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Pradhan Mantri Kisan Urja Suraksha Evam Utthaan Mahabhiyan Yojana: Enhancing Farmers' Income and Environmental Sustainability for Vikshit Bharat @2047

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ABSTRACT

The Pradhan Mantri Kisan Urja Suraksha Evam Utthaan Mahabhiyan (PMKUSUM) is a transformative initiative aimed at providing solar-powered irrigation pumps, promoting sustainable farming practices, and reducing dependence on traditional energy sources. PMKUSUM scheme launched on 8 March 2019 and aimed to install 17.50 lakh standalone Solar Powered Agriculture Pumps of individual pump capacity up to 10 HP. The primary objective is to understand the economic and environmental benefits of adopting solar irrigation systems. A primary survey was conducted in the Sirsa district with 150 farmers, in which 75 farmers used solar irrigation pumps and 75 farmers used diesel pumps. To assess the economic savings on fuel and electricity, income generation from improved crop yield, and the environmental impact of reduced CO_2 *emissions. The study focuses on cost comparisons, including fuel cost and maintenance, and evaluates the financial benefits derived from higher crop yields and reduced operational costs. Environmental data were collected to estimate reductions in* CO_2 *emissions resulting from the use of solar-powered pumps. The results are expected to show that solar pump users achieve higher net income due to significant cost savings in fuel cost and maintenance, as well as better crop productivity. Additionally, solar-powered irrigation systems contribute to a cleaner environment by reducing* CO_2 *emissions and decreasing reliance on diesel. These findings will underline the role of solar irrigation in enhancing farmers' economic security and advancing India's goal of becoming a Viksit Bharat by 2047, with green, sustainable agricultural practices at the forefront.*

Key Word: PMKUSUM, Sustainable farming, Solar pump, Diesel pump, CO_2 emissions

Introduction:

Agriculture is the primary source of livelihood for a significant portion of India's population, especially in rural areas. However, Indian farmers continue to face several persistent challenges, including high input costs, erratic power supply, and dependence on fossil fuels such as diesel for irrigation. In India, the total of 79312 hectares of net area irrigated is 56.37% of the total sown area. In 1966-67, the total net area irrigated in Haryana was 1293 hectares, which was 37.8 per cent of the net sown area. Now, in 2023 -24, the total area under net irrigated in Haryana is 3317 hectares, which is 95.5 per cent of the net sown area. The most plentiful renewable energy source is solar power. Because solar energy is a dependable energy source and can be utilised in off-grid locations for both large-scale irrigation and smallholder irrigated agriculture, solar energy for irrigation is growing in popularity (Hartung & Plushke, 2018).

Government Initiatives: The support, subsidies, and financial aid provided by the government define any nation's government initiatives (Pathania et al., 2017). Kevin (2013) emphasised that government subsidies have a positive impact on the sales of solar energy products. One of India's key initiatives for advancing sustainable and clean energy is the Jawaharlal Nehru National Solar Mission (JNNSM), which was introduced in 2010. In order to harness India's enormous solar potential and lessen reliance on fossil fuels, it was implemented as part of the nation's National Action Plan on Climate Change. Given the expanding potential, the mission's initial target of generating 20 GW of solar power by 2022 was later increased to 100 GW. Its goal is to increase the affordability and accessibility of solar energy by concentrating on both large-scale solar projects and smaller rooftop or off-grid systems. The mission has contributed to the nationwide expansion of solar power, particularly in rural areas, by fostering innovation, policy support, and private investment. Prior studies on environmental issues were grounded in theoretical frameworks that included the perspectives of shareholders, political economy, and stakeholders (Joshi & Rahman, 2015). These challenges not only affect agricultural productivity but also increase the financial burden on farmers and contribute to environmental degradation through increased carbon emissions. The Pradhan Mantri Kisan Urja Suraksha Evam Utthaan Mahabhiyan (PM-KUSUM) scheme was introduced by the Government of India in 2019 as an initiative to encourage solar energy generation across the country. The implementation of this scheme is under the purview of the Ministry of New and Renewable Energy (MNRE). The KUSUM scheme has three components:

- Component-A: This component aims to set up 10,000 MW of small solar power plants on barren land. These plants will be owned and operated by farmers, individuals, or groups of farmers.

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- Component-B: This component aims to install 17.5 lakh standalone solar pumps for farmers. These pumps will be used to irrigate agricultural land.
- Component-C: This component aims to solarise 10 lakh grid-connected agriculture pumps.

These pumps will be converted from diesel or electric pumps to solar pumps. The scheme provides farmers with financial support and incentives to install solar-powered pumps and decentralised solar energy systems on their farms. The core idea is to reduce farmers' dependence on expensive and polluting diesel generators or unreliable grid electricity, while also allowing them to become energy producers. Through this model, farmers can generate their electricity and sell surplus power to the grid, creating an additional stream of income and promoting decentralised renewable energy generation in rural areas. One of the most promising aspects of PM-KUSUM is its potential contribution to India's broader environmental and developmental goals. The scheme directly supports the objectives of the **National Solar Mission**, which is part of India's commitment to the Paris Climate Agreement and its goal of reaching **500 GW of non-fossil fuel-based power capacity by 2030**. In addition, PM-KUSUM aligns with the government's long-term vision of **"Viksit Bharat @2047"**, which envisions a self-reliant, sustainable, and developed India by the year 2047—when the nation celebrates 100 years of independence. By promoting clean energy use at the grassroots level, the scheme plays a key role in ensuring sustainable agricultural practices, reducing greenhouse gas emissions, and creating income-generating opportunities for rural households.

This research paper aims to explore the **impact and implementation** of PM-KUSUM, with a specific focus on the state of **Haryana**, which has shown significant adoption of solar pumps under the scheme. The study examines how PM-KUSUM is influencing farmer incomes, energy access, and environmental sustainability in the region. By analysing district-wise data, policy frameworks, and stakeholder experiences, the paper seeks to provide evidence-based insights into the opportunities and constraints of solar irrigation in India. Ultimately, the research contributes to understanding how renewable energy interventions like PM-KUSUM can play a transformative role in building a **climate-resilient, economically empowered, and energy-secure agricultural sector** for India's future.

Review of literature:

An extensive literature review is necessary because some theoretical and existing foundations must back the research. This has been accomplished by incorporating the review of prior studies.

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Jiterwal and Sharma (2007) found that, about drip irrigation technology, 52.92 per cent of farmers, 26.25 per cent, and 20.83 per cent, respectively, belonged to the medium, low, and high knowledge categories.

Kumar et al. (2009) found that a sizable majority of respondents, or 72.34 per cent, had a medium level of general knowledge, 67.38 per cent had technical knowledge, and 70.22 per cent had overall knowledge about solar power water pumping systems.

Parmar et al. (2016) concluded that the significant constraints perceived by respondents in the adoption of drip irrigation technology were high initial costs, costly equipment and spare parts of the system, improper pressure, which impedes uniform distribution of water, and clogging of drippers and microtubules due to salt deposition.

Gautam and Singh (2021) installed a solar irrigation pump, resulting in a considerable financial gain in terms of diesel savings. 41,937.89 was the total estimated cost savings from using diesel. Additionally, beginning in the fourth year, the farmer had to pay $3,000 per year for maintenance. The benefit's present value was determined to be 4,88,726.63, whereas the cost's present value was 1,24,039.11. It was found that the benefit-cost ratio was 3.94. As a result, the savings from using less diesel were the primary source of the financial benefits of installing a solar irrigation pump. These results demonstrate the viability and possible financial advantages of implementing solar-powered irrigation systems.

Nain et al. (2017) carried out a study to assess farmers' awareness of agricultural insurance schemes. In a sample of 100 farmers, which included 50 men and 50 women, they found that only 34.70% of the male respondents and 19.70% of the female respondents were aware of such schemes. This indicates a relatively low level of awareness among both groups, with women being significantly less informed compared to men.

Bhati (2022) discussed the PM KUSUM program, which encourages farmers to install renewable energy plants and solar pumps. Solar pumps offer dependable irrigation and reduce the need for diesel. Within three years, the KUSUM program can convert between one-third and one-fourth of all irrigation pumps to solar-powered pumps. With a 30% federal subsidy and a 30% state subsidy, the program offers reasonably priced pumps. Bank loans can cover 30% of the pump's purchase price. The burden of subsidies will be considerably lessened when agricultural feeders are solarised. Millions of pumps can be powered by 25,750 MW of solar energy. The program uses dry, uncultivable land to generate steady income for 25 years. Intends to supply rural load centres with local solar and renewable energy.

Mustafa et al. (2022) examined the cost-benefit analysis of solar photovoltaic energy systems in Quetta, Pakistan's agricultural sector. The study looked into the cost-benefit analysis of solar

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photovoltaic energy systems in Pakistan's Baluchistan province's agricultural sector. To determine the net benefit of installing a solar photovoltaic system, a study based on primary data and cost-benefit analysis was conducted. The investigation's findings demonstrated that solar photovoltaic (PV) systems are relatively cost-effective, with a benefit-to-cost ratio of 9.3 as opposed to 8.4 for grid-sourced electricity.

Objectives:

To analyse the economic and environmental benefits of adopting solar-powered irrigation pumps under the PM-KUSUM scheme.

Methodology:

This study is based on in-depth fieldwork and a survey of 150 randomly selected farmers in Sirsa district in Haryana who installed PV pumps in their fields with Government subsidies. Study Area Selection – The study was conducted in Sirsa district, Haryana, a region with significant agricultural activity.

1. Sample Selection – A primary survey was conducted with 150 farmers, divided into:
    1. 75 farmers using solar-powered irrigation pumps
    2. 75 farmers using diesel-powered pumps
2. Data Collection – Structured questionnaires were used to collect:
    1. Cost-related data (fuel, maintenance, and operational costs)
    2. Crop yield and income levels
    3. Farmers' perceptions of solar irrigation benefits
    4. Environmental impact data related to CO_2 emissions
3. Data Analysis – Statistical tools were used to compare economic outcomes, cost savings, and environmental benefits between solar and diesel pump users.

The study was conducted in the Sirsa district of Haryana, an area with extensive agricultural activity, to evaluate the economic and environmental impacts of solar-powered irrigation systems. A total of 150 farmers were randomly selected for the primary survey, with half of them (75) using solar photovoltaic pumps installed with government subsidies, and the other half (75) operating diesel-powered pumps. Data was gathered through structured questionnaires covering aspects such as fuel, maintenance, and operational costs, crop yields, farm income, farmers'

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perceptions about the benefits of solar irrigation, and environmental indicators like CO_2 emissions. The collected information was then analysed using statistical methods to compare cost savings, profitability, and environmental advantages between the two groups, providing insights into how solar irrigation influences both livelihoods and sustainable farming practices.

Result and discussion:

In Haryana, the number of solar irrigation pumps installed increased steadily between 2019–20 and 2024–25, totalling 1,57,073 units. Growing adoption is reflected in the Compound Annual Growth Rate (CAGR) for this time frame, which is roughly 7.32%. Depending on the crop, solar pumps can save irrigation costs by ₹5,290 to ₹6,576 per acre by drastically reducing the use of diesel. Furthermore, significant carbon emissions are avoided by solar irrigation—roughly 127 kg CO_2 per acre for wheat and 165 kg CO_2 per acre for cotton. Farmers have a high degree of awareness; more than 94% are aware of solar pumps and subsidies, and 98.5% say they would be willing to use them. But obstacles like high upfront costs, low voltage problems, and a lack of technical expertise

Table 1: Installation of Solar Pump in Haryana During 2019-20 to 2023-24

Installation of Solar Pump in Haryana During 2019-20 to 2023-24		
Sr.no.	Year or installation	Number of installed solar irrigation pumps
1	2019-20	23828
2	2020-21	21155
3	2021-22	20861
4	2022-23	17894
5	2023-24	39926
6	2024-25	34009
	Total	157073

Source: Statistical Abstract of Haryana

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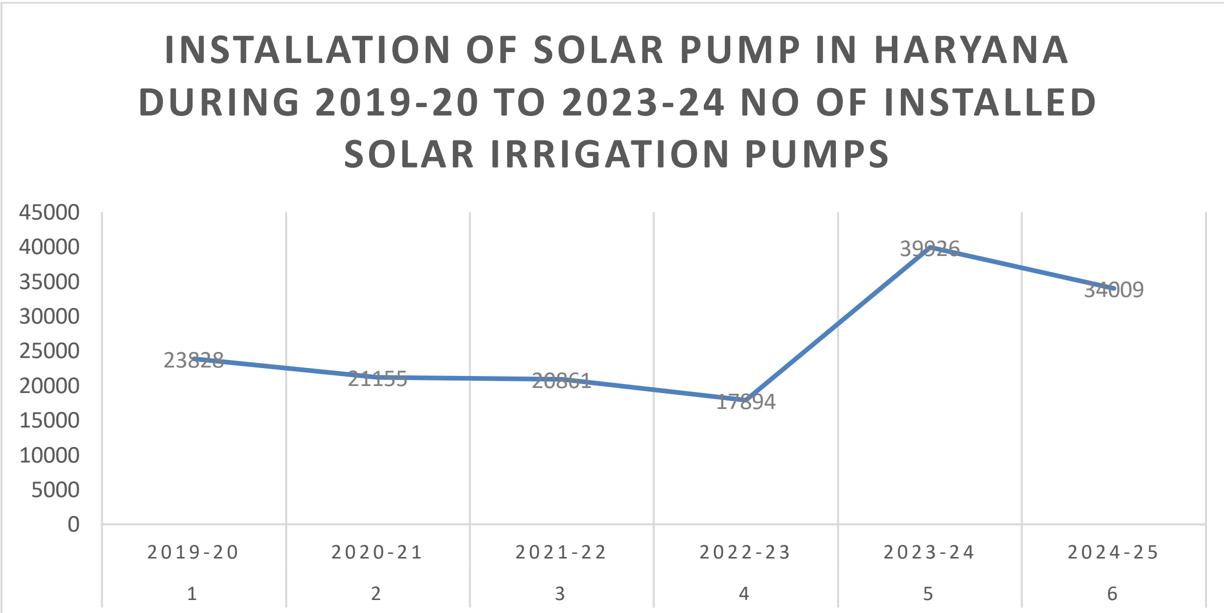

Table 2: Total cost of Diesel Irrigation for Wheat and Cotton (Area per acre)

	Crop	Irrigated Area per acre	Number of irrigations in one session	Time taken for irrigation in (5-6)	Diesel consumption /hour	Total diesel consumption	Maintenance cost of diesel pump /year	Total cost of diesel irrigation pump (Cost of Diesel (₹ 88))
1	Wheat	1	5	6.5	1.5	48.75	2500	4290+2500=6790 ₹
2	cotton	1	6.5	6.5	1.5	63.37	2500	5576+2500=8076 ₹

Source: data collected and compiled by the author.

Irrigating one acre of wheat with a diesel pump costs about ₹6,790 per year, using nearly 49 litres of diesel. For cotton, the cost increases to ₹8,076 with diesel consumption of over 63 litres, mainly because cotton requires more frequent watering. These numbers show how expensive diesel irrigation can be and highlight the advantages of adopting cleaner, more affordable options like solar-powered pumps.

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Table 3: Diesel savings by a 7.5 HP solar irrigation pump per acre

Sr.no.	Crop	Irrigated Area per acre	Total diesel consumption saving in 1 acre	Maintenance cost of solar pump /year	Total cost of solar irrigation pump
1	Wheat	1	48.75	1500	1500
2	cotton	1	63.37	1500	1500

Source: Data collected and compiled by the author.

Farmers can save approximately 63 litres of diesel per acre with a 7.5 HP solar pump, which translates into significantly lower fuel expenses. Compared to diesel pumps, these solar pumps provide an economical and environmentally friendly alternative, making farming more cost-effective and cleaner. Their annual maintenance costs are only around ₹1,500.

Table 4: Diesel consumption, carbon dioxide and carbon emission from 1 acre of each major crop irrigated by a 7.5 HP diesel pump

Crops	Diesel Consumption (Litre/acre) in a session	CO_2 Emissions in 1 litre diesel (2.6 kg CO_2 emission)	Carbon Emissions (Kg/Ha) (1 kg CO_2 = 0.27 kg carbon)
Wheat	48.75	126.75 kg	34.22 kg
Cotton	63.37	164.76 kg	44.48

Source: Data collected and compiled by the author's own

Irrigating one acre of wheat and cotton with a 7.5 HP diesel pump produces substantial carbon emissions—about 126.75 kg CO_2 (34 kg carbon) for wheat and 164.76kg CO_2 (44.48 kg carbon) for cotton. These figures underscore the environmental cost of diesel-based irrigation and reinforce the need to shift towards cleaner, sustainable alternatives like solar-powered pumps to reduce pollution and promote eco-friendly farming.

Table 5: Awareness and Willingness to Buy Solar-Powered Pumps

Particulars	Frequency (Aware)	Frequency (Not Aware)	% (Aware)	% (Not Aware)

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Awareness about solar-powered pumps	*146*	*4*	97.01	2.99
Awareness about subsidy schemes	*143*	*7*	95.52	4.48
Awareness about the warranty period	*141*	*9*	94.03	5.97
Awareness about photovoltaic technology	*83*	*67*	55.22	44.78
Willingness to buy solar-powered pumps	*148*	*2*	98.51	1.49

Source: Data collected and compiled by the author's own

The majority of respondents (more than 94%) are aware of solar-powered pumps, their warranty periods, and subsidy programs, and 98.5% are willing to buy them. Nonetheless, only roughly 55% are familiar with photovoltaic technology, suggesting a sizable technical knowledge gap that must be filled to encourage informed adoption.

Table 6: Factors affecting the non-adoption of solar-powered pumps

Rank	Particulars	Frequency (Aware)	Frequency (Not Aware)	% (Aware)	% (Not Aware)
1	Investment cost	130	20	86.67	13.33
2	Maintenance cost	23	127	15.33	84.67
3	Seasonal	94	56	62.67	37.33
4	Long loan procedure	26	124	17.33	82.67
5	Long payback period	29	121	19.33	80.67
6	Low-voltage application	32	118	21.33	78.67

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9	Non-availability	36	114	24.00	76.00
8	Unattractive	86	64	57.33	42.67
9	Lack of guidance	76	74	50.67	49.33

Source: Data collected and compiled by the author's own

The majority of respondents mention low-voltage application (78.67%) and investment cost (86.67%) as their top concerns. Very few people are aware of maintenance costs (15.33%), which suggests that many people ignore continuing costs. There is moderate awareness of lack of direction (50.67%), seasonal factors (56%), and unattractiveness (57.33%). On the other hand, fewer respondents demonstrated limited knowledge of these barriers, specifically due to unawareness of non-availability (24%), lengthy loan procedures (26%), and long payback periods (29%). To promote better adoption, it is suggested that, in addition to financial and technical concerns, there is a need to raise awareness of procedural and availability challenges.

Table 7: Frequency of Information Sources about Solar Irrigation Pump

Rank	Particulars	Response	Frequency (Count)	Frequency (%)
1	Friends and Families	Yes	106	70.6
		No	44	29.4
2	Newspapers and Magazines	Yes	108	72.2
		No	42	27.8
3	Television and Radio	Yes	82	54.5
		No	68	45.5
4	Internet	Yes	87	57.8
		No	63	42.3
5	Books and Encyclopedias	Yes	43	28.5
		No	107	71.5
6.	Environmental Organisations and NGOs	Yes	54	36.1
		No	96	63.9
			150	100

Data collected and compiled by the author's own

The majority of people learn about solar irrigation pumps from commonplace sources, according to the data. With 72.2% of the population using newspapers and magazines, friends and family come in second with 70.6%. People also frequently obtain their information from the internet (57.8%) and radio or television (54.5%). However, just 28.5% of people use books and encyclopedias, and only 36.1% rely on environmental organisations or NGOs. In contrast to

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formal or educational sources, this indicates that informal sources, such as the media and personal contacts, are far more important in raising awareness about solar pumps. The role of books, NGOs, and educational materials could be strengthened in order to raise awareness.

Conclusion:

Haryana's move to solar irrigation pumps is a revolutionary step in the direction of sustainable farming. In order to lessen farmers' reliance on diesel-powered systems, the state is installing more than 1.57 lakh pumps between 2019–20 and 2024–25. According to economic analysis, solar pumps can save up to ₹6,500 per acre per year. This is in contrast to diesel irrigation, which is not only costly but also environmentally damaging, emitting up to 165 kg of CO_2 per acre. The PM-KUSUM scheme has significantly contributed to the adoption of solar-powered irrigation pumps among farmers in Haryana, yielding considerable economic and environmental benefits. Empirical evidence from the Sirsa district indicates that farmers utilising solar pumps achieve annual cost savings of up to ₹6,790 per acre for wheat and ₹8,076 per acre for cotton, primarily due to reduced diesel consumption and lower maintenance expenses. Additionally, solar irrigation substantially mitigates carbon dioxide emissions, reducing approximately 127 kg CO_2 per acre for wheat and 165 kg CO_2 per acre for cotton, thus aligning with India's climate commitments. Awareness levels regarding solar pumps and associated subsidy schemes exceed 94%, with an adoption willingness of 98.5%; however, technical knowledge of photovoltaic technology remains limited to 55%, revealing a critical gap. Key challenges hindering broader adoption include the high initial investment cost, seasonal irrigation constraints, procedural complexities related to loan acquisition, and insufficient guidance. Information dissemination predominantly occurs through informal channels, such as family and media, indicating underutilization of formal educational and institutional resources.

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