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COST AND RETURN ANALYSIS OF WHEAT CROP UNDER SOLAR IRRIGATION IN UDAIPUR, RAJASTHAN, INDIA

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ABSTRACT

Wheat is the major cereal crop in the country, grown under both irrigated and unirrigated conditions. Wheat production in Rajasthan increased substantially from 8.99 to 10.92 million tonnes, with an annual growth rate reaching a peak of 8.33 per cent in 2020. India primarily relies on fossil fuels to meet its energy requirements and is currently the third-largest greenhouse gas emitter in the world, after China and the USA. To reduce greenhouse gas emissions and address climate change, the government has implemented several initiatives to promote the adoption of green energy. Crop production under solar irrigation systems provides higher income compared to production under diesel irrigation systems because the costs associated with diesel irrigation, such as fuel expenses, are eliminated. This study aims to analyse the economics of wheat cultivation using solar irrigation systems.
***Keywords*:** Wheat, Solar, Irrigation, Diesel, Green Energy.

Introduction

Wheat is one of the main staple crops and is crucial to the food economy in India. For the Indian populace, it is the most consumed crop after rice. With a carbohydrate content of about 71 per cent, wheat is the most abundant source of carbohydrates in human food worldwide. Additionally, wheat provides a significant amount of magnesium, fiber, and protein (13%). In 2013-14, 700 million tons of wheat were produced globally, making it the third most produced cereal after maize and paddy. The world's leading producers of wheat are China, India, the United States, and Russia. However, India is now the world's second-largest producer of wheat after China. India has a wheat productivity of 35.07 quintals per hectare and covers an area of 30.47 million hectares, producing 106.84 million tons.

All states in India, with the exception of the southern and north-eastern ones, grow wheat. The main wheat-producing states are Uttar Pradesh, Haryana, Punjab, and Rajasthan, which together account for nearly 80 per cent of the country's total production. Major rainfed wheat regions are found in West Bengal, Gujarat, Maharashtra, Madhya Pradesh, and Karnataka. The Central and Peninsular Zones comprise one-third of India's wheat-growing area.

Rajasthan contributes 8.47 per cent (2.58 million hectares) of the total area and 8.88 per cent (9.48 million tons) of the total wheat production in India (E&S Division, DA&FW, 2021-22). Important wheat-producing districts in the state include Ganganagar, Hanumangarh, Bharatpur, Kota, Alwar, Jaipur, Tonk, Sawai Madhopur, Udaipur, Chittorgarh, and Pali. Under RACP, wheat is a value chain crop in the Palayatha, Jakham, Gudha, and Orai-bassi clusters. The state cultivates commercial varieties such as LOK-1, Raj-3037, Raj-3765, GW-496, and GW-322. Wheat is sown from late October to early December in various parts of the state, and harvesting is carried out in March-April.

According to KPMG (2014), India's water pumping for irrigation requires over 4 billion liters of diesel and about 85 million tons of coal annually. One liter of diesel fuel burns to produce 2.6 kg of carbon dioxide, and from one kilogram of carbon dioxide, about 0.27 kg of carbon is released. The amount of carbon emissions becomes apparent when considering the amount of wheat produced in India and the quantity of diesel used for irrigation. India derives the majority of its energy from fossil fuels, with thermal power plants producing about 69.50 per cent of the country's total electricity (MoP, 2020). In India, 37.80 per cent of all greenhouse gases released into the atmosphere are produced by burning fossil fuels to generate electricity (GOI, 2016). Fossil fuel combustion results in higher emissions of carbon dioxide, a primary cause of the current climate change crisis. India is currently the world's third-largest emitter of greenhouse gases, behind the United States and China. The effects of climate change are already evident, and if action is not taken, it will only worsen.

The issue of sustainable development posed by fossil fuel-based power plants can be resolved by renewable energy sources, which are limitless, environmental friendly, and produce energy with very low emissions of greenhouse gases and air pollutants (Singal, 2007). Solar energy and other renewable sources can easily replace the current fossil fuel infrastructure, reducing CO_2 emissions to levels consistent with the most ambitious climate change targets (Fthenakis *et al*., 2009).

Compared to crop production using a diesel irrigation system, crop production using a solar irrigation system yields a higher income. This is because solar irrigation systems save money on irrigation charges, which are equivalent to the charges for diesel irrigation systems (Shivangi Upadhyay *et al*., 2023; Upadhyay *et al*., 2024). The Indian states of Rajasthan, Punjab, Bihar, and Haryana have the greatest concentrations of installed solar irrigation pumps. The intensity of solar radiation varies with location, with Rajasthan and northern Gujarat receiving the highest annual global radiation of ≥2400 kWh/m². Rajasthan experiences 6.0-7.0 kWh/m² of solar radiation, little rainfall, and 325 days of bright sunshine annually. In western regions like the Thar Desert, sunshine can last up to 345-355 days a year, as rain falls there only 10.4-20.5 days annually (Meena *et al*., 2014).

The government has taken several steps to encourage the use of green energy to lower greenhouse gas emissions and address climate change. Initiatives such as the KUSUM scheme and the Jawaharlal Nehru National Solar Mission are aimed at promoting sustainable development. Through these programs, farmers can install solar irrigation pumps on their fields and barren areas with financial assistance and subsidies from the government. Additionally, the government is keen on pursuing large-scale solarization of multiple community diesel pumps. Incentives are also being provided to DISCOMS (Distribution Companies) for purchasing the additional energy generated through these initiatives.

The objective of these efforts is to prioritize solar irrigation pumps over diesel irrigation pumps. Transitioning to solar irrigation pumps is crucial, given the importance of the wheat crop and the substantial fuel requirements for irrigation. Therefore, the following study was undertaken to analyse the economic feasibility of wheat production under a solar irrigation pump system.

Materials and Methods

Data Source

The research relied on primary data collected through personal interviews using structured schedules during the rabi season of 2022-23.

Study Area

The study focused on Udaipur district in Rajasthan, chosen purposefully because it ranked second in the installation of solar water pumps under PM-KUSUM Component-B for the fiscal year 2020-21 in the tribal region (Department of Agriculture, Government of Rajasthan, Jaipur). Out of the 13 tehsils in Udaipur district, the study selected two tehsils, namely Jhadol and Kotra, based on the highest number of solar water pumps installed during the year 2020-21.

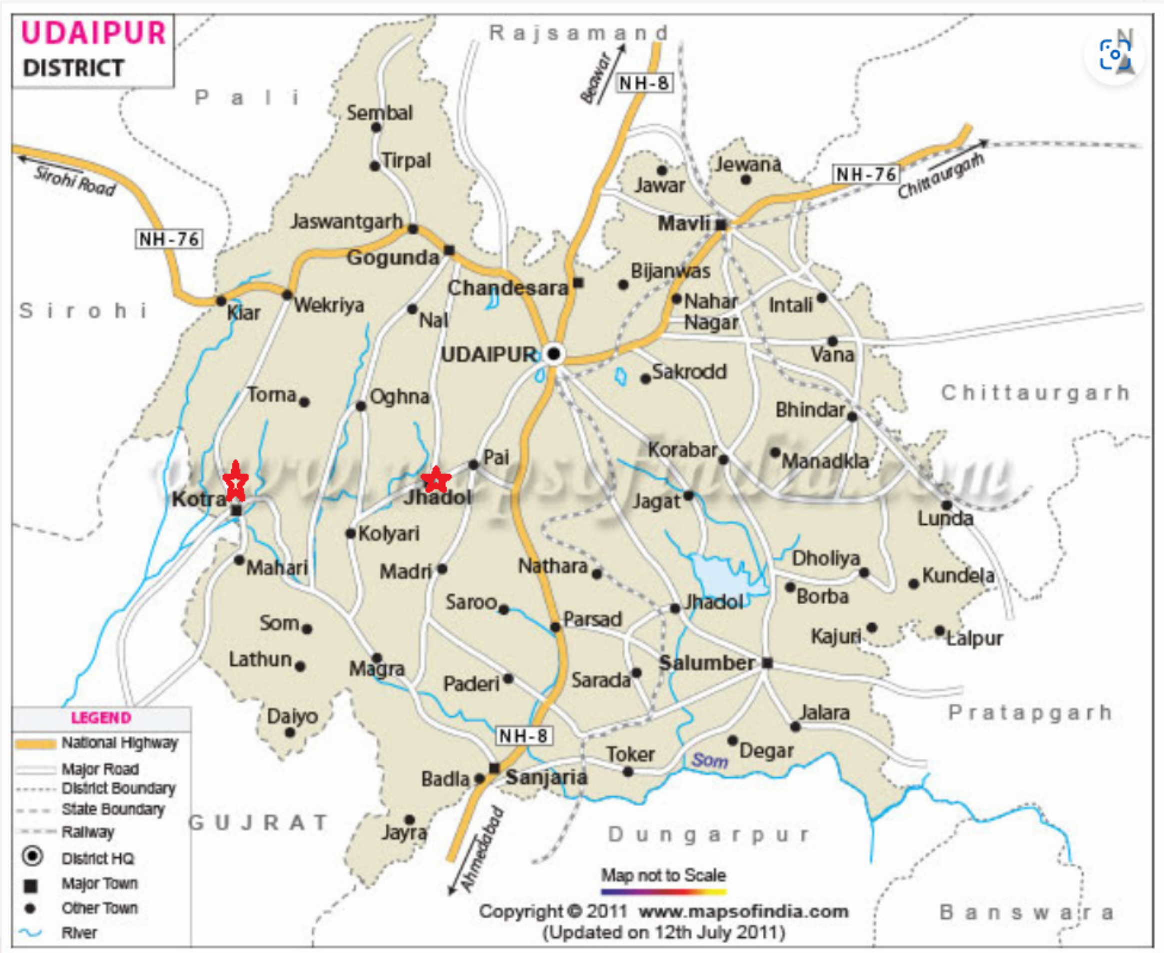

Fig. 1 : Geographical map of Udaipur District

Analytical and Statistical Tools

Cost of cultivation and return were calculated using cost concept suggested by Commission for Agricultural Costs and Prices. Following types of costs were considered:

Cost A_1 = All actual expenses in cash and kind incurred in production by the owner.

Cost A_2: Cost A_1 + rent paid for leased-in land

Cost B_1: Cost A_1 + interest on value of owned fixed capital assets (excluding land)

Cost B_2: Cost B_1 + rental value of owned land +rent paid for leased-in land

Cost C_1: Cost B_1 + imputed value of family labour

Cost C_2: Cost B_2 + imputed value of family labour

Cost C_3: Cost C_2 +10 percent of cost C_2 as management cost

The cost A_1 and cost A_2 were found to be same, because there was no land taken on lease.

Results and Discussion

Cost Analysis in Jhadol Tehsil

Upon reviewing Table 1, it was found that the total cost of cultivating wheat for beneficiary farmers amounted to Rs. 49,571.55. This cost comprised 35.99 per cent of fixed costs (Rs. 17,841.04) and 64.01 per cent of variable costs (Rs. 31,730.51).

The primary variable cost, which accounted for nearly 21.58 per cent of the total cultivation cost, was human labour. This finding is in line with Gautam *et al.* (2021). Following human labour, other significant components of the variable costs included machine labour (20.93%), seeds (5.25%), animal labour (4.49%), fertilizers (3.72%), irrigation (2.79%), interest on working capital (2.37%), manures (1.59%), and other incidental charges (1.30%).

Table 2 displays the per hectare returns from growing wheat. The total cost of cultivating wheat was Rs. 49,571.55, while the gross return per hectare for the beneficiary farmer was Rs. 66,136.50. Consequently, the net return per hectare was Rs.

16,564.95. The cost of production per quintal of wheat was observed to be Rs. 1,443.72.

The cost of cultivating wheat per hectare is shown in Table 3. The total cost of A1 per hectare of wheat cultivation for the Jhadol beneficiary farmers was found to be Rs. 21,468.32. The costs for B1, B2, C1, and C2 were Rs. 27,618.72, Rs. 38,874.35, Rs. 38,315.92, and Rs. 49,571.55, respectively. The cost C3, which includes the farmer's managerial role, was Rs. 54,528.70.

Table 4 shows that the gross income from wheat was estimated at Rs. 66,136.50 per hectare. The average net income over cost C2 and the average family labour income were Rs. 16,564.95 and Rs. 27,262.15 per hectare, respectively. The farm business income for the farmer was estimated at Rs. 44,668.18 per hectare. The average return per rupee invested was calculated to be 1.33.

Table 1: Item-wise breakup of cost of cultivation of wheat under solar irrigation system

S. N.	Particulars	Jhadol	Percentage	Kotra	Percentage
	Variable costs				
1.	Human labour	10697.20	21.58	10758.50	21.46
2.	Machine labour	10372.90	20.93	10072.90	20.09
3.	Animal labour	2225.66	4.49	2305.56	4.60
4.	Seeds	2601.41	5.25	2636.13	5.26
5.	Irrigation charges	1382.40	2.79	1252.80	2.50
6.	Manure	788.96	1.59	722.35	1.44
7.	Fertilizer (DAP+Urea)	1841.90	3.72	1791.80	3.57
8.	Miscellaneous	645.00	1.30	650	1.29
9.	Interest on working capital	1175.08	2.37	1155.95	2.30
10.	**Subtotal of variable cost**	**31730.51**	**64.01**	**31345.99**	**62.52**
	Fixed costs				
11.	Rental Value of owned land	11255.63	22.71	12212.54	24.36
12.	Depreciation on farm implements	435.01	0.88	444.56	0.88
13.	Interest on fixed capital	6150.40	12.41	6130.71	12.22
14.	**Subtotal of fixed cost**	**17841.04**	**35.99**	**18787.81**	**37.48**
15.	**Total Cost**	**49571.55**	**100.00**	**50133.80**	**100.00**

Table 2: Per hectare returns of wheat under solar irrigation system

S. No.	Particulars	Jhadol	Kotra
1.	Gross return (Rs./ha.)	66136.50	66450.00
2.	Total cost (Rs./ha.)	49571.55	50133.80
3.	Net return (Rs./ha.)	16564.95	16316.20
4.	Cost of production (Rs./qtl)	1443.72	1454.29

Table 3: Per hectare cost of cultivation of wheat under solar irrigation system

S. No.	Cost Item	Jhadol	Kotra
1.	Cost A_1	21468.32	21032.05
2.	Cost A_2	21468.32	21032.05
3.	Cost B_1	27618.72	27162.76
4.	Cost B_2	38874.35	39375.30
5.	Cost C_1	38315.92	37921.26
6.	Cost C_2	49571.55	50133.80
7.	Cost C_3	54528.70	55147.18

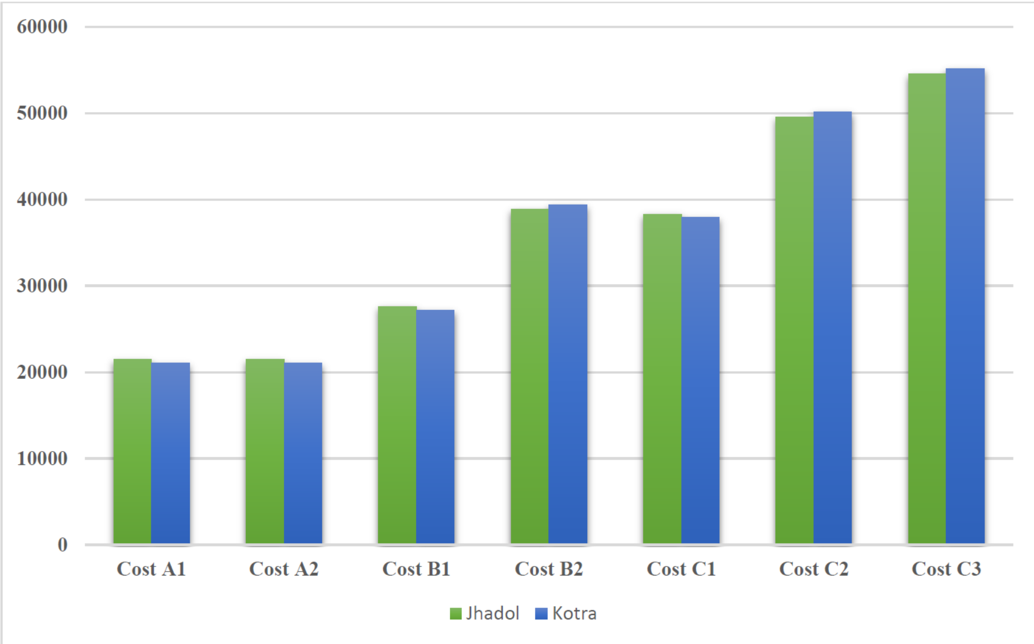

Fig. 2: Standard cost concepts for wheat cultivation in Jhadol and Kotra tehsil

Table 4: Farmer's income measures from wheat under solar irrigation system

S. No.	Particulars	Jhadol	Kotra
1.	Cost of cultivation (Rs./ha)	49571.55	50133.80
2.	Gross income (Rs./ha)	66136.50	66450.00
3.	Farm business income (Rs./ha)	44668.18	45417.95
4.	Family labour income (Rs./ha)	27262.15	27074.70
5.	Net income (Rs./ha)	16564.95	16316.20
6.	Return per rupee	1.33	1.32

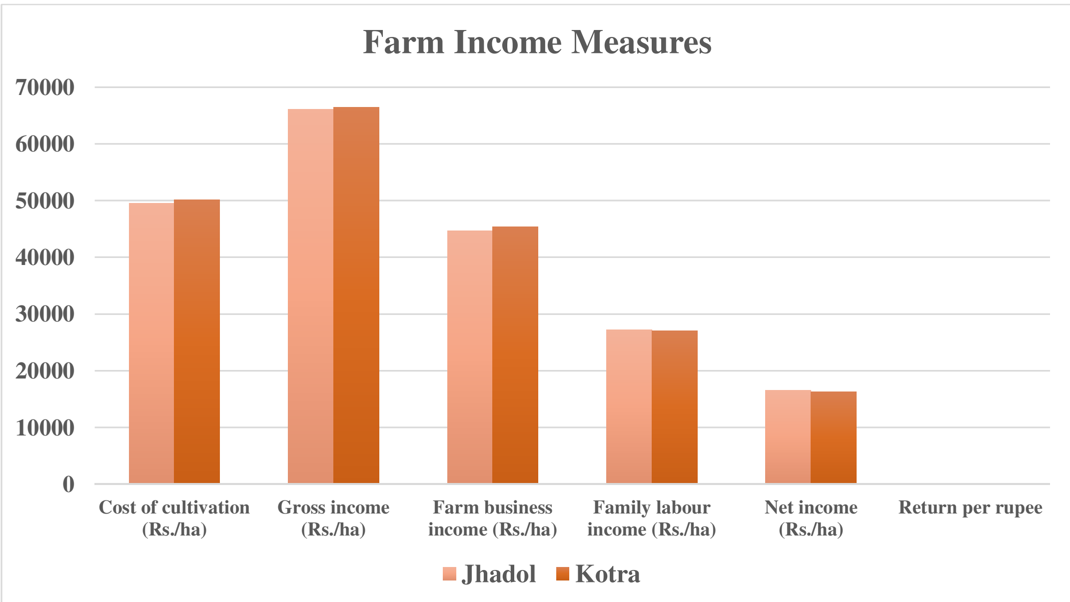

Fig. 3: Farm income measures for wheat cultivation in Jhadol and Kotra tehsil

Cost analysis in Kotra Tehsil

Table 1 displays the per hectare cost associated with wheat cultivation in Kotra tehsil. The total cost for farmers who received benefits was Rs. 50,133.80, with 62.52 per cent attributed to variable costs (Rs. 31,345.99) and 37.48 per cent to fixed costs (Rs. 18,787.81). This finding matches the findings of Gautam and Singh (2020).

The primary component of operating costs, which made up almost 21.46 per cent of the total cultivation cost, was human labour. The next major cost items of the variable cost component were machine labour (20.09%), seeds (5.26%), animal labour (4.60%), fertilizer (3.57%), irrigation (2.50%), interest on working capital (2.30%), manures (1.44%), and other miscellaneous charges (1.29%).

Table 2 displays the yields per hectare from growing wheat. A gross return of Rs. 66,450 per hectare and a net return of Rs. 16,316.20 per hectare were observed. The total cost of production of wheat was found to be Rs. 1,454.29 per quintal.

Table 3 presents the per hectare cost of wheat cultivation. The overall cost A1 per hectare for beneficiary farmers in Kotra was Rs. 21,032.05. The cost A1 and cost A2 were the same since no land was leased. The costs B1, B2, C1, and C2 were Rs. 27,162.76, Rs. 39,375.30, Rs. 37,921.26, and Rs. 50,133.80, respectively. The cost C3, which includes the managerial function of the farmer, was Rs. 55,147.18.

Table 4 shows that the gross income from wheat was estimated at Rs. 66,450 per hectare. The net income over cost C2 and family labour income were Rs. 16,316.20 and Rs. 27,074.70 per hectare, respectively. The farm business income for beneficiary farmers was estimated at Rs. 45,417.95 per hectare. The return per rupee invested was calculated to be 1.32.

Conclusion and Implications

Conclusion

The study concludes that wheat cultivation under solar irrigation systems is economically viable, with higher net returns compared to diesel or electric irrigation systems. Solar irrigation reduces variable costs, particularly those associated with fuel or electricity, leading to overall savings and improved profitability for farmers. Additionally, transitioning to solar irrigation aligns with sustainable development goals by reducing greenhouse gas emissions and dependency on fossil fuels.

Policy Implications

1. Promotion of Solar Irrigation Systems:

Incentives and Subsidies: Enhance financial support through subsidies and incentives to encourage more farmers to adopt solar irrigation systems. Programs like the KUSUM scheme should be expanded and made more accessible.

Financing Options: Develop affordable financing options for farmers to invest in solar irrigation infrastructure. Collaborate with financial institutions to provide low-interest loans or installment-based payment plans.

2. Infrastructure Development:

Grid Integration: Facilitate the integration of solar pumps with the local power grid to allow farmers to sell excess power, providing an additional income stream and encouraging investment in solar technology.

Maintenance and Support: Establish support centers for the maintenance and repair of solar irrigation systems to ensure their long-term viability and efficiency.

3. Awareness and Training:

Education Campaigns: Conduct awareness campaigns highlighting the economic and environmental benefits of solar irrigation. Use success stories and case studies to demonstrate the potential returns and sustainability.

Training Programs: Implement training programs for farmers on the installation, operation, and maintenance of solar irrigation systems. Collaboration with agricultural universities and local NGOs can facilitate this.

4. Research and Development:

Technology Advancements: Invest in R&D to improve the efficiency and cost-effectiveness of solar irrigation systems. Focus on developing affordable, high-efficiency solar panels and durable, low-maintenance pump systems.

Data Collection: Continuously collect and analyse data on the performance of solar irrigation systems to identify best practices and areas for improvement. Use this data to refine policies and support mechanisms.

5. Environmental and Economic Policies:

Carbon Credits: Explore the possibility of carbon credits for farmers using solar irrigation, providing an additional financial incentive by monetizing the reduction in greenhouse gas emissions.

Water Management: Promote efficient water use practices in conjunction with solar irrigation to maximize the benefits and ensure sustainable water resource management.

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