ijamrsd.com
JAMRSD
ISSN: 2583-6404
Journal of Advanced Multidisciplinary Research Studies and Development
Peer Reviewed Referred Journal | Bi-monthly | Open Access

BARRIERS AND MOTIVATIONS IN THE UTILIZATION OF SOLAR POWER IN GREATER MUMBAI

Ms. Anita Panigrahi[1], Dr. Chandani Bhattacharjee[2]
[1] *Research Scholar, HSNC University, Mumbai.*
Email: anitajee81@gmail.com
[2] *Professor, H.R College of Commerce and Economics.*
Email: bhattacharjee.chandani@hrcollege.edu

Abstract
As per an article by The Indian Express,2023 and data from the India Climate & Energy Dashboard (NITI Aayog, 2025), in a more applied scenario, it has been estimated that rooftop installations (residential and other buildings) in Mumbai could generate up to 1,724 MWp, sufficient to meet about half of the city's peak electricity demand. However, this is not the case. Even though there is huge potential and huge demand for solar power in the continuously growing city, the installation and generation of solar power is very limited. Against this backdrop, this study aims to understand the barriers to solar energy adoption in Greater Mumbai, a densely populated metropolitan region with high energy demand but limited physical space for renewable infrastructure and to identify the economic, social, and technical constraints that hinder the integration of solar technologies in urban environments. The methodology follows a mixed-methods approach, combining primary data collected through structured surveys with secondary data from existing literature, and applying statistical techniques to analyse public awareness levels and institutional challenges. The findings from the primary study reveal that although general awareness of solar energy is relatively high (72.7%; Primary Survey, 2025), knowledge of government schemes and incentives remains low (43.6%; Primary Survey, 2025). Economic concerns—particularly high installation costs (49.1%; Primary Survey, 2025) and perceived maintenance burdens (50.9%; Primary Survey, 2025)—emerge as major obstacles. Additional challenges include inadequate coordination among municipal authorities, complex regulatory processes, and a shortage of trained technical personnel. Despite these constraints, over half of respondents (58.2%; Primary Survey, 2025) express a willingness to adopt solar systems in the future. The conclusion highlights that improving institutional efficiency, enhancing public awareness, and expanding financial accessibility are crucial to advancing solar energy uptake in Mumbai. The recommendations include streamlining approval procedures, strengthening public–private partnerships, and developing more attractive subsidy and incentive mechanisms to accelerate the city's transition toward cleaner and more sustainable energy solutions.
Keywords: Solar Power, Electricity Generation, Urban Challenges, Barriers, High Energy Demand.

► *Corresponding Author: Ms. Anita Panigrahi*

Introduction

India receives a large amount of sunlight throughout the year, making it an ideal country for using solar energy. Over the years, the government has taken strong steps to promote renewable energy,

especially solar power. However, in big cities like Greater Mumbai, the use of solar energy has not grown as much as expected, though the city has a high demand for electricity and great potential for solar power. The main reasons for this slow progress include limited rooftop space, tightly packed high-rise buildings, technical issues, and old infrastructure that is not ready for modern solar systems. Though the central government has introduced supportive policies like the Jawaharlal Nehru National Solar Mission (JNNSM), these programs often face delays or complications at the local level. Apart from technical problems, there are also financial challenges, such as the high upfront cost of installation and limited access to loans. Additionally, regulatory issues, lack of skilled manpower, low public awareness, and poor cooperation between city agencies also create roadblocks. This research focuses on understanding all these barriers in detail. It aims to study the reasons behind the limited use of solar power in Mumbai and to suggest practical solutions that fit the city's unique conditions so that solar energy can become a bigger part of Mumbai's future energy supply.

Review of Literature

Several studies examining urban Indian settings highlight that while awareness of solar energy is moderately high, actual utilization remains limited due to economic and perceptual barriers. Research conducted in Mumbai's suburban regions found that **high initial installation costs**, lack of technical knowledge, and uncertainty about maintenance discourage households from adopting solar systems **(Patil & Kulkarni, 2014)**. The study also notes that residents perceive solar power as unreliable during monsoon months, which is particularly relevant to Greater Mumbai's climatic conditions. Despite environmental awareness, adoption decisions are strongly influenced by affordability and trust in technology. Economic benefits and environmental consciousness emerge as the most significant motivational factors for solar energy adoption. A comprehensive literature review by **(Sharma et al., 2022)** reveals that consumers are motivated by long-term savings on electricity bills, energy security, and reduced carbon footprint. In metropolitan cities like Mumbai, where electricity tariffs are relatively high, solar power is perceived as a viable cost-saving alternative. However, the study emphasizes that motivations translate into adoption only when supported by effective subsidies, financing mechanisms, and simplified approval processes. Policy frameworks and institutional mechanisms play a critical role in shaping solar power utilization. Studies on rooftop solar photovoltaic (PV) adoption in Indian cities identify complex regulatory procedures, lack of coordination between municipal bodies and electricity distribution companies, and limited awareness of net-metering policies as major barriers **(Gambhir et al., 2017)**. In Greater Mumbai, space constraints in high-rise buildings further complicate rooftop installations. The literature suggests that stronger municipal support and streamlined policies are essential to enhance solar penetration in dense urban areas. Behavioral and social dimensions significantly affect household decisions regarding solar power adoption. A systematic review by **(Karakaya and Sriwannawit, 2015)** indicates that social norms, peer influence, and perceived social status associated with renewable energy use can motivate adoption in urban communities. Conversely, skepticism about technology performance and lack of visible success stories act as deterrents. In cities like Mumbai, housing societies often make collective decisions, making social acceptance and group consensus crucial determinants of solar utilization. Financial constraints remain the most consistently reported barrier across studies in developing urban economies. Research focusing on solar adoption in developing countries shows that limited access to credit, long payback periods, and insufficient financial incentives restrict adoption despite strong interest **(Bhattacharyya, 2013).** For Greater Mumbai, where middle-income households dominate, the

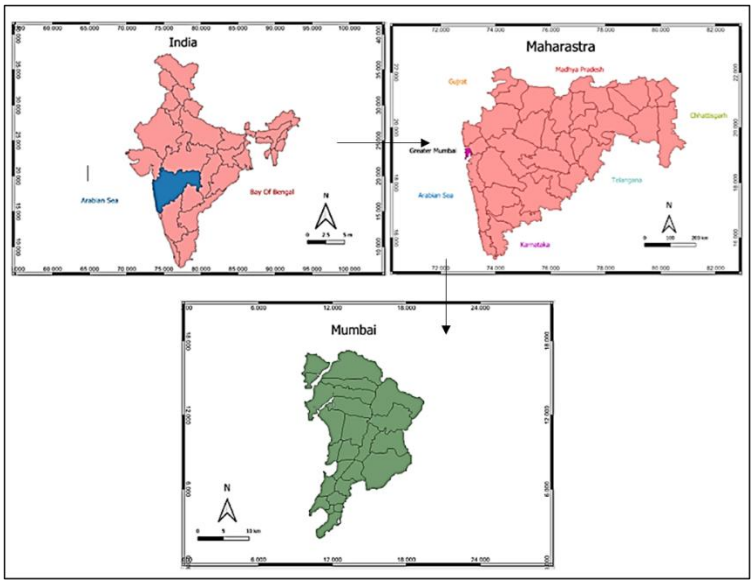
literature stresses the importance of government subsidies, low-interest loans, and innovative financing models to convert motivation into actual utilization of solar power.

Research Objectives

- To understand the barriers to solar energy adoption in Greater Mumbai
- To identify the economic, social, and technical constraints that hinder the integration of solar technologies in urban environments
- To give applicable suggestions for improvement

Hypothesis

Research Methodology



Mumbai is a major coastal city located on India's western shoreline, spread across Salsette Island at the point where the Ulhas River flows into the Arabian Sea. Administratively, the city is organized into three broad units. The first is the historic Mumbai City area, which originally developed as a British colonial port. With urban expansion, this core area merged with adjoining suburban regions to create what is now known as Greater Mumbai. The entire Greater Mumbai area is governed by the Municipal Corporation of Greater Mumbai (MCGM). Beyond this lies the Mumbai Metropolitan Region (MMR), a wider planning region that includes Greater Mumbai along with several surrounding municipalities and urban local bodies. The MMR is responsible for coordinated regional planning and addressing large-scale urban development challenges. Topographically, much of Mumbai is low-lying, with elevations generally ranging between 10 and 15 meters above mean sea level, and an average elevation of approximately 14 meters.

The present study adopts a mixed-methods research design to comprehensively examine the barriers to solar energy adoption in Greater Mumbai. This approach is considered appropriate given the complex and multidimensional nature of renewable energy adoption in a densely populated metropolitan context. Secondary data were first reviewed to establish the background and contextual framework of solar energy potential and utilization in Mumbai. Reports published by The Indian Express (2023) and data from the India Climate & Energy Dashboard developed by NITI Aayog (2025) were used to assess the estimated rooftop solar potential of the city. These sources indicate that Mumbai has the capacity to generate up to 1,724 MWp of solar power through rooftop installations, capable of meeting nearly half of the city's peak electricity demand. Despite this significant potential, actual solar deployment remains limited, necessitating an in-depth investigation into the underlying barriers.

The primary data collection component involved a structured questionnaire survey conducted across selected residential, commercial, and institutional areas within Greater Mumbai. The survey

instrument was designed to capture respondents' levels of awareness, perceptions, and attitudes toward solar energy adoption, as well as to identify economic, social, and technical constraints influencing decision-making. Questions were both closed-ended and Likert-scale based, enabling quantitative assessment of awareness levels, willingness to adopt solar technologies, and perceived challenges. The survey also included items related to familiarity with government policies, subsidy schemes, and regulatory procedures associated with rooftop solar installations.

To ensure representativeness, 55 respondents were selected using a purposive sampling technique, focusing on energy consumers in high-density urban settings where rooftop solar adoption is technically feasible yet underutilized. Data collected from the field survey were systematically coded and analyzed using descriptive statistical techniques, including percentage analysis and cross-tabulation, to identify dominant trends and patterns. This quantitative analysis facilitated an objective assessment of public awareness and institutional challenges related to solar energy adoption in the city.

Data Analysis and Discussion

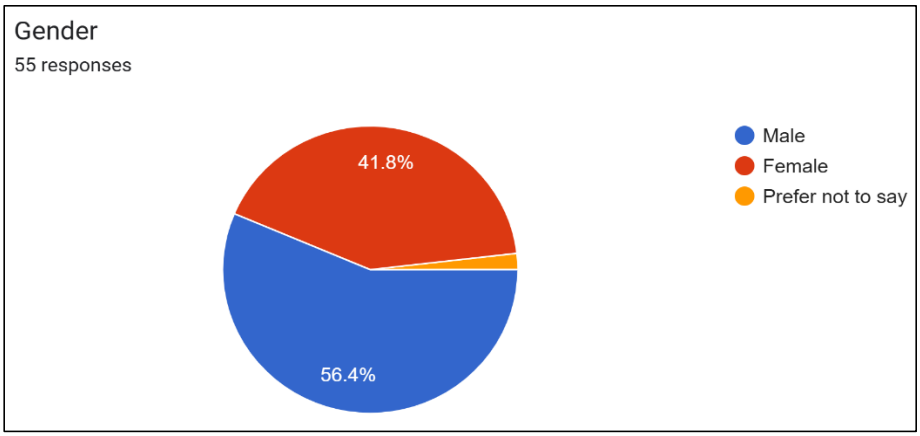


Fig No. 1

The gender-wise distribution of respondents shows a moderately balanced participation, with males constituting 56.4% of the sample and females accounting for 41.8%, while a very small proportion preferred not to disclose their gender. This composition indicates that perspectives on solar energy utilization in Greater Mumbai are drawn from both male and female respondents, ensuring a relatively inclusive representation. The slightly higher male participation may reflect greater involvement of men in decision-making related to household or business infrastructure investments. However, the substantial female representation highlights growing awareness and interest among women regarding renewable energy adoption, sustainability, and long-term economic benefits, suggesting a positive shift toward inclusive engagement in energy-related decisions.

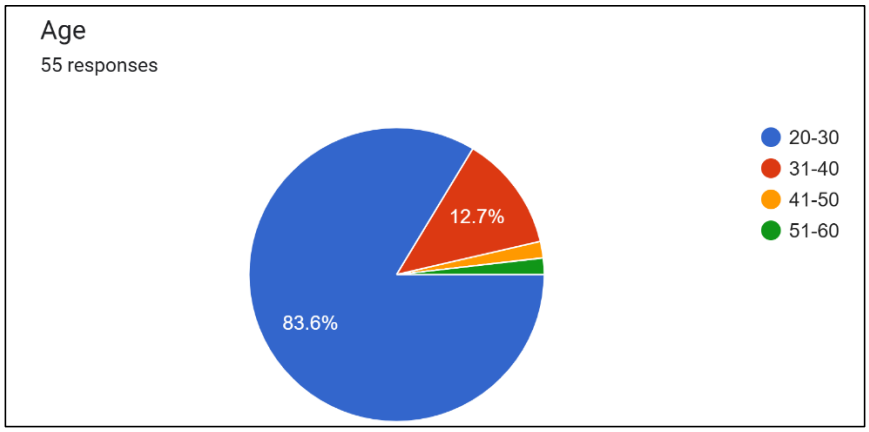


Fig No. 2

The age-wise distribution of respondents indicates a strong dominance of the 20–30 years' age group, which constitutes 83.6% of the total sample. This is followed by respondents in the 31–40 years' category, accounting for 12.7%, while a very small proportion falls within the 41–50 years and 51–60 years' age brackets. This skewed age composition suggests that the study largely reflects the perceptions and awareness levels of younger, economically active individuals who are more likely to be exposed to contemporary discussions on renewable energy and sustainability. The limited representation of older age groups may also imply comparatively lower engagement or accessibility among them, which could influence overall adoption patterns of solar power in Greater Mumbai.

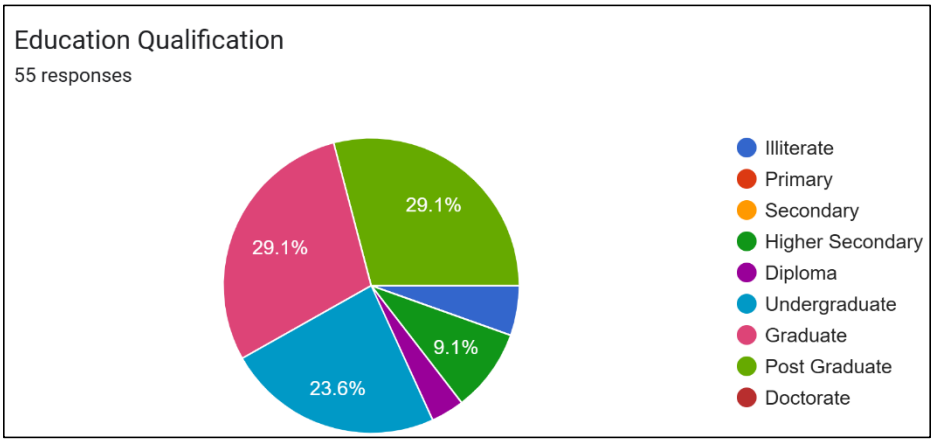


Fig No. 3

The educational profile of respondents reveals a relatively high level of academic attainment. A significant 29.1% of respondents are postgraduates, while an equal proportion (29.1%) are graduates, indicating that over half of the respondents possess higher education qualifications. Additionally, 23.6% are undergraduates, and 9.1% have completed higher secondary education. Only a marginal share belongs to diploma or lower educational categories. This educational composition suggests that the sample is largely informed and capable of understanding technical, environmental, and economic aspects of solar power. However, despite this educational advantage, subsequent findings indicate that awareness does not always translate into adoption, highlighting the role of non-educational barriers such as cost, infrastructure, and policy clarity.

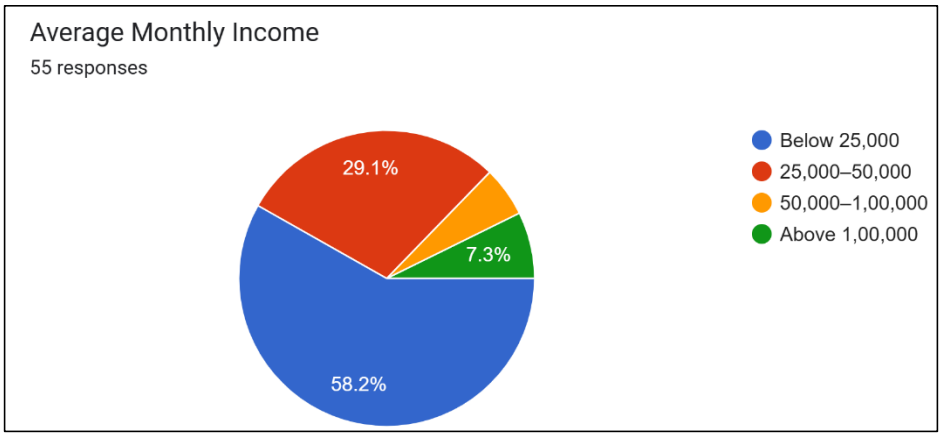


Fig No. 4

The income distribution shows that a majority of respondents (58.2%) fall within the below ₹25,000 income category, followed by 29.1% earning between ₹25,000 and ₹50,000. Only 7.3% of respondents report an income above ₹1,00,000, with a small proportion in the ₹50,000–₹1,00,000 range. This income pattern is crucial in understanding solar power adoption, as lower income levels directly influence affordability and investment capacity. The dominance of lower-income groups underscores why high initial installation costs emerge as a major barrier, despite awareness of long-term savings associated with solar energy.

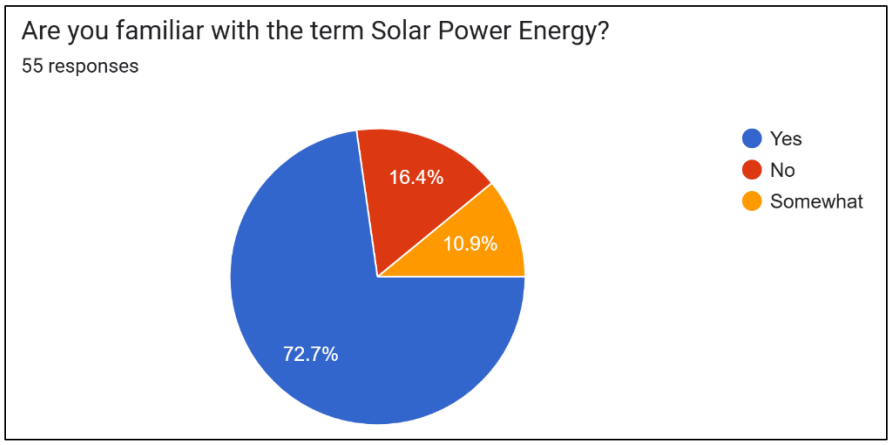


Fig No. 5

An encouraging 72.7% of respondents' report being familiar with the term solar power energy, indicating widespread basic awareness. However, 16.4% state that they are not familiar, while 10.9% are only somewhat familiar. This suggests that although the concept of solar energy is well known, a notable section of the population still lacks clarity or detailed understanding. This partial or superficial awareness may limit informed decision-making and could contribute to hesitation in adopting solar technology, especially when combined with financial or technical uncertainties.

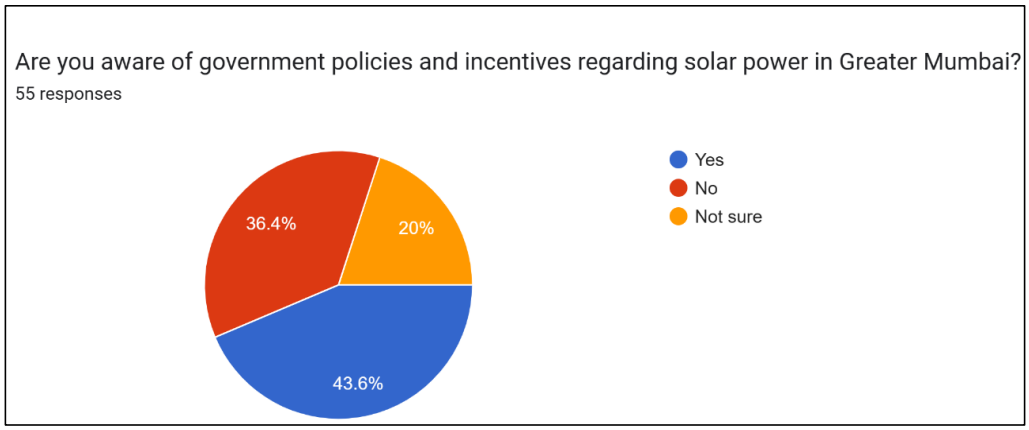


Fig No. 6

Awareness regarding government policies and incentives for solar power appears to be moderate but not universal. While 43.6% of respondents are aware of such policies, a considerable 36.4% report being unaware, and 20% are not sure. This gap highlights a critical information disconnect between policy formulation and public outreach. Given that subsidies, net metering, and incentives are key motivators for solar adoption, limited policy awareness significantly weakens the motivational framework necessary for large-scale utilization of solar energy in an urban context like Greater Mumbai.

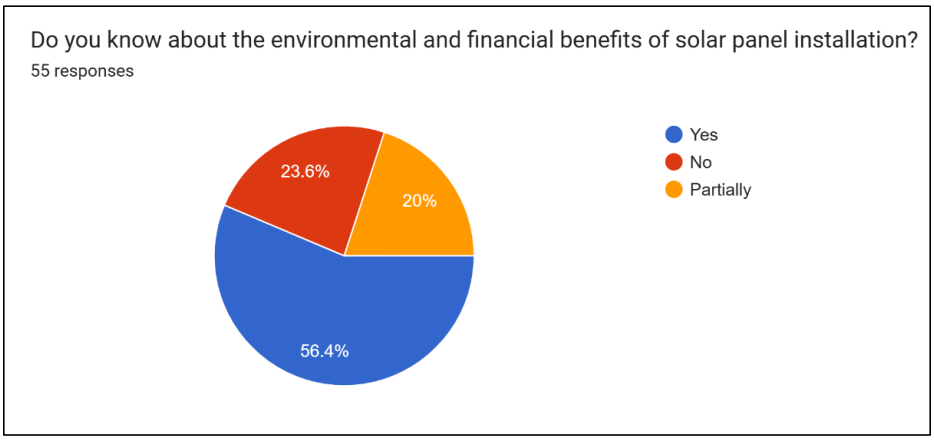


Fig No. 7

More than half of the respondents (56.4%) acknowledge awareness of both the environmental and financial benefits of solar panel installation. However, 23.6% indicate no awareness, and 20% possess only partial knowledge. This distribution suggests that while sustainability and cost-saving narratives have reached a majority, a substantial proportion remains unconvinced or insufficiently informed. Partial awareness may result in underestimation of long-term benefits, thereby weakening motivation and reinforcing perceived barriers such as high initial costs and maintenance concerns.

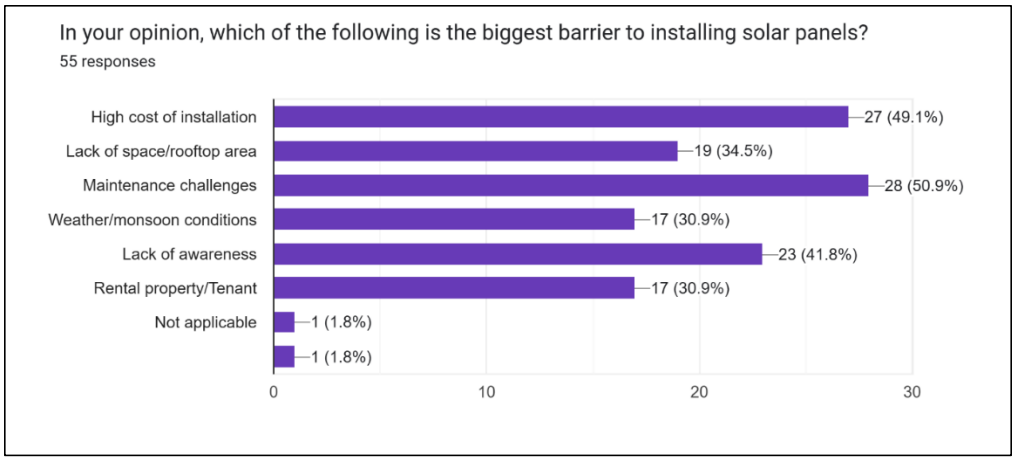


Fig No. 8

When respondents were asked about the biggest barriers to solar panel installation, maintenance challenges emerged as the most significant concern (50.9%), closely followed by the high cost of installation (49.1%). Other prominent barriers include lack of awareness (41.8%), lack of space or rooftop area (34.5%), and weather or monsoon-related conditions (30.9%). Additionally, rental housing and tenant-related issues were cited by 30.9% of respondents. These findings clearly indicate that barriers are multi-dimensional, encompassing financial, technical, spatial, climatic, and institutional factors. In a dense and vertical city like Greater Mumbai, these challenges significantly constrain solar adoption despite favorable solar potential.

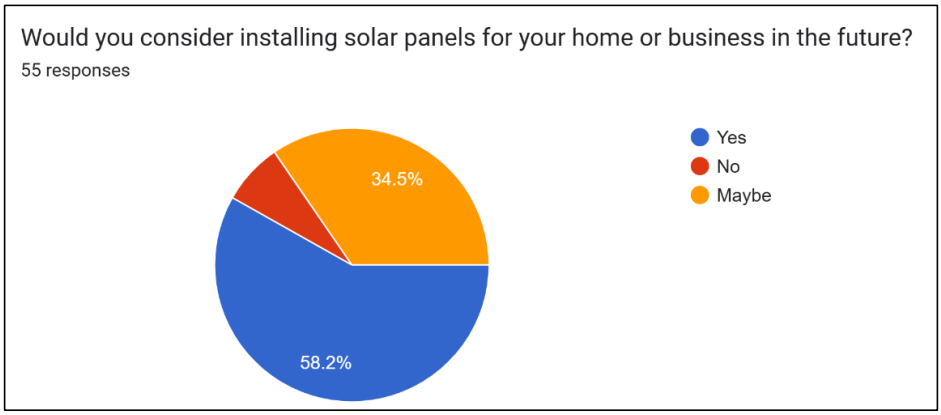


Fig No. 9

The findings reveal a strong inclination toward the future adoption of solar energy, with 58.2% of respondents expressing a clear willingness to install solar panels for their homes or businesses. Additionally, 34.5% of respondents indicated a “maybe,” reflecting cautious optimism influenced by conditional factors such as cost, policy support, or technological clarity. Only a small percentage reported unwillingness, suggesting that outright resistance to solar power is limited. This distribution highlights significant potential for expansion of solar energy in Greater Mumbai, provided existing barriers—particularly financial and informational—are effectively addressed. The high combined percentage of affirmative and tentative responses underscores a favorable mindset toward renewable energy transitions in urban settings.

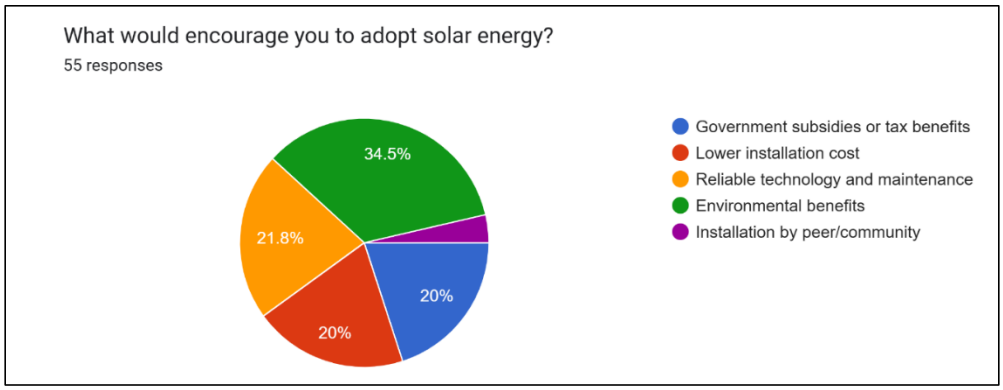


Fig No. 10

The analysis of motivating factors indicates that environmental benefits emerge as the most influential driver, accounting for 34.5% of responses. This reflects heightened environmental consciousness among urban residents concerned about pollution, climate change, and sustainability. Government subsidies or tax benefits and lower installation costs each motivate 20% of respondents, emphasizing the critical role of financial incentives in decision-making. Reliable technology and ease of maintenance encourage 21.8% of respondents, suggesting that trust in system performance and long-term usability significantly affects adoption intentions. Installation driven by peer or community influence represents a minimal proportion, indicating that while social influence exists, economic and environmental considerations remain the dominant motivational forces in Greater Mumbai.

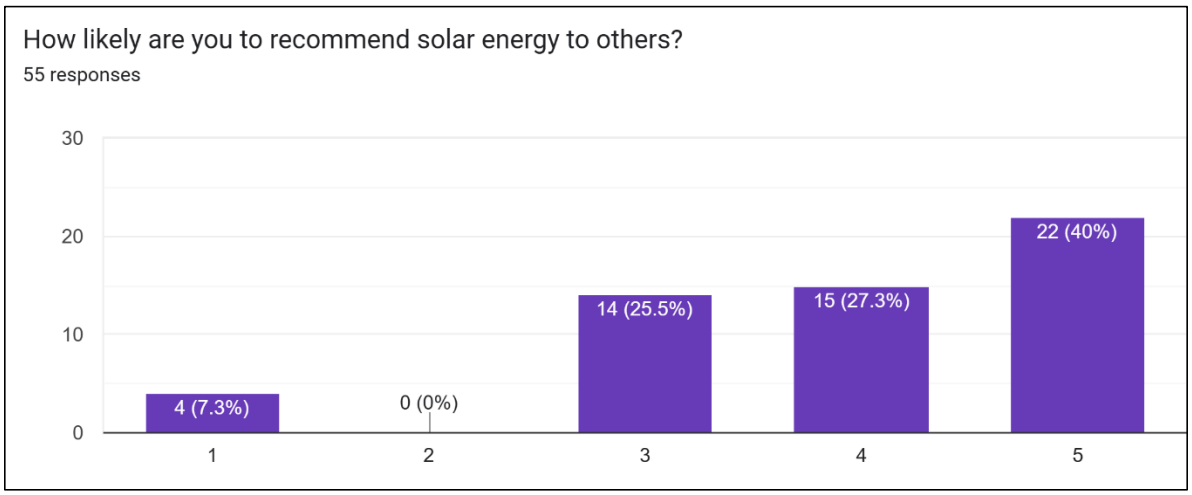


Fig No. 11

The likelihood of recommending solar energy shows a generally positive trend, with 40% of respondents giving the highest recommendation rating. A further 27.3% rated their likelihood at the second-highest level, indicating strong advocacy for solar power among a majority of participants. Moderate recommendation levels account for 25.5%, suggesting cautious endorsement based on personal evaluation or perceived barriers. Only a small fraction expressed low likelihood of recommendation, while no respondents selected the second-lowest rating. This distribution reflects high satisfaction levels, growing confidence in solar energy systems, and

positive user perceptions, reinforcing the role of word-of-mouth and social validation in accelerating solar adoption across Greater Mumbai.

Conclusion

H_{01}: Levels of awareness of government policies and solar panel installation do not have a positive relationship.

H_{11}: Levels of awareness of government policies and solar panel installation have a positive relationship.

Since the value of z score is 1.21 which is less than the p value 1.96, the null hypothesis is accepted with 95% level of confidence. It implies that levels of awareness of government policies and solar panel installation do not have a positive relationship. It further indicate that there are certain other factors which affect solar panel installation along with awareness of government policies.

H_{02}: Maintenance cost and solar panel installation is not inversely proportional to each other

H_{12}: Maintenance cost and solar panel installation is inversely proportional to each other

Since the value of z score is 0.13 which is less than the p value 1.96, the null hypothesis is accepted with 95% level of confidence. It implies that maintenance cost and solar panel installation is not inversely proportional to each other It further indicates that higher maintenance cost leads to lesser installation of solar panels and vice-versa.

The present study examined the barriers and motivations influencing the utilization of solar power in Greater Mumbai, a densely populated metropolitan region with substantial solar potential but limited adoption. The findings reveal that while general awareness of solar energy is relatively high, awareness of government policies and incentive schemes remains inadequate, thereby weakening the impact of policy-driven adoption efforts. Hypothesis testing confirms that awareness of government policies does not have a statistically significant positive relationship with solar panel installation, indicating that awareness alone is insufficient to drive adoption. Similarly, although maintenance cost and high installation expenses are perceived as major barriers, statistical results suggest that these factors do not independently exert a dominant influence on solar installation decisions. Instead, the study highlights that solar adoption in Greater Mumbai is constrained by a combination of economic limitations, procedural complexities, infrastructural constraints, and institutional inefficiencies. Despite these challenges, a strong willingness among respondents to adopt solar energy in the future reflects considerable untapped potential. The study concludes that improving institutional coordination, enhancing targeted awareness initiatives, simplifying regulatory processes, and expanding accessible financial support mechanisms are essential to translating positive attitudes into actual solar power utilization, thereby supporting Mumbai's transition toward a more sustainable and resilient urban energy system.

Recommendations

1. Strengthen awareness campaigns to improve public knowledge about government solar schemes, subsidies, and net-metering benefits, as policy awareness remains relatively low among respondents.
2. Enhance financial support mechanisms, such as higher subsidies, low-interest loans, and easy EMI options, to address high installation and maintenance cost concerns, especially among lower-income households
3. Simplify regulatory and approval procedures by improving coordination between municipal authorities and electricity distribution companies to reduce delays and procedural complexity.

4. Promote community-level and housing society solar projects, particularly in high-rise and rental housing areas, to overcome space constraints and collective decision-making challenges.
5. Invest in technical training and maintenance support, including the development of skilled manpower and reliable after-sales services, to reduce apprehensions regarding system upkeep and performance during monsoon conditions

References

1. Bhattacharyya, S. C. (2013). Financing energy access and off-grid electrification: A review of status, options and challenges. Renewable and Sustainable Energy Reviews, 20, 462–472. https://doi.org/10.1016/j.rser.2012.12.008
2. Gambhir, A., Jain, A., & Tongia, R. (2017). Rooftop solar in India: Potential, barriers and policy options. Brookings India.
3. Indian Express. (2023). *Mumbai's rooftop solar potential remains largely untapped despite high energy demand*. Indian Express.
4. Karakaya, E., & Sriwannawit, P. (2015). Barriers to the adoption of photovoltaic systems: The state of the art. Renewable and Sustainable Energy Reviews, 49, 60–66. https://doi.org/10.1016/j.rser.2015.04.058
5. NITI Aayog. (2025). *India Climate & Energy Dashboard*. Government of India. https://iced.niti.gov.in
6. Patil, S. S., & Kulkarni, S. V. (2014). Public perception and awareness of solar energy in urban India: A case study of Mumbai suburbs. IOSR Journal of Mechanical and Civil Engineering, 11(4), 1–5.
7. Primary Survey. (2025). *Barriers and motivations in the utilization of solar power in Greater Mumbai* (Unpublished primary survey data).
8. Sharma, N. K., Tiwari, P. K., & Sood, Y. R. (2022). Motivations to adopt solar energy systems: A literature review using the TCCM framework. IIM Shillong Journal of Management Science, 3(1), 1–18.