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Assessing the Economic Impact of Solar Panel Adoption in Jhansi City: A Cost–Benefit Analysis

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ABSTRACT

The transition to renewable energy is central to sustainable urban development, with solar technology playing a pivotal role in reducing dependence on conventional power sources. The study aimed to examine the current level of awareness, adoption patterns, and barriers associated with solar panel usage in Jhansi. It divided respondents into adopters and non-adopters to comprehensively understand both perspectives. The findings reveal critical insights into the adoption behaviour, motivators, financial influences, and social acceptance of solar energy in the region. This study, titled "Assessing the Economic Impact of Solar Panel Adoption in Jhansi City: A Cost-Benefit Analysis", investigates the adoption patterns, economic outcomes, and barriers related to solar panel usage among households in Jhansi. Based on survey data 80 responses were collected via Google Forms, 68 of respondents were adopters while 12 were non-adopters. The study explored two key aspects of solar adoption in Jhansi: whether electricity cost savings were the primary motivation for adopting solar panels, and the extent of monthly electricity bill reduction after installation. The study concludes that solar energy adoption in Jhansi is both economically and environmentally beneficial, but greater outreach, financial support, and public education are essential to encourage broader adoption.

Keywords: *Renewable Energy, Solar Panels, Electricity Bill Reduction, Cost-Benefit Analysis, Maintenance or Repair Cost, Households, Chi-Square Test.*

Introduction

Jhansi, a city in Uttar Pradesh. It lies in the region of Bundelkhand on the banks of the Pahuj River, in the extreme south of Uttar Pradesh. Jhansi city is spreaded over 160 sq km. of land. As our study focuses on the Jhansi city of Bundelkhand region so the total consumers belong to the Jhansi city of U. P. Bundelkhand. The current estimate population of Jhansi city in 2025 is 737,000 the current estimates of Jhansi city are based on past growth rate, which faces the dual challenge of meeting growing energy demands and shifting towards sustainable practices.

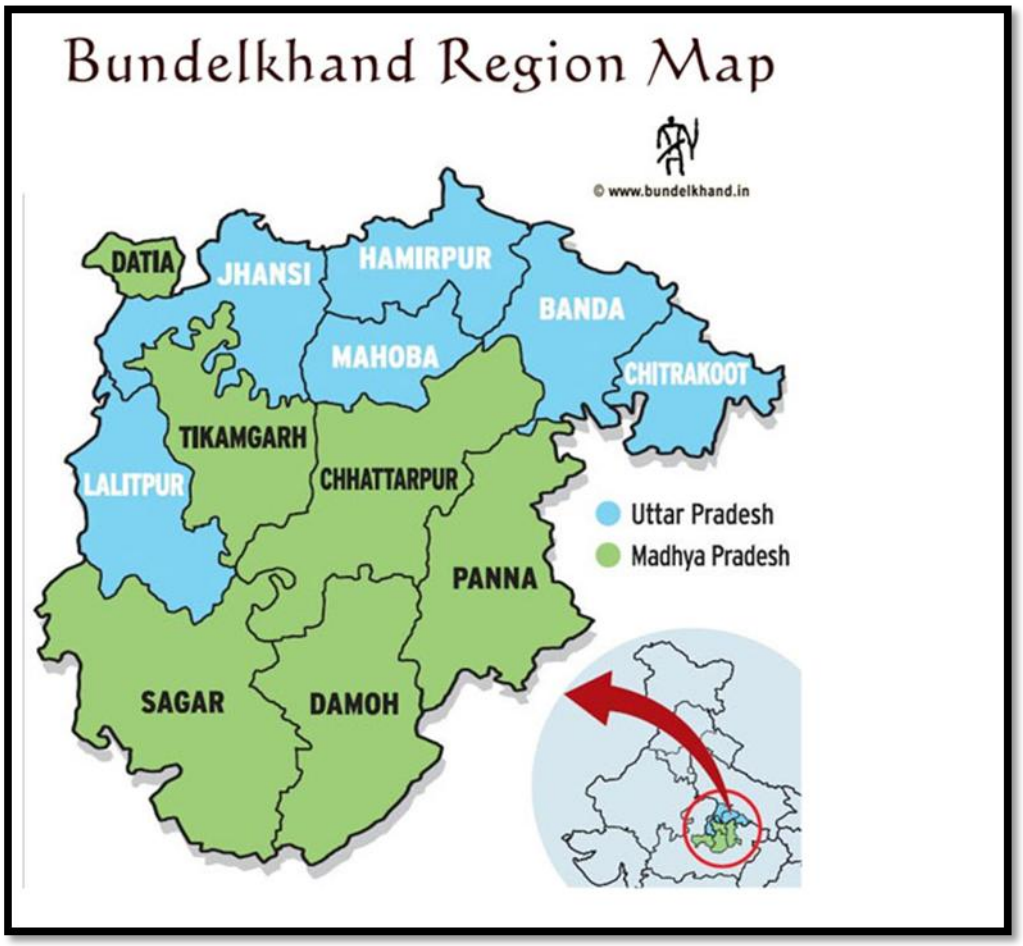

Figure 1: Map of Bundelkhand

Role of Bundelkhand in adoption of Solar energy

- **Bundelkhand region has appeared as a major region in the domain of renewable energy and is encouraging regional growth and employment.**
- **The ample sunlight and climatic conditions in this region make it desirable for solar energy production.**

This research investigates into the economic significance of solar panel adoption within Jhansi city, aiming to provide a comprehensive cost-benefit analysis. With increasing awareness of climate change and the decreasing costs of solar technology, exploring the attainability and impact of solar adoption is crucial. The Bundelkhand region, once seen as one of the most barren and backward areas, is taking rapid strides in development. With the ground-breaking ceremony of projects worth more than Rs 10 lakh crore recently, the entire region is set to become the new energy hub of Uttar Pradesh. Jhansi's solar panel adoption offers advantageous situation to flourish Sustainable Development Goals (SDGs) in India. This research directly aligns with SDG 7 (Affordable and Clean Energy) by assessing the economic benefits of solar adoption, promoting renewable energy assess, and decreasing dependence on fossil fuels. Furthermore, the study indirectly contributes to SDG 8(Decent Work and Economic Growth) by analyzing job creation with solar sector and potential economic gains for Jhansi. A cost-benefit analysis will highlight the financial viability and sustainability of solar energy, supporting India's transition to a greener economy.

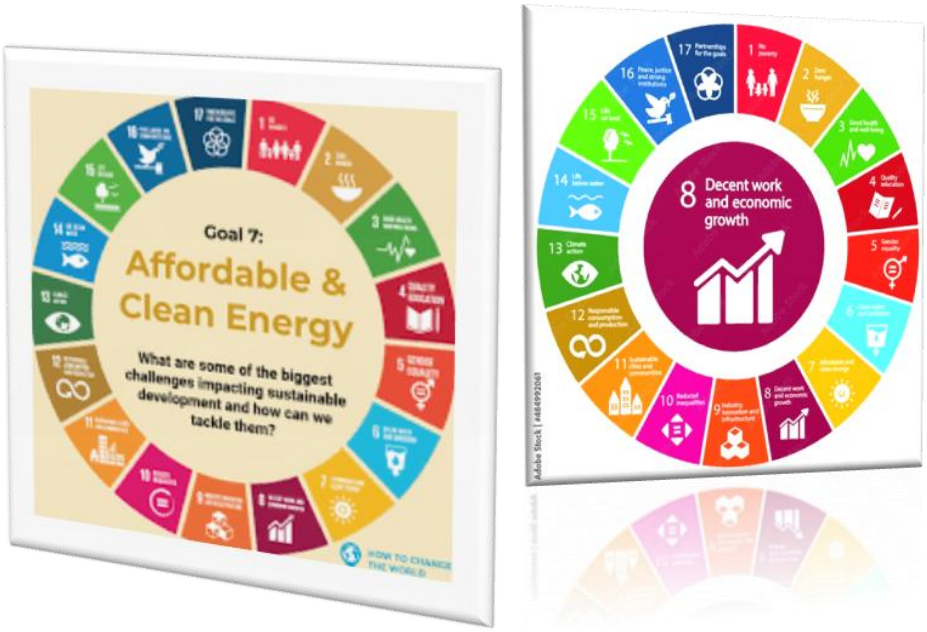

Figure 2: Sustainable Development Goals.

Pradhan Mantri Kisan Urja Suraksha evamUtthaanMahabhiyan (PM-KUSUM) Yojana, or Kusum Yojana, is a central government scheme that promotes solar energy in agriculture, including the Bundelkhand region. The scheme objective is to provide funding to farmers for installing solar pumps and grid-connected renewable energy-based power plants. Specifically, the scheme stimulate the use of solar irrigation pumps (SIPs) to replace diesel pumpsets, which is particularly relevant in drought-prone areas like Bundelkhand.

Key Solar Schemes and Projects in Bundelkhand

These initiatives demonstrate the Uttar Pradesh government's commitment to harnessing solar energy in Bundelkhand, with the goal of enhancing electricity generation, promoting economic growth, and creating employment opportunities in the region

- **Solar Parks**
- **Bundelkhand Saur Urja Limited (BSUL)**
- **Rooftop Solar Program**
- **Open Access Solar**
- **Green Energy Corridor**
- **Bundelkhand Expressway Solar Project**
- **PM Surya Ghar: Muft Bijli Yojana**
- **UP Solar Energy Policy 2022**

This study will determine the initial investment costs, including panel installation, infrastructure, and maintenance, alongside the long-term benefits such as reduced electricity bills and potential revenue generation through excess energy sales. By examining various sectors including commercial, residential and public, this research seeks to determine the economic impact of solar adoption. Ultimately, this study aims to offer insights into the feasibility of solar energy as a sustainable and economically beneficial solution for Jhansi, contributing to strategic decision making and promoting a cleaner energy future. This study also ascertain the current level of solar panel adoption in Jhansi city. It will analyze the number of residential and commercial utilizing the solar energy and examining the factors influencing adoption rates. The central aim of this research is to explore the social impacts of solar panel adoption in Jhansi

city. The study investigates the respondents engagement and awareness levels regarding solar panel technology. This involves examining the current understanding, perceptions and attitudes towards solar energy among Jhansi residents. The study will also look into the social and economic factors influencing solar panel adoption, considering household income and information access. The ultimate goal is to provide actionable insights for boosting respondents engagement and fostering broader solar panel adoption within Jhansi city contributing to sustainable energy practices.

The research seeks to offer insights of solar panel adoption, also its impact and cost-benefit analysis. This research delves into the economic advantage of solar panel adoption within Jhansi city. It will evaluate the potential benefits, including reduced energy costs for residents and businesses as well as overall impact on the local economy.

Research Objectives

- To ascertain the current level of solar panel adoption in Jhansi city.
- To identify the key drivers and barriers affecting solar panel adoption in Jhansi city.
- To study the social impacts of solar panel adoption in Jhansi city such as engagement and awareness regarding solar panel adoption.
- To evaluate the economic benefits of solar panel adoption in Jhansi city.
- To provide recommendations and suggestions for promoting and expanding solar panel adoption in Jhansi city.

Research Hypotheses

H_0: Reduced electricity bill are not the primary reason for adopting solar panels in Jhansi.

H_1: Reduced electricity bills are the primary reason for adopting solar panels in Jhansi.

H_0: Reduction in monthly bill is not associated with whether maintenance/repair costs were incurred.

H_1: Reduction in monthly bill is associated with whether maintenance/repair costs were incurred.

Research Methodology

- **Research Type:** Qualitative research, descriptive research, exploratory research.
- **Target people:** Solar panel adopters of Jhansi city.
- **Sample technique:** Purposive sampling technique.
- **Targeted people:** Solar and non-solar adopters of Jhansi city.
- **Statistical tools and techniques:** Chi- square, pie chart and bar graph.
- **Questionnaire type:** Structured questionnaire.
- **Mode of data collection:** Through online (GoogleForm), telephonic interactions(schedule). **Statistical Software:** Microsoft excel and SPSS.
- **Sample size:** Large sample size 80 (68-solar adopter; 12- non solar adopters).
- **Data Type:** The study follows a quantitative research design focusing on examining relationships between key variables influencing solar panel adoption in Jhansi. It involves the collection and analysis of numerical data to test predefined hypothesis.The study is based on primary data collection from residents of Jhansi city. Some names and contact details of people who had installed solar panels were first obtained from local solar dealers and vendors. Each identified person was then contacted individually to participate in the survey. Alongside adopters, responses were also collected from people who have not adopted solar panels to understand the reasons behind non-adoption.The research is grounded in real-life data gathered from individuals living in Jhansi city. Both adopters and non-adopters were included to ensure a holistic view. By directly collecting information through structured questionnaire and telephonic interactions, the study captures authentic experiences and opinions rather than relying on secondary information.

Data Analysis and Observations

- **Gender**: A total of 80 respondents participated in the survey. Out of these, 41 respondents (51.25%) were male and 39 respondents (48.75%) were female, indicating an almost balanced gender composition. The age profile of respondents revealed that about 40% were between 21–30 years, around 35% were between 31–40 years, approximately 18% fell in the age group of 41–50 years, nearly 5% were above 50 years, while only a very small proportion, close to 2%, were below 20 years of age.
- **Education Qualification**: The sample showed a wide range: 4 respondents (5%) had no formal education, 4 respondents (5%) were matriculate, 8 respondents (10%) were educated up to intermediate level, 23 respondents (28.75%) were graduates, 27 respondents (33.75%) were postgraduates and 1 respondent (1.25%) held a doctorate degree. This indicates that the majority of respondents were well educated, with more than 60% holding graduate or postgraduate degrees.
- **Occupation**: The sample showed that about 45% of respondents were business owners, around 25% were students, approximately 15% were private employees, nearly 8% were public employees and the remaining 7% were housewives.
- **Family Type**: The data revealed that 75% of the respondents belonged to nuclear families while 25% lived in joint families.
- **Family Size:** The data shows that 10% of respondents had families with less than three members, 70% lived in families with three to five members and about 20% reported more than five members in their household.
- **Monthly Family Income**: The data showed about 5% of respondents reported earning less than Rs 50,000, nearly 50% fell in the Rs 50,000–Rs 1,00,000 bracket, around 30% earned between Rs 1,00,001 and Rs 2,00,000 and approximately 15% reported incomes above Rs 2,00,000.

In terms of adoption of solar energy, almost all respondents highlighted “reduced electricity bills” as the major benefit. When asked about the extent of reduction, only around 3% reported a reduction of less than 25%, approximately 5% indicated a reduction between 25% and 50%, about 12% reported a 50–75% reduction, while a vast majority of nearly 80% experienced a reduction of more than 75%. With regard to system capacity installed, around 30% of respondents had 2 KW systems, about 60% had 3 KW systems, while roughly 10% had systems larger than 3 KW. On being asked about the overall impact on electricity expenditure, around 65% of the respondents stated that there had been a significant decrease, approximately 30% reported a moderate decrease and only a negligible proportion felt there was no change.

Level of Solar Panel Adoption: Analysis of the 80 valid responses reveals that 68 respondents have already adopted solar panels in their households or businesses, while the remaining 12 have not yet adopted solar panels. This indicates a high overall adoption rate among the surveyed population in Jhansi city, with a smaller segment still considering or planning adoption.

Section 2 of the questionnaire was designed to assess the respondents’ level of knowledge, awareness, and perceptions regarding solar panel adoption in Jhansi city. This section was targeted to both existing adopters and non-adopters in order to capture a comprehensive view of how the community understands solar energy. It included questions exploring whether respondents have heard about solar panels, their familiarity with government schemes or subsidies, their perception of the advantages and disadvantages, and their general attitude towards shifting to renewable sources of energy.

The aim of this section was to gauge not only factual awareness (such as knowledge of cost savings or incentives) but also subjective opinions, including their perceived benefits, concerns, or misconceptions. By collecting this information, the study could identify common drivers that encourage people to adopt solar technology and barriers that may still hinder adoption despite growing interest in renewable energy. Overall, the responses in Section 2 form a critical foundation for understanding how awareness campaigns, education initiatives, and policy measures might be shaped to further promote solar panel usage in Jhansi city.

The respondents were asked whether they are familiar with government policies or incentives related to solar power. The analysis of responses indicates that awareness about government policies and incentives for solar power is moderate among the respondents. The below pie chart shows that out of the total participants, 67.5% reported that they are familiar with such policies and incentives, while 32.5% stated that they are not familiar with any government support in this area. This suggests that although a majority have some level of awareness, there is still a considerable proportion of respondents who are not informed about the existing government initiatives, highlighting the need for better information dissemination and awareness programs.

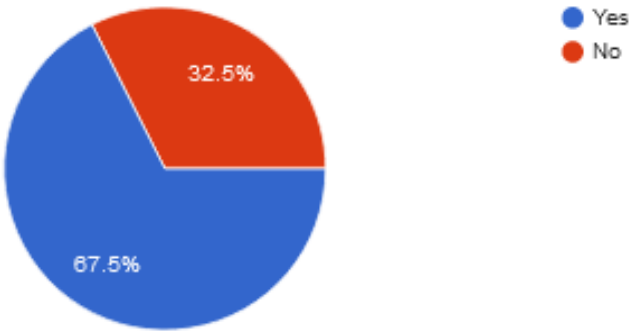

Figure 3: Pie chart showing distribution of respondents based on their familiarity with government policies or incentives related to solar power.

Next, the respondents were asked about the availability of rooftop access or sufficient space for installing solar panels. Interestingly, the pie chart below shows that all the respondents (100%) confirmed that they have rooftop access or adequate space. This clearly shows that physical space is not a limiting factor for solar panel installation among the surveyed population.

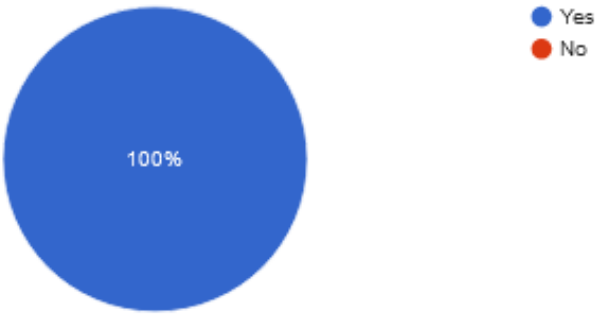

Figure 4: Pie chart showing respondents' access to rooftop or space for solar panels.

The respondents were asked whether they experience frequent power cuts in their locality. The responses in the below pie chart revealed that 55% of the respondents reported experiencing frequent power cuts, while 16.2% stated that they do not experience frequent power cuts, and 28.7% indicated that they sometimes face power cuts. This shows that a significant majority of respondents encounter power supply issues at least occasionally, which can be an important factor influencing their attitude toward adopting solar energy solutions.

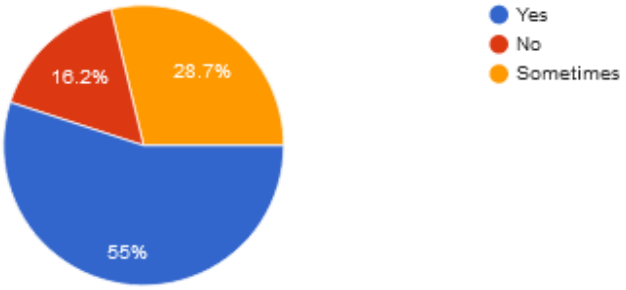

Figure 5: Pie chart showing the distribution of respondents based on their experience with power cut

The respondents were asked about their opinion on the government's promotion of solar energy in Jhansi using a five-point Likert scale. A considerable portion (23.8%) expressed a very negative opinion, while 2.5% rated it as negative. About 30% of the respondents remained neutral, whereas a large share (41.3%) expressed a positive opinion, and 2.5% reported a very positive opinion. These findings suggest that while some respondents are dissatisfied, a greater proportion holds neutral to positive views about the government's efforts in promoting solar energy.

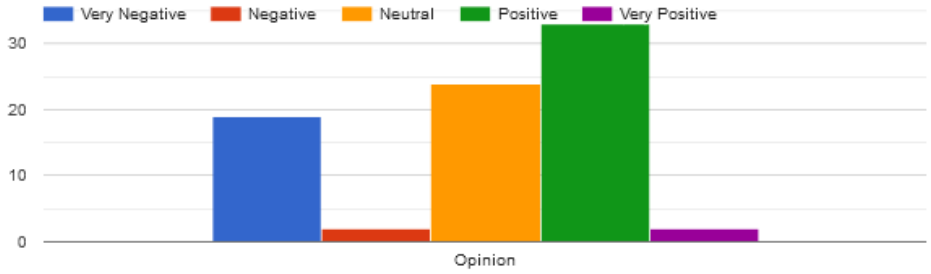

Figure 6: Bar graph showing respondents' opinions on government promotion of solar energy

The respondents were asked whether they believe that solar adoption can contribute to the economic development of Jhansi. Pie chart below shows an overwhelming majority, 92.5%, responded "Yes," indicating a strong perception that solar adoption has the potential to drive local economic growth. Only 7.5% of the respondents answered "No," showing that very few participants disagreed with this idea.

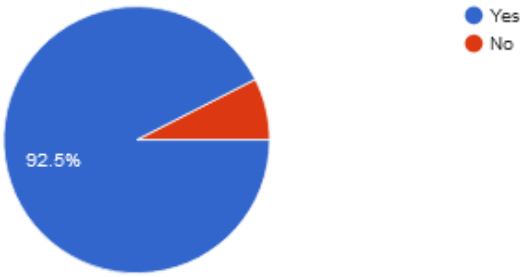

Figure 7: Pie chart showing respondents' views on solar adoption and economic development in Jhansi

The respondents were asked whether they consider solar energy to be more beneficial than traditional energy sources for the environment. The results below in the pie chart indicates a vast majority, 96.3%, responded “Yes,” reflecting a strong awareness of the environmental advantages of solar energy. Only 3.7% of the respondents answered “No,” indicating minimal disagreement.

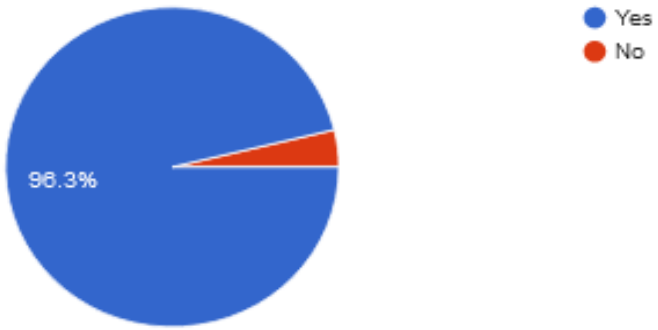

Figure 8: Pie chart showing respondents’ views on whether solar energy is more beneficial than traditional energy for the environment

The respondents were asked whether they think the introduction of solar energy has affected local employment opportunities in Jhansi. The results below in the pie chart shows that the large majority, 73.8%, expressed that solar energy adoption has indeed contributed to local employment, reflecting a positive perception of the sector’s role in creating or supporting jobs. On the other hand, 10% of the respondents felt that solar energy has not had any noticeable impact on employment in the area. Meanwhile, 16.2% were uncertain and selected “Maybe,” which suggests that while they recognize the potential of solar energy, they might not have observed any direct effect on job creation in their surroundings. Overall, the data highlights that most participants associate solar energy with an improvement in local employment conditions.

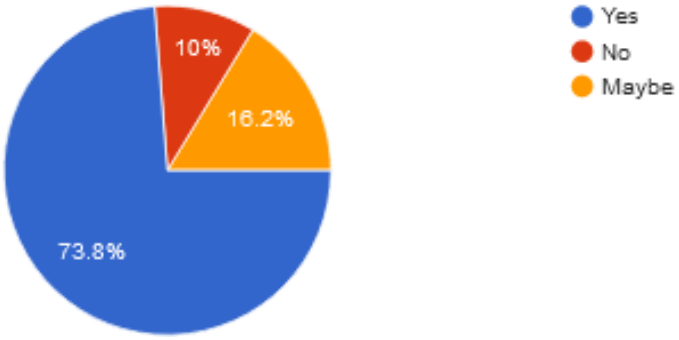

Figure 9: Pie chart showing respondents’ views on whether the introduction of solar energy has affected local employment in Jhansi

The respondents were asked whether they have made any prior investment in alternative energy solutions such as solar water heaters, solar inverters, or similar technologies. The results below in pie chart indicate a fairly balanced distribution. 47.8% of the respondents reported having prior investments in alternative energy, showing a considerable level of early adoption and interest in sustainable technologies. In contrast, 52.2% stated that they have not invested in any alternative energy solutions so far, which reflects that a slightly larger segment of the population is yet to explore or adopt such systems. This mix of responses highlights both the existing awareness and the untapped potential for further promotion of alternative energy options in Jhansi.

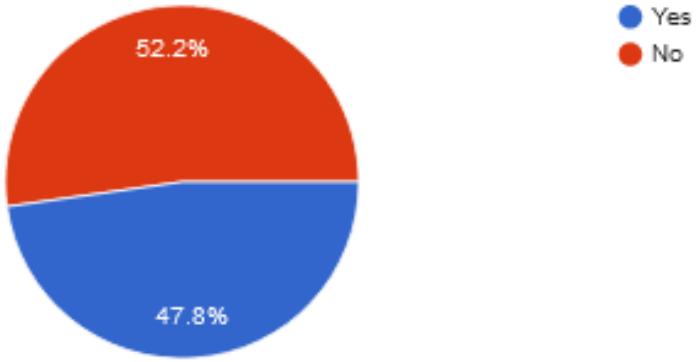

Figure 10: Pie chart showing distribution of respondents based on prior investment in alternative solar energy solutions (solar water heaters, solar inverters, etc.)

The respondents were asked whether they personally knew anyone who had adopted solar panels. This question aimed to assess the level of community exposure and indirect awareness regarding solar technology. The responses indicated that a significant majority, 94%, reported knowing someone who had installed solar panels, while only 6% stated that they did not know anyone with such an adoption. This finding reflects a high level of visibility and familiarity with solar panel usage within the community.

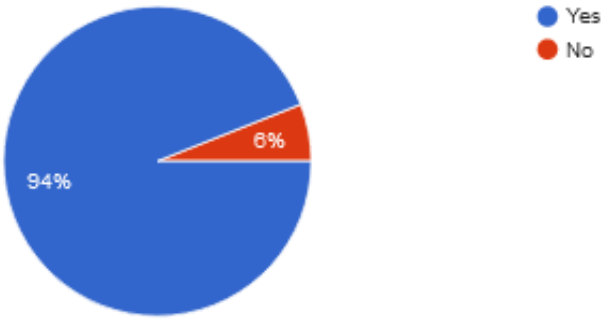

Figure 11: Pie chart showing distribution of respondents based on whether they know someone who has adopted solar panels.

The respondents were asked whether they currently have a solar power system installed at their home, business, or organization. This question was crucial to determine the actual adoption level of solar technology among the participants. Out of the total 80 respondents, 68 reported that they currently have a solar power system installed, while 12 stated that they do not have any solar installation. This clearly reflects a strong penetration of solar power systems among the surveyed population.

In Section 3 of the questionnaire, only those respondents who confirmed that they had already adopted solar power systems at their homes, businesses, or organizations were directed to answer. Out of the total 80 respondents in the study, 68 respondents indicated that they currently have a solar power system installed. Therefore, the analysis in this section is based on these 68 individuals who represent the segment of solar adopters within Jhansi city.

This section aimed to gather detailed insights into the experiences, preferences, and perceptions of existing solar users. The questions explored a range of aspects, such as the type and capacity of solar systems installed, the primary motivations behind their adoption, the barriers they faced during installation, and their overall satisfaction with the performance and economic benefits of solar technology. It also sought to understand how solar energy has impacted their electricity bills, their awareness of government schemes, and whether adopting solar has influenced their social or economic outlook.

By focusing exclusively on actual adopters, this part of the study provides an in-depth understanding of real-world adoption patterns, behavioural drivers, and the tangible outcomes of shifting towards renewable energy at the household or organizational level. The data collected in this section is crucial for assessing the effectiveness of solar initiatives in Jhansi and for identifying areas where policy interventions or awareness campaigns could further accelerate the transition to solar energy.

The 68 respondents who had adopted solar energy were further asked about the primary reason that motivated them to make this transition. Among all the solar adopters in Jhansi who participated in the survey, the responses were strikingly unanimous. 67 respondents reported that the primary reason for installing solar panels was to reduce their electricity bills.

This finding clearly highlights that the strongest driver for adopting solar energy in the city is the tangible economic benefit it provides to households and businesses. Such a result indicates that solar adoption in Jhansi is largely a cost-oriented decision. It reflects that when residents and business owners see a direct and measurable reduction in electricity costs, they are more willing to invest in renewable energy technologies. This insight also suggests that future strategies to promote solar adoption could further emphasize and communicate the monetary advantages, as this appears to be the most compelling factor for potential adopters in the region.

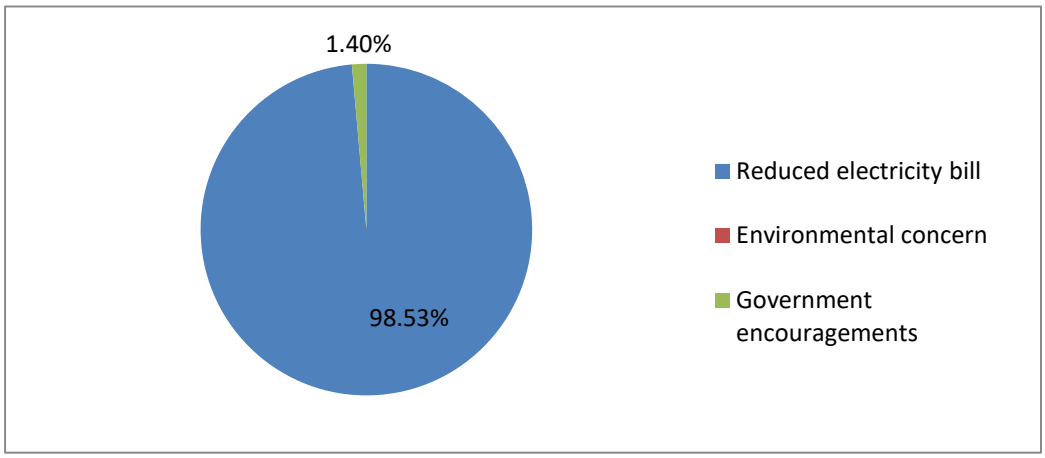

Figure 12: Pie chart showing the distribution of primary reasons for adopting solar energy

The respondents who had installed solar systems were asked to indicate the extent to which their monthly electricity bills had been reduced after adopting solar energy.

The responses from the below pie chart revealed that the majority of solar adopters experienced a significant reduction in their electricity expenses. Out of the total adopters, 42 respondents reported that their bills had been reduced by more than 75%. This shows that for a large portion of households and businesses, solar installation brought about a substantial drop in their monthly energy costs. A further 15 respondents stated that their electricity bills had decreased by 50% to 75%, while 7 respondents indicated a reduction of 25% to 50%. These figures demonstrate that for most adopters, the savings achieved are not only visible but also considerable, contributing to quicker financial payback periods on their investment. Interestingly, 3 respondents reported only a marginal reduction of less than 25%, which may be due to factors such as lower energy consumption patterns, partial system utilization, or technical limitations. Only 1 respondent reported no change in their electricity bill despite installing solar systems, which could be an anomaly caused by specific usage behaviour or system inefficiency.

Overall, these findings emphasize that solar panel adoption in Jhansi has resulted in substantial economic benefits for a vast majority of users, with over half achieving reductions above 75%. This underlines the value of solar energy not just as an environmentally friendly alternative, but also as a highly effective cost-saving measure

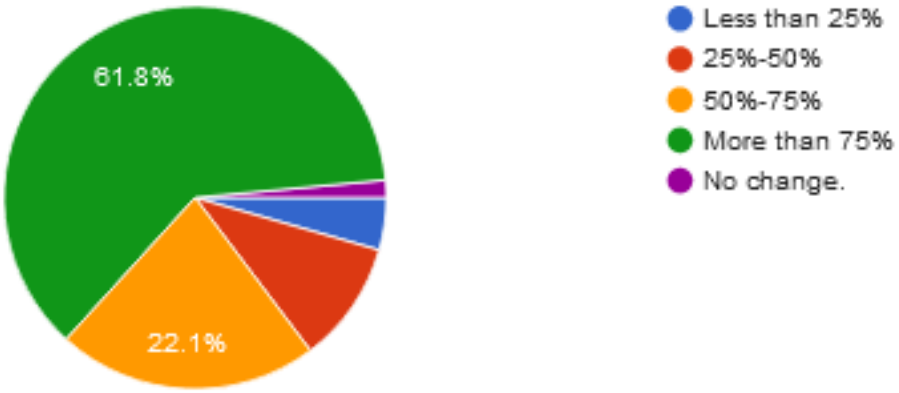

Figure 13: Pie chart showing the percentage reduction in monthly electricity bills after solar adoption

The respondents who had adopted solar energy were asked about the capacity of the solar panel systems installed in their households, businesses, or organizations. The analysis in the pie chart below shows that the majority of adopters in Jhansi preferred a moderate-sized system suitable for average energy needs. Most respondents (63.4%) reported installing a 3 KW solar panel system. This indicates that a 3 KW setup is the most common choice among adopters, likely because it offers a balance between cost and sufficient power generation for typical household or small business consumption.

A significant portion, accounting for 25% of respondents, reported having installed a 2 KW system. This suggests that many adopters with smaller energy requirements or budget considerations still found it worthwhile to opt for solar installations, albeit at a slightly lower capacity. Around 10.3% of the respondents stated that they had installed systems with a capacity of more than 3 KW. These higher-capacity systems are likely used by larger households or commercial establishments with greater electricity demands.

A very small segment, only 1.5% of the respondents, reported having a 1 KW solar panel system, indicating minimal usage or possibly as a supplementary setup alongside other power sources. Overall, these findings reveal that the 3 KW system dominates the adoption pattern, with smaller systems also finding place among users with lesser requirements, and a minority opting for larger systems.

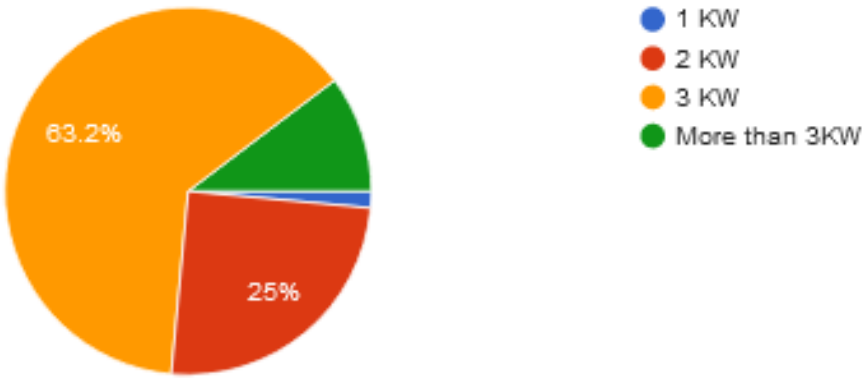

Figure 14: Pie chart showing the capacity of solar panel systems installed among respondents

The respondents who had adopted solar systems were further asked whether they had encountered any maintenance or repair costs after the installation of their systems.

The results in the below pie chart reveal that a large majority of adopters (69.1%) reported that they have not experienced any maintenance or repair costs for their solar panels. This reflects positively on the reliability and durability of the installed systems, suggesting that solar technology in the area generally operates with minimal upkeep once installed. On the other hand, 30.9% of the respondents indicated that they have incurred some maintenance or repair expenses. These costs could be attributed to factors such as cleaning panels in dusty environments, replacing minor components like inverters or wiring, or dealing with unforeseen technical issues over time.

Overall, these findings highlight that most users did not face significant post-installation costs, reinforcing the perception of solar systems as a low-maintenance and economically viable investment, while a smaller segment experienced occasional upkeep or repair requirements.

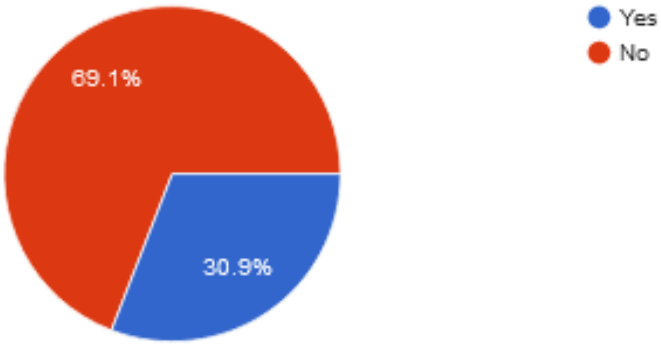

Figure 15: Pie chart showing the respondents encountering maintenance or repair costs

The respondents who had adopted solar energy were asked whether they believe that the adoption of solar power has improved their overall quality of life.

The findings in the pie chart show a strongly positive perception among the adopters. A substantial majority 95.6% of the respondent affirmed that solar adoption has indeed enhanced their quality of life, while only 4.4% stated that they have not observed any improvement.

This overwhelmingly positive response suggests that the benefits of solar adoption go beyond mere cost savings. Many respondents likely experience greater energy security, reduced dependency on erratic grid supply, and the satisfaction of contributing to a cleaner environment. These factors together translate into tangible improvements in daily living, comfort, and household management. In contrast, the small proportion of 4.4% who did not feel any improvement might belong to groups whose energy needs were already well-met prior to installation or who have not fully integrated solar use into their routines.

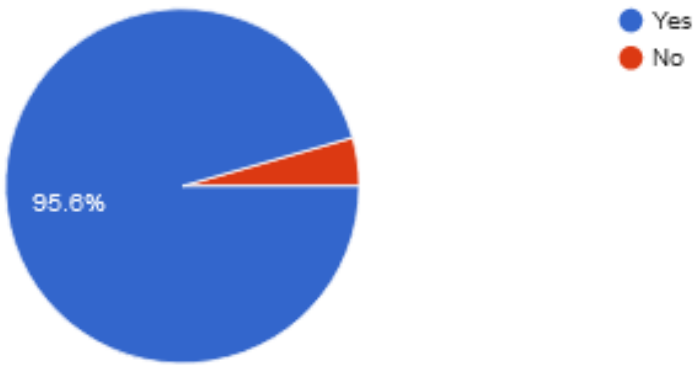

Figure 16: Pie chart showing the impact of solar adoption on quality of life

The respondents who had adopted solar energy were further asked whether they think the shift to solar energy has reduced the environmental burden caused by traditional energy sources. The responses from the pie chart clearly indicate a strong consensus in favour of solar energy's environmental benefits. A vast majority 97.1% of the respondents agreed that adopting solar power has indeed helped reduce the environmental burden, while only 2.9% of respondents did not share this view.

This strong agreement reflects a growing awareness among users about the ecological advantages of renewable energy. By moving away from fossil fuelbased electricity, these adopters recognize that they are directly contributing to lowering greenhouse gas emissions, reducing air pollution, and decreasing dependence on non-renewable resources.

The very small share of respondents (2.9%) who did not perceive a reduction in environmental burden might either be uncertain about the broader environmental impact or may not have access to enough information linking solar adoption to ecological benefits.

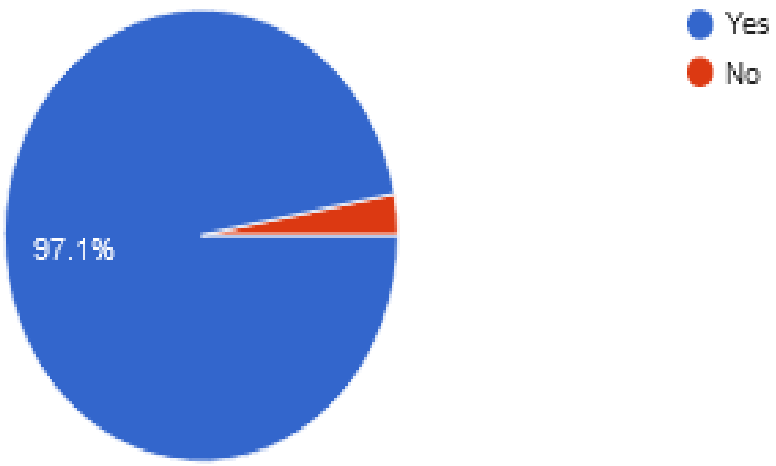

Figure 17: Pie chart showing the perception of solar energy in reducing environmental burden

Respondents were asked whether they received any subsidies or financial assistance for the installation of solar panels. The results in the pie chart shows that a significant majority—92.5% of the respondents—reported receiving some form of subsidy or financial aid during the installation process.

This indicates that government or institutional support has played a vital role in encouraging solar adoption among users. Subsidies significantly reduce the initial investment burden, which is often seen as a barrier to switching to renewable energy. The financial assistance might have come through central or state government schemes, DISCOM (distribution company) incentives, or other public-private initiatives promoting solar energy adoption. Only 7.5% of the respondents reported not receiving any subsidies or financial help, which may point to either a lack of awareness, delays in processing, or exclusion from scheme eligibility criteria.

This data highlights the critical role of financial incentives in making solar energy more accessible and affordable, especially in a developing city context like Jhansi.

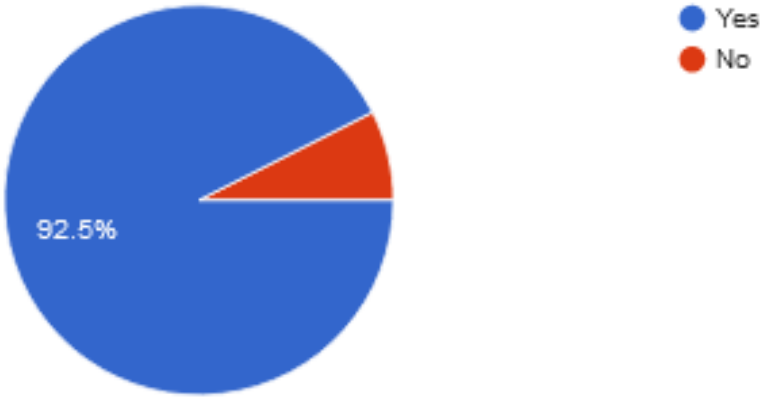

Figure 18: Pie chart showing the Subsidy or Financial Assistance Received for Solar Panel Installation

To understand the economic impact of solar adoption more deeply, respondents were asked how the solar system affected their overall expenses—whether for household use, business operations, or other organizational needs. The feedback was recorded using a 5-point Likert scale.

28 respondents (approximately 41.2%) reported a significant decrease in their overall expenses, indicating that solar energy has brought substantial financial relief. These individuals likely experienced major reductions in their electricity bills or operational energy costs.

26 respondents (around 38.2%) indicated a moderate decrease, suggesting that while the savings were noticeable, they were not drastic. This could be due to relatively lower energy consumption, partial solar usage, or higher upfront recovery times.

11 respondents (about 16.2%) reported no change, meaning their expenditure levels remained similar even after installing solar panels. This might be due to lower sunlight efficiency, minimal pre-existing costs, or limited system capacity. 3 respondents (around 4.4%) experienced a slight increase in expenses. This increase might be attributed to maintenance needs, EMI repayments, or unforeseen setup costs. 0 respondents reported significant increase.

These results clearly indicate that for the majority of users, solar installation has resulted in decreased financial burden, strengthening the argument for solar as an economically viable alternative energy source.

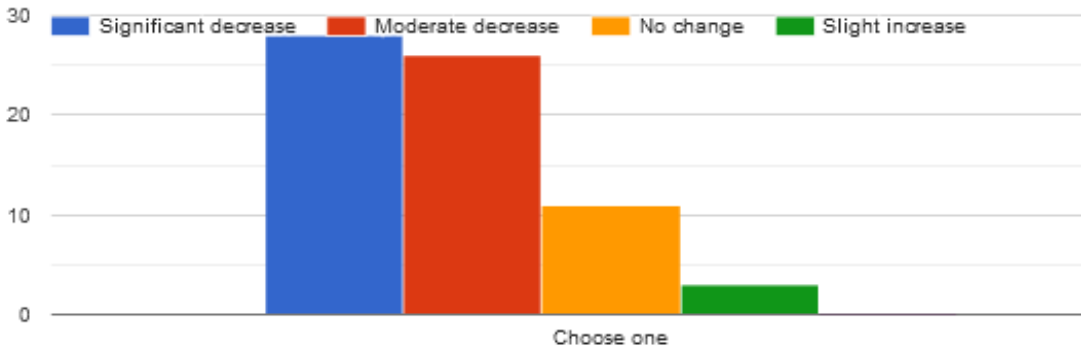

Figure 19: Bar chart showing distribution across Effect of Solar System on Household/ Business/ Organization Expenses

To evaluate satisfaction levels among adopters, respondents were asked to rate the performance of their installed solar panel systems on a 5-star scale. The results are a strong indicator of user confidence and perceived system effectiveness: 14.9% of respondents rated their system 3 stars, which reflects moderate satisfaction. These users may have experienced occasional inefficiencies, maintenance needs, or had higher expectations from the system. 50.7% of respondents gave a 4-star rating, which indicates a high level of satisfaction. These users likely found their systems reliable, cost-saving, and well-performing under most circumstances. 34.3% of respondents provided a 5-star rating, showcasing complete satisfaction. This segment experienced optimal results from their solar installations in terms of performance, durability, and savings. The average rating was 4.19 out of 5, suggesting that overall user experience is highly positive, with most systems meeting or exceeding expectations.

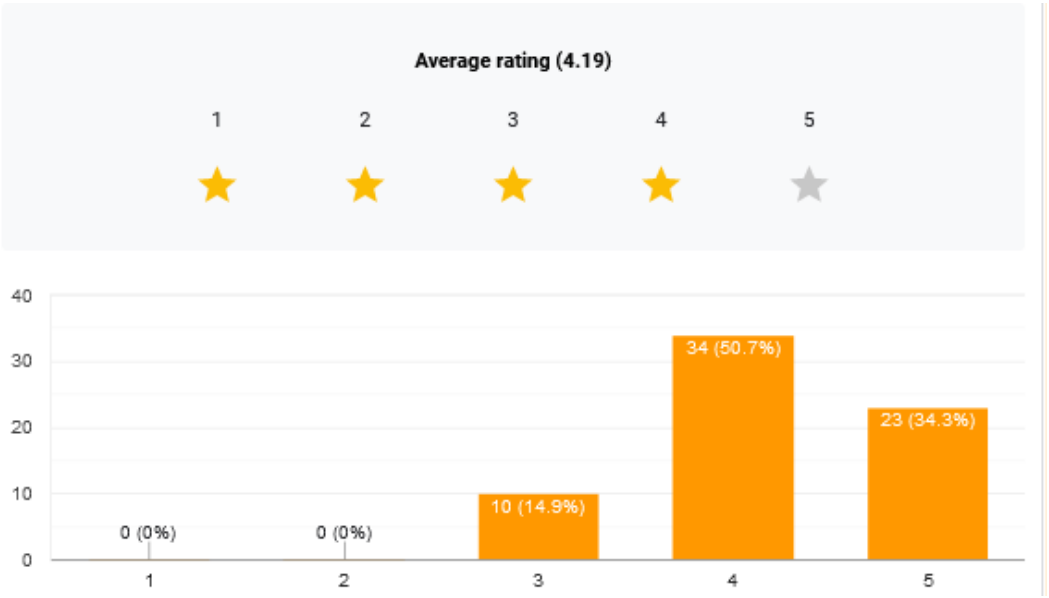

Figure 20: Bar graph showing the solar panel ratings as per the respondents

A 4.19 average rating not only supports the quality and reliability of the solar technology adopted but also strengthens the case for wider adoption across Jhansi. High satisfaction also implies a lower likelihood of system abandonment and greater word-of-mouth promotion.

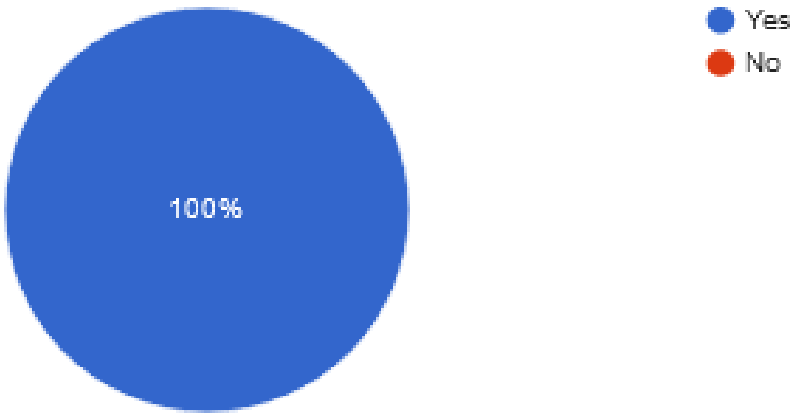

Figure 21: Pie chart showing the respondents willingness to recommend solar to others

Lastly the solar adopters were asked that will they recommend solar panels to others? 100% of the respondents answered "Yes". This unanimous response strongly reinforces user satisfaction and trust in solar technology. A 100% recommendation rate implies that users not only found the system beneficial in terms of cost and performance but also feel confident enough in its value to advocate it to others. Such high advocacy suggests that word-of-mouth could be a powerful channel for promoting solar adoption further in the community. It also indicates that those who have experienced the benefits are likely to influence others to make the switch, contributing to wider sustainable energy adoption.

The experiences of solar adopters in Jhansi present a highly encouraging picture. The systems are yielding significant cost savings, enhancing quality of life, and contributing positively to environmental sustainability. Moreover, the strong performance ratings and widespread subsidy support have made solar energy a practical and appealing option. These findings reinforce the case for expanding solar adoption and optimizing policy efforts to reach more users.

Respondents who were solar non adopters were asked to choose the most relevant reason for not adopting solar systems. The responses revealed a mix of financial, informational, and technical concerns: In response to the question regarding the reasons for not adopting solar panels, the majority of non-adopters (47.6%) cited the high initial cost as the primary barrier. This indicates that the upfront investment required for installation remains a significant deterrent despite potential long-term savings. Additionally, 23.8% of respondents reported a lack of information about solar energy systems, reflecting the need for better awareness campaigns and educational initiatives.

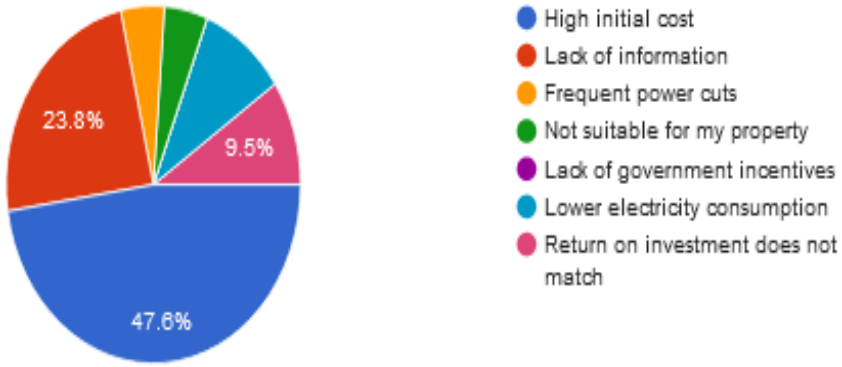

Figure 22: Pie chart showing the reasons for non-adoption of solar panels among respondents

About 9.5% felt that the return on investment does not match their expectations, while another 9.5% mentioned their low electricity consumption as a reason, suggesting that they did not find solar energy economically justifiable given their limited power usage. A smaller portion, 4.8%, stated that their property is not suitable for solar installations, possibly due to issues like lack of rooftop space or poor sunlight exposure. Another 4.8% cited frequent power cuts as a concern, which may affect the performance of grid-connected systems. Interestingly, none of the respondents felt that the lack of government incentives was a reason for not adopting solar, implying that awareness or access to available schemes may not be the primary issue in this context.

When asked whether they are considering adopting solar panels in the future, an overwhelming 95.2% of non-adopters expressed a positive intent, indicating a strong future potential for solar energy adoption in the region. This suggests that despite current barriers like high initial costs or lack of information, most respondents recognize the long-term benefits of solar power and are open to making the transition when circumstances become more favourable. On the other hand, only 4.8% responded with a definitive no, reflecting a very small segment that remains uninterested or unconvinced about the viability or relevance of solar energy for their specific needs. Overall, the data highlights a promising outlook for increased solar adoption, provided the existing challenges are effectively addressed

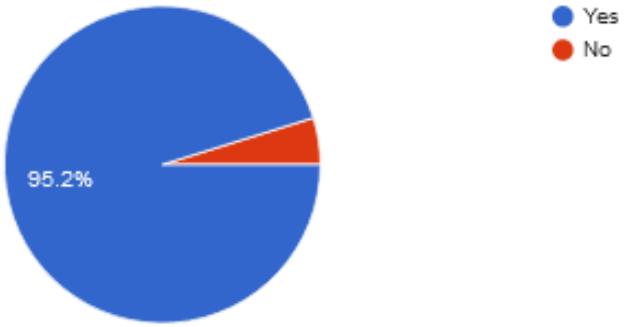

Figure 23: Pie chart showing the percentage respondents willingness to adopt solar panels in future

Among those who expressed willingness to adopt solar panels in the future, a follow-up question was asked to identify the key factors that would influence their decision. The most influential factor cited was reduction in electricity bills, selected by 70% of the respondents. This highlights the strong appeal of long-term cost savings associated with solar energy. The next most significant factor was government incentives, chosen by 50% of respondents indicating the importance of supportive policy measures and financial assistance in promoting adoption. Lower initial cost was selected by 40%, further emphasizing the barrier of upfront investment. In addition, 35% pointed to improvement in technology, suggesting a preference for more efficient or user-friendly solar solutions. A smaller segment, 15% (3 respondents), noted the availability of rooftop space as a determinant, while only 5% (1 respondent) identified it as the primary issue. These findings suggest that both economic and infrastructural considerations play a critical role in shaping future decisions regarding solar panel installation.

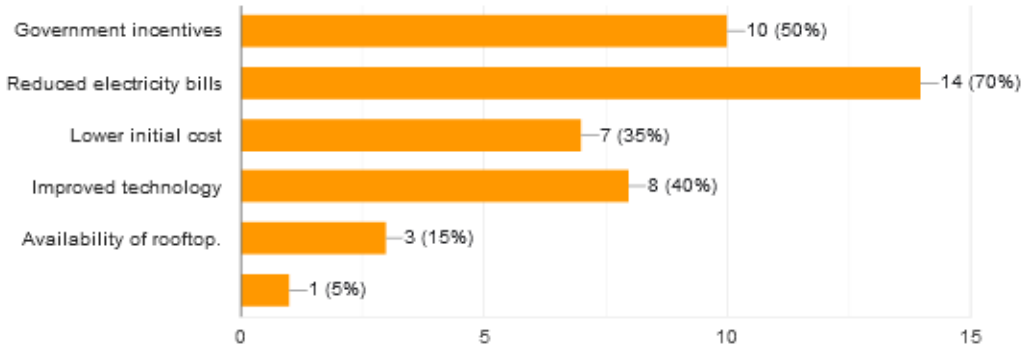

Figure 24: Chart showing the multiple reasons for future adoption of solar panels among respondents

Statistical Analysis of Solar Panel Adoption in Jhansi City

After examining the frequency distributions and visual representations of responses using charts, the study proceeded to test the formulated hypotheses to determine the statistical significance of key relationships. Two hypotheses were tested using Chi-square analysis: (i) whether reduced electricity bills are the primary reason for adopting solar panels, and (ii) whether the extent of monthly electricity bill reduction is associated with maintenance or repair costs. The results of these tests provide further insight into the financial and practical considerations influencing solar adoption in Jhansi.

Hypothesis 1: Reduced Electricity Bills as the Primary Reason for Solar Adoption.

H_0: Reduced electricity bill is not the primary reason for adopting solar panels in Jhansi

H_1: Reduced electricity bills are the primary reason for adopting solar panels in Jhansi

To examine this, a Chi-square Goodness of Fit test was conducted, comparing the observed frequency of responses with the expected frequency if all adoption reasons were equally likely.

Table 1: The Chi-square Goodness of Fit test showing that reduced electricity bills are the primary reason for adopting solar panels.

Chi-Square Test

Frequencies

What was the primary reason for adopting solar panels?			
	Observed N	**Expected N**	**Residual**
reduced electricity	67	34.0	33.0
government encouragements	1	34.0	-33.0
Total	68		

Test Statistics	
	what was the primary reason for adopting solar panels
Chi-Square	64.059[a]
df	1
Asymp. Sig.	.000
a. 0 cells (.0%) have expected frequencies less than 5. The minimum expected cell frequency is 34.0.	

The chi-square goodness of fit test results was $\chi^2 = 64.059$, df = 1, $p \approx 1.22 \times 10^{-15}$, indicating that the observed distribution of responses is highly significantly different from the expected distribution.

Interpretation: Since the p-value is much less than 0.05, the null hypothesis (H_0) is rejected. This supports the alternative hypothesis (H_1), confirming that reduced electricity bills are indeed the primary reason for adopting solar panels in Jhansi. These findings highlight the strong financial motivation behind solar adoption, aligning with the cost–benefit perspective of the study.

Hypothesis 2: Association between monthly electricity bill reduction and maintenance/repair cost after installation.

H_0: Reduction in monthly electricity bill is not associated with whether maintenance/repair costs were incurred.

H_1: Reduction in monthly electricity bill is associated with whether maintenance/repair costs were incurred.

To test this, a Chi-square Test of Independence was conducted using SPSS. The two categorical variables were:

- Monthly electricity bill reduction (e.g., <50%, 50–75%, >75%)
- Maintenance/repair costs incurred (Yes/No)

Table 2: The Chi-square Test of Independence indicates a significant association between monthly bill reduction and maintenance/repair costs

Crosstabs

Case Processing Summary						
	Cases					
	Valid		Missing		Total	
	N	**Percent**	**N**	**Percent**	**N**	**Percent**
how much your monthly electricity bill has been reduced since installing the solar system * have you encountered any maintenance or repair costs for your solar system	68	85.0%	12	15.0%	80	100.0%

How much your monthly electricity bill has been reduced since installing the solar system * have you encountered any maintenance or repair costs for your solar system

Cross Tabulation

			have you encountered any maintenance or repair costs for your solar system		Total
			Yes	No	
how much your monthly electricity bill has been reduced since installing the solar system	less than 25%	Count	3	0	3
		Expected Count	.9	2.1	3.0
		% within how much your monthly electricity bill has been reduced since installing the solar system	100.0%	.0%	100.0%
	25-50%	Count	4	4	8
			2.5	5.5	8.0
		% within how much your monthly electricity bill has been reduced since installing the solar system	50.0%	50.0%	100.0%
	50-75%	Count	3	12	15
		Expected Count	4.6	10.4	15.0
		% within how much your monthly electricity bill has been reduced since installing the solar system	20.0%	80.0%	100.0%
	more than 75%	Count	11	30	41
		Expected Count	12.7	28.3	41.0
		% within how much your monthly electricity bill has been reduced since installing the solar system	26.8%	73.2%	100.0%
	no change	Count	0	1	1
		Expected Count	.3	.7	1.0
		% within how much your monthly electricity bill has been reduced since installing the solar system	.0%	100.0%	100.0%
Total		Count	21	47	68
		Expected Count	21.0	47.0	68.0
		% within how much your monthly electricity bill has been reduced since installing the solar system	30.9%	69.1%	100.0%

Chi-Square Tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	9.679[a]	4	.046
Likelihood Ratio	10.279	4	.036
Linear-by-Linear Association	5.551	1	.018
N of Valid Cases	68		

a. 6 cells (60.0%) have expected count less than 5. The minimum expected count is .31.

The Chi-square test results were: $\chi^2 = 9.679$, degree of freedom (df) = 4, $p < 0.05$, indicating a moderate association between the variables.

Interpretation: Since the p-value is less than 0.05, the null hypothesis (H_0) is rejected, supporting the alternative hypothesis (H_1). This indicates that the extent of monthly electricity bill reduction is associated with whether maintenance or repair costs were incurred. In other words, households experiencing higher maintenance or repair costs may see different net savings from solar adoption, highlighting the financial considerations beyond just electricity bill reduction

Discussion

The study aimed to examine the current level of awareness, adoption patterns, and barriers associated with solar panel usage in Jhansi. It divided respondents into adopters and non-adopters to comprehensively understand both perspectives. The findings reveal critical insights into the adoption behaviour, motivators, financial influences, and social acceptance of solar energy in the region.

For those who adopted solar panels, the decision was influenced by multiple practical and environmental factors. Reducing electricity bills was cited as the primary motivation by 48.5% of the respondents, indicating that economic benefits are a dominant driver. This was followed by long-term financial savings (25%), which reinforces the perception of solar energy as a worthwhile investment over time. Interestingly, environmental concerns motivated 16.2% of the respondents, reflecting a growing consciousness about climate change and clean energy among the urban population. A smaller but notable proportion (10.3%) reported being encouraged by government promotions and subsidies, showcasing the impact of policy incentives.

System Size and Maintenance: Regarding the size of installed systems, 3 kW was the most common installation size (63.4%), followed by 2 kW (25%), larger than 3 kW (10.3%), and 1 kW (1.5%). This distribution reflects that medium-sized systems are considered optimal by most households or small businesses in Jhansi, balancing cost with energy requirements. The responses also suggest that large-scale installations are less common, possibly due to financial constraints or limited rooftop space. An encouraging 69.1% of adopters reported no repair or maintenance costs after installation. This finding counters a common misconception about solar panels requiring frequent and expensive upkeep. The perception of solar panels being low-maintenance could further support future adoption if communicated effectively.

Energy Impact and ROI Awareness: When asked about the impact of solar panels on their electricity consumption, 76.5% of respondents acknowledged a positive effect, affirming the operational efficiency of solar systems. However, when it came to the return on investment (ROI), only 45.6% were aware of their payback period, while a larger group (54.4%) admitted ignorance. This finding is significant as it suggests that although users see immediate benefits in terms of lower bills, there is a lack of in-depth financial understanding. Educating current and potential adopters on ROI could further reinforce confidence in solar investments.

Subsidy and Financial Support: A very large majority (92.5%) of adopters confirmed receiving subsidies or financial assistance for installation. This highlights the pivotal role of government incentives in making solar energy accessible and financially viable for middle-income populations. Only 7.5% did not receive any financial support, suggesting the broad effectiveness of the subsidy mechanism in this context.

Impact on Household or Business Expenses: To assess the economic impact, respondents were asked on a 4-point Likert scale how the installation of solar panels affected their overall expenses. The results revealed that 28 respondents experienced a significant decrease, 26 reported a moderate decrease, while 11 saw no change, and only 3 reported a slight increase in expenses. This overwhelmingly positive feedback reflects the financial effectiveness of solar panels in the long run, especially in offsetting electricity costs.

Performance Rating and Satisfaction: The performance of the installed solar panel systems was generally rated highly. 50.7% of users gave a 4-star rating, while 34.3% gave 5 stars, indicating strong satisfaction. A smaller group, 14.9%, rated the system 3 stars. The average rating of 4.19 out of 5 reflects a broadly positive user experience. Notably, 100% of users stated they would recommend solar panels to others, which indicates a strong word-of-mouth potential and satisfaction-driven promotion.

Non-Adopters' Perspectives and Barriers: Among the non-adopter group, the most significant barrier was the high initial cost, cited by 47.6% of respondents.

The chi-square goodness of fit test results findings highlight the strong financial motivation behind solar adoption, aligning with the cost–benefit perspective of the study. The Chi-square test results , indicating households experiencing higher maintenance or repair costs may see different net savings from solar adoption, highlighting the financial considerations beyond just electricity bill reduction.

Findings

- High awareness of solar energy benefits among respondents.
- Strong agreement that solar contributes to economic development in Jhansi.
- Positive perception that solar is more beneficial than traditional energy.
- Primary motivation for adoption is reduction in electricity bill.
- Significant savings reported, with most respondents experiencing over 75% reduction in monthly bills.
- Widespread acceptance of solar as a sustainable alternative to conventional electricity.
- Financial incentive is the key driver, overshadowing environmental or social reasons.
- Data highlights scope for wider adoption if awareness and support increases.

Limitations

- The survey did not fully represent the entire population of Jhansi, limiting the universality of results.
- Data was collected within a short period, limiting the ability to assess long term adoption trends.
- Some respondents may lack complete understanding of solar technology, affecting their answers.

Suggestions/Policy Recommendations

- **Boost Subsidy Awareness and Accessibility**: Ensure that government subsidies are not only available but also well-publicized and easily obtainable through digital and offline platforms
- **Develop Tiered Financial Models:** Introduce elastic financing plans, low-interest loans, or EMI options specially designed for lower-income and middle-income households.
- **Motivate local Installers and Technicians**: Boost the solar job ecosystem in Jhansi by training and supporting local youth in installation and maintenance services which thereby increases the employment rate.
- **Promote Case Study:** Share real-life success stories of local adopters to build trust and reduce misconceptions among hesitant users.
- **Workshops on ROI Calculation:** Arrange interactive sessions to help individuals understand long-term financial savings and environmental returns of solar systems.
- **Community Outreach Campaigns:** Conduct consistent outreach via local radio, schools, and public gatherings to educate people about the benefits and feasibility of solar energy.

Conclusion

The study titled "Assessing the Economic Impact of Solar Panel Adoption in Jhansi City: A Cost-Benefit Analysis" reveals a positive track toward renewable energy use, with 68 of surveyed households adopting solar panels. The major catalyst behind this adoption is the desire to reduce electricity expenses, supplemented by environmental awareness and improvements in living standards. A major percentage of users received government subsidies or financial assistance, which significantly influenced their decision.

The economic benefits were evident: a notable portion of users experienced reduction in electricity bills, with most investing in 3 kW systems. Despite small maintenance challenges faced by 30.9% of users, the overall satisfaction level was high, averaging 4.19 stars, and all adopters expressed their willingness towards recommending solar systems to others. On the other hand, 18.7% of

respondents had not adopted solar panels, primarily due to high upfront costs, lack of awareness, or concerns about the return on investment. However, the motivating part is that 95.2% of these non-adopters are open to future adoption, provided certain economic and informational barriers are addressed.

The study confirms that while solar adoption is growing and economically rewarding, certain gaps like-particularly in affordability, awareness, and perception of ROI need to be filled to achieve broader adoption in semi-urban regions like Jhansi.

Future Scope

The future scope of this study lies in the extending the analysis to a larger sample size across different regions to capture diverse socio-economic and cultural factors influencing solar adoption. Further research can integrate advanced econometric and machine learning models for more precise predictions of adoption behaviour. Exploring policy interventions, financial incentives, and technological innovations such as smart grids and energy storage solutions can provide deeper insights. Moreover, a longitudinal study on the long-term economic and environmental impacts of solar adoption can strengthen the evidence base for promoting sustainable energy transitions.

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