7 Adoption of Solar Irrigation Systems and it's Impact on Rural Development-A Study

Om Dilip Tivhane[1*] & Dr. Pavan M. Kuchar[2]

[1]Student, Department of Business Administration and Research, Shri Sant Gajanan Maharaj College of Engineering Shegaon, Maharashtra, India.

[2]Assistant Professor and Head of Department, Department of Business Administration and Research, Shri Sant Gajanan Maharaj College of Engineering Shegaon, Maharashtra, India.

*Corresponding Author: omtivhane123@gmail.com

Abstract

The study titled “Adoption of Solar Irrigation Systems and it's Impact on Rural Development-A study” examines the role of solar-powered irrigation in enhancing agricultural productivity and promoting sustainable rural development in India, with a specific focus on Maharashtra and the Vidarbha region. Agriculture in rural India heavily depends on reliable irrigation; however, traditional methods powered by electricity and diesel face challenges such as high operational costs, energy insecurity, and environmental degradation. Solar irrigation systems have emerged as a viable and eco-friendly alternative to address these issues. The primary objective of this research is to analyse the adoption level of solar irrigation among farmers, identify the key factors influencing its adoption, and evaluate its economic, social, and environmental impacts. The study adopts a descriptive and analytical research design, using both primary and secondary data. Primary data were collected through structured questionnaires and interviews with 100 farmers, while secondary data were sourced from government reports, research articles, and institutional publications. The findings reveal that solar irrigation significantly reduces dependence on conventional energy sources, lowers irrigation costs, and ensures reliable water supply, leading to increased cropping intensity and improved farm income. Additionally, the technology contributes to rural development by generating employment opportunities, empowering farmers (including women), and reducing seasonal migration. However, the study also identifies key challenges such as high initial investment, lack of technical awareness, limited access to financing, and concerns related to groundwater over-extraction. The research concludes that while solar irrigation systems hold immense potential for sustainable agricultural growth and rural development, their widespread adoption requires stronger policy support, enhanced awareness programs, improved financial accessibility, and effective water management practices. The study provides valuable insights for policymakers,

researchers, and stakeholders to promote renewable energy-based irrigation solutions in rural areas.

Keywords: Solar Irrigation Systems, Rural Development, Renewable Energy, PM-KUSUM, Sustainable Agriculture, Agricultural Productivity, Cost Reduction, Farmer Income.

Introduction

Agriculture remains the backbone of rural India, employing over half of the population and playing a crucial role in food security. However, conventional irrigation methods such as diesel and electric pumps are associated with high costs, unreliable power supply, and environmental concerns. In this context, solar irrigation has emerged as a sustainable alternative, utilising solar energy to operate water pumps without dependence on fossil fuels or grid electricity.

Solar irrigation integrates photovoltaic technology with water pumping systems to provide an efficient, eco-friendly solution for agricultural water management. In India, its adoption has increased significantly due to government initiatives such as the PM-KUSUM scheme, which aims to reduce farmers' reliance on diesel and electricity while ensuring reliable irrigation.

States like Maharashtra have led the adoption due to favourable solar conditions, strong policy support, and high subsidy provisions. The technology has contributed to reduced irrigation costs, improved cropping intensity, increased farmer income, and enhanced rural development. Despite these benefits, challenges such as high initial investment, maintenance issues, and groundwater management remain critical concerns.

Overall, solar irrigation represents a promising pathway toward sustainable agriculture, energy security, and rural economic development in India.

Literature Review

Solar irrigation systems have emerged as a sustainable alternative to conventional irrigation methods in India, addressing issues such as high energy costs, unreliable power supply, and environmental degradation. With increasing pressure on water and energy resources, solar-powered irrigation systems (SPIS) offer a viable solution by improving agricultural productivity, reducing input costs, and promoting rural energy self-sufficiency.

Existing literature highlights significant economic benefits of solar irrigation. Studies indicate that farmers adopting solar pumps experience a reduction in irrigation costs by 15–30% and an increase in crop productivity and income. Adoption, however, is influenced by factors such as farm size, access to credit,

ISBN: 978-81-999799-3-2

awareness, and government subsidies. Programs like PM-KUSUM have played a crucial role in accelerating adoption across rural India.

From a policy perspective, government support through subsidies and institutional frameworks has been identified as a key driver for large-scale implementation. However, research also emphasizes the need for better coordination between energy and water management policies to avoid issues such as groundwater over-extraction.

Environmental studies confirm that solar irrigation reduces dependence on fossil fuels and lowers greenhouse gas emissions, contributing to climate-resilient agriculture. At the same time, improper regulation may lead to excessive groundwater usage. Socially, solar irrigation has contributed to rural employment generation, increased participation of women in agriculture, and reduced rural-to-urban migration due to improved irrigation reliability. Region-specific studies, particularly in Maharashtra and Vidarbha, demonstrate positive outcomes such as increased cropping intensity, higher farmer income, and community-based irrigation models. However, there remains a gap in large-scale empirical and longitudinal studies evaluating long-term impacts.

Overall, the literature establishes solar irrigation as a transformative tool for sustainable agriculture and rural development, while also highlighting the need for integrated policy frameworks and resource management strategies.

Research Methodology

Objectives of the Study

- Adoption rate of rural solar irrigation.
- Identify the socio-economic and demographic factors, which influence the adoption.
- Measuring the Solar Irrigation System's economic, social, and environmental impacts
- Recognize obstacles that farmers face when they want to adopt and keep using solar systems.
- Show policy options to facilitate adoption and support the rural sector's sustainable development

Scope of the Study

The study focuses on rural farmers and their adoption of solar irrigation systems. It examines adoption trends, economic benefits, productivity improvements, and overall impact on rural development.

ISBN: 978-81-999799-3-2

The research is limited to selected regions; however, the findings can be generalised to similar rural settings with comparable socio-economic and agricultural conditions.

Research Design

The study adopts a **descriptive and analytical research design**.

- The descriptive approach is used to understand the current level of awareness and adoption of solar irrigation systems.
- The a**nalytical approach** is used to evaluate the relationship between adoption and its impact on income, cost, and productivity.

The study primarily uses **percentage analysis** for data interpretation

Data Collection

The study is based on both primary and secondary data:

- **Primary Data:** Collected through structured questionnaires and personal interviews with farmers
- **Secondary Data:** Collected from government reports, research publications, journals, and official sources

This combination ensures the reliability and validity of the research findings.

Data Collection Tools

The following tools were used:

- Structured Questionnaire
- Interviews
- Observation Method
- Focus Group Discussions (FGDs)

These tools helped in collecting both quantitative and qualitative data for comprehensive analysis.

Sampling Design

The study uses a **multistage random sampling technique**.

Initially, the study area was selected, followed by the selection of villages where solar irrigation systems are implemented. Farmers were then selected randomly, including both adopters and non-adopters.

The total sample size consists of **100 farmers**, which is considered adequate for meaningful analysis. This approach ensures proper representation and reduces sampling bias.

Limitations of the Study

Despite careful planning, the study has certain limitations:

ISBN: 978-81-999799-3-2

- The study is restricted to a limited geographical area
- The sample size is relatively small
- Data is based on respondents' opinions, which may involve bias
- Long-term impacts of solar irrigation are not covered

Data Analysis and Interpretation

- **Awareness of Solar Irrigation Schemes**

Table 1: Awareness of Government Irrigation Schemes

Level of Agreement	Percentage (%)
Strongly Agree	10
Agree	45
Neutral	20
Disagree	15
Strongly Disagree	10

Interpretation: A majority (55%) of respondents are aware of government irrigation schemes, while 25% lack awareness. This indicates moderate awareness but highlights the need for improved outreach and awareness programs.

- **Economic Impact of Solar Irrigation**

Table 2: Reduction in Irrigation Cost

Level of Agreement	Percentage (%)
Strongly Agree	16
Agree	46
Neutral	29
Disagree	3
Strongly Disagree	6

Interpretation: Around **62%** of respondents agreed that solar irrigation reduces irrigation costs, confirming strong economic benefits and reduced dependency on diesel and electricity

- **Factors Influencing Adoption**

Table 3: Factors Influencing Adoption of Solar Irrigation

Factors	Percentage (%)
Subsidy Availability	31
Electricity Reliability	26
Expected Long-term Savings	20
Initial Investment	17
Initial Investment	6

ISBN: 978-81-999799-3-2

Interpretation: Subsidy availability (**31%**) and electricity reliability (**26%**) are the major factors influencing adoption, highlighting the importance of financial support and infrastructure reliability.

- **Barriers to Adoption**

Table 4: Reasons for Not Adopting Solar Irrigation

Factors	Percentage (%)
High Initial Cost	29
Lack of Awareness	26
Lack of Technical Knowledge	19
Space Constraints	19
Already Using Other Systems	7

Interpretation: High initial cost (**29%**) and lack of awareness (**26%**) are the primary barriers, indicating the need for subsidies, training, and awareness programs to improve adoption

- **Benefits of Solar Irrigation**

Table 5: Benefits After Installing a Solar Pump

Benefit	Percentage (%)
Reliable Water Supply	25
Reduced Diesel/Electricity Use	24
Reduced Irrigation Cost	22
Increased Crop Production	20
Increased Income	9

Interpretation: Reliable water supply (25%) and reduced energy usage (24%) are the most significant benefits include demonstrating improved efficiency and sustainability in agriculture.

- **Impact on Rural Development**

Table 5: Improvement in Standard of Living

Level of Agreement	Percentage (%)
Strongly Agree	12
Agree	54
Neutral	21
Disagree	5
Strongly Disagree	8

Interpretation: A majority (**66%**) of respondents reported improved standard of living, indicating that solar irrigation contributes significantly to rural development and livelihood improvement.

ISBN: 978-81-999799-3-2

Findings

The study on the adoption of solar irrigation systems among rural farmers reveals several important findings: A moderate level of awareness exists, with 55% of respondents aware of government schemes, indicating the need for stronger awareness initiatives.

Solar irrigation has a significant economic impact, as 62% of farmers reported reduced irrigation costs. Around 59% of respondents observed an increase in crop yield, showing improved agricultural productivity. Subsidy availability (31%) and electricity reliability (26%) are the most influential factors driving adoption. The major barriers to adoption are high initial cost (29%) and lack of awareness (26%), along with technical knowledge gaps.

Key benefits include reliable water supply (25%), reduced energy consumption, and improved farming efficiency. A majority (66%) of respondents reported an improvement in standard of living, indicating a positive contribution to rural development. These findings confirm that solar irrigation is both economically viable and socially beneficial, though certain barriers still limit its widespread adoption.

Conclusion

The present study highlights the growing importance of solar irrigation systems as a sustainable solution for rural agricultural development. The findings demonstrate that solar irrigation not only reduces dependency on conventional energy sources but also improves farm productivity, lowers operational costs, and enhances farmers' income levels.

Despite these benefits, the adoption of solar irrigation remains constrained by challenges such as high initial investment, lack of awareness, and limited technical knowledge. These barriers prevent many farmers, especially small and marginal ones, from fully utilizing the potential of this technology.

The study concludes that with appropriate policy support, including increased subsidies, easy financing options, and effective awareness programs, the adoption of solar irrigation can be significantly enhanced. Furthermore, strengthening technical training and improving service infrastructure will ensure better utilization and long-term sustainability.

Overall, solar irrigation has the potential to play a transformative role in promoting sustainable agriculture, energy efficiency, and rural development. By addressing existing challenges and improving accessibility, it can become a key driver of economic growth and environmental sustainability in rural areas.

ISBN: 978-81-999799-3-2

References

1. Ministry of New and Renewable Energy (MNRE). (2023). Annual Report *2022–23.* Government of India https://mnre.gov.in
2. MNRE. (2020). Operational Guidelines for *PM-KUSUM Scheme.* Government of India.https://mnre.gov.in/solar/schemes/
3. Maharashtra Energy Development Agency (MEDA). (2022–2025).*State Solar Pump Installation Status Reports.* Government of Maharashtra.https://www.mahaurja.com
4. Ministry of Agriculture & Farmers Welfare (2024).*Agricultural Statistics at a Glance.* Government of India. https://agricoop.gov.in
5. NABARD - Solar Irrigation Financing Report (2022). Financing Solar Irrigation India.
6. Sharma, R., & Pal, S. (2018). Solar irrigation pumps: A solution for Indian farmers. *Journal of Rural Energy*, 12(3), 45–58.
7. IRENA. (2020). Renewable energy solutions for agriculture. International Renewable Energy Agency. Retrieved from https://www.irena.org
8. Singh, R., & Mishra, S. (2021). Socio-economic impact of solar irrigation systems in Eastern India. *Agricultural Economics Research Review*, 34(1), 78–94.
9. Yin, R. K. (2018). *Case study research and applications: Design and methods* (6th ed.). SAGE Publications.
10. MNRE. (2023). *Annual Report 2022–23*. Ministry of New and Renewable Energy, Government of India.