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Post-Adoption Satisfaction and Policy Demand Paradox among Household Solar Users in Ladakh

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HIGHLIGHTS

- Financially stable and satisfied households showed the strongest demand for continued subsidies, contradicting equity assumptions.
- Financial barriers significantly reduced post-adoption satisfaction but did not increase subsidy demand among poorer households.
- Financial capability, not satisfaction or attitude, significantly predicts policy support demand, whereas K-means clustering exposed a dominant Happy Rent-Seeker group benefiting disproportionately from universal subsidy schemes.

ARTICLE INFO

Keywords: Solar energy adoption, Post-adoption satisfaction, Principal component analysis, K-means cluster analysis.

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ABSTRACT

The study aimed to identify factors that influence satisfaction after-adoption and explain why households continue to request government support despite owning functional solar systems. Using a quantitative cross-sectional design, primary data were collected in 2025 from 440 selected solar-adopting households in Ladakh through a primary field study. A structured questionnaire captured demographic, financial, attitudinal, technical, and environmental variables. The analysis employed Principal Component Analysis (PCA) to extract latent constructs, logistic regression to determine predictors of policy demand, and K-means clustering to segment adopters into behavioural groups. The results showed that financially stable and highly satisfied households unexpectedly exhibit the strongest demand for continued subsidies, while financially constrained users report lower satisfaction but have limited policy influence. Three clusters emerged: Happy Rent-Seekers, Contented Independents, and Struggling Dissatisfied, revealing subsidy capture by wealthier users. The study concluded that universal subsidies contribute to inequitable resource distribution and recommends shifting toward targeted, performance-based support, enhanced maintenance services, and improved post-adoption monitoring. This research contributed novel empirical evidence on post-adoption dynamics in high-altitude regions, highlighting the need for policy frameworks that align financial support with household needs.

INTRODUCTION

The world now understands that sustainable energy stands as a basic requirement because countries work to solve climate change, their growing energy vulnerabilities, and ongoing environmental damage (Najam & Cleveland, 2003; Elum & Momodu, 2017). Solar energy stands as the primary renewable energy source because it provides an abundant supply that can be expanded easily while being friendly to the environment (Haq et al., 2024; El-Afifi, 2024). The photovoltaic system produces electricity through an emission-free process, which needs only occasional maintenance for rural areas with their spread-out settlements (Hosseini & Wahid, 2020). The worldwide implementation of solar power systems has increased because solar panel installation expenses have dropped while PV

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module efficiency has improved (Al-Mohamad, 2004; Upreti et al., 2023). The adoption of solar power systems in households depends on various social and economic factors, like public knowledge about solar power, the costs of installation, the reliability of solar systems, and environmental protection concerns (Zegeye et al., 2025; Kumar & Rathore, 2023). The Indian environment provides an excellent setting to research solar power systems because the country houses 18% of worldwide inhabitants, and its power consumption relies on coal (Khare et al., 2013). The Indian government launched major renewable energy programs through the National Solar Mission to create self-sufficient solar technology systems (Chandel et al., 2016).

The Union Territory of Ladakh is cold desert climate, scattered settlements, and fragile ecosystem create persistent challenges for grid-based electrification (Joshi & Kothari, 2025). The winter season brings temperatures below –25 °C, while hydropower operations become limited because of frozen water resources; thus, the system depends on backup power systems (Namgyal & Sarkar, 2025). The Ladakh region receives more than 300 sunny days annually with strong solar radiation, which makes solar power an ideal solution, but users encounter various system performance issues and battery breakdowns when temperatures reach extreme lows, and they do not have access to suitable maintenance services (Lahmouri et al., 2019). Research has thoroughly studied how Indian consumers first adopted solar power through different factors, which include their financial status and educational background, their level of knowledge, and their environmental concerns (Etongo & Naidu, 2022; Ahmed et al., 2022). The post-adoption research field lacks sufficient studies because scholars focus on user satisfaction assessment, system performance, system maintenance difficulties, and policy adaptation requirements. The present system reduces the operational duration of systems and decreases user satisfaction. The amount of financial help families need for adoption depends on their adoption process, requiring support from adoption policies (Dhami et al., 2007; Penner, 2024). In an ecologically fragile and remote region like Ladakh, where solar energy is not merely an alternative but a necessity, optimizing post-adoption support is vital for ensuring long-term sustainability, reducing dependency on fossil-based backup systems, and preventing resource misallocation through unintended subsidy capture. The study examines three main research questions, which include how satisfied households need state assistance, how financial constraints affect household policy needs, and how environmental motivations affect government scheme dependency.

METHODOLOGY

The study was conducted in the Union Territory of Ladakh during the year 2025. The Survey was conducted in the districts of Leh and Kargil because these districts presented the best conditions for solar energy exploitation through their distinctive high-altitude cold desert environment (Singh et al., 2023; Namgyal & Sarkar, 2025). The study design used quantitative methods to study solar technology adoption by conducting a cross-sectional survey, which measured all relevant factors. A total of 440 sample households were surveyed, having operational solar energy systems. The study used a structured questionnaire to collect data, which measured different elements of solar adoption. The survey instrument contained five separate sections that assessed different essential areas of study. The survey collected demographic data from participants about their age and gender, their educational background, professional work, financial situation, and family composition. The survey measured how people use energy and their understanding of solar technology systems. The survey evaluated respondents' attitudes and their perceptions about solar technology advantages and disadvantages. The survey evaluated financial aspects through three questions about budget constraints, investment readiness, and the need for financial support. The field work survey assessed environmental and geographical factors by asking participants about their contentment levels, how their community views them, and what policy support they receive.

The survey included nominal-scale questions together with 5-point Likert-scale statements, which measured both participant awareness and their household agreement and perception responses for statistical analysis. The study used a structured multi-stage analytical framework to study how households choose solar energy and their patterns of energy usage. The collected primary data were systematically processed and analyzed using the R statistical programming environment. The study used Data Pre-processing and Reliability Testing, which required them to clean the dataset by fixing missing values and resolving logical errors (Famili et al., 1997). The study used Principal Component Analysis (PCA) to decrease data dimensions while creating three latent factors that represent customer attitudes, financial aspects, and satisfaction levels (Merlino et al., 2022; Yadav et al., 2026; Khalkho et al., 2023). The derived latent scores were subsequently incorporated into a logistic regression model to assess their influence on households' demand for solar-related policy support (Jatav, 2024). The study also applied K-means cluster analysis to analyse adopter diversity because this method enabled researchers to group households based on their actions to determine how subsidies affect their adoption choices by following (Hemalatha & Nayaki, 2014; Pundir et al., 2025; Ofetotse et al., 2021). The study investigated which factors affect the current solar system to keep government solar policy advantages after they install solar panels. The study investigated which particular factors among Ladakh Union Territory solar users drive them to pursue ongoing government financial support and policy support. The study establishes three fundamental hypotheses that combine behavioral economic principles with energy policy theoretical foundations.

RESULTS

The results section revealed and explained the post-adoption satisfaction and solar energy adopters' ongoing need for policy backing in Ladakh's Union Territory. The regression results and adopter segmentation revealed that how economic requirements differ from what actual policy makers prefer. The adoption process mainly involves financially stable family members who serve as the decision-makers for their households.

The adopters show higher educational attainment because more than 58% of them possess undergraduate or postgraduate degrees, which enables them to understand technology and access information better. The data in Figure 1 and 2 demonstrates how education levels

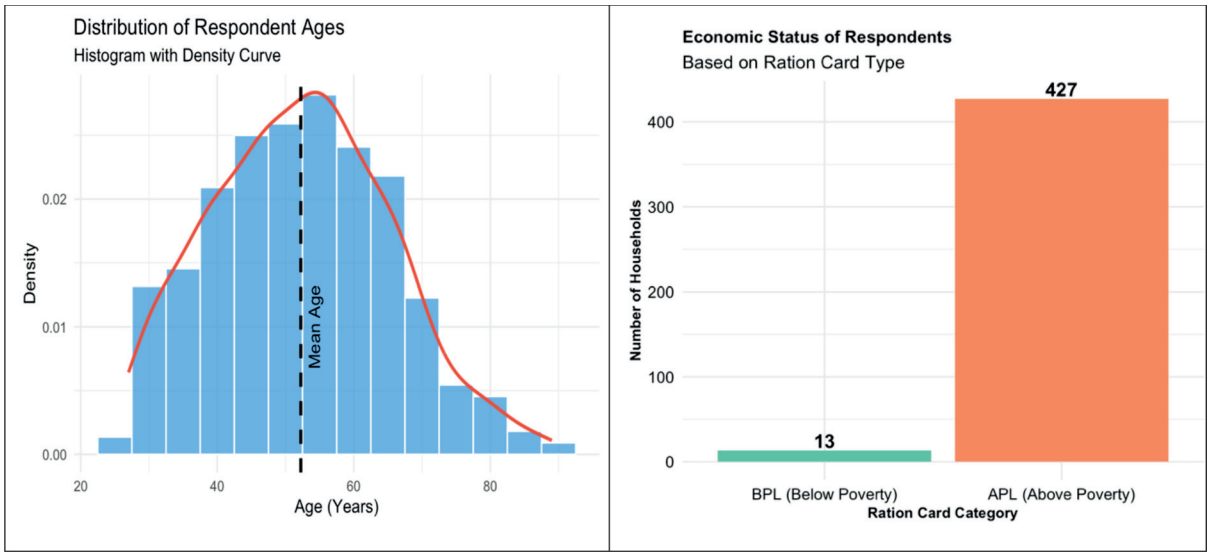

Figure 1. Distribution of respondents' age and economic status (ration card classification)

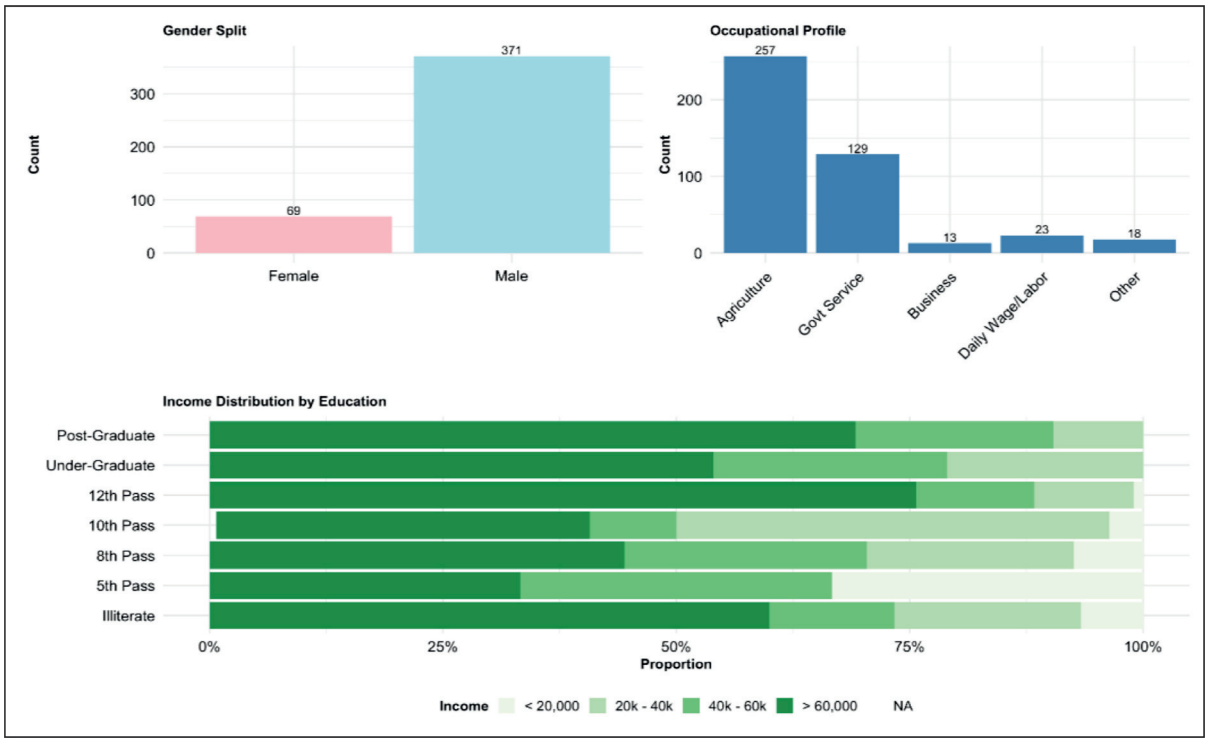

Figure 2. Gender split, occupation profile, and income distribution by education of respondents

affect both income and occupation because government workers and professionals make up the majority of adopters. The absolute numbers show that agriculture continues to be the largest employment sector despite income data showing that solar adopters who used to work in agriculture now earn better salaries. The research findings indicated that high initial expenses, together with institutional entry obstacles, prevent most people from joining the program because they belong to wealthy households that have higher education levels. People need to understand the current social and economic conditions because these factors will determine their reactions to satisfaction assessments and policy standards.

Determinants of policy demand among solar adopters

The research question about existing adopter policy support demand requires a logistic regression model, which uses PCA-derived latent scores to answer the question in Table 1.

The results yield a counter-intuitive but policy-critical insight. Contrary to the Financial Barrier Hypothesis (H2), the logistic regression results indicate that the Financial Barrier Score has a statistically significant negative association with policy demand ($\beta = -1.795$, $p < 0.01$). The odds ratio (OR = 0.166) suggests that a one-unit increase in financial barriers reduces the odds of demanding continued policy support by approximately 83.4%, holding other

Table 1. Logistic regression analysis: Determinants of continued policy demand among adopters

Predictor	Coefficient (β)	Std. Error	z-value	p-value	Odds Ratio (OR)	Sig.
(Intercept)	5.942	2.767	2.15	0.032	380.54	*
Satisfaction Score	-0.537	0.486	-1.11	0.269	0.584	
Financial Barrier Score	-1.795	0.572	-3.14	0.002	0.166	**
Attitude Score	-0.066	0.115	-0.58	0.564	0.936	

Model Fit Statistics: Observations: 440; Null Deviance: 451.22 (df = 439); Residual Deviance: 441.43 (df = 436); AIC: 449.43

factors constant. This implies that households facing greater financial constraints are substantially less likely to request additional subsidies compared to financially stable households. In contrast, post-adoption satisfaction and attitudinal commitment were not statistically significant predictors, indicating that changes in these factors do not meaningfully alter the likelihood of policy demand. The research findings show that economic problems do not affect the amount of subsidy assistance that people require. The financial data showed that capable adopters actively seek out subsidy opportunities because they want to maximize their returns from their successful current investments. The research data indicated that post-adoption satisfaction (H_1) and attitudinal commitment (H_3) do not affect policy demand to any significant extent. Users who achieve complete satisfaction will keep asking for financial help through subsidies because their environmental knowledge does not affect their capacity to develop policies. The research findings demonstrate that financial ability stands as the primary factor that drives policy enforcement rather than need requirements, thus it contradicts the fundamental principle of equity, which supports wide-ranging subsidy programs.

Drivers of post-adoption satisfaction

The Linear regression analysis of post-adoption satisfaction produced different results than the policy demand patterns, which wealthy households controlled, Table 2. The model explains 32% of satisfaction variation through its statistical model (Adjusted $R^2 = 0.314$, $F = 68.09$, $p < 0.001$). Financial stress serves as the main factor that determines how satisfied people become. The Financial Barrier Score shows a powerful negative relationship with satisfaction because households who faced difficulties with system funding costs experienced lower satisfaction after the system became operational ($\beta = -0.722$, $p < 0.001$). Users continue to experience the "pain of paying" effect because they keep their unfavorable financial views about the product even after they have installed it. Users base their satisfaction on financial factors instead of using their overall system usage time during the day. The financial situation of households creates a vital difference because they show lower satisfaction levels, but they do not lead to the demand for subsidies, which proves that current policy systems maintain unfair distribution of benefits.

Demographic concentration of policy demand

The regression results receive additional support from cross-tabulation and chi-square analysis, which examine how different population groups affect the "paradox of policy demand." As shown in Table 3, income level is strongly associated with subsidy demand ($\chi^2 = 23.14$, $p < 0.001$). The highest income group, which earns more than Rs. 60,000, has 179 high-demand households that exceed the total demand from all lower-income groups. The research data includes only a few low-income families who actively participate in policy decisions, yet their collective influence on policy development remains restricted. The data indicated that various professions share the same distribution pattern. The majority of households that need continuous support consist of people who work in government and business ($\chi^2 = 25.01$, $p < 0.001$). The two groups maintain financial stability, which enables them to use their influence to shape institutional decisions according to the theory that subsidy requests originate from dominant economic and political forces rather than vulnerable communities. This demographic concentration confirms that the "cry for support" is emanating from the top of the socio-economic pyramid, raising concerns about distributive inefficiency and policy mis-targeting.

Adopter segmentation and the emergence of happy rent-seekers

To synthesize these findings, K-means cluster analysis (k = 3) was employed to identify distinct adopters (Table 4). The

Table 2. Linear regression results: Technical and financial drivers of post-adoption satisfaction

Variable	Coefficient (β)	Std. Error	t-value	p-value	Sig.
(Intercept)	5.582	0.081	68.57	< 0.001	***
Hours of Daily Access	0.041	0.017	2.48	0.013	*
No Outages (1=Stable)	-0.055	0.022	-2.46	0.015	*
Financial Barrier Score	-0.722	0.053	-13.66	< 0.001	***
Model Summary					
Observations	440				
Multiple R^2	0.319				
Adjusted R^2	0.314				
F-statistic	68.09	(df = 3; 436)		< 0.001	***
Residual Std. Error	0.23				

**Note*: Level of Significance is 5%

Table 3. Household Income, Occupation, and Policy Support Demand: Cross-Tabulation and Chi-Square Results

Income Level	High Demand (Count)	Low Demand (Count)	Total (N)	% High Demand
Level 1 (< Rs. 20k)	6	4	10	60.00%
Level 2 (Rs. 20k–40k)	100	11	111	90.10%
Level 3 (Rs. 40k–60k)	63	9	72	87.50%
Level 4 (> Rs. 60k)	179	67	246	72.80%
Imputed (Mean)	0	1	1	0.00%
Total	348	92	440	79.10%
Chi-Square Statistics	Value: 23.14	df: 4	p-value:	< 0.001*
Primary Occupation				
Govt. Service	210	47	257	81.70%
Business	101	28	129	78.30%
Agriculture	11	2	13	84.60%
Private Sector	20	3	23	87.00%
Other	6	12	18	33.30%
Total	348	92	440	79.10%
Chi-Square Statistics	Value: 25.01	df: 4	p-value:	< 0.001*

Table 4. Taxonomy of solar adopters: cluster analysis of satisfaction, financial barriers, and policy demand

Cluster	Name	Size (N)	Avg. Satisfaction	Fin. Barriers	Policy Demand
1	The Happy Rent-Seekers	320 (73%)	5.0 (Max)	1.04 (Low)	100% (High)
2	The Contented Independents	83 (19%)	5.0 (Max)	1.08 (Low)	0% (None)
3	The Struggling Dissatisfied	37 (8%)	4.0 (Low)	1.46 (High)	76% (High)

resulting segmentation provides the most compelling evidence of subsidy capture.

The largest group, Cluster 1 "The Happy Rent-Seekers", comprises 73% of the sample as shown in Figure 3. The highest level of satisfaction exists in these households because they have no financial challenges, but they require permanent policy support to succeed. The research showed that users who need no financial assistance and have no technical issues continue to request financial assistance at the highest rate. In contrast, Cluster 3 – "The Struggling Dissatisfied", represents only 8% of the sample.

The financial struggles of most households lead to lower satisfaction levels because their collective power does not impact national policy decisions. The "The Contented Independents" cluster from Cluster 2 showed that people who have money but feel unhappy with their life choose to avoid policy work, although this group remains small in numbers. The adopter clusters imply differentiated policies: stricter eligibility and performance-based subsidies for "Happy Rent-Seekers," targeted financial and maintenance support for "Struggling Dissatisfied," and phased subsidy withdrawal for self-reliant "Contented Independents.

DISCUSSION

The research results showed multiple unexpected, important patterns that describe how people of Ladakh use solar energy after adopting it, and these results contradicted the typical findings from previous studies. The results consistently showed that financially stable and highly satisfied households exhibit the strongest demand for continued government subsidies and policy support. The study differs from previous studies because users who have limited resources need monetary help because they cannot find suitable services (Penner, 2024; Dhami et al., 2007; Yang & Zhao, 2015). In the context of Ladakh, however, the relationship is reversed. These findings have important implications for agricultural extension systems that promote renewable energy technologies for rural development and farm resilience. In remote regions like Ladakh, solar energy functions as a critical support technology for agriculture, enabling irrigation, protected cultivation, and post-harvest activities where conventional electricity supply is unreliable. The finding is in line with Gupta et al. (2022). The logistic regression analysis results showed that post-adoption satisfaction and environmental attitudes do not affect policy demand at all. Instead, financial capacity emerges as the strongest predictor. The data showed that users who have more economic resources can initiate policy requests, and they also gain access to existing subsidy programs. The theory of subsidy capture explained this behavior because wealthy households use benefits that were intended to help disadvantaged population groups. The evidence contradicts the Financial Need Hypothesis and confirms that economic vulnerability does not translate into higher policy demand in this region. The demographic analysis supported this interpretation because it showed that 97% of adopters come from households that exceed the poverty line, and high-income groups demonstrate an unusual rise in their policy requests. Research studies about Indian energy adoption show that poor families need financial assistance to decrease their energy costs (Etongo & Naidu, 2022; Ahmed et al., 2022). The region of Ladakh stands as an exception because it follows different solar adoption patterns than the rest of the nation. Research data indicated that people showed approval for policies, yet their actual behavior differed from their stated satisfaction with these policies. Users experiencing the highest satisfaction, including stable electricity access and minimal outages, nevertheless demand

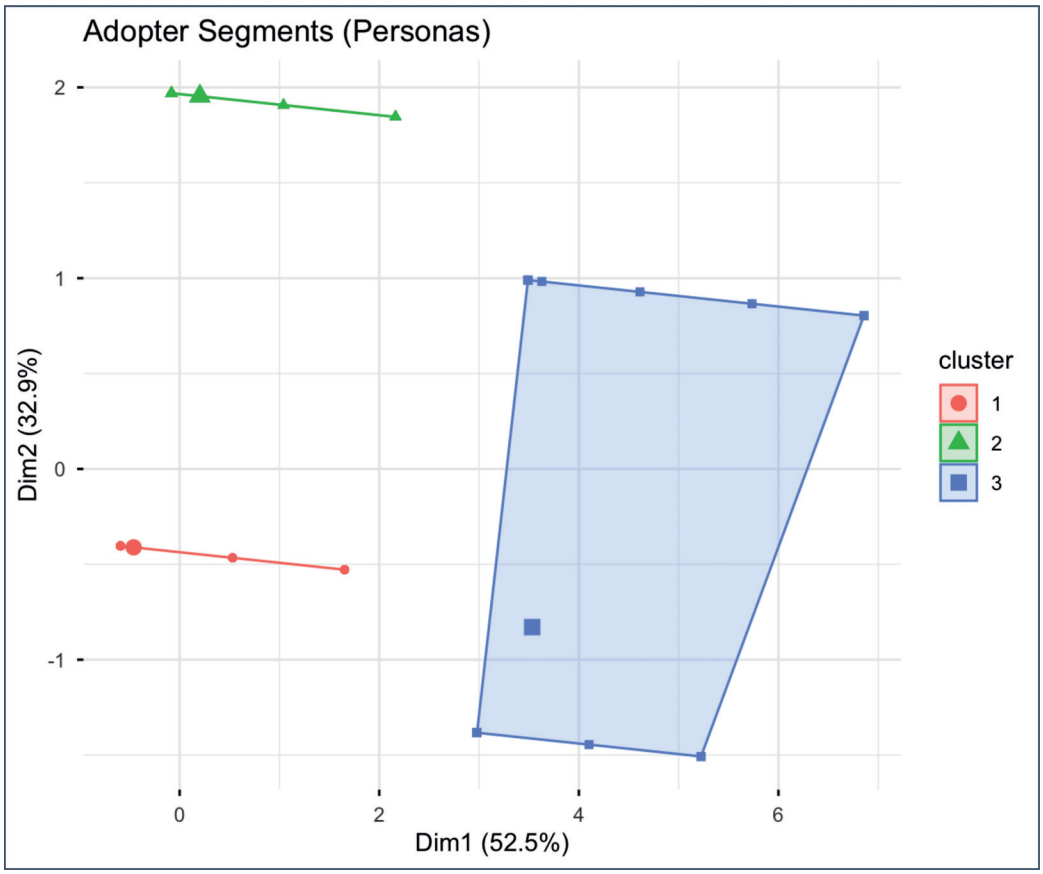

Figure 3. Visualizing adopter personas: K-means cluster plot of satisfaction vs. financial barriers

ongoing subsidies. Users who face financial difficulties show decreased satisfaction after installing because they must continue paying money, but they do not request higher financial support from the government. The outcome demonstrated the pain of paying effect because people experience financial stress, which decreases their satisfaction, but they do not actively work to change policies. The research method of cluster analysis produced the most compelling evidence, which showed that 73% of participants belong to the "Happy Rent-Seekers" group. These users achieve the highest level of satisfaction because they encounter minimal financial obstacles while requiring complete policy backing. The "Struggling Dissatisfied" cluster makes up only 8% of households because it does not have enough economic power to determine which policies should receive priority. This reinforces the argument that universal subsidies benefit those with power rather than those with need. The study showed that the present subsidy system in Ladakh allows people to commit illegal activities for financial benefit, while public funds are distributed incorrectly. The system requires performance-based support systems, which should deliver particular help through better maintenance protocols and ongoing evaluation following implementation to support families who need financial and operational support.

CONCLUSION

The results from descriptive analysis, regression, and cluster methods showed that the aims of solar policies don't really match with the ground happenings. Many users who already have solar systems keep demanding more government help, not because they face technical or financial problems, but mostly because they are already well-off and satisfied. The subsidy requests are not based on financial need, which goes against common assumptions. A small group of users struggles with real money issues, but they form a minority and don't shape policy demand. Cluster results show "happy rent-seekers," users who face no difficulty yet still want support. The study suggests targeted subsidies, better monitoring, and policy reforms for Ladakh's unique conditions. A potential limitation is endogeneity between post-adoption satisfaction and policy demand, as expectations of continued subsidies may influence reported satisfaction; future longitudinal or instrumental-variable studies could better address this and strengthen causal inference.

DECLARATIONS

Ethics approval and informed consent: Informed consent was sought from the respondents regarding the study during the course of the data collection.

Conflict of interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest. The authors declare that during the preparation of this work, they thoroughly reviewed, revised, and edited the content as needed. The authors take full responsibility for the final content of this publication.

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