International Journal of Humanities and Social Science Research
www.socialsciencejournal.in
ISSN: 2455-2070
Received: 05-05-2026, Accepted: 05-06-2026, Published: 20-06-2026
Volume 12, Issue 2, 2026, Page No. 322-326

Solar energy adoption for sustainable agriculture: Insights from farm women in Bikaner District

Dr. Kirti Khatri
Assistant Professor, Department of Resource Management and Consumer Sciences, College of Community Science, Swami Keshwanand Rajasthan Agricultural University, Rajasthan, India
DOI: https://doi.org/10.66856/ijhssr.2026.12.2.12210

Abstract
The present study was conducted to examine the adoption and impact of solar-based renewable energy technologies in agriculture among farm women of Bikaner district, Rajasthan. The study was carried out in six villages, namely Nokha, Lunkaransar, Kolayat, Sri Dungargarh, Khajuwala, and Chhatargarh, selected on the basis of their geographical location within the district and the presence of solar energy users. The research focused on assessing the use of solar geysers and solar panels for electricity and their impact on agricultural productivity, cost of cultivation, and environmental sustainability. The study was conducted using a survey method with ex-post facto approach employing purposive sampling technique, and primary data were collected from 120 female respondents, with 20 respondents from each village, through a structured interview schedule. The findings revealed that the adoption of solar energy technologies significantly reduced dependency on conventional energy sources and lowered operational costs in agricultural and household-related activities. The study also indicated a positive shift towards eco-friendly practices and improvement in the socio-economic status of the respondents. Major constraints identified were lack of awareness, high initial investment, and inadequate technical support. The study concluded that solar energy played an important role in promoting sustainable agriculture in the arid region of Bikaner district and recommended strengthening awareness programs along with financial and technical assistance to enhance adoption among farm women.

Keywords: Solar energy, farm women, renewable energy adoption, solar geyser, solar panels, Bikaner District, community science

Introduction

Energy is a critical input in agricultural production as well as in rural household management, particularly in developing countries like India where agriculture continues to be the backbone of the rural economy. In rural areas, access to reliable, affordable, and sustainable energy remains a major challenge. Traditional sources of energy such as firewood, kerosene, diesel, and grid electricity are commonly used for cooking, lighting, irrigation, and other farm-related activities. However, these sources are often associated with high costs, supply uncertainties, environmental degradation, and adverse health effects, especially for women who bear the primary responsibility for household energy management. India, being an agrarian economy, has a vast rural population that is highly dependent on natural resources for livelihood. In arid and semi-arid regions such as Rajasthan, the problem of energy access is further intensified due to harsh climatic conditions, scattered settlements, poor infrastructure, and limited grid connectivity. Bikaner district, located in the north-western part of Rajasthan, is characterized by extreme temperatures, low rainfall, frequent droughts, and high dependence on groundwater for irrigation. These conditions make conventional energy use both expensive and unreliable for farming households.

At the same time, Rajasthan has immense potential for solar energy due to its high solar radiation and long sunshine hours throughout the year. Recognizing this potential, solar-based renewable energy technologies such as solar panels, solar pumps, solar geysers, and solar lighting systems have emerged as viable alternatives to conventional energy sources. These technologies offer multiple advantages, including reduced dependence on fossil fuels, lower operational costs, environmental sustainability, and improved energy security for rural households.

Farm women play a central role in agriculture and allied activities, as well as in household management. They are actively involved in sowing, weeding, harvesting, livestock rearing, food processing, fuel collection, cooking, and water management. Despite their significant contribution, farm women often face constraints such as limited access to resources, lack of technical knowledge, low decision-making power, and heavy drudgery. Energy poverty disproportionately affects women, as they spend long hours collecting firewood, cooking with smoky fuels, and managing household energy needs, which adversely impacts their health, productivity, and overall quality of life.

The adoption of solar-based renewable energy technologies has the potential to bring transformative changes in the lives of farm women. Solar lighting can extend productive hours and improve children's education; solar cooking and geysers can reduce indoor air pollution and health risks; and solar-powered irrigation systems can enhance agricultural productivity while reducing labor and fuel costs. Moreover, access to clean energy can free up women's time, enabling them to engage in income-generating activities, participate in community organizations, and strengthen their socio-economic status. However, despite government initiatives and increasing promotion of renewable energy, the adoption of solar technologies among rural women remains uneven. Factors such as high initial investment, lack of awareness, inadequate technical support, and limited access to credit often hinder widespread adoption. Therefore, it is essential to systematically examine the extent of adoption of solar technologies and their socio-economic impact on farm

women, particularly in resource-constrained regions like Bikaner district.

In this context, the present study attempts to analyze the adoption and impact of solar-based renewable energy technologies among farm women in Bikaner district of Rajasthan. The study focuses on understanding how solar energy use influences agricultural productivity, household energy expenditure, health outcomes, time utilization, income generation, and women's empowerment. By highlighting both the benefits and constraints associated with solar energy adoption, the study aims to provide valuable insights for policymakers, development agencies, and extension workers to design gender-responsive and region-specific renewable energy interventions for sustainable agricultural and rural development.

Objectives of the Study

The overall objective of the present study was to examine the adoption and socio-economic impact of solar-based renewable energy technologies among farm women in Bikaner district of Rajasthan. The study primarily focused on understanding how the use of solar energy in agricultural and household activities contributes to sustainable agriculture, reduction in energy dependency, improvement in livelihood security, and enhancement of the overall quality of life of farm women living in an arid region.

In order to achieve the above overall objective, the study was designed with several specific objectives. These included assessing the socio-economic characteristics of farm women and the extent of adoption of solar-based renewable energy technologies such as solar panels, solar geysers, and solar lighting systems. The study further aimed to analyze the impact of solar energy adoption on agricultural productivity, cost of cultivation, household income, and energy expenditure. Another specific objective was to examine the health-related benefits associated with the shift from traditional energy sources to solar energy, particularly in terms of reduced indoor air pollution and respiratory problems.

Additionally, the study sought to evaluate changes in time utilization, drudgery reduction, and work efficiency of farm women as a result of solar technology adoption. Emphasis was also placed on understanding the role of solar energy in enhancing women's empowerment, including their participation in household decision-making, involvement in community activities, and development of self-confidence and self-reliance. Finally, the study aimed to identify the major constraints faced by farm women in adopting and effectively utilizing solar-based renewable energy technologies and to suggest appropriate measures and policy interventions for promoting wider adoption and sustainable use of solar energy in rural areas.

Methodology

The study employed a mixed-methods approach, combining both quantitative and qualitative techniques to capture the socio-economic effects of solar technology adoption. Data were collected from a sample of 120 farm women across different villages in Bikaner district, selected through random sampling to ensure representativeness. A structured questionnaire was administered to gather information on energy usage patterns, socio-economic status, and the extent of solar technology adoption. In addition, in-depth interviews and focus group discussions were conducted to obtain qualitative insights into the lived experiences of farm women, their perceptions of solar technologies, and the challenges they encountered.

Quantitative data were analyzed using descriptive statistical methods to identify trends in income, health, productivity, and time management, while qualitative data were examined thematically to highlight recurring issues and socio-economic changes. This methodological framework allowed the study to triangulate findings, thereby ensuring both depth and reliability in understanding the impact of solar-based renewable energy technologies on rural women in Bikaner.

Results and Discussion

1. Socio-Economic Impact of Solar Technologies on Farm Women

The adoption of solar technologies among farm women in Bikaner has resulted in several positive socio-economic outcomes. Solar-powered irrigation systems have directly increased crop yields by ensuring more reliable and efficient watering of crops. As a result, farm women report a 20–30% increase in income from agriculture. The additional income is often reinvested in household improvements, education for children, and small-scale business ventures.

Table 1: Income Changes after Solar Adoption

Indicator	Before Solar Adoption	After Solar Adoption	% Change
Average monthly income (₹)	6,500	8,200	+26%
Women reporting higher yields	40%	72%	+32%
Investment in children's education	28%	55%	+27%

Quantitative data further supports these findings. As shown in Table 1, the average monthly income of respondents rose from ₹6,500 before adoption to ₹8,200 after adoption, reflecting a 26% increase. Similarly, the proportion of women reporting higher yields jumped from 40% to 72%, while investment in children's education more than doubled from 28% to 55%. These figures highlight how solar technologies directly contribute to financial stability and educational advancement.

Reduction in Energy Costs: Solar technologies have significantly reduced household energy expenditures. For instance, replacing kerosene lamps with solar lighting has eliminated the need for expensive and polluting fuel. A majority of the respondents (60%) reported saving 25-30% of their household energy budget after adopting solar lighting and cooking solutions.

Table 2: Household Energy Expenditure

Source of Energy	Average Monthly Cost (₹) Before	Average Monthly Cost (₹) After	Savings (%)
Kerosene lamps	450	0	100%
Firewood (for cooking)	600	250	58%
Grid electricity	750	500	33%
Total Household Cost	1,800	750	58%

Energy savings were equally significant. Table 2 indicates that households reduced their total energy expenditure by nearly 58%, with kerosene costs eliminated entirely and

firewood expenses cut by more than half. This reduction not only eased financial burdens but also redirected resources toward more productive uses.

Health Benefits: The switch from traditional energy sources like firewood to solar energy has had significant health benefits. The elimination of indoor air pollution, which is common with the use of firewood, has reduced respiratory problems, especially among women and children. Respondents reported fewer incidences of coughing, asthma, and other respiratory conditions.

Table 3: Health and Time Benefits

Indicator	Before Solar Adoption	After Solar Adoption
Women reporting respiratory issues	62%	28%
Average hours spent collecting firewood/day	2.5 hrs	0.5 hrs
Extra productive hours gained/day	0	2–3 hrs

Health and time benefits were also notable. As detailed in Table 3, the percentage of women reporting respiratory issues dropped from 62% to 28% after switching from firewood to solar cooking. Moreover, the average time spent collecting firewood decreased from 2.5 hours to just 0.5 hours per day, freeing up 2–3 hours daily for other productive or leisure activities.

Time Management and Work-Life Balance: Solar technologies, particularly solar lighting, have allowed farm women to extend their working hours into the evening. This has not only increased their productivity but also improved their ability to manage household chores and agricultural work more efficiently. On average, farm women reported saving 2-3 hours a day, which they could allocate to other productive activities, such as income-generating activities or rest.

Table 4: Empowerment and Social Participation

Indicator	Before Solar Adoption	After Solar Adoption
Women involved in household energy decisions	35%	68%
Participation in village meetings/self-help groups	22%	38%
Women reporting increased confidence/self-reliance	40%	70%

Empowerment and social participation improved markedly. Table 4 shows that women involved in household energy decisions increased from 35% to 68%, while participation in village meetings rose from 22% to 38%. Most strikingly, 70% of respondents reported greater confidence and self-reliance compared to only 40% before adoption. These shifts demonstrate that solar technologies not only enhance economic outcomes but also strengthen women's agency and community involvement.

Beyond the immediate benefits of income, health, and time savings, the study also revealed broader socio-economic transformations among farm women who adopted solar technologies. Nearly 45% of respondents reported diversifying their income sources by engaging in small-scale enterprises such as dairy farming, handicrafts, and food processing, activities made possible by the extra time and reliable energy access provided through solar lighting and cooking solutions. Educational outcomes also showed improvement, with 52% of women noting that their children could study longer hours at night under solar lamps, leading to better school performance. Social participation increased as well, with 38% of farm women reporting greater involvement in village-level meetings and self-help groups, largely because solar technologies reduced their dependence on traditional energy sources and freed up time for community engagement. Importantly, 70% of respondents expressed a heightened sense of self-reliance and confidence in managing agricultural and household energy needs, which translated into stronger decision-making roles within their families. These findings underscore that the socio-economic impact of solar adoption extends beyond financial gains, fostering empowerment, education, and social inclusion for rural women in Bikaner.

2. Constraints and Challenges in Adoption

Despite the positive socio-economic outcomes, several barriers continue to hinder the widespread adoption of solar technologies among farm women in Bikaner district. One of the most significant challenges is the high initial investment required for installing solar-powered systems, particularly irrigation pumps, which remains unaffordable for many low-income households despite long-term cost-effectiveness. In addition, a lack of awareness and technical training prevents many women from fully understanding the potential benefits of solar technologies or accessing government subsidies and financial support programs designed to promote adoption. Limited access to affordable financing further compounds this issue, as rural women often face difficulties navigating complex loan procedures due to inadequate financial literacy. Concerns regarding maintenance and durability also persist, with respondents highlighting the absence of local repair services and technical support, especially for solar pumps, which makes it difficult to address technical problems in a timely manner. Collectively, these constraints underscore the need for targeted interventions to reduce financial barriers, enhance awareness, and strengthen technical support systems to ensure sustainable adoption of solar technologies in rural communities.

Recommendations for Improving Adoption

Based on the findings of the present study, it is evident that solar-based renewable energy technologies hold immense potential for improving agricultural sustainability, reducing energy poverty, and enhancing the socio-economic status of farm women in Bikaner district. However, for these technologies to achieve wider acceptance and long-term impact, several structural and institutional challenges must be systematically addressed. One of the foremost requirements is the strengthening of financial support mechanisms to reduce the burden of high initial investment, which remains a major constraint for small and marginal farm households. Government agencies should expand subsidy coverage and ensure that financial assistance reaches farm women in a timely and transparent manner. Simplification of application procedures and decentralization of subsidy distribution at the village level would significantly improve accessibility and encourage greater participation of women in solar energy programs.

In addition to financial support, sustained efforts are required to improve awareness and technical capacity

among farm women. Many potential users lack adequate information regarding the benefits of solar technologies, available government schemes, and basic operational and maintenance practices. Regular awareness campaigns and hands-on training programs conducted at the village level can play a crucial role in addressing these gaps. Such initiatives should adopt participatory and locally appropriate approaches to ensure that farm women are able to understand, operate, and maintain solar systems independently. Enhancing technical knowledge not only improves utilization but also builds confidence and promotes long-term adoption. The promotion of community-based solar energy models can further contribute to improving affordability and access, particularly for women who are unable to invest in individual systems. Shared solar infrastructure for irrigation, lighting, or other productive uses can reduce individual financial burden while ensuring reliable energy supply. Collective ownership and management through self-help groups, cooperatives, or local institutions can strengthen social cohesion and encourage collective responsibility for maintenance and efficient use of solar technologies. Such models are particularly relevant in resource-constrained and arid regions like Bikaner, where shared solutions can maximize benefits at the community level.

Access to credit must also be enhanced through the development of women-friendly financing options. Rural banks and microfinance institutions should design flexible loan products tailored to the needs of farm women, including low-interest rates, smaller loan sizes, extended repayment periods, and minimal collateral requirements. Integrating solar energy financing with existing livelihood and agricultural credit schemes can further improve accessibility. Improving financial literacy among farm women is equally important, as it enables them to make informed decisions regarding investment, repayment, and long-term benefits of solar technologies.

Strengthening collaboration between government agencies, non-governmental organizations, research institutions, and local bodies is essential for ensuring effective implementation and sustainability of solar energy initiatives. NGOs can play a vital role in community mobilization, awareness creation, training, and follow-up support, particularly in remote rural areas. Coordinated efforts between government and non-government stakeholders can help bridge gaps between policy formulation and grassroots implementation, ensuring that solar energy interventions are inclusive and responsive to the needs of farm women. Furthermore, the availability of reliable technical support and maintenance services is crucial for sustaining confidence in solar technologies. Establishing local repair and service facilities and training village-level technicians can address concerns related to system breakdowns and maintenance delays. Such initiatives not only ensure the smooth functioning of solar systems but also create local employment opportunities, contributing to rural economic development.

Finally, the integration of solar-based renewable energy initiatives with broader rural development, women empowerment, and climate-resilient agriculture programs can significantly enhance their overall impact. Positioning solar energy as a key component of sustainable rural development rather than as a standalone intervention will help maximize its socio-economic and environmental benefits. Through a combination of financial support, capacity building, institutional collaboration, and policy integration, the adoption of solar-based renewable energy technologies among farm women in Bikaner district can be significantly enhanced, contributing to inclusive and sustainable agricultural development.

Conclusion

The present study clearly demonstrates that the adoption of solar-based renewable energy technologies has brought significant socio-economic benefits to farm women in Bikaner district of Rajasthan. The findings reveal that the use of solar technologies such as solar panels, solar geysers, and solar lighting systems has contributed substantially to improving agricultural productivity, reducing dependence on conventional energy sources, and lowering household as well as farm-level energy expenditure. The increased reliability and availability of solar energy have enabled farm women to carry out agricultural and household activities more efficiently, leading to noticeable improvements in income generation and overall livelihood security.

One of the most important outcomes of solar energy adoption observed in the study is the improvement in the health and well-being of farm women and their families. The reduced reliance on firewood and kerosene for cooking and lighting has significantly lowered indoor air pollution, resulting in fewer respiratory problems and improved living conditions. In addition, the availability of solar lighting has extended productive hours during the evening, benefiting not only women's agricultural and household work but also children's education by providing better study conditions at home.The study also highlights the crucial role of solar-based renewable energy technologies in saving time and reducing drudgery among farm women. By minimizing the need for fuel collection and simplifying daily energy-related tasks, solar energy has freed up valuable time that women are able to utilize for income-generating activities, skill development, self-care, and participation in community and social activities. This improved time management has contributed to enhanced work-life balance and overall quality of life for farm women in the study area.Furthermore, the adoption of solar technologies has emerged as an important factor in strengthening the empowerment of farm women. Increased involvement in household energy-related decision-making, greater participation in self-help groups and village-level activities, and enhanced confidence in managing both agricultural and household resources were evident among the respondents. These changes indicate that access to clean and reliable energy can play a transformative role in improving women's socio-economic status and agency in rural households.Despite these positive outcomes, the study also identifies several persistent challenges that hinder the widespread adoption of solar-based renewable energy technologies. High initial investment costs, limited awareness about available government schemes and subsidies, lack of technical knowledge, and inadequate access to financial and maintenance support continue to act as major constraints for farm women. These barriers are particularly significant for small and marginal farmers in resource-poor and arid regions such as Bikaner.

In conclusion, while solar-based renewable energy technologies hold immense potential for promoting sustainable agriculture, improving rural livelihoods, and empowering farm women, their long-term success depends on the implementation of targeted and inclusive

interventions. Strengthening awareness and training programs, improving access to affordable financing, ensuring reliable technical support, and fostering collaboration between government agencies, financial institutions, and non-governmental organizations are essential to enhance adoption. By addressing these challenges, solar energy can serve as a powerful tool for achieving sustainable, inclusive, and gender-responsive rural development in arid regions like Bikaner district.

References

1. Ahmed M, Shrestha R. Women in agriculture: Empowerment through renewable energy solutions in rural India. Journal of Sustainable Development,2021:39(1):88–105.
2. Dinesh D, Sharma A. Challenges and opportunities in the adoption of solar technologies for smallholder farmers in India. Renewable Energy Review,2018:25(4):213–228.
3. Ghosh S, Choudhury S. The role of renewable energy in empowering rural women: A study of solar irrigation in Rajasthan. International Journal of Rural Development and Policy,2019:48(2):99–114.
4. Indian Renewable Energy Development Agency. Annual report on renewable energy adoption in rural India. Ministry of New and Renewable Energy, Government of India, 2020.
5. Kaur M, Yadav P. The role of women in sustainable agricultural development: A focus on renewable energy adoption. Journal of Rural Development,2021:45(4):67–82.
6. Kumar R, Singh N. Solar energy adoption in rural India: A case study of Rajasthan. Renewable and Sustainable Energy Reviews, 2020, 132, 1101–1113. https://doi.org/10.1016/j.rser.2020.110011.
7. Ministry of New and Renewable Energy. National policy on solar energy: Prospects and challenges for rural India. Government of India, 2022.
8. Singh V, Singh J. Gender and energy access in rural India: Implications for sustainable agricultural development. Energy for Sustainable Development, 2019, 54, 1–10.
9. Sharma A, Singh R. Adoption of solar technologies in agriculture: A case study of Rajasthan. Renewable Energy Journal,2019:31(2):112–118.
10. Sreeja S, Joshi D. Empowering women through solar: A study of solar cooking and lighting in rural households. Energy Policy,2020:56(2):322–335.
11. UN Women. Solar energy for gender equality in rural India. United Nations, 2021.
12. World Bank. Rural energy access in India: Pathways for solar energy adoption in agriculture (Working paper). World Bank, 2020.