Does Solar Pump Improve Productivity and Income of Farmers in India?

Vikas Kumar[1], Vijay Kumar[2], Archit[3]
[1] *Research Scholar, Department of Economics, CRSU, Jind*
[2] *Assistant Professor, Department of Economics, CRSU, Jind*
[3] *Research Scholar, Department of Economics, CRSU, Jind*

Abstract-The agriculture sector is backbone of Indian economy. At current prices, its share in the gross value added of the country for the year 2019-20 is about 17.8 per cent. About 54.6 per cent of total workforce in India still engaged in agriculture sector for livelihood. Indian agriculture is suffering from problem of low crop yield like India's rice yield was 2191 kg/hectare, while the global average stood at 3026 kg/hectare, while wheat is 2750 kg/hectare as against the world average yield of 3289 kg/hectare (The economic times, 2016) and the cost of production is increasing continuously. These problems have a negative impact on the socio-economic condition of the farmers, mainly on the income of the farmers. Therefore, to uplift the socio-economic status of the farmers there is a need to increase their income. But conventional energy sources are not very effective in achieving this goal. In this situation solar energy can play an important role in increasing the income of farmers in two ways, in the form of additional income of farmers and reducing the cost of agricultural production. Therefore, the main objective of this study is to analyze the impact of solar energy on crop productivity and farmers' income. The study is based on secondary data collected from various studies in India over the last two decades. The studies shows that the solar pump increase the crop productivity and farmers income.

INTRODUCTION

Agriculture sector is the largest employment provider in India. About 54.6 per cent of the total workforce in India is still engaged in agriculture for livelihood. Climate change, drought prone, and energy crisis have forced agriculture to shift towards solar energy, especially solar pumps for irrigation. Solar pump is not only providing irrigation facilities but it is also creating new employment opportunities, increasing crop production, crop productivity and also increasing the income of farmers. The Government of India has a vision to double the income of the farmers. The Government of India provides subsidy for setting up solar pumps under the 'PM-KUSUM' scheme. A total of 35 lakh solar pumps will be installed by 2026 under this scheme (PIB, 2022).

The study analyzed the impact of solar pump on production, productivity and income of farmers. The study includes different methods of irrigation by solar pump such as drip method, flood method etc. The Solar pumps provide better irrigation facilities to farmers, generate additional electricity, and sell water to other farmers. Normally, the life of a solar pump is 25 years and pay-back period is about 4-6 years (Giri, N.C., 2020). Solar pumps also have some problems like technical know-how, high cost of installation, working only during day time etc. (Short, T. D., 2002).

METHODOLOGY

The study is based on secondary data collected from various studies in India over the last two decades. Solar energy based irrigation system is effective and cheap in irrigation in India. The reviewed studies are conducted across India, involving different crops and different irrigation methods. We selected around fifteen studies from across India that fit our criteria to review crop productivity and farmers' income through solar energy based irrigation systems.

EFFECT OF SOLAR PUMP ON CROP PRODUCTIVITY

As all the studies show that solar powered irrigation pumps are successful in increasing the productivity of crops. Actually, there are two main reasons for installing solar pumps for irrigation; firstly, all the crops need to be irrigated at the right time, due to

which the crop yield is reduced. Crop yield can easily increase by 10% if the required amount of water is available when required (Shakti foundation 2014). Second, the solar pump increases cropping intensity to produce crops more than once in a year (IRENA 2016). Almost all the studies argue that there is a significant increase in productivity by using solar pump. Almost all studies show that there is a significant increase in productivity by using solar pumps. Impact of solar pump has been concluded in Table: 1.

Table: 1, Effect of Solar Pump on Crop Productivity

Authors, Products, and Places	Findings
Gupta, E. (2019). "*The impact of solar water pumps on energy-water-food nexus: Evidence from Rajasthan, India"*	In Jaipur, the gross cropped area (GCA) under fruits and vegetables increased by an average of 1 acre or 33%; Sikar saw an average increase of 0.5 acres or 45% in GCA under fruits and vegetables; And in Bikaner, the GCA under fruits and vegetables increased by an average of 1.6 acres or 64% for solar pump adopters.
Kishore et al. (2014) "Solar irrigation pumps"	The study reported that crop productivity increased by 5-10% in the area irrigated by solar pumps.
MNRE (2018)	The crop yield and income of the farmers has also increased. A farmer, who has one acre of land, says that earlier he paid Rs 6,000 for water in a season, now he pays Rs 2,000 and the yield has doubled due to the increase in flow. He gets sometimes two, sometimes three crops in a season.
Shakti foundation (2014) "Feasibility analysis for solar agricultural water pumps in India"	Benefit of 10% improvement in crop yield (INR 20,000 for 2.2kW pump and INR 30,000 for 3kW pump)
Shirsath, P. B., et. Al, (2020). Compendium on solar powered irrigation systems in India.	The productivity of vegetables per acre increased from 4.85 MT to 8.45 MT after solar powered irrigation pump.

Solar pump increases the production and productivity of all crops in all term viz, crop productivity, land productivity (Shakti foundation, 2014). Productivity is higher in case of solar pump than the other (Gupta, E. 2019). Kishore et al. (2014) and Shakti foundation (2014) reported that crop productivity increased by 5-10% in the area irrigated by solar pumps. The production has doubled due to the increase in flow of water and produced two or more time crops in a season (MNRE 2018). The production and productivity of fruits and vegetables also increased almost doubled per acre from 4.85 MT to 8.45 MT after installation of solar pump (Shirsath, P. B., et. al. 2020).

EFFECTS OF SOLAR PUMP ON FARMERS' INCOME

The income of farmers has also increased through solar pumps. There are many reasons for increasing the income of farmers from solar pumps. First, it increased the production and productivity of all crops by providing timely irrigation to the crops (Shakti foundation, 2014). Second, the water sold for irrigation to other farmers. Third, the surplus electricity sold to DISCOM and Government (Shah et al. 2016). Fourth, the income generating in the form of saving of irrigation fuel cost (Shakti foundation 2018). Impact of solar pump on farmers' income has been concluded in Table: 2.

Table: 2, Effects of Solar Pump on farmers' income

Authors, Products, and Places	Findings
GGGI (2014) "Solar-Powered Irrigation Pumps in India — Capital Subsidy Policies and the Water-Energy Efficiency Nexus"	In a case, solar water pump of 8 kW on its peak allowed a farmer to sell surplus electricity for ₹5/unit, earning the farmer additionally US$112 (₹7,500) over four months in 2015.
Gupta, E. (2019). "The impact of solar water pumps on energy-water-food nexus: Evidence from Rajasthan, India"	In Jaipur the farmer's income increased by Rs. 8,000 or 23%; In Bikaner farmer's income increased by Rs. 157,000 or 83% annually of adopters of solar pump.
Patil, M. (2017) "Solar irrigation: India's farmers can sell electricity and save groundwater"	The pump owners will use 40,000 kWh/year for irrigation, and sell the remaining 45,000 kWh/year to the grid out of the total 85,000

	kWh/year solar energy generates by six solar pumps of a total capacity of 56.4 kWp, earning Rs 3,00,000/year in Dec 2016.
Raymond, Anne and Abhishek Jain.(2018) "Solar for Irrigation A Comparative Assessment of Deployment Strategies"	Connecting the solar pump to the grid can generate some extra income for the solar pump owners. However, they would prefer to sell water using the surplus energy if there is local demand. For this type of pumping service a farmer can earn revenue as low as Rs 20 per kWh, which is much higher than the viable feed-in tariff. However, not all surplus energy can be used to sell water locally, as demand is also seasonal and intermittent.
SEWA (2015) "Worth their salt: Draft case study for clean energy access in the salt marshes of gujarat"	Solar pumps significantly reduce production costs for saltpan framers in Gujarat and have resulted in a 161% increase in solar pump farmer profits compared to farmers using diesel pumps.
Shah, T., Verma, S. and Durga, N. (2014) "Karnataka's smart, new solar policy for irrigation"	Grid-connected solar systems of up to 8 kilowatts per hour were allowed to export excess power to the grid at Rs 5 per unit (USD 0.078). In June 2015, the farmer received INR 7 500 (USD 118) as compensation for the electricity he fed into the grid over a period of four months.
Shah, T. et al. (2016) "Sustainable agriculture: A new Anand cooperative model – this time, in solar farming."	A similar buy-back scheme in Gujarat could generate an additional income of US$900 (Rs 60,000) for a farmer with one hectare of 7.5 kW solar pump from selling surplus electricity to the grid.
Shakti foundation (2014) "Feasibility analysis for solar agricultural water pumps in India"	Benefit of 10% improvement in crop yield (Income increased INR 20,000 for 2.2kW pump and INR 30,000 for kW pump)
Shakti foundation (2018) "Impact assessment of the National Solar Pumps Programme Through a survey based approach Evolving Broad Policy Recommendations"	In Bihar and Uttar Pradesh, where most SWP pump owners use over diesel pumps, solar pumps displaced ~1 hour per day (from 7.8 hours to 6.87 hours in Bihar and 7.7 to 6.4 hours in Uttar Pradesh). , and use of diesel pump ~1 day in a month. This has resulted in significant annual savings of ~INR 13,500 for the average farmer, which is almost three-four times the average monthly income of farmers in these states. It should be noted that over the same period, the control group of diesel users in these states maintained or increased their diesel pump use.
Shirsath, P. B., et. Al, (2020). "Compendium on solar powered irrigation systems in India"	The biggest achievement after adopting solar pumps is that the income of the farmers has increased. The income often ranges from 35,000 to 40,000 and some farmers can now earn an average expected income of up to Rs. 80,000 annually.
Srinivasarao, M., Ramasudha, K., & Bhanu, C. V. K. (2020). "Quantifying environmental and economic benefits of grid-connected solar water pumps for irrigation in India"	The average additional energy generated is 22.8 kWh per day which increases the revenue to the farmer by 193% compared to 7 hours of operation for the 5kWp system and the pay-back period is 3.5 years.
Suman, S. (2018) "Evaluation and Impact Assessment of the Solar Irrigation Pumps Program in Andhra Pradesh and Chhattisgarh"	Additional income to the farmer • As a result of having solar irrigation pumps, the number of farmers earning more than Rs 100,000 per year has more than doubled. • On average, 45% of farmers saw their annual income increase by 50% or more and 70% of farmers started earning an additional 25%. In the interview sample, 52 farmers were earning above Rs. 100,000 per year before pump installation. The income of 116 farmers is Rs. 100,000 per year after the solar pump is operational.

All the studies show that solar pump have increased farmers' income (Shakti foundation, 2014, Shah et al., 2016, GGGI, 2017, Suman, S. 2018, Gupta, E., 2019). The solar pump increased production and productivity compared to other sources of irrigation; as a result, the farmers' income increased up to double or more (Shakti foundation, 2014, Shirsath, P. B. et. Al, 2020). The farmers' also getting additional income from average additional energy generated is 22.8 kWh per day which increases the revenue to the farmer by 193% compared to 7 hours of operation for the 5kWp system (Srinivasarao, M. et. Al, 2020). In a case, solar water pump of 8 kW on its peak allowed a farmer to sell surplus electricity for ₹5/unit, earning the farmer additionally US$112 (₹7,500) over four months in 2015(GGGI, 2017). However, they would

prefer to sell water using the surplus energy if there is local demand. For this type of pumping service a farmer can earn revenue as low as Rs 20 per kWh, which is much higher than the viable feed-in tariff (Raymond, A. and Jain, A., 2018). The Solar pumps significantly reduce production costs for framers and have resulted in a 161% increase in solar pump farmer profits compared to farmers using diesel pumps (SEWA, 2015). Thus, all the above studies argued that solar pump is increased the farmers' income.

CONCLUSION

To conclude up, all the studies have the similar arguments that the solar pump has increased the crop production, productivity, irrigated area, crop intensity and farmers' income. Solar pump provides convenience to the farmers to irrigate the crops on time. This allows farmers to grow crops more than once in a year. Solar pump is also successful for irrigation of crops in dry areas. There are also some constraints in the adoption of solar pump such as high initial cost, lack of awareness among the farmers etc. Therefore, it is very helpful to increase the farmers' income and the productivity.

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