**CONSTRAINTS FACED BY FARMERS IN ADOPTION OF SOLAR POWERED IRRIGATION SYSTEM IN SOUTHERN RAJASTHAN**

**Abstract**

India’s agriculture sector is heavily dependent on energy for irrigation, yet many rural areas suffer from unreliable electricity and costly diesel usage. Solar Powered Irrigation Systems (SPIS) offer a sustainable solution by utilizing abundant solar energy for farm operations. With rising fuel prices and a push for clean energy, SPIS is gaining popularity among farmers. However, many farmers have faced challenges in adoption of Solar Powered Irrigation System. To address these constraints, a study was conducted to know the various constraints which were faced by the farmers who installed solar powered irrigation in Udaipur and Sirohi districts of Rajasthan. For this study, 100 farmers of ten villages (10 from each village) from Udaipur district and 100 farmers of ten villages (10 from each village) from Sirohi district were selected. The findings of the study ranked the constraints based on their Mean Percent Score (MPS). The most severe constraints were unable to locate fault during operation (88.66 MPS), unavailability of credit at marginal rate (85.00 MPS), difficulty in finding a service mechanic in nearby area (82.33 MPS) and customer care centers are unavailable in nearby areas (81.16 MPS).

**Keywords**: Solar Power, Constraints, Adoption, Irrigation, Farmers

1. **INTRODUCTION:**

Renewable energy sources and technologies have potential to provide solutions to the long-standing energy problems being faced by the developing countries. The renewable energy sources like wind energy, solar energy, geothermal energy, ocean energy, biomass energy and fuel cell technology can be used to overcome energy shortage in India. Solar energy technology is very important tool which can lowers worldwide carbon emissions. Solar-electrical (photovoltaic) pumping systems provide a welcome alternative to fuel burning generators, cumbersome windmills and hand pumps. A solar pump is a lot like a windfall which fills a tank when the energy is available. The big difference is that solar pumps don't slow-down in summer when winds are low. Solar energy use can also help in reducing the electricity and diesel subsidy bill of the government and farmers' dependency on erratic electricity supply and costly diesel. Therefore, the use of solar energy in agriculture is a potential area in the country and has vast scope to make substantial contributions towards the increasing farmers' income by reducing cost of irrigation and enhancing access to irrigation, especially in the remote areas.

In recent years, solar irrigation has become increasingly interesting for countries as a reliable, clean energy solution for agricultural water management, especially in areas with high incident solar radiation as investment costs for solar powered irrigation systems are decreasing Solar Powered Irrigation System (SPIS) technologies are becoming a viable option for many farmers. In rural areas, solar irrigation can be a means to ensuring access to energy for agriculture, and possibly for other users in rural areas that lack reliable access to electricity or where diesel fuel is expensive.

Agriculture is undergoing rapid scientific advancement during these days. There is no technical and operational know-how in these days but the most complex and significant problems are dissemination of new farm technologies and its utilization by the farmers. Choudhary *et al*. (2025) showed that high cost of solar pumps equipment was the main problem in adoption of solar pumps. Sehgal (2017) highlighted that lack of awareness about government subsidies and high initial costs were major barriers in adoption of solar technologies. Biele (2024) referred operating and maintaining a solar irrigation system requires technical knowledge that many farmers may not possess. Regular maintenance is crucial to ensure the system operates efficiently and has a long lifespan. Chandrakala *et al*. (2023) revealed that farmers were facing two major problems: 'the solar pump is notworking during cloudy days and "low farm income" in her study area. Durga *et al*. (2024) found that the lack of cost-effective ways for quality assurance of panels and pumps, which results in widespread sales of poor-quality products. There are many obstacles which hinder the adoption process. Adoption of technology depends upon various factors which may either accelerate the level of adoption. Solar irrigation systems present a promising solution for sustainable farming, offering renewable energy to power water pumps. However, adopting these systems is not without its challenges. Understanding these hurdles is the first step towards overcoming them and empowering farmers.

**2. MATERIALS AND METHODS**

**2.1 Locale and Sampling**

**2.1.1 Area of study**

This study was carried out in Southern part of Rajasthan state. This study area comes under the jurisdiction area of MPUAT, Udaipur. Two districts namely; Udaipur and Sirohi was selected purposively on the basis of maximum number of farmers having solar powered irrigation system.

**2.2.2 Research Design**

An ex-post facto research design was employed to carry out the study.

**2.2.3 Method of data collection**

Survey, in-depth discussion, and participant observation methods were used for collection of primary data with the help of interview schedule (structured and semi-structured). Reports, literature published by various government/ non-government agencies and reference material available on institutes project report of watershed were referred for secondary data collection.

**2.2.4 Sample size**

Two tehsils from each district were selected purposively on the basis of having maximum number of solar powered irrigation system. Thus, total 4 tehsils were selected for study purpose. Five villages from each selected tehsil having maximum number of solar powered irrigation system at farmer level were selected. Thus, the total 20 villages were selected for study purpose. Ten farmers from each selected village was selected randomly. Thus, a total of 200 farmers were selected for the present investigation.

**3. RESULTS AND DISCUSSION:**

In the context of this study, the constraints perceived by farmers, both during and after adoption of Solar Powered Irrigation System were examined and categorized into technical, financial, repair and maintenance and other constraints. Additionally, efforts also made to identify overall scenario. Findings related to these constraints are presented in subsequent tables, providing valuable insights into the factors that influenced technology adoption among respondents.

**3.1 Technical constraint perceived by farmers**

The data showed in Table 1 shaded light on technical constraints perceived by farmers regarding Solar Powered Irrigation System. Among farmers, technical constraint perceived as most severe was "In case of water pump inoperative, beneficiaries unable to locate fault" with 88.66 MPS. The second constraint with an MPS of 87.33 was “Beneficiaries need auto sunlight adjustable solar panel rather than fixed type due to my farming situation”. Other important constraints faced by farmers were “Lack of knowledge about specifications of wires and cables required for SPIS”, “Beneficiaries hesitate to clean solar panel due to fear of water can damage solar panel”, “Lack of knowledge to check leakage of current in power cables”, “Water pump given to beneficiaries were not as per the depth of ground water table”, “The water available through the SPIS is insufficient for farming”, “SPIS installed at water logged area”, “SPIS does not deliver or less deliver irrigation water in cloudy or rainy days”, “Sand, dirt, rodents and insects in the borehole or well” and “SPIS given to me of less capacity as compare to beneficiaries land holding” with an MPS of 74.66, 73.83, 70.00, 69.33, 68.16, 67.00, 66.33, 65.33 and 54.83, respectively and given third, fourth, fifth, sixth, seventh, eighth, ninth, tenth and eleventh, respectively.

The least severe constraints were “Termites and rats damage plastic of electric cables” with an MPS of 48.33 and given twelfth. The thirteenth ranked constraint was “SPIS frequently damaged by lightening” with an MPS of 43.16 indicating that it was perceived as less severe or less commonly experienced by the majority of farmers. The constraint “Wrong orientation of photovoltaic panel” was ranked fourteenth with a MPS of 41.66 making it the least severe technical constraint reported by farmers.

Similar result obtained by Choudhary *et al.* (2025), Raghuwanshi (2019) and Meena (2019).

**Table 1 Technical constraint faced by farmers about Solar Powered Irrigation System**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Sr. No**. | **Constraint** | **Udaipur**  **(n1=100)** | | **Sirohi**  **(n2=100)** | | **Overall**  **(n=200)** | |
| **MPS** | **Rank** | **MPS** | **Rank** | **MPS** | **Rank** |
| 1 | SPIS deliver or less deliver irrigation water in cloudy or rainy days | 65.66 | VIII | 67.00 | VI | 66.33 | IX |
| 2 | Lack of knowledge about specifications of wires and cables required for SPIS | 67.66 | VII | 81.66 | II | 74.66 | III |
| 3 | SPIS given to me of less capacity as compare to beneficiaries land holding | 52.33 | X | 57.33 | X | 54.83 | XI |
| 4 | The water available through the SPIS is insufficient for farming | 67.66 | VII | 68.66 | IV | 68.16 | VII |
| 5 | Water pump given to beneficiaries were not as per the depth of ground water table | 72.33 | V | 66.33 | VII | 69.33 | VI |
| 6 | Beneficiaries need auto sunlight adjustable solar panel rather than fixed type due to my farming situation | 87.66 | II | 87.00 | I | 87.33 | II |
| 7 | Lack of knowledge to check leakage of current in power cables | 74.66 | IV | 65.33 | VIII | 70.00 | V |
| 8 | Wrong orientation of photovoltaic panel | 43.33 | XIII | 40.00 | XIII | 41.66 | XIV |
| 9 | Termites and rats damage plastic of electric cables | 47.00 | XI | 49.66 | XI | 48.33 | XII |
| 10 | Sand, dirt, rodents and insects in the borehole or well | 69.00 | VI | 61.66 | IX | 65.33 | X |
| 11 | SPIS frequently damaged by lightening | 44.00 | XII | 42.33 | XII | 43.16 | XIII |
| 12 | SPIS installed at water logged area | 63.33 | IX | 70.66 | III | 67.00 | VIII |
| 13 | Beneficiaries hesitate to clean solar panel due to fear of water can damage solar panel | 79.33 | III | 68.33 | V | 73.83 | IV |
| 14 | In case of water pump inoperative, beneficiaries unable to locate fault | 90.33 | I | 87.00 | I | 88.66 | I |

**3.2 Financial constraint perceived by farmers**

The data showed in Table 2 provided valuable insights into the financial constraints faced by farmers. "Unavailability of credit at marginal rate" received the most severe financial constraint by farmers with 85.00 MPS and given first rank. The constraint "Inadequate subsidy provided by Government" received an MPS of 84.33 and was ranked second. The moderate financial constraints faced by the farmers were "Replacement is difficult due to high cost of components" and "High operational cost of SPIS due to repair and maintenance" which got same third rank with an MPS of 84.00. This was followed by “High wage charged by service mechanic” and "High cost of Solar Powered Irrigation System" with an MPS of 82.33 and 75.16 and given fourth and fifth rank, respectively.

The least severe financial constraint was "Particularly high price charged if SPIS purchased under subsidy" with 73.83 MPS and given sixth rank. The least severe financial constraint was "High maintenance cost of SPIS" with 66.66 MPS and given seventh rank.

This finding supported by the findings of Prajapati *et al.* (2019) and Wassie *et al.* (2021).

**Table 2** **Financial constraint faced by farmers about Solar Powered Irrigation System**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Sr. No**. | **Constraints** | **Udaipur**  **(n1=100)** | | **Sirohi**  **(n2=100)** | | **Overall**  **(n=200)** | |
| **MPS** | **Rank** | **MPS** | **Rank** | **MPS** | **Rank** |
| 1 | High cost of Solar Powered Irrigation System | 78.33 | VII | 72.00 | V | 75.33 | V |
| 2 | Inadequate subsidy provided by Government | 79.66 | V | 89.00 | I | 84.33 | II |
| 3 | Unavailability of credit at marginal rate | 84.00 | I | 86.00 | III | 85.00 | I |
| 4 | High maintenance cost of Solar Powered Irrigation System | 66.66 | VIII | 66.66 | VII | 66.66 | VII |
| 5 | Replacement is difficult due to high cost of components | 83.66 | II | 84.33 | IV | 84.00 | III |
| 6 | Particularly high price charged if SPIS purchased under subsidy | 79.33 | VI | 68.33 | VI | 73.83 | VI |
| 7 | High wage charged by Service mechanic | 81.33 | IV | 84.33 | IV | 82.83 | IV |
| 8 | High operational cost of SPIS due to repair and maintenance | 81.66 | III | 86.33 | II | 84.00 | III |

**3.3 Repair and maintenance constraint perceived by farmers**

The data showed in Table 3 provided valuable insights into the repair and maintenance constraint faced by farmers. "Difficulty in finding a service mechanic in nearby area" received the most severe constraint by farmers with 82.33 MPS and given first rank. The second most severe constraint was “Free-lance mechanics were also unavailable in local market” with 80.66 MPS. The other constraints were “Service centers are located at far distance” which was given third rank with 78.33 MPS, followed by “Unaffordable cost of controller in case of replacement”, “Components or spare parts are unavailable in nearby locale market”, “Beneficiaries hesitate to clean and wash solar panels due to current shock” and “Less availability of wear-out or burn-out components in nearby area” with 76.00, 75.16, 73.83 and 66.63 MPS and given fourth, fifth, sixth and seventh, respectively. The least severe constraint was “Beneficiaries cannot rewire controller in case of its replacement or burn-out” which was given eighth rank with 63.83 MPS.

This result are in conformity with the findings of Raghuwanshi (2019), Choudhary *et al.* (2025) and Upadhyay (2023).

**Table 3 Repair and maintenance constraint faced by farmers about Solar Powered Irrigation System**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Sr. No**. | **Constraints** | **Udaipur**  **(n1=100)** | | **Sirohi**  **(n2=100)** | | **Overall**  **(n=200)** | |
| **MPS** | **Rank** | **MPS** | **Rank** | **MPS** | **Rank** |
| 1 | Beneficiaries cannot rewire controller in case of its replacement or burn out | 61.00 | IX | 66.66 | VII | 63.83 | VIII |
| 2 | Unaffordable cost of comptroller in case of replacement | 79.33 | III | 72.66 | V | 76.00 | IV |
| 3 | Less availability of wear out or burn out component in nearby area | 66.00 | VIII | 66.66 | VII | 66.33 | VII |
| 4 | Difficulty in finding a service mechanic in nearby area | 82.66 | I | 82.00 | I | 82.33 | I |
| 5 | Beneficiaries hesitate to clean and wash solar panels due to current shock | 79.33 | III | 68.33 | VI | 73.83 | VI |
| 6 | Service centers are located at far distance | 78.33 | V | 78.33 | III | 78.33 | III |
| 7 | Components or spare-parts are unavailable in nearby locale market | 74.66 | VII | 75.66 | IV | 75.16 | V |
| 8 | Free-lance mechanics are also unavailable in local market | 81.66 | II | 79.66 | II | 80.66 | II |

**3.4 Other constraints perceived by farmers**

The analysis of the data showed in Table 4 indicates that "Customer care centers are unavailable in nearby areas" emerged as the most severe with 81.16 MPS and given first rank by beneficiary farmers. The second major constraint perceived by farmers was " I am not satisfied by the service of dealer " 68.16 MPS, followed by “Solar panels and comptroller fixer are incompatible to minimize their theft” given third rank with 66.83 MPS.

**Table 4 Statement wise other constraint faced by farmers about Solar Powered Irrigation System**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Sr. No**. | **Constraints** | **Udaipur**  **(n1=100)** | | **Sirohi**  **(n2=100)** | | **Overall**  **(n=200)** | |
| **MPS** | **Rank** | **MPS** | **Rank** | **MPS** | **Rank** |
| 1 | I am not satisfied by the service of dealer | 65.66 | III | 70.66 | II | 68.16 | II |
| 2 | Customer care centers are unavailable in nearby areas | 82.00 | I | 80.33 | I | 81.16 | I |
| 3 | Solar panels and comptroller fixer are incompatible to minimize their theft | 68.33 | II | 65.33 | III | 66.83 | III |

**3.5 Types of constraints perceived by beneficiary farmers**

To get an overview of different categories of constraints perceived by farmers during and after adoption of Solar Powered Irrigation System, overall score for each category was pooled and results have been presented in Table 5.

The analysis of the data presented in Table 5 reveals that financial constraints emerged as the most significant constraint securing first rank by farmers with 80.00 MPS. This might be due to high initial installation cost, inadequate subsidies and lack of access to affordable credit facility. Repair and maintenance constraints were placed on second rank by farmers with 74.24 MPS. Key reasons for this constraint were non-availability of skilled mechanics in nearby areas, long distances to service centers and unaffordable replacement costs for essential components like controllers or inverters. The third ranked given by farmers with 72.05 MPS to other constraints. This was because of unsatisfactory performance by service dealer and non-availability of customer centers. Technical constraints obtained the fourth rank with 65.63 MPS by farmers.

**Table 5 Constraints faced by farmers about Solar Powered Irrigation System (n=200)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Sr. No.** | **Constraints** | **MPS** | **Rank** |
| **1** | Other constraints | 72.05 | III |
| **2** | Technical constraints | 65.63 | IV |
| **3** | Financial constraints | 80.00 | I |
| **4** | Repair and maintenance constraints | 74.24 | II |

**3.6 Comparison of constraint between farmers of Udaipur and Sirohi districts in adoption of Solar Power Irrigation System**

To find out the difference in constraint faced by the farmers of Udaipur and Sirohi district in adoption of Solar Power Irrigation System, following hypotheses were formed and tested by employing ‘Z’ test and results are presented in Table 6.

**NH0:** There is no significant difference between Udaipur and Sirohi district farmers regarding constraint faced by farmers in adoption of Solar Power Irrigation System.

**RH1:** There is significant difference between Udaipur and Sirohi district farmers regarding constraint faced by farmers in adoption of Solar Power Irrigation System.

**Table 6 Comparison of constraint between farmers of Udaipur and Sirohi districts regarding Solar Power Irrigation System (n=200)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sr. No.** | **Category** | **Mean** | **S.D.** | **‘Z’ value** |
| **1** | Udaipur | 50.60 | 4.80 | 01.27NS |
| **2** | Sirohi | 47.85 | 4.49 |

Data reported in Table 6 show that calculated Z value 01.11 found to be less than the tabulated value, which indicates statically non-significant difference. So, the null hypothesis (NH0) “There is no significant difference between Udaipur and Sirohi district farmers regarding constraint faced by farmers in adoption of Solar Power Irrigation System” is accepted and research hypothesis (RH1) is rejected. From the above discussion it can be concluded that farmers of selected districts Rajasthan were possessed similar level of constraint in adoption of Solar Power Irrigation System.

**4. CONCLUSION**

The study concludes that farmers in Southern Rajasthan encounter multiple constraints in adopting and utilizing Solar Powered Irrigation Systems (SPIS), with financial issues emerging as the most severe, particularly due to high installation costs, inadequate subsidies, and limited access to affordable credit. Repair and maintenance challenges, such as the unavailability of nearby service centers and skilled technicians, further hinder system efficiency. Technical constraints, including a lack of knowledge on troubleshooting, system specifications, and hesitation in maintenance practices, also pose significant barriers. Additionally, issues like poor customer service, absence of local support infrastructure, and theft-related concerns reflect systemic gaps in implementation. Despite regional differences, no significant variation was observed between Udaipur and Sirohi districts, indicating uniform challenges across locations. These findings emphasize the urgent need for improved policy support, localized service infrastructure, enhanced farmer training, and streamlined subsidy mechanisms to promote the sustainable adoption of SPIS in rural India.

**DISCLAIMER**

Authors hereby declare that no generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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