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Testing Rogers' Diffusion of Innovation Theory: A Study of Household Solar Adoption under the PM Suryaghar Mufti Bijli Yojana in Assam

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Abstract: *Rooftop solar energy is a key component of India's renewable energy transition and its broader commitment to mitigate climate change.To accelerate its adoption, the government of India launched PM Surya Ghar Muft Bijli Yojana (PMSGY), which provides subsidised rooftop solar PV installations. However, the uneven uptake of rooftop solar across regions highlights the need for a deeper understanding of household adoption patterns, supporting factors, and barriers, particularly in states that lag behind in adoption. In this context, Assam presents an important case for analysing adoption dynamics, as despite having the highest installed solar capacity in northeastern India, rooftop solar adoption at the household level remains relatively low. Drawing on the framework of Rogers' Diffusion of Innovations, this study examines households' rooftop solar adoption patterns using a qualitative case study. The findings indicate that the adoption of rooftop solar under PMSGY in Guwahati, Assam, is limited and at an early stage, with adoption predominantly concentrated among late adopters. This can be attributed to the small size of early adopters and the prolonged innovation–decision phase among late adopters. Theoretically, laggards delay adoption because of their traditional and risk-averse tendencies; however, this study indicates that their adoption decision is constrained by awareness, structural, financial, utility, and environmental barriers. Therefore, targeted policy interventions are needed to address these barriers. Furthermore, financial incentives such as subsidised installation can facilitate adoption, raising awareness, and communicating adopters' experiences are essential for accelerating rooftop solar diffusion.*

Keywords: Rooftop solar, Household, Adoption, Diffusion, Assam

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INTRODUCTION

The transition towards renewable energy has become the central component of India's energy policy to meet its rising electricity demand, reduce its dependence on conventional fossil fuels, and fulfil its global commitments to reduce carbon emissions (Bansal 2021; Irfan et al., 2021).

The PM Surya Ghar Muft Bijli Yojana (PMSGY), launched on 15 February 2024, is one of the major policy initiatives promoted by the Indian government to encourage the adoption of rooftop solar as the founding member and host of the International Solar Alliance. This scheme aims to completely transform India's energy landscape by providing solar power to one-crore households by March 2027, and is offering subsidised installations of rooftop solar photovoltaic (PV) systems and free electricity up to 300 units per month for residential consumers. As of December 2025, 23.9 lakh households have already installed rooftop solar under this scheme, accelerating renewable energy adoption, promoting sustainable living, and strengthening India's clean technology ecosystem (PIB, 2025).

Despite government incentives, the adoption of rooftop solar systems is highly uneven (Mohammed and Maheswari, 2025); particularly, the northeastern states are lagging (Patil, 2025). Although Assam has the highest installed solar capacity within this region, the adoption of rooftop solar energy remains relatively low (Das et al., 2023). This highlights the need for a comprehensive analysis of solar rooftop adoption in Assam to understand the diffusion pattern and identify the underlying supporting factors and barriers to adoption, given its strategic location in the northeastern region, infrastructure constraints, and growing electricity demand. In this context, the present study adopts Rogers' diffusion of innovation framework to examine the research questions listed below:

i. What is the pattern of rooftop solar panel adoption among households?

ii. What are the supporting factors and barriers underlying the innovation decision pattern across different adopter categories?

The results indicate that adoption of rooftop solar under the PMSGY is relatively low and at its early stage of adoption in Guwahati, Assam, mainly due to the small size of early adopters, who play a prime role in accelerating the innovation-diffusion process,and a prolonged innovation-decision phase for laggards caused by various barriers. Therefore, policymakers should focus on expanding awareness and sharing adopters' experiences to accelerate the diffusion process.

REVIEW OF LITERATURE

Prasad et al. (2020) reports that when a new technology is launched, government subsidies play a critical role in overcoming the initial risk of investment and facilitating adoption. Qureshi et al. (2017) find that the absence of adequate government financial support acts as a major barrier to household solar PV adoption in Pakistan. Shelly (2014) reveals that environmental considerations may not solely motivate households to adopt residential solar electricity; instead, homeowners are largely motivated by cost reduction. Walters et al. (2018) find that financial incentives and financial barriers strongly influence solar adoption, while environmental motivations and technical barriers are the least important in Santiago, Chile.

El Khozondar and El batta (2022) reveal that knowledge about renewable energy significantly determines households 'solar adoption in the Gaza Strip. Similarly, Alan et al. (2021) find that awareness is the strongest predictor of solar PV adoption in Malaysia. Pandey et al. (2026) find that financial incentives and awareness significantly encourage the adoption of solar across residential, agricultural, and business users in Assam, India. Zulu et al. (2021) states that a positive attitude created by trust and perceived benefit results in a positive intention to adopt solar solutions among households in Zambia.

Overall, the literature suggests that financial incentives, awareness, cost reduction, and perceived benefits shape households' solar adoption behaviour. However, understanding household adoption patterns and how different factors affect various adopter categories has received little attention. Moreover, no literature has specifically examined rooftop solar adoption patterns in the urban residential sector of Guwahati, Assam. Therefore, this study seeks to address this gap in the literature.

THEORETICAL FRAMEWORK

Adoption behaviour relating to innovations and technologies is widely examined through Rogers' Diffusion of Innovation framework. For instance, Shelly (2014), Qureshi et al. (2017), and Alam et al. (2021) applied this framework to examine households' intention to adopt PV solar technology.

Rogers defines innovation as an idea, practice, or object perceived as new by an individual or other unit of adoption. In this study, we consider rooftop solar panels as an innovation to meet household electricity demand while reducing dependence on non-renewable energy sources. Roger states that the adoption of innovation progresses through five stages, namely knowledge, persuasion, decision, implementation, and confirmation, collectively forming the innovation-decision process. The decision stage is particularly critical, as it is affected by various supporting factors and barriers that can shorten the innovation–decision period, prolong it, or, in some cases, lead to rejection of the innovation. The theory classifies adopters into five categories: innovators, early adopters, early majority, late majority, and laggards.It also highlights that opinion leaders and change agents are critical in accelerating adoption decisions.

Therefore, Rogers' diffusion of innovation provides a comprehensive framework for understanding households' rooftop solar adoption patterns in Guwahati. In this study, the framework is applied to analyse the innovation–decision process of households and to evaluate the supporting factors and barriers influencing their adoption decisions. Although Rogers' theory does not consider non-adopters, in this study, we categorised them as laggards to specifically examine the barriers that have prevented them from adopting rooftop solar technology. This, in turn, will be insightful for policymakers to formulate effective solutions so that the innovation-decision outcome of non-adopters can be changed positively towards adoption.

METHODOLOGY

This study examines households' rooftop solar adoption patterns under PM Surya Ghar Muft Bijli Yojana using a qualitative case study. The adoption pattern is conceptualised based on the adopter categories of Rogers Diffusion of Innovation Theory. The case study approach enables an in-depth exploration of households' solar adoption behaviour and identification of the underlying supporting factors as well as the barriers affecting the innovation decision process.

The study was based on primary data collected from a household survey conducted using a structured questionnaire. During the household survey, the household head was interviewed; if unavailable, the spouse or another adult member of the household was interviewed using open-ended questions. The qualitative responses were thematically coded into supporting factors and barriers, and their frequency enabled the identification of major drivers and barriers influencing rooftop solar adoption under the PMSGY in the study area.

The household survey was conducted among 225 households from 30 wards of Guwahati city during July 2025 and January 2026. The sample households were selected using proportionate random sampling according to the number of households in each ward. The study area is Guwahati, which is the largest metropolitan city in Northeast India, and falls under the administrative jurisdiction of Kamrup Metro, Assam. The total geographical area of the city is around 216.79 square kilometers. According to the Census of India (2011), the population of the Guwahati metropolitan area was 963,429. Based on a decennial growth rate of 18percent, the Guwahati Municipal Corporation (GMC) projects the city's population to be 1,136,846 as of 2021.

RESULTS

Rooftop Solar Adoption in the Context of Rogers' Diffusion of Innovation Theory

Following Rogers' diffusion framework, we categorise households as innovators, early adopters, early majority, late majority, and laggards.to identify the predominant category and, in turn, get a clear indication of the prevailing rooftop solar adoption dynamics. The year of installation was 2024, after which adoption began.This year is particularly important to differentiate the categories of adopters based on their innovation decision duration.

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Table 1: Households categorisation based on Rogers' Diffusion Innovation Theory

Status of solar adoption	Category	Number of households	Percentage
Adopted within 6-12 months of launch	Innovators	3	1.33
Adopted after 12-18 months of launch	Early adopters	4	1.78
Adopted after 18-24 months of launch	Early majority	14	6.22
Planning to adopt after 30-36 months of launch	Late majority	49	21.78
Not planned to adopt as of now	Laggards	155	68.89
Total (n)		**225**	**100**

Source: Author's estimation from field survey

Table 1 indicates that rooftop solar adoption in Guwahati and Assam remains relatively low and is at an early stage. Only about one percent of the households installed rooftop solar within 6-12 months the subsidised installation began through the PMSGY, and we have categorised them as innovators because they adopted the technology at the earliest. Early adopters, who play a pivotal role in diffusion dynamics by serving as opinion leaders and reducing uncertainty for subsequent adopters, constitute only about two percent of the sample households. The relatively small size of this critical adopter category may partly explain the slow diffusion of rooftop solar energy. The early majority constitutes roughly six percent, while the late majority is relatively higher at 22 percent.

Factors supporting the adoption of rooftop solar across different adopter categories

Table 2: Thematic classification of interviewee responses to identify the key factors affecting household adoption of rooftop solar

Interviewee response(s)	Identified factor(s)
"I decided to adopt /am planning to adopt solar because the government is providing a subsidy under the PM Surya Ghar Yojana. The financial support makes the installation more affordable."	Financial incentive
"I decided to adopt /am planning to adopt solar because it is a green, environmentally friendly source of energy that reduces pollution and benefits the environment."	Environmental consciousness
"I decided to adopt /am planning to adopt solar to reduce my electricity bill. I expect that by adopting solar, my dependency on electricity will decrease, and therefore, I can save on my electricity bill."	Cost reduction
"I decided to adopt /am planning to adopt solar because some of my relatives and friends have already installed it, and they have given positive feedback."	Social and peer influence
"I decided to adopt /am planning to adopt solar because I have the necessary infrastructure, such as sufficient rooftop space and proper structural support, to install rooftop solar panels."	Supporting infrastructure

Source: Authors' construct

From Table 2, it is evident that five factors primarily support the household solar adoption decision in Guwahati: financial incentive, environmental consciousness, cost reduction, social and peer influence, and supporting infrastructure. Figure 1 shows the effects of these identified factors on household rooftop solar adoption decisions.

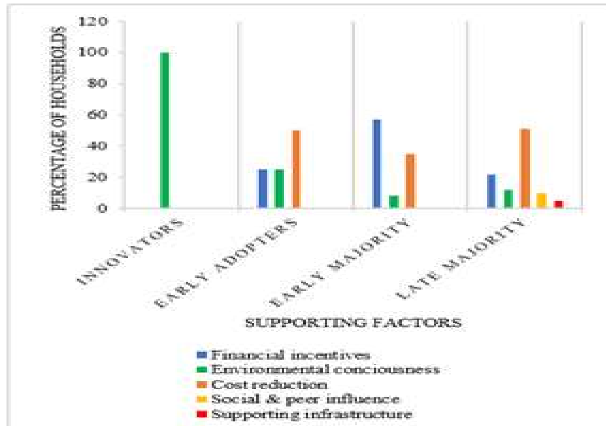

Figure 1: Factors supporting the adoption of rooftop solar among different categories

Figure 1 clearly shows that innovators are solely motivated by environmental consciousness to adopt rooftop solar power. Among the early adopters, almost half have adopted rooftop solar for cost reduction through reduced electricity bill, about one-fourth are motivated by subsidised installation offered by the PMSGY, while the remaining one-fourth are motivated by environmental consciousness.

Nearly 57 percent of early majority households are primarily motivated by financial incentives, whereas about 35percent have adopted rooftop solar mainly to reduce electricity bills. Only Eight percent have reported environmental consciousness as a motivating factor.

Cost reduction is the key factor for 51percent of late majority households. While financial incentives have motivate about 22 percent of respondents, environmental consideration have influenced about 12 percent. Approximately 10 percent of the late majority households have adopted solar after receiving positive feedback from peers and relatives, whereas only five percent have adopted solar due to the availability of supporting infrastructure, such as sufficient rooftop space.

Barriers to rooftop solar adoption

Table 3: Thematic classification of interviewee responses to identify the barriers influencing household rooftop solar adoption

Interviewee response(s)	Identified barrier(s)
"I have not planned to install solar because I am not aware of what advantages I would get from it."	Lack of awareness
"I am not aware of the application, installation, or subsidy process, so there is no plan to adopt solar."	

Interviewee response(s)	Identified barrier(s)
"I cannot adopt solar because I stay in a rented house."	Structural/Dwelling-related barrier
"Since I live in an apartment, I cannot instal solar panels independently. The residents and committee would have to agree collectively."	
"There is not enough space to install rooftop solar in my house, so I cannot adopt solar."	
"I have not considered installing rooftop solar now, because construction work is still ongoing at our house."	
"The initial cost of installing solar is very high for me, so I have decided not to adopt it."	Financial barrier
I tried to avail a bank loan to install rooftop solar, but because of my low CIBIL score, I am not eligible, and hence I should not adopt solar."	
"I don't think solar would be particularly useful for my household, so I haven't adopted it."	Low perceived utility
"I don't believe solar would make much difference, given our current electricity usage."	
"I think the opportunity cost of solar is very high for me, because my electricity consumption is quite low, so investing in solar does not seem worthwhile for me."	
"I don't think solar will be feasible in my area because there are large trees surrounding my house, so I don't think solar panels would receive enough sunlight."	Environmental barriers
"I haven't considered installing rooftop solar because of limited sunlight exposure."	
"I cannot adopt solar because there are monkeys in my area, and there is a high chance that they will damage the rooftop panels."	

Source: Authors' construct

Table 3 clearly identifies five barriers to household solar adoption: lack of awareness about rooftop solar, structural and dwelling-related constraints, financial constraints to installation, low perceived utility of rooftop solar systems, and environmental constraints. The impact of these barriers on laggards' adoption decisions is presented in Figure 2.

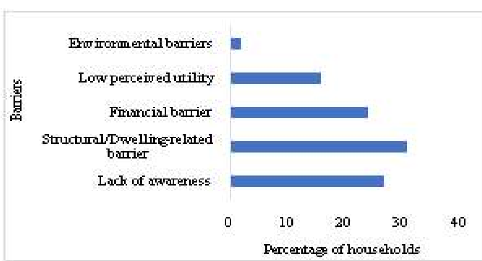

Figure 2: Key barriers of rooftop solar adoption

Figure 2 indicates that structural and dwelling-related barriers constitute the most significant constraint, affecting nearly 31 percent of the laggards. Approximately 27 percent and 24 percent of laggards report a lack of awareness and financial constraints, respectively. Limited perceived utility has discouraged around 16 percent of them from adopting solar. Only about two percent have decided not to adopt rooftop solar due to environmental barriers such as low sunlight and the presence of large trees and monkeys.

DISCUSSION

The findings indicate that rooftop solar adoption through PMSGY in Guwahati, Assam remains relatively low and is presently at an early stage of diffusion. This is evident from the predominance of the late majority and laggards in the sample, resulting in a skewed distribution towards prospective adopters. This pattern can be attributed to the following reasons: First, the proportion of early adopters, who typically act as opinion leaders by accelerating the diffusion process, is very small. Second, the barriers underlying rooftop solar adoption have prolonged the innovation-decision period for laggards, pushing them towards non-adoption.

A clear variation in the timing of adoption across adopter categories is observed, indicating that the innovation-decision period increases progressively from innovators to the late majority. This aligns with Rogers' theory, in which early adopters' innovation decisions are typically shorter than those of late adopters. This can be attributed to early adopters 'greater willingness to experiment with new technologies and tolerate uncertainty. By contrast, late adopters tend to delay their decisions until the innovation is widely accepted and successful installation benefits are observed among relatives or neighbours.

The findings reveal that innovators are exclusively motivated by environmental consciousness to adopt rooftop solar power. This contrasts with the findings of Schelly (2014), in which no respondent reported being motivated solely by environmental considerations to adopt residential solar electricity. Moreover,the decisions of the first three adopter categories primarily rely on financial incentives, cost reductions, and environmental considerations. This finding is consistent with the findings of Prasad et al. (2020), who reported that environmental and financial factors are the strongest motivating factors for solar adoption in Kerala, India. The study indicates that social and peer motivation become more evident among the late majority, who tend to adopt solar after getting positive feedback from their relatives and friends. This pattern is consistent with Rogers' diffusion framework, suggesting that later adopters tend to depend more on social influence and the observed experiences of others before adopting an innovation. This highlights that the demonstration effect has a critical role in the decision phase by reducing the perceived risks and encouraging the adoption of rooftop solar among late majority households.

Even with subsidised rooftop solar installations provided through the PMSGY, a significantly large number of households have not yet planned to adopt it. A major constraint for them is structural or dwelling-related barriers, as they live either in rented houses or apartments. In addition, lack of awareness, environmental constraints, financial constraints, and low perceived utility further prolong the innovation-decision stage, often leading to rejection of the innovation. Traditionally, in Rogers' diffusion of innovation theory, laggards are portrayed as individuals who delay the adoption of innovations and are characterised as traditional and risk-averse. However, the findings of this study suggest that delayed adoption may not be solely driven by behavioural traits; instead, it could be attributed to various barriers to adoption, particularly situational factors like dwelling characteristics and environmental factors.

CONCLUSION

Rooftop solar energy is an integral part of India's renewable energy transition and climate change mitigation commitments. However, the results of the present study indicate that the adoption of rooftop solar remains relatively low and is still in its early stages of diffusion in Guwahati, Assam. Despite the provision of subsidised rooftop solar installations through PMSGY, late adopters are predominant. In line with Rogers' diffusion of innovation theory, the relatively small share of early adopters and prolonged innovation-decision period for laggards contribute to this pattern. Considering that early adopters can significantly acclerate the diffusion process, policymakers should consider strategies to disseminate feedback to encourage and raise the awareness of late adopters.

Moreover, the delayed adoption cannot be attributed solely to the traditional and risk-averse behaviour of laggards, as suggested by the classical diffusion theory; instead, it is largely constrained by awareness about rooftop solar, structural and dwelling-related constraints, financial constraints to installation, low perceived utility of rooftop solar systems, and environmental constraints. Therefore, to address these barriers, targeted policy interventions are required, including promoting collective rooftop solar PV systems for apartment dwellers, enabling renters to benefit through owner-installed systems, expanding awareness programs, and improving access to credit to cover upfront investment.

To sum up, financial incentives such as subsidised installation can facilitate adoption, but raising awareness and communicating adopters' experiences are essential in accelerating rooftop solar diffusion.

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