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Social and economic impact assessment of solar water pumping system on farmers in Nagpur district of Maharashtra state of India

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Abstract

In India, farmers depend on variable rainfall and groundwater for irrigation. Load shedding and high diesel cost are the barriers for regular watering of crops. Solar photovoltaic water pumping system (SPVWPS) is a better sustainable option, but the high capital cost is hindering widespread applications. The Maharashtra state government distributed SPVWPS to marginal farmers (Whose land holding is less than 5 acres) and are grid isolated providing subsidies as high as 95%. Total, 8959 pumps are distributed till November 2018 in the whole Maharashtra state with 210 in Nagpur district only. Current work assesses the impact of the use of SPVWPS on the livelihoods of farmers, their social and economic condition by conducting a survey. The aim of the study is to evaluate the health, reliability and durability of SPVWPS. An effort has been made to understand the grassroots level insights associated with solar pump use. The field research was carried on by interviewing farmers and by keeping their fields and irrigation schemes. Questionnaires were created in order to facilitate the study. By splitting up the questionnaires into different areas, the results gave a general impression of the farmer's daily challenges and troubles. The authors surveyed total 25 sites from 17 villages of 8 Talukas of Nagpur district. Economic comparison of solar pump is made out with diesel pump and electric pump using the cost benefit analysis method and found that farmers using diesel pumps are in more favourable side to switch to solar pumps.

***Keywords*:** Solar photovoltaic water pumping, Survey, Irrigation, Cost benefit analysis

1. Introduction

In a developing country like India whose economy is depend on agriculture, and which is rapidly changing into the realm of renewable energy, the future of solar pumps seems brighter than ever [1–3]. Agriculture sector in India employs almost 50% of the work force, and gives 17.32% to India's GDP. Thus, it is important to assure a high return of agricultural crops, by introducing new practices like efficient irrigation techniques. Water pumps have come forth as a reliable mode of irrigation, and the advent of renewable energy has ensured the speedy progress of solar water pumps. At the fore of this breakthrough is The Ministry of New and Renewable Energy (MNRE), which has collaborated with various state governments and started promoting solar water pumps by providing various subsidies to farmers [4].

Solar water pumps scheme for farmers in Maharashtra was launched by the State Government of Maharashtra in 2016. Farmers got solar pumps at a highly subsidized rate and beneficiaries paid just 5 to 10 % of the pumps cost. One solar pump cost between 3 to 7.5 lakh depending on the horsepower [5]. To get benefits from this scheme, a farmer has to have a landholding smaller than five acres. Up to date 8959 pumps are distributed. The main objective of this survey is to assess the socioeconomic impact, on field performance of the system and train the farmers for better uses of System. We are also in process of writing report suggesting changes for improvement in the scheme and submitting to all stakeholders.

2. Methodology

2.1 Survey design

The Maharashtra state government distributed solar water pumps in 20 districts, including major quantities in the drought-hit districts. In this study surveys are conducted in 8 talukas covering whole Nagpur district. Nagpur region fall in the "Hot & Dry" zone, all survey sites fall under Hot Zone[6]. A total of 1200 km was covered in remote villages of Nagpur for the study.

The field research was conducted by interviewing farmers and by observing their fields and irrigation systems. Questionnaires were created in order to facilitate the survey. By splitting up the questionnaires into different arenas, the results gave a general picture of cropping pattern, irrigation method, peak water requirement, water head, total cultivated area, and the daily challenges and troubles confronted by farmers. All farmers were questioned at their farm. As a consequence of this, it was more comfortable to watch over their situation and get extra notes if required. We also talked to engineers of Jain Irrigation Systems Ltd. (The supplier and responsible for maintenance for 5 years).

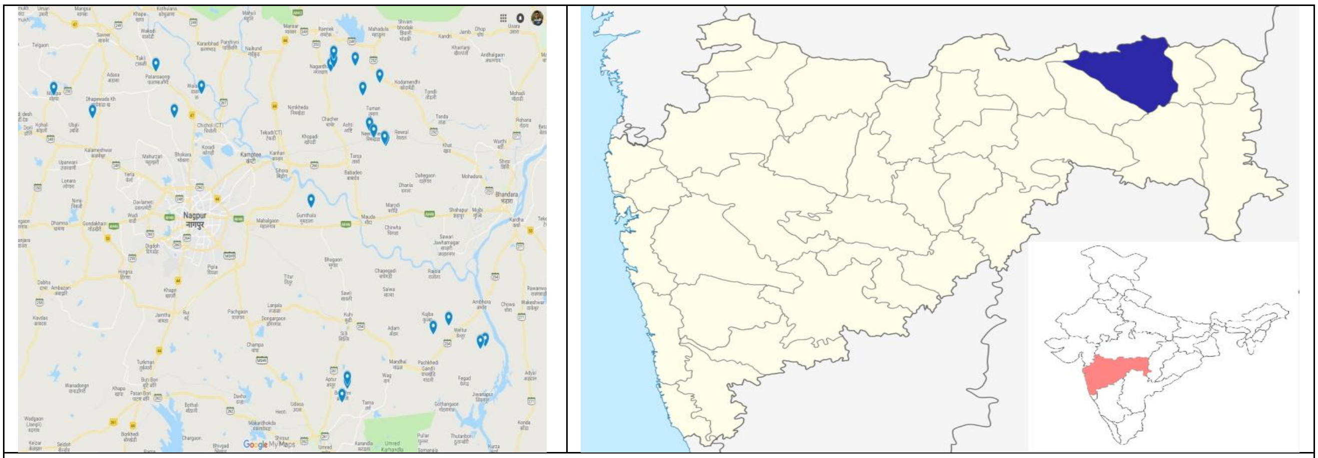


Fig. 1. Surveyed farmer's location in Nagpur district of Maharashtra

Total 25 farmers interviewed from 17 villages of 8 Talukas of Nagpur district. The survey sites are marked in Fig.1. Inside information of beneficiaries are presented in Table 1. Altogether the 25 farmers interviewed were male, education level among farmers were low; 52 % farmers studied up to elementary school.

Table1. Details of farmers interviewed

Average Age of Respondents	43.2
Education Level	
Primary	13
Secondary	5
Graduation	7

2.2 Cost benefit analysis

Cost benefit analysis (CBA) is a systematic procedure for estimating and comparing benefits and costs of a project, decision or government insurance. This method compares the total anticipated cost of each alternative against the total expected benefits, to examine whether the benefits compensate the costs, and by how much [7].

In this research, diesel driven pump, electric driven pump and SPVWPS are analyzed with cost benefit analysis with different power ratings of 3 hp, 5 hp. The breakeven point is worked out for diesel driven pump and electric driven pump against SPVWPS by considering subsidy provided and without subsidy.

$$\text{Total Cost (TC)} = CC + OC + MC \qquad (1)$$

Where, CC= Capital cost

OC= Operating cost

MC= Maintenance cost

The cumulative total cost is calculated over the years to find breakeven point or payback period for different scenario mentioned above. Total cost from second year onwards does not include capital cost.

3. Results and discussion

Most of the farmers had the field size of less than 5 acres. Open well and Borehole was the primary source of water for irrigation, as it was mandatory to have source at farm to obtain the benefit of the system. Rice (Paddy), Wheat, Black Gram, and cotton are the principal crops cultivated in Nagpur district. Most of the farmers used basin irrigation method to irrigate; only 20 % used drip irrigation method. 44 % system runs against a water head of 10 to 20 m.

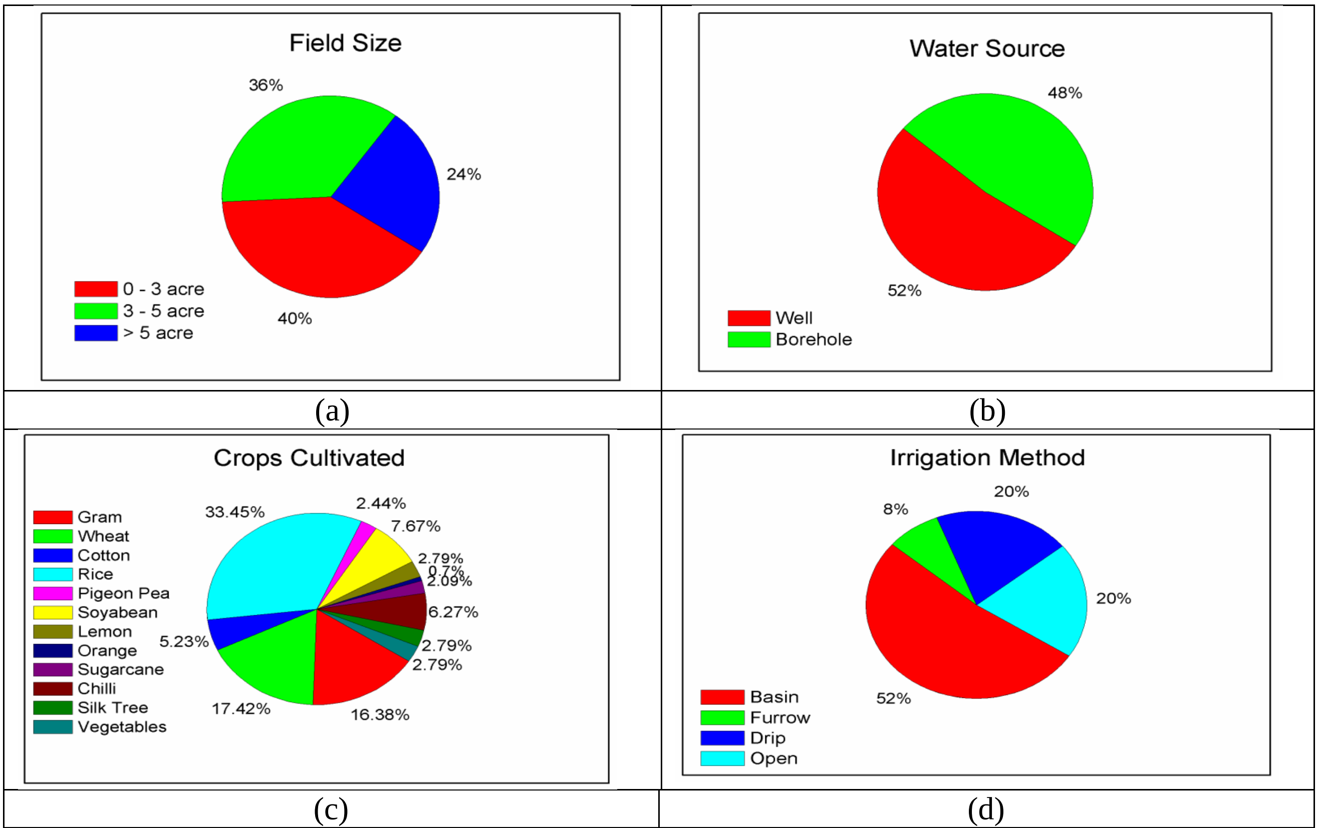


Fig. 2. Most common (a) field sizes, (b) water source, (c) crops cultivated, (d) irrigation method

3.1 Economic analysis

For an economic analysis of the system, following factors considered for better conclusions.

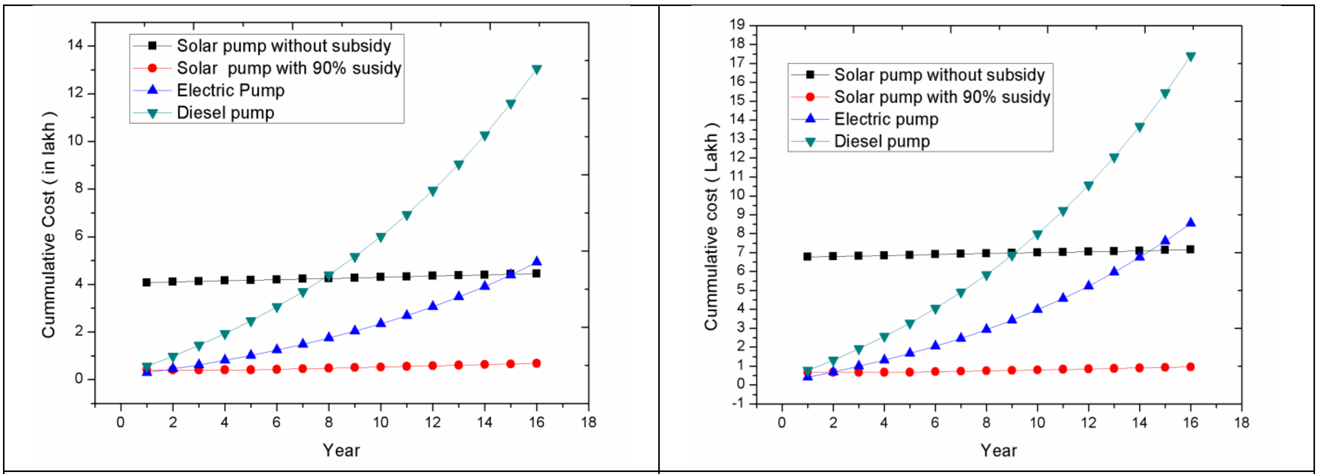
1. The capital cost of the systems in Indian rupees as shown in Table 2.

Table 2. The capital cost of systems

Capacity of the pump	Solar pump without subsidy	Solar pump with 90 % subsidy	Electric Pump	Diesel Pump
3 hp	405000	40500	13500	19000
5 hp	675000	67500	17000	27000

2. Diesel consumed by 3 hp & 5 hp diesel pump is found to be 1.25 litre/hour and 1.8 litre/hour respectively.
3. Average electric bill per year reported by the farmers during survey for 3 hp pump is 1200 and to 5 hp is 22000.

4. A total of 270 Sunny days in an year are considered in the calculation.
5. Maintenance cost per year of solar pump, electric pump and diesel pump is considered as 2500, 3000 and 4000 respectively.
6. Every year 10 % increase in bill and fuel prices is taken in calculations. Due to hike in fuel prices, this assumption is justifiable.



(a) (b)

Fig. 3. Cost benefit analysis of solar, diesel and electric pump for (a) 3 hp capacity (b) 5 hp capacity

The cost benefit analysis for switching to solar pump from diesel and electric pumps for capacities 3hp and 5hp are represented on fig 3(a) and (b) respectively. From fig 3.(a) it can be seen that the for farmers using 3 hp pumps payback period in the case of switching to solar pump from that of diesel is 8 years where as in the case of switching to solar pump from that of electric pump is 15.1 years. Similarly from 3.(b) it can be seen that for the farmers using 5hp pumps the payback period for switching to solar pump from that of diesel is 9.2 years and where as in the case of switching to solar pump from that of electric pump is 14.5 years. hence it is clear that for both 3hp and 5hp capacities pumps, farmers using diesel pumps are in more favourable side to switch to solar pumps.

3.2 Findings from survey

- Around, 80 % of farmers used daily tracking regularly. Remaining 20 % never used daily tracking of the PV module. Not a single farmer used seasonal tracking out of system surveyed.
- Most farmers used DG pumps before opting for the SPVWPS. According to farmers, they used 8-10 liters of oil (diesel + kerosene) in the DG pump for irrigation before. Because of SPVWPS they saved 40-50 Thousands of rupees per year.
- 20 % of farmers have never cleaned the PV module. Remaining 80% said they cleaned the module every 8- 10 days.
- We discovered that those who cleaned modules regularly, the first few modules have been cleansed properly, but modules which were stationed at more than 2.5 meters above from the ground were not cleaned.
- The length of the wiper given to farmers was only 1.5 meters. Proper cleaning tools with appropriate size should be provided to farmers.
- Around 20 % of beneficiaries used tricks to get the pump. One beneficiary in Mauda taluka has never used the pump for the farming.
- Farmer growing cotton and wheat told due to use of solar pump production of wheat and cotton increased. Wheat production increased by 7 quintal and cotton production increased by 13 quintal per acre
- In addition the chili farmers told that significant improvement in production of chili. Previously they used to irrigate chili crops in every 10 days and they used to pluck chilies every 20-25

days. After installing SPVWPS, all farmers used drip irrigation and they irrigate chili daily. According to them, they pluck the chilies every 15-20 days. The production of chilies increased by 15 to 25%.

- DC pumping system has better performance in cloudy and overcast conditions compared to AC. Moreover DC also requires lesser maintenance.
- The maintenance time for the any break down of motor and pump varied from 8 to 12 days as told by farmers and restated by Jain irrigation.
- No formal training has been given to farmers about the operation of SPVWPS. Because of that we found that initially the response to the scheme was poor. In our study, we establish that all beneficiaries are comfortable with the operation but with proper training the production from these installations can be amended substantially.

4. Conclusion

- Use of SPVWPS provides regular water to crops, which ensued in an increase in crop production quantity and also saved fuel cost substantially.
- Since no operational cost is required for SPVWPS, habit of overuse of pumping system is observed. This may eventually result in greater rate of decrease in ground water level.
- Less maintenance is required for solar pumping system compared to diesel and electric pumping system.
- Though the solar pump system is technically complex to understand, it is found that all users considered the solar systems very easy to use.
- Payback period is shorter, when switching from diesel pump to solar pump in comparison to switching from electric pump to solar pump.

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