



From Hearth to Wellbeing: Clean Cooking, Women's Welfare and Socioeconomic Development in Agricultural Households

T. S. Ajayan¹, Anjali Dhengle², Deepak Kumar³ and Anived Mishra⁴

¹Research Scholar, ^{2,3}Assistant Professor, Department of Humanities and Social Sciences, Maulana Azad National Institute of Technology, Bhopal, Madhya Pradesh, India

⁴Research Scholar, Department of Political Science, Institute for Excellence in Higher Education, Bhopal-462026, Madhya Pradesh, India

*Corresponding author email id: ajayan22ts@gmail.com

HIGHLIGHTS

- Economic independence was the strongest determinant of improved living standards.
- Social participation and LPG refill affordability enhanced rural household well-being.
- PMUY supports agricultural livelihoods through women's socio-economic empowerment.

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Reviewed by: Siti Amanah (siti_amanah@apps.ipb.ac.id); Simple Jain (simplejain2@sdau.edu.in); Adi Firmansyah (adifirman@apps.ipb.ac.id)

ABSTRACT

Clean cooking is an important rural development issue for agricultural households because it can reduce women's domestic drudgery and promote their participation in household and community activities. Although the Pradhan Mantri Ujjwala Yojana (PMUY) has expanded LPG access among economically disadvantaged rural households, its welfare outcomes remain underexplored. This cross-sectional study examined the socioeconomic determinants of perceived living standards among 279 women PMUY beneficiaries in rural Madhya Pradesh, selected through multistage stratified random sampling during 2025. An Ordered Logit Model and Average Marginal Effects were used for analysis. The model was statistically significant ($LR \chi^2 = 130.92, p < 0.001$). Education, perceived health improvement, refill affordability, social participation, perceived LPG safety, decision-making respect, and economic independence were positively associated with higher perceived living standards, whereas income increase, reported by only 3% of respondents, showed a potentially fragile negative association. Refill affordability, social participation, and economic independence had the largest marginal effects. The findings highlight the importance of sustained refill affordability, women's agency, and social participation in improving perceived welfare and underscore the role of extension institutions in promoting awareness, refill support, and women-centred livelihood interventions.

INTRODUCTION

Rural development in agricultural communities depends not only on farm production and household income, but also on the health, time use, social participation, and decision-making capacity of rural households. Access to clean cooking energy is therefore relevant to agricultural and rural development, particularly in low-

and middle-income countries (Mounika et al., 2026). Energy poverty limits access to modern fuels and reinforces multidimensional deprivation through reduced health, educational opportunities, economic participation, and community engagement. Rural women and children bear a disproportionate burden because they are often responsible for biomass collection and cooking, leading to prolonged smoke exposure and time-intensive domestic

work (International Energy Agency, 2020). Affordable, reliable, and sustainable modern energy is consequently linked with SDG 7, gender equality, and improved well-being (Rao & Pachauri, 2017; Elavarasan et al., 2021).

Many rural households continue to depend on firewood, crop residues, and animal dung for cooking. This dependence contributes to household air pollution, environmental degradation, health risks, and social inequality (Guta et al., 2024; Byaro et al., 2024). For women in agricultural households, the labour involved in fuel collection and cooking may reduce the time available for farm activities, income-generating work, skill development, and participation in local institutions. Clean cooking is therefore not only an energy-access concern; it is also associated with women's welfare, social inclusion, and inclusive rural development. The transition to cleaner fuel may create conditions that enable women to participate more effectively in household, social, and livelihood activities.

The PMUY, launched in 2016, provides subsidised LPG connections to women from economically disadvantaged households in India (NITI Aayog, 2020). In agricultural households, access to LPG may reduce cooking-related drudgery and support improvements in health, safety, social participation, and women's agency. Previous studies have examined PMUY mainly in relation to LPG adoption, affordability, usage, and household energy transitions (Dash et al., 2018; Gould & Urpelainen, 2018; Swain & Mishra, 2020). However, limited attention has been given to perceived living standards as a broader welfare outcome and to how PMUY-related factors such as affordability, health, social participation, safety, decision-making, and economic independence are associated with women's perceived welfare. This study addresses this gap by examining the socioeconomic determinants of perceived living standards among women PMUY beneficiaries in rural agricultural households, providing a broader assessment of PMUY outcomes beyond LPG adoption and use.

This study addresses that gap by examining the socioeconomic determinants of perceived living standards among 279 women PMUY beneficiaries in rural agricultural households in Madhya Pradesh. By integrating affordability, health, social participation, perceived safety, respect for decision-making, and economic independence within a single empirical framework, the study provides evidence for rural development and women's welfare. The findings can help extension agencies, self-help groups, Gram Sabha platforms, and local institutions design targeted awareness, refill support, and women-centred livelihood interventions.

METHODOLOGY

The study was conducted in 2025 in rural Madhya Pradesh, India, selected for its large rural and agricultural population and continued need for clean cooking among economically disadvantaged households. The study sample was drawn from 8 districts and 16 villages, with 16 respondents selected from each village, yielding a total of 279 women participants. Eight districts, Vidisha, Raisen, Rajgarh, Sehore, Dewas, Ujjain, Hoshangabad, and Damoh, were purposively selected to capture socioeconomic, agricultural, and PMUY coverage variations. The study included women PMUY beneficiaries from agricultural households. Agricultural status was

verified based on the household's primary livelihood, while village-level PMUY beneficiary lists served as the sampling frame. Eligible women were randomly selected. Informed consent was obtained from all respondents, and the study followed the ethical principles of the Declaration of Helsinki.

A multistage stratified random sampling technique was employed. Districts were selected in the first stage, followed by the selection of villages and eligible women beneficiaries through random sampling. Data were collected through personal interviews using a pre-tested structured interview schedule. The sampling approach was based on previous studies of clean cooking adoption and women's decision-making in rural households (Swain & Mishra, 2020).

The required sample size was estimated at a 95% confidence level and a 5% margin of error using the formula:

$$n = \frac{[Z^2 \times p \times (1 - p)]}{E^2}$$

where, $Z = 1.96$, $p = 0.24$, and $E = 0.05$. Based on an estimated PMUY beneficiary population of 1,484,028 households, the required sample size was 280 (Ministry of Petroleum and Natural Gas, n.d.; Ranjan et al., 2025). After data screening, 279 complete and valid responses were retained for analysis. Primary data were complemented with official PMUY and government records.

The dependent variable was women's perceived standard of living after PMUY benefits, measured using the question, "How would you rate your household's standard of living after receiving PMUY benefits?" Responses were coded 1 = poor, 2 = good, and 3 = very good. The questionnaire was pre-tested for clarity and suitability before the survey. Education was coded as an ordered score according to the highest educational attainment; LPG refill affordability and social participation were similarly measured using ordered categories. Health improvement, income increase, LPG safety, decision-making respect, and economic independence were coded 0 = no and 1 = yes. An Ordered Logit Model was used because the dependent variable was ordinal, and Average Marginal Effects were estimated to facilitate interpretation (Asiama & Ankrah, 2026). The model was specified as:

$$\text{Logit} [P(Y_i \leq j)] = \alpha_j - (\beta_1 \text{ Education} + \beta_2 \text{ Health improvements} + \beta_3 \text{ Affordability} + \beta_4 \text{ Social gatherings} + \beta_5 \text{ Income increase} + \beta_6 \text{ Safe gas} + \beta_7 \text{ Decision respect} + \beta_8 \text{ Economic independence})$$

where (Y_i) denotes the living-standard category, (j) the threshold, (α_j) the threshold parameters, and (β) the estimated coefficients. Results were reported as odds ratios, p-values, and Average Marginal Effects, with significance assessed at 5%.

RESULTS

Factors associated with perceived living standards

The results of the Ordered Logit Model are detailed in Table 1. The model demonstrated statistical significance (LR $\chi^2 = 130.92$, $p < 0.001$), with a pseudo- R^2 of 0.267. Factors such as education, perceived health improvement, refill affordability, social participation, LPG safety, respect in decision-making, and economic

Table 1. Ordered logit result

Variable	Coefficient	Odds Ratio	Std. Error	z-value	p-value	AME (%)	95% CI (Lower)	95% CI (Upper)
Education	0.013	1.013	0.005	2.88	0.004	+1.8%	0.004	0.022
Health improvements	0.278	1.320	0.090	3.09	0.002	+4.3%	0.102	0.454
Affordability	0.967	2.632	0.192	5.03	0.000	+15.1%	0.590	1.345
Social gatherings	1.176	3.244	0.226	5.21	0.000	+18.3%	0.733	1.619
Income increases	-1.743	0.175	0.749	-2.32	0.020	-27.2%	-3.212	-0.274
Safe gas	0.157	1.170	0.063	2.48	0.013	+2.4%	0.033	0.281
Decision respect	0.252	1.287	0.118	2.15	0.032	+3.9%	0.022	0.482
Economic independence	1.259	3.522	0.316	3.98	0.000	+19.6%	0.639	1.878
Cut 1	2.271		0.860				0.584	3.958
Cut 2	6.531		0.948				4.671	8.390
No. of Obser	279							
LR chi ²	130.92							
Prob>chi ²	0.000							
Pseudo R ²	0.267							
Log likelihood	-179.511							

independence were positively correlated with higher perceived living standards. Notably, economic independence, social participation, and refill affordability exhibited the strongest associations. Conversely, an increase in income was found to be negatively related to perceived living standards. Concerns regarding multicollinearity were minimal (mean VIF = 1.26). To ensure robustness, a Generalized Ordered Logit model was also estimated, yielding consistent findings; the Wald test results were not significant (χ^2 (7) = 8.09, p = 0.324). All analyses were carried out using Stata.

Average marginal effects (AME)

The AME presented in Table 1 indicated the magnitude of association between the explanatory variables and the probability of reporting a higher perceived living standard. Education increased this probability by 1.8 percentage points, while perceived health improvement increased it by 4.3 percentage points. Refill affordability increased the probability of reporting a higher perceived living standard by 15.1 percentage points. Participation in social gatherings increased this probability by 18.3 percentage points. Perceived LPG safety and decision-making respect increased the probability by 2.4 and 3.9 percentage points, respectively. Economic independence had the largest positive marginal effect, increasing the probability of reporting a higher perceived living standard by 19.6 percentage. In contrast, income increase reduced this probability by 27.2 percentage points.

Goodness-of-fit of the model

The goodness of fit tests (Table 2) indicated no significant difference between observed and model predicted frequencies (Pearson χ^2 = 0.073, df = 2, p = 0.964; Deviance χ^2 = 0.057, df =

2, p = 0.972). With both p values well above 0.05, the ordered logit model demonstrates an acceptable fit. The low degrees of freedom reflect the limited number of distinct covariate patterns/groups used in the test, rather than the number of predictors, and therefore should be interpreted as a property of the grouping structure.

DISCUSSION

The findings suggest that PMUY's rural development contribution extends beyond LPG access to broader dimensions of women's well-being, including health, safety, social participation, decision-making, and economic agency. This indicates that rural extension interventions should view clean cooking as part of an integrated livelihood and women's empowerment strategy. Sustained benefits, however, depend on affordable and regular LPG refills. When refill costs compete with food, health, education, and agricultural expenditures, households may continue using biomass alongside LPG. Thus, PMUY's effectiveness depends not only on providing connections but also on enabling sustained use, consistent with evidence identifying refill affordability as a key constraint among economically vulnerable households (Guta et al., 2024).

Social participation is also positively associated with perceived living standards. Women who participate in social gatherings may have greater access to self-help groups, community meetings, informal support networks, and local information channels. These platforms can strengthen social inclusion and facilitate awareness of livelihood, welfare, and energy-related opportunities (Rathour et al., 2022). The finding aligns with studies linking cleaner cooking practices to reduced domestic drudgery, increased social participation, and community-level benefits (Behera et al., 2015; Gould & Urpelainen, 2018). Although the present study does not measure time saved from fuel collection or cooking, the association indicates that women's participation is an important dimension of rural development.

Economic independence has the largest positive marginal effect among the significant positive variables, indicating that greater

Table 2. Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	0.073	2	0.964
Deviance	0.057	2	0.972

economic independence is associated with higher perceived living standards. This may reflect women's greater participation in household decisions, livelihood activities, and community institutions, consistent with research highlighting women's agency in cleaner-fuel adoption and rural welfare (Swain & Mishra, 2020). Education, perceived health improvement from reduced smoke exposure, LPG safety, and decision-making respect further indicate that perceived welfare extends beyond material conditions and includes social, health, and agency-related dimensions (Rao & Pachauri, 2017; Melin et al., 2021). The negative association for income increase requires particular caution because only 3.0% of respondents reported an increase, raising the possibility of estimation instability or quasi-complete separation. A sensitivity analysis excluding this variable showed that the principal effects of affordability, social participation, and economic independence remained positive and statistically significant, with similar odds ratios to the full model. Thus, the negative income-increase coefficient should not be interpreted as evidence that higher income reduces perceived welfare.

The findings suggest that maximising the welfare benefits of PMUY requires policy interventions beyond LPG connection provision. Improving refill affordability through targeted support, adapting implementation to local socioeconomic conditions, strengthening awareness through PAHAL and Gram Sabha platforms, and promoting women's livelihood opportunities and community participation can support sustained clean cooking adoption and inclusive rural development. Extension agencies, self-help groups, Gram Sabha platforms, and local institutions can further assist vulnerable households through awareness, refill-related support, and livelihood linkages (World Health Organization, 2016; Sharma & Dash, 2022). However, this study has several limitations. The cross-sectional design permits identification of associations rather than causal relationships, while the single-state setting may limit generalisability to all PMUY beneficiaries. In addition, both the explanatory and outcome measures are based on self-reported perceptions and may therefore be subject to recall and social-desirability bias. This possibility is particularly relevant because PMUY is a government welfare programme, which may have encouraged some respondents to report more favourable perceptions of its benefits. Future research should use longitudinal designs, broader geographical coverage, objective measures of LPG use and expenditure, and validated measures of extension exposure to strengthen causal inference and reduce potential reporting bias.

CONCLUSION

The study highlights that the welfare potential of PMUY depends not only on LPG connections but also on sustained affordability, women's agency, and social participation. Policy efforts should therefore move beyond connection coverage towards measures supporting regular refill use and women-centred livelihood and community engagement. Rural extension agencies, self-help groups, Gram Sabha platforms, and local institutions can contribute through targeted awareness, information on refill support, and livelihood linkages. However, the findings have important limitations. The cross-sectional design prevents causal inference, while the single-state setting limits generalisability. Further, reliance

on self-reported explanatory and outcome measures may introduce recall and social-desirability bias, particularly because PMUY is a government welfare programme. Future research should employ longitudinal designs, broader geographical coverage, objective measures of LPG use and expenditure, and validated measures of extension exposure. Such evidence can strengthen understanding of PMUY's sustained welfare effects and support more equitable clean-cooking interventions.

DECLARATIONS

Ethical approval and consent to participate: The study involved no invasive procedure on human participants as such the committee of Department of Humanities and Social Sciences, Maulana Azad National Institute of Technology, Bhopal, Madhya Pradesh, India waived the ethical approval. Informed consent was obtained from all respondents before data collection. The respondents were informed about the purpose of the study, and their participation was voluntary.

Data availability statement: Data is available upon reasonable request from the first author as well as corresponding author.

Conflict of interest: The authors declare that there is no conflict of interest regarding the publication of this manuscript. All authors have critically reviewed, revised and approved the final version of the manuscript and take full responsibility for its content.

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