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Analysis of resource use efficiency, costs and returns in wheat production under solar irrigation system in Jaipur, Rajasthan

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Abstract
Wheat is one of the main cereal crop of India. India stands on second position in production after China. India has come a long way in terms of area, production and productivity of the wheat since 1950. India relies heavily on fossil fuels to meet its energy requirements. Currently, India is the third largest Greenhouse gas emitter in the world after China and USA. The results of climate change are clearly visible and they are going to worsen further if initiatives are not taken. Wheat uses significant amount of irrigation during its entire growing period. Cultivation of wheat in India is done on a wider scale. Hence, it can be easily understood the amount of fuel it takes to irrigate wheat crop on a large scale. Rajasthan is among the highest wheat producing states. Wheat cultivation is carried out under solar irrigation system in major parts of Rajasthan. Government is also providing various subsidies for promotion of solar irrigation pump over diesel irrigation pumps. Hence, an economic analysis is conducted to assess the profitability of wheat production under solar irrigation system in Rajasthan.

Keywords: wheat, solar irrigation system, carbon emission, cacp cost concept, resource use efficiency, cobb douglas

Introduction

Wheat is one of the main cereal crop of India. India stands on second position in production after China. It is one of the first domesticated crops and has been one of the staples in the diet of many civilizations for more than 8,000 years. Wheat crop has wide adaptability. It can be grown not only in the tropical and sub-tropical zones, but also in the temperate zone and the cold tracts of the far north. The best wheat are produced in areas favoured with cool, moist weather during the major portion of the growing period followed by dry, warm weather to enable the grain to ripen properly. Indian wheat is largely a soft/medium hard, medium protein, white bread wheat, somewhat similar to U.S. hard white wheat. Wheat grown in central and western India is typically hard, with high protein and high gluten content.

India has come a long way in terms of area, production and productivity of the wheat since 1950. Area under wheat in 1950–51 was 9.75 million hectares which increased to 29.14 million hectares in 2018-19. Production of wheat increased from 6.46 million hectares in 1950-51 to 102.19 in 2018-19. Similarly, yield also increased manifold. In the yield 19 50–51, it was 33.99 kg/ha which increased to 94.22 kg/ha in the year 2015-16 (DACNET, 2019). Rajasthan is among the highest wheat producing states. In year 2018-19, area under wheat in Rajasthan contributed up to 10.29 per cent of the total area under wheat in India. 10.27 per cent of the total wheat production of India came from Rajasthan (DACNET, 2019). An important point to note was that, in Rajasthan, 99.7 per cent of the total area under wheat production was under irrigated condition. Only 0.3% of the total area under wheat production was under Rainford condition. This means that wheat production requires a strong irrigation infrastructure especially in the state where rainfall is very less.

In 2014, India used more than 4 billion litres of diesel and around 85 million tons of coal per annum to support water pumping for irrigation (KPMG, 2014). Burning one litre of diesel produces 2.6 Kg of carbon dioxide and from one kilogram of carbon dioxide, approximately 0.27 kg of carbon is emitted. Considering the level of production of wheat in the country and the amount of diesel used for irrigation, it can be easily understood what impact it has on the environment.

Today, India relies heavily on fossil fuels to meet its energy requirements. Around 69.5 per cent of the total power is generated by thermal power plants (MoP, 2020). In India electricity generated by burning fossil fuels contributes 37.8% of the total greenhouse gasses released in the atmosphere (GOI 2016). Burning of fossil fuels increases carbon-dioxide emission which is a major contributor to the climate change crisis today (Schock *et al*., 2007) [7]. In 2016, World Health Organization (WHO) released a report in which, 11 Indian cities have occupied positions in the list of top 25 polluted cities of the world (WHO, 2017) [9]. Currently India is the third largest Greenhouse gas emitter in the world after China and USA. Today, the results of climate change are clearly visible and they are going to worsen further if initiatives are not taken. Renewable energy sources are capable to solve the problem of sustainable development associated with fossil fuel based power plants as these energy sources are unlimited, eco-friendly and provides energy with negligible emissions of air pollutant and greenhouse gases (Singal, 2007) [8]. It is clearly feasible to replace the current fossil fuel infrastructure with solar power and other renewable, and reduce CO2 emissions to a level commensurate with the most aggressive climate change goal (Fthenakis *et al.*, 2009) [1].

In India, highest numbers of solar irrigation pumps are installed in Punjab, Rajasthan, Bihar and Haryana. Solar energy intensity varies geographically. Highest annual global radiation of ≥2400 kWh/m2 is received in Rajasthan and northern Gujarat. Rajasthan receives solar radiation of 6.0–7.0 kWh/m2. It receives low rainfall and about 325 days have good sunshine in a year. In western areas like Thar Desert it may extend up to 345–355 days as rains occur only for 10.4–20.5 days in a year (Meena *et al.*, 2014) [10].

In order to reduce the greenhouse gas emissions and tackle climate change problem, country government took several initiatives that promote green energy. Schemes like Jawaharlal Nehru National Solar Mission, KUSUM scheme etc are few steps such initiatives taken in the direction of sustainable development. Under these schemes, government provides subsidies and financial support to the farmers for setting up solar irrigation pumps on their field and barren lands. Government is taking keen interest in solarising several community diesel pumps on a large scale.

The government will provide incentive to DISCOMS for purchasing additional energy generated. All these initiatives are taken to promote solar irrigation pumps over diesel irrigation pumps. Considering the importance of the wheat crop and the amount of fuel it requires for irrigation, it is a wise step to move towards solar irrigation pump. Hence, following study was undertaken to analyse the economic feasibility of wheat production under solar irrigation pump system.

Research Methodology

The study was based on primary data collected with the help of survey schedule. Rajasthan was purposively selected because it receives the highest annual global radiation and the installation of solar irrigation pumps are maximum. Jaipur was selected purposively because number of solar irrigation pumps installed were maximum in the district. Respondents were selected with snowball sampling method. Cost of cultivation and return were calculated using cost concept suggested by Commission for Agricultural Costs and Prices (Gautam, 2018). Cobb Douglas production function was used to analyse the resource use efficiency of the inputs included in the model.

a. Cost A1 = All actual expenses in cash and kind incurred in production by the owner. It includes:
b. Cost A2 = Cost A1 + rent paid for leased in land
c. Cost B1 = Cost A1 + interest on value of owned capital asset (excluding land)
d. Cost B2 = Cost B1+ rental value of owned land
e. Cost C1 = Cost B1 + imputed value of family labour.
f. Cost C_2 = Cost B2 + imputed value of family labour
g. Cost C_3 = Cost C2 + 10% of C_2

Productivity of key input factors

To work out the productivity, Cobb Douglas production function was used in following form:

$$Y = a\, x_1^{b_1} x_2^{b_2} x_3^{b_3} x_4^{b_4} x_5^{b_5}$$

Where,
Y = Gross return per hectare in Rs.
a = Constant
x_1 = Human Labor use per hectare in Rs.
x_2 = Machine use per hectare in Rs.
x_3 = Seed per hectare in Rs.
x_4 = Fertilizer use per hectare in Rs.
x_5 = Irrigation per hectare in Rs.
b_1, b_2, b_3, b_4 and b_5 are the elasticities of production for inputs x_1, x_2, x_3, x_4 and x_5 respectively.

Results and Discussion

Cost concept analysis

Per hectare operational cost and fixed cost incurred in the cultivation of wheat under solar irrigation system is presented in the Table 1. It was found that the average total cost of cultivation was ₹ 67,504.27, out of which operational cost was ₹ 43,079.43 and fixed cost amounted to ₹ 18,287.70. The percentage contribution of operational cost in the total cost was 63.81 per cent and that a fixed cost was 36.18 per cent. Managerial cost was estimated to be ₹ 6136.713.

Table 1: Item wise Breakup of Cost of Production (₹ per Ha.)

	Costs		**Amount**
A	**Operational Cost**		**43,079.43**
1	Human Labour	Family	15,846.91
		Attached	0.00
		Casual	3,103.03
		Total	18,949.94
2	Animal Labour	Hired	0.00
		Owned	0.00
		Total	0.00
3	Machine Labour	Hired	3,209.54
		Owned	1,495.24
		Total	4,704.78
4	Seed		3,672.00
5	Fertilizer & Manure	Fertilizer	2,528.38
		Manure	3,113.76
		Total	5,642.14
6	Insecticides		197.71
7	Irrigation Charges		9,171.94
8	Miscellaneous		0.00
9	Interest on Working Capital		740.92
B	Fixed Costs		18,287.70
1	Rental Value of Owned Land		14,992.42
2	Rent Paid For Leased-in-Land		531.67
3	Land Revenue, Taxes, Cesses		18.17
4	Depreciation on Implements & Farm Building		1,874.60
5	Interest on Fixed Capital		870.84
C	Operational Cost + Fixed Cost [A+B]		61,367.13
D	Managerial cost		6,136.713
F	Total cost [C+D]		67,504.27

Figure 1 shows the share of major inputs in the cost of cultivation of wheat under solar irrigation system. It was observed that highest contribution in the total cost was of human labour (28 per cent), irrigation (14 per cent) and fertilizer (8 per cent), machine labour (7 per cent) seed (5 per cent). The fixed cost contributed to the extent of 27 per cent in the total cost.

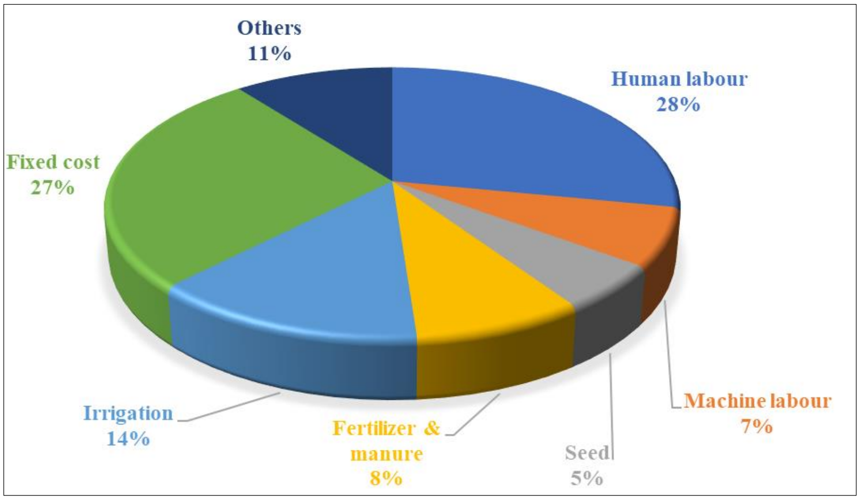

Fig 1: Share of different factors in cost of cultivation of wheat under solar irrigation system.

Cost of cultivation as suggested by cost concept Commission on Agricultural Cost and Prices (CACP) is shown in table 2. It can be observed it was observed that Cost A1 was ₹ 29,125.69 and Cost A2 was 29,657.35 in the study area. Cost B1, B2, C1, C2, C3 were estimated to be ₹ 30,528.19, ₹ 45,520.62, ₹ 46,375.10, ₹ 61,367.52, and ₹ 67,504.27 respectively.

Table 2: Per hectare cost of cultivation of wheat under solar irrigation system

S. No.	Particulars	Amount (₹)
1	Cost A1	29,125.69
2	Cost A2	29,657.35
3	Cost B1	30,528.19
4	Cost B2	45,520.62
5	Cost C1	46,375.10
6	Cost C2	61,367.52
7	Cost C3	67,504.27

Table 3 shows the returns of wheat under solar irrigation system. It was estimated that the return from main product and by product was equal to ₹ 66,181.58 and ₹ 24,965.58 respectively. The net return was ₹ 23,642.90. Under solar irrigation system, farmer didn't have to pay any irrigation charge because farmer had installed solar pump on their farm and operation of solar pump doesn't require any additional input or charges. Therefore the irrigation charges that farmer had to pay before the installation of solar pump were saved. Hence, that irrigation charge which was saved was considered to be the part of the income of the farmer. So, the net income of the farmer after including irrigation charges was estimated to be ₹ 32,814.84.

Table 3: Per hectare returns of wheat under solar irrigation system

S. No.	Particulars	Amount (₹)
1	Main product	66,181.58
2	By product	24,965.58
3	Gross return	91,147.17
4	COC	61,367.52
5	Cost C3	67,504.27
6	Net return	23,642.90
7	Net Income = Irrigation charges + Net return	32,814.84

Resource Use efficiency

The value of coefficient of multiple determination capital R square was 0.8441. It indicates that 84.41 per cent variation in logarithmic value of gross returns was explained by the independent variables (human labour, machine labour, seed, fertiliser and irrigation) included in the regression model.

The coefficient of elasticity of production of seed turned out to be positive and significant. It means that for every 1 per cent increase in human labour there be an increase in the gross return by 0.3137 per cent keeping the other variable resources considered in the equation constant at their geometric mean level. Similarly, coefficient of elasticity of production of fertilizer was found to be positive and significant. Coefficient of elasticity of production of human labour, machine labour and irrigation was positive but insignificant. Since the elasticity of coefficient was statistically insignificant so it means that no impact of human labour machine labour and irrigation was visible on the gross returns. This may be because of the uniform rate of application of these inputs (expressed in monetary terms) in the operational practices.

Table 4: Regression coefficients of variables included in the regression model

Particulars	Intercept	Human Labour	Machine Labour	Seed	Fertilizer	Irrigation
Coefficients	1.2326	0.2024	0.0473	0.3137	0.2582	0.1762
t Stat		1.9491	0.9599	2.4936	5.0469	1.8565
P value		0.0552	0.3404	0.0150	0	0.0675
$\sum b_i = 0.9978$				$R^2 = 0.8441$		

Significant at 5 per cent level.

The sum of the regression coefficients of variables was more than one i.e. $\sum b_i = 0.9978$ which meant that there was decreasing returns to scale. It implies that with the increase in input the output is increasing but with decreasing rate. It may be because of the operation of diseconomies of scale. Also, some inputs were not used optimally. If the inputs which were positive and significant like fertilizer and seed were used increasingly and optimally, production will also increase.

Conclusion

Cost concept analysis showed that the wheat production was profitable even in solar irrigated condition. Net return of the farmer was ₹ 32,814.84 per ha. Regression analyses shows that there was decreasing returns to scale but with a very small margin. It can be improved by the optimal utilisation of all inputs that are underutilised or overutilized.

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