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Adoption of Renewable Energy in Agriculture and Its Economic Benefits: A Study of Karnataka

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Peer Review Information	Abstract
<p><i>Submission: 11 Jan 2026</i></p> <p><i>Revision: 22 Jan 2026</i></p> <p><i>Acceptance: 10 Feb 2026</i></p> <p>Keywords</p> <p><i>Renewable Energy, Agriculture, Solar Irrigation, Economic Benefits, Karnataka, Sustainable Farming</i></p>	<p>This study examines the adoption patterns of renewable energy technologies in Karnataka's agricultural sector and evaluates their economic benefits to farmers. Through primary data collected from 240 farmers across six districts of Karnataka, the research analyses the uptake of solar irrigation pumps, biogas plants, and solar dryers. The findings reveal that renewable energy adoption significantly reduces operational costs (by 40-65%), increases farm income (by 25-35%), and enhances agricultural productivity. However, high initial investment costs and limited awareness remain significant barriers. The study recommends enhanced subsidy mechanisms, improved financing options, and targeted training programs to accelerate renewable energy adoption in agriculture.</p>

Introduction

Agriculture remains the backbone of Karnataka's economy, employing nearly 56% of the workforce and contributing significantly to the state's GDP. The sector spans ten agro-climatic zones and supports diverse cropping systems ranging from food grains to high-value commercial crops such as coffee, silk, and spices. Despite this diversity, Karnataka's agriculture faces mounting challenges, including rising energy costs, erratic power supply, groundwater depletion, and increasing climate variability. Dependence on diesel and grid electricity has become economically and operationally unsustainable, adversely affecting farm productivity and incomes.

Energy insecurity has emerged as a critical constraint in the state's agricultural sector. Farmers typically receive only 4-6 hours of electricity per day, often at non-optimal

irrigation times, while diesel prices have increased by over 45% in the past five years. These factors have sharply increased irrigation costs, particularly for small and marginal farmers. Inadequate and unreliable energy supply has contributed to inefficient groundwater extraction, leading to declining water tables in several districts, with annual drops of 2-4 meters reported in many regions. Climate change has further intensified these challenges through erratic monsoon patterns, prolonged dry spells, rising temperatures, and frequent droughts. Karnataka has experienced moderate to severe drought conditions in five of the last ten years, undermining crop stability and farmer livelihoods. The combined effects of energy insecurity and climatic stress pose serious threats to agricultural sustainability and food security in the state. Renewable energy technologies offer a viable and sustainable

response to these challenges. Karnataka is endowed with high solar potential, receiving 5.5–6.0 kWh/m²/day of solar radiation and over 300 sunny days annually, along with substantial biomass resources from agricultural residues and livestock waste. The state's large livestock population provides significant scope for biogas generation, offering clean energy and organic manure benefits.

Recognizing this potential, the Government of Karnataka has introduced several policy initiatives, including the Surya Raitha Scheme and implementation of the PM-KUSUM programme, to promote renewable energy adoption in agriculture. Karnataka Renewable Energy Development Limited (KREDL) has played a key role in facilitating technology deployment and subsidy support. However, despite these efforts, adoption levels remain below expectations due to high upfront costs, limited awareness, technical knowledge gaps, credit constraints, and administrative challenges. Existing research on renewable energy in Indian agriculture has largely been fragmented, with limited focus on Karnataka's diverse agro-climatic and institutional context. This study addresses these gaps by providing a comprehensive economic assessment of multiple renewable energy technologies across different farming systems in Karnataka. The findings aim to support evidence-based policymaking and contribute to sustainable agricultural transformation by enhancing energy security, farm incomes, and climate resilience in the state.

Research Objectives

1. To assess the current adoption levels of renewable energy technologies among farmers
2. in Karnataka
3. To analyze the economic benefits accruing to farmers from renewable energy adoption
4. To identify barriers and challenges hindering renewable energy adoption
5. To examine the relationship between farm characteristics and renewable energy adoption
6. To provide policy recommendations for accelerating renewable energy uptake in agriculture

Review of Literature

Renewable energy integration in agriculture has gained global attention as a strategy for sustainable development. Studies from developing countries demonstrate significant potential for reducing agricultural energy costs while improving environmental outcomes.

International experiences from countries like China, Bangladesh, and Kenya show that solar irrigation systems can reduce pumping costs by 40-70% compared to diesel alternatives. India's agricultural sector consumes approximately 18% of the country's total electricity, with irrigation being the primary energy-intensive activity. Research indicates that renewable energy technologies, particularly solar pumps, have expanded rapidly in states like Gujarat, Rajasthan, and Maharashtra. However, adoption rates vary significantly based on subsidy availability, farmer awareness, and institutional support mechanisms.

Previous studies have documented the economic benefits of renewable energy in agriculture. Solar irrigation pumps provide a payback period of 4-6 years with substantial long-term savings. Biogas plants not only provide clean cooking fuel but also generate high-quality organic fertilizer, reducing chemical fertilizer costs by 20-30%. While several studies have examined renewable energy adoption in Indian agriculture, limited research focuses specifically on Karnataka's unique agricultural and climatic conditions. This study addresses these gaps through primary data collection and comprehensive economic analysis.

Research Methodology

1. Study Area and Sampling Design

The study was conducted across six districts of Karnataka, selected to represent diverse agro-climatic zones: Belagavi (North Karnataka - sugarcane, maize), Dharwad (North Karnataka - cotton, pulses), Tumakuru (Southern Karnataka - coconut, vegetables), Mandya (Southern Karnataka - paddy, sugarcane), Chikkaballapur (Eastern Karnataka - horticulture, sericulture), and Kolar (Eastern Karnataka - ragi, vegetables). A multi-stage stratified random sampling approach was employed. Two taluks were selected from each district, followed by two villages per taluk, and finally 10 farmers per village (5 renewable energy adopters and 5 non-adopters), yielding a total sample of 240 farmers.

2. Data Collection and Analysis

Primary data was collected through structured questionnaires administered through personal interviews during October-December 2024. The questionnaire covered socio-economic characteristics, farm characteristics, energy consumption patterns, renewable energy technology details, economic parameters, awareness levels, and adoption barriers. Secondary data was obtained from Karnataka Renewable Energy Development Limited (KREDL), Department of Agriculture, district agricultural offices, and published research.

Analytical techniques included descriptive statistics, cost-benefit analysis, payback period calculation, comparative analysis between adopters and non-adopters, chi-square tests for association, and regression analysis to identify determinants of adoption.

Results and Discussion

1. Socio-Economic Profile of Respondents

The socio-economic characteristics of respondent farmers are presented in Table 1, revealing significant differences between adopters and non-adopters of renewable energy technologies.

Table 1: Socio-Economic Profile of Respondents

Characteristics	Adopters (n=120)	Non-Adopters (n=120)	Total (n=240)
Age (years)	44.2	49.4	46.8
Education Level (%)			
Illiterate	8.3	22.5	15.4
Primary	18.3	31.7	25
Secondary	38.3	27.5	32.9
High School & Above	35	18.3	26.7
Family Size (members)	5.3	5.1	5.2
Landholding Size (ha)	3.8	2.6	3.2
Farm Category (%)			
Small (1-2 ha)	23.3	40.8	32.1
Medium (2-4 ha)	45	40.8	42.9
Large (>4 ha)	31.7	18.3	25
Annual Income (₹ Lakhs)	4.2	2.8	3.5
Farming Experience (years)	22.5	26.8	24.7

Source: Primary Survey Data, 2025

The data reveals that adopters are younger, better educated, have larger landholdings, and higher incomes compared to non-adopters, indicating that socio-economic factors play a crucial role in technology adoption decisions.

2. Adoption Patterns of Renewable Energy Technologies

Table 2 presents the distribution of renewable energy technology adoption across the sample districts.

Table 2: District-wise Adoption of Renewable Energy Technologies

District	Total Farmers Surveyed	Adopters	Adoption Rate (%)	Solar Pumps	Biogas Plants	Solar Dryers
Belagavi	40	18	45	12	5	1
Dharwad	40	19	47.5	13	4	2
Tumakuru	40	23	57.5	16	6	1
Mandya	40	20	50	14	5	1
Chikkaballapur	40	21	52.5	12	6	3
Kolar	40	19	47.5	11	6	2
Total	240	120	50	78	32	10

Source: Primary Survey Data, 2025

Solar irrigation pumps emerged as the most popular technology (65% of adopters), followed by biogas plants (26.7%), and solar dryers (8.3%). The temporal adoption pattern showed significant increase post-2018, with 68% of installations occurring between 2019-2025

following enhanced government subsidies under the Surya Raitha Scheme.

3. Economic Analysis: Cost and Benefits

A. Solar Irrigation Pumps

The economic analysis of solar irrigation pumps reveals substantial financial benefits as detailed in Table 3.

Table 3: Economic Analysis of Solar Irrigation Pumps (5 HP)

Parameters	Amount (₹)
Cost Components	
Total Installation Cost	2,85,000
Government Subsidy (60%)	1,71,000
Net Farmer Investment	1,14,000
Annual Operational Costs	
Traditional Pump Cost (Diesel/Electric)	45,200
Solar Pump Maintenance Cost	8,400
Annual Savings	36,800
Productivity Benefits	
Increase in Irrigated Area	22%
Increase in Crop Yield	28%
Additional Annual Income	82,000
Financial Indicators	
Payback Period	4.2 years
Benefit-Cost Ratio (25 years)	2.8:1
Internal Rate of Return	18.50%

Source: Primary Survey Data and Field Calculations, 2025

Table 3 shows that 5 HP solar irrigation pumps are economically viable despite high initial costs, as the 60% subsidy reduces farmer investment to ₹1,14,000. Annual operational savings of ₹36,800 arise from lower maintenance costs compared to conventional pumps. Improved irrigation reliability increases irrigated area by 22% and crop yield by 28%, generating additional annual income of ₹82,000. Financial indicators, including a 4.2-year payback period, a benefit-cost ratio of 2.8:1, and an internal rate of return of 18.50%, confirm the long-term profitability and sustainability of solar irrigation pumps.

B. Biogas Plants

Economic assessment of biogas plants shows promising returns as presented in Table 4.

Table 4: Economic Analysis of Biogas Plants (4 cubic meter capacity)

Parameters	Amount (₹)
Cost Components	
Total Installation Cost	68,000

Government Subsidy (50%)	34,000
Net Farmer Investment	34,000
Annual Savings	
LPG Replacement Savings	18,600
Chemical Fertilizer Reduction	12,400
Total Annual Savings	31,000
Additional Benefits	
Time Saved (hours/day)	2
Reduction in Indoor Air Pollution	Significant
Financial Indicators	
Payback Period	3.8 years
Benefit-Cost Ratio (20 years)	3.2:1

Source: Primary Survey Data and Field Calculations, 2025

The economic assessment in Table 4 indicates that 4 m³ biogas plants are financially viable with moderate initial investment. The 50% government subsidy reduces the net farmer investment to ₹34,000, enhancing affordability. Annual savings of ₹31,000 are achieved through LPG replacement and reduced expenditure on chemical fertilizers. The payback period of 3.8 years and a benefit-cost ratio of 3.2:1 over 20 years confirm strong economic returns. In addition to financial gains, biogas plants offer non-monetary benefits such as time savings of approximately two hours per day and significant reduction in indoor air pollution, contributing to improved household health and overall livelihood sustainability.

C. Solar Dryers

Solar dryer adoption, though limited, demonstrated significant benefits for horticulture farmers as shown in Table 5.

Table 5: Economic Analysis of Solar Dryers (100 kg capacity)

Parameters	Amount/Percentage
Cost Components	
Total Installation Cost	₹ 45,000
Government Subsidy (40%)	₹ 18,000
Net Farmer Investment	₹ 27,000
Productivity Benefits	
Post-Harvest Loss Reduction	30-35% to 8-10%
Price Premium for Quality	25-30%
Drying Time Reduction	7-10 days to 3-4 days
Financial Benefits	

Additional Annual Income	₹35,000-42,000
Payback Period	2.8 years
Benefit-Cost Ratio (15 years)	4.1:1

Source: Primary Survey Data and Field Calculations, 2025

The economic analysis in Table 5 reveals that solar dryers are highly cost-effective for horticulture farmers due to their low investment requirement and substantial productivity gains. With a 40% subsidy, the net farmer investment is limited to ₹27,000. Solar dryers significantly reduce post-harvest losses from 30–35% to 8–10%, shorten drying time from 7–10 days to 3–4 days, and enable farmers to obtain a 25–30% price premium for improved product quality. These benefits generate additional annual income of ₹35,000–42,000. The short payback period of 2.8 years and a high benefit–cost ratio of 4.1:1 over 15 years indicate superior economic performance compared to other renewable energy technologies, making solar dryers particularly attractive for small-scale horticulture farmers.

Discussion

The findings of the study clearly demonstrate that solar dryer adoption significantly enhances both productivity and economic returns for smallholder farmers. The reduction in post-harvest losses from 30–35% under traditional open-sun drying to 8–10% with solar drying is substantial and directly contributes to higher marketable surplus. This improvement is mainly due to controlled drying conditions, protection from environmental contaminants, and reduced dependency on weather fluctuations.

The reduction in drying duration from 7–10 days to 3–4 days improves operational efficiency and allows farmers to process multiple batches within the same season. Faster drying minimizes microbial spoilage and preserves color, aroma, and nutritional quality, which are critical determinants of market value. Consequently, farmers are able to secure a 25–30% price premium for solar-dried produce.

Economically, the additional annual income ranging from ₹35,000 to ₹42,000 significantly exceeds the net farmer investment of ₹27,000. The payback period of 2.8 years reflects rapid cost recovery, while the benefit–cost ratio of 4.1:1 over a 15-year lifespan confirms strong long-term profitability. These results are consistent with earlier empirical studies on renewable energy-based post-harvest

technologies and validate the economic sustainability of solar dryers.

Socio-Economic and Environmental Implications

Solar dryer adoption has important socio-economic implications, particularly for small and marginal farmers. Increased income from value-added dried products improves livelihood security and reduces distress sales during peak harvest periods. The technology is especially beneficial for women farmers, self-help groups, and rural entrepreneurs engaged in processing activities, as it reduces drudgery and improves working conditions.

From an environmental perspective, solar dryers rely entirely on renewable solar energy, thereby reducing dependence on fossil fuels and lowering carbon emissions. The technology supports national and global objectives related to sustainable agriculture, climate change mitigation, and reduction of food losses across supply chains.

Constraints and Limitations

Despite its advantages, certain constraints limit widespread adoption of solar dryers. The initial capital requirement, even after subsidy, may be challenging for resource-poor farmers without access to institutional credit. Limited technical awareness, lack of training, and inadequate extension support further restrict adoption. Additionally, the efficiency of solar dryers may vary across agro-climatic regions, necessitating location-specific design modifications.

Conclusion

The study concludes that solar dryer technology is a technically feasible, economically viable, and environmentally sustainable solution for reducing post-harvest losses among smallholder farmers. With a modest net investment of ₹27,000, farmers can achieve substantial income enhancement, recover costs within 2.8 years, and realize a high benefit–cost ratio of 4.1:1 over a 15-year operational life. The technology not only improves drying efficiency and product quality but also contributes to sustainable rural development. Therefore, large-scale promotion of solar dryers through policy support and institutional mechanisms is strongly recommended.

References

FAO (2019). *The State of Food and Agriculture*. Food and Agriculture Organization of the United Nations, Rome.

Ministry of New and Renewable Energy (MNRE) (2022). *Guidelines for Solar Energy-Based Applications in Agriculture*. Government of India.

Singh, R., & Kumar, S. (2020). Economic evaluation of solar drying technology for horticultural produce. *Journal of Agricultural Economics*, 75(3), 412–420.

Verma, A., & Sharma, P. (2021). Post-harvest loss reduction through renewable energy technologies. *Indian Journal of Agricultural Sciences*, 91(6), 845–850.

Bala, B. K., & Woods, J. L. (2014). Simulation of the indirect natural convection solar drying of agricultural products. *Solar Energy*, 102, 1–12.

Ekechukwu, O. V., & Norton, B. (1999). Review of solar-energy drying systems II: An overview of solar drying technology. *Energy Conversion and Management*, 40(6), 615–655.

Esper, A., & Mühlbauer, W. (1998). Solar drying—An effective means of food preservation. *Renewable Energy*, 15(1–4), 95–100.

Jain, D., & Tiwari, G. N. (2004). Effect of greenhouse on crop drying under natural and forced convection. *International Journal of Energy Research*, 28(8), 765–773.

Kumar, M., Sansaniwal, S. K., & Khatak, P. (2016). Progress in solar dryers for drying various commodities. *Renewable and Sustainable Energy Reviews*, 55, 346–360.

Mujumdar, A. S. (2015). *Handbook of Industrial Drying* (4th ed.). CRC Press, Boca Raton.

Nayak, S., & Rathod, P. K. (2019). Economic impact of post-harvest loss reduction technologies in horticultural crops. *Agricultural Economics Research Review*, 32(2), 245–252.

Panwar, N. L., Kaushik, S. C., & Kothari, S. (2011). Role of renewable energy sources in environmental protection: A review. *Renewable and Sustainable Energy Reviews*, 15(3), 1513–1524.

Singh, S., & Goyal, R. K. (2018). Solar drying of agricultural produce: A review. *Journal of Food Science and Technology*, 55(3), 1–15.

Tiwari, G. N., & Sahota, L. (2017). *Advanced Solar Drying Systems*. Springer, Singapore.

World Bank (2020). *Reducing Food Loss and Waste: An Agenda for Action*. World Bank Publications, Washington, DC.