadvantaged populations.

Table 3: Clean vs. Unclean Cooking Fuel Usage in by Education Level

Clean fuel	No Education	Primary	Secondary	higher	Don't know	Total
Unclean	74.87	65.3	51.16	23.78	59.41	58.58
Clean	25.13	34.7	48.84	76.22	40.59	41.42
Total	100	100	100	100	100	100

Source: Author's calculations using NFHS-5 unit-level data, 2019–21

Beyond wealth and educational attainment, an individual's social identity significantly influences energy consumption patterns in Rajasthan. Data indicates a notably high prevalence of unclean fuel use among Scheduled Tribes (85.54%), with clean fuel adoption at a mere 14.46%, the lowest observed across all caste classifications. This disparity can be attributed to the compounded disadvantages faced by tribal communities, often situated in remote areas with limited resources. Conversely, households identifying with no caste affiliation or those categorized as "don't know" exhibit the highest clean fuel adoption rates, at 61.25% and 67.51% respectively. Households belonging to Scheduled Castes and Other Backward Classes (captured under the 'Enter caste' category here) demonstrate intermediate adoption levels, with approximately 44% utilizing clean fuels, closely aligning with the state average.

When analyzed in conjunction with wealth and education gradients, caste-based disparities highlight how interconnected economic, educational, and social disadvantages contribute to energy poverty. Tribal households, frequently experiencing lower incomes, reduced educational opportunities, and greater geographical isolation, represent the most marginalized segment in Rajasthan's clean energy transition. In contrast, socially advantaged groups display substantially higher clean fuel adoption, suggesting an inequitable distribution of benefits from initiatives like the Pradhan Mantri Ujjwala Yojana across different social strata.

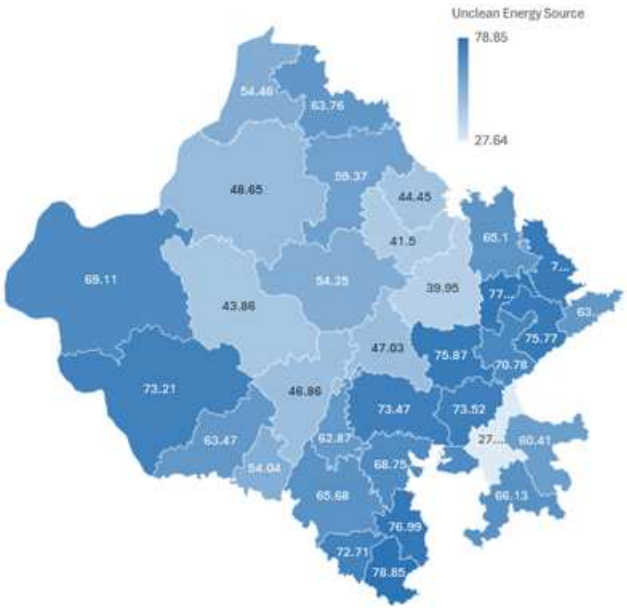
Therefore, while economic capacity enables the procurement of clean fuels and education fosters awareness of their advantages, caste position reflects deeper systemic inequalities that impede access to energy infrastructure. These three dimensions collectively illustrate that clean fuel adoption in Rajasthan is influenced not only by affordability but also by social stratification and exclusion, factors that necessitate specific attention within policy frameworks aimed at achieving universal clean energy access.

2. District-Wise Patterns of Clean Fuel Adoption: The district-wise distribution of dependence on unclean cooking fuels in Rajasthan reveals marked spatial disparities (Figure 3) The district-wise patterns of reliance on unclean cooking fuels in Rajasthan exhibit significant spatial variations. The proportion of households continuing to use polluting fuels ranges from under 30 percent in districts such as Jaipur, Ajmer, and Jhunjhunun, to over 70 percent in southern tribal districts including Dungarpur, Banswara, Pratapgarh, and Udaipur. This uneven distribution is a consequence of the combined effects of geography, socio-economic standing, and demographic composition. Districts characterized by tribal populations and hilly terrains show the highest dependence on unclean fuels, whereas urbanized and economically developed districts report considerably lower reliance.

A more detailed perspective emerges when the rural-urban divide is examined (Table4). In virtually all districts, urban households demonstrate substantially less dependence on unclean fuels compared to their rural counterparts, mirroring the state-level trend previously discussed. For instance, Barmer reports an unclean fuel dependence of 4.57 percent in rural areas versus only 0.65 percent in urban areas. Similarly, Jaipur shows figures of 5.45 percent for rural areas and 12.8 percent for urban areas, although this latter figure represents an anomaly where rapid urbanization and in-migration might have inflated the denominator of biomass-using households in peripheral settlements. Tribal districts like Dungarpur and Banswara continue to reflect a predominantly rural pattern of unclean energy dependence, underscoring structural limitations in access, affordability, and awareness.

Table 4 (See in alst page)

Figure 3: Rajasthan: District-wise Dependence on Unclean Cooking Fuel



Source: Author's calculations using NFHS-5 unit-level data, 2019–21

Discussion, and Policy Implications: The examination

of clean cooking fuel adoption within Rajasthan, one of India's largest and most varied states, offers critical insights into how socio-economic, cultural, and infrastructural elements influence energy transitions. Despite significant national progress in expanding access to modern energy sources, notably through programs like the Pradhan Mantri Ujjwala Yojana, the Rajasthan data indicates that mere access does not guarantee sustained utilization. The continued prevalence of unclean fuel use among substantial population segments underscores the intricate interplay of affordability, prevailing social structures, and geographical inequities. This analysis reveals that the transition to clean fuels is a multi-dimensional challenge, extending beyond simple provision to encompass behavioral, economic, and systemic factors (Bajpayee et al., 2024).

Socio-economic structure and its influence on adoption: Rajasthan's energy landscape mirrors a national trend of gradual migration from traditional biomass to modern cooking fuels. However, the extent and speed of this transition exhibit significant disparities across districts, communities, and income strata. Urban centers such as Jaipur, Ajmer, and Alwar demonstrate high clean fuel utilization, contrasting with the substantial reliance on biomass in rural tribal and desert regions. This divergence reflects Rajasthan's dual economic structure, characterized by an urban sector driven by services and industry, and a rural sector predominantly engaged in subsistence agriculture and traditional practices.

Tribal concentration and cultural determinants: Tribal populations significantly influence Rajasthan's energy choices. Districts like Dungarpur, Banswara, Udaipur, and Pratapgarh, with large tribal communities, show much higher use of unclean fuels. This is due to poverty, cultural habits, and easy access to resources like firewood. People are used to traditional cooking methods and often see fuelwood as free. Collecting fuelwood can also be a shared community or women's activity. Studies show that when biomass is easily available, just offering money incentives isn't enough to change behavior. Rajasthan's tribal areas are a clear example of how cultural and environmental factors keep people using fuelwood. This underscores the necessity of culturally sensitive interventions that acknowledge and integrate existing practices, rather than solely focusing on the provision of cleaner alternatives (Gould et al., 2019).

Rural poverty and affordability constraints: Affordability is a major hurdle to continued LPG use. Although PMUY successfully provided more LPG connections in Rajasthan, many rural households find the cost of refills prohibitive. In poorer districts, the need to cover essential expenses often forces households to return to using biomass instead of buying a gas cylinder. This situation aligns with national research, which indicates that the ongoing expense of clean fuels, rather than the initial availability, is the primary factor determining their sustained use. This cost barrier is particularly significant in rural Rajasthan, where household earnings fluctuate, work is seasonal, and money is mostly spent on food. Consequently, the use of clean fuels in these areas is vulnerable to financial setbacks, making adoption inconsistent and precarious.

Comparisons with national findings: National surveys, such as the National Family Health Survey and the India Human Development Survey, show steady progress in adopting clean fuels. While urban areas are close to universal coverage, rural areas are gradually improving. Rajasthan's progress aligns with this national trend, but with two key differences:

1. **A wider rural-urban gap:** The difference between rural and urban households in Rajasthan is larger than the national average, indicating deeper inequalities.
2. **More varied within the state:** National surveys often hide the disparities seen at the district level. Rajasthan shows extremes, with districts like Ajmer and Alwar achieving significant clean fuel adoption, while Banswara, Barmer, and Dungarpur lag far behind.

These differences suggest that state- or national-level averages cannot fully capture the complexity of energy transitions. Rajasthan's situation highlights the need for local analyses that consider local conditions, cultural practices, and geographical challenges.

Policy interpretation: Ujjwala Yojana and beyond: Thus, while Ujjwala has succeeded in improving *access*, it has not addressed sustained affordability and reliability. In Rajasthan, the limitations of PMUY are especially stark because of the state's socio-economic diversity and challenging geography. The main bottlenecks are:

1. **Affordability of refills**, which discourages regular use.
2. **Distributional gaps**, especially in tribal and desert areas.
3. **Cultural inertia**, where households perceive biomass as sufficient.

Intra-state inequality: lagging districts and marginalized groups: One of the most striking findings is the persistence of intra-state inequality. Urbanized districts such as Jaipur and Alwar enjoy better infrastructure and higher incomes, enabling sustained clean fuel use. In contrast, tribal districts in the south and desert districts in the west remain far behind. Moreover, caste and social identity play an important role. The analysis shows that Scheduled Tribes and marginalized caste groups disproportionately rely on unclean fuels. This intersection of poverty, geography, and social exclusion creates overlapping disadvantages, reinforcing the cycle of energy poverty.

Such inequalities underline the inadequacy of "one-size-fits-all" policies. Without district-sensitive strategies, state-level averages risk obscuring the fact that certain regions and groups are systematically left behind.

Conclusion: The evidence shows that Rajasthan faces significant challenges in providing clean cooking fuel to everyone, despite national progress. Key issues include:

1. Continued use of unclean fuels, especially in rural, tribal, and desert areas.
2. There is a large gap between rural and urban areas due to cost and infrastructure problems.
3. Unequal progress within the state, with marginalized groups still relying heavily on biomass.

This study provides a detailed look at individual districts, going beyond general statistics to show the variety in Rajasthan's shift to cleaner energy. This local view highlights that adopting clean energy is tied to social, economic, cultural, and environmental factors, requiring flexible and varied policy solutions.

From a policy perspective, it's clear that one-size-fits-all plans for Rajasthan won't work. Instead, strategies tailored to each district are needed. These should include help with the cost of fuel refills, better infrastructure, renewable energy options, and links to programs for women and tribal communities.

Future research should build on this descriptive analysis with studies that track changes over time and explore cause-and-effect relationships in household behavior. Understanding why people continue to use multiple types of fuel, the influence of cultural habits, and the long-term effects of financial support will be important. Additionally, qualitative studies on gender roles and community practices can add richer insights to quantitative surveys about adoption trends.

In summary, Rajasthan reflects both the successes and the limitations of India's clean energy efforts. While large programs have increased access, deep-rooted inequalities continue to leave many people behind. A more inclusive, district-focused, and sustainable approach is necessary to ensure that everyone gains access to clean cooking fuel.

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Table 4: Rural vs. Urban District-wise Unclean Cooking Fuel Usage

S.	District	Rural	Urban	S.	District	Rural	Urban	S.	District	Rural	Urban
1	Ganganagar	2.8	2.83	**12**	Jaipur	5.45	12.8	**23**	Bundi	2.19	2.23
2	Hanumangarh	2.84	5.72	**13**	Sikar	2.63	3.68	**24**	Bhilwara	2.93	3.78
3	Bikaner	2.7	0.66	**14**	Nagaur	4.65	4.24	**25**	Rajsamand	2.07	1.45
4	Churu	3.02	3.53	**15**	Jodhpur	3.9	5.3	**26**	Dungarpur	2.99	0.12
5	Jhunjhunun	2.28	5.14	**16**	Jaisalmer	1.18	0.38	**27**	Banswara	4.19	0.69
6	Alwar	5.71	4.97	**17**	Barmer	4.57	0.65	**28**	Chittaurgarh	2.99	3.22
7	Bharatpur	4.16	6.21	**18**	Jalor	3.35	1.43	**29**	Kota	1.4	3.76
8	Dhaulpur	1.85	1.93	**19**	Sirohi	1.5	1.42	**30**	Baran	2.09	0.78
9	Karauli	2.77	2.47	**20**	Pali	2.72	0.59	**31**	Jhalawar	2.64	1.52
10	Sawai Madhopur	2.39	3.17	**21**	Ajmer	2.95	3.81	**32**	Udaipur	5.52	3.88
11	Dausa	3.02	2.38	**22**	Tonk	2.56	4.75	**33**	Pratapgarh	1.99	0.51

Source: Author's calculations using NFHS-5 unit-level data, 2019–21

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