Impact Report

2021

Impact of solar pump on small and marginal farmers

SWITCH ON FOUNDATION
Building Sustainable Enterprises and Ecosystems

10 YEARS OF IMPACT AND INNOVATION

EXECUTIVE SUMMARY

SwitchON Foundation started promoting a slew of solar products in 2015 and it was seen that solar pumps are a marketable technology and can **bring huge profits for farmers**. This report is an attempt to dig deeper and understand the nuances of solar irrigation and its benefit from 25 farmers of West Bengal. The major findings are based on **economic, social** and **environmental benefits** and are described below.

Economic

Impact of Solar Pump

- The highest percentage rise in annual income is witnessed among farmers who practiced **rain fed agriculture (100% or more),** followed by **diesel pump users (65%),** those who **purchased water (55%),** and lastly those who used **electric cum diesel pumps (45%).**
- There are four streams of income through which farmers can increase their income post solar: **increase in productivity, crop intensity and diversification, aquaculture and water selling.**

Social

Impact of Solar Pump

- Farmers reported that after solar. they could save time on water management, have **access to nutritious foods and also buy new assets.**
- After shifting to solar, farmers were **relieved from anxiousness** due to rising fuel prices and their faith and pride in agriculture was restored.

Environmental

Impact of Solar Pump

- Replacing **1 5HP diesel or electric pump** for 1 year is **equal to replacing 1 car** from the road for one year.
- SwitchON encourages the farmer to **use water efficient technologies and practices** to address the energy, water and agriculture nexus.

CONTENT

SETTING THE CONTEXT

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According to Agricultural Survey (2010-11), 60%-70% share of agricultural area in West Bengal is irrigated, but there is a high reliance on diesel based irrigation which they find difficult to afford. 96% (Egiye Bangla) of farmers in Bengal are small and marginal and **many farmers have to forgo the entire summer crop due to lack of an affordable and reliable source of water.** Under such challenges, solar water pumps are capable of providing economical and reliable irrigation, and were introduced to address the irrigation woes of the farmers.

SwitchON Foundation began **facilitating financing for solar pumps among small and marginal farmers in Bengal in 2019** by operationalizing a **guarantee fund** partnering with public and private banks. The initiative was implemented through the **Solar Waterpreneur Model** to enable a conducive financing ecosystem for the promotion of green energy among small and marginal farmers. SwitchON also encouraged the Solar Waterpreneur's to create a water user group (WUG) and sell water to neighboring farmers. The additional revenue stream helped to improve the financial viability of operating the solar driven pump. To enable widespread adoption of solar based irrigation among small and marginal farmers, this report tries to investigate the social, economic impact as well as the environmental impact after the installation of solar pumps.

OBJECTIVES OF THE STUDY

A comparative study was undertaken to understand the changes in farm-based livelihoods by assessing the livelihoods and environmental impacts of solar pump adoption **among 25 beneficiaries of the project**. The larger objective of this report is **to broaden the understanding and analyze the overall impacts of solar water pumps on small and marginal farmers. The study has involved an in-depth assessment of the socio-economic changes of the beneficiary group in few intervention villages after the installation of solar pumps**. The broad objectives of the study have been broken down as follows –

1

To assess the economic impact of solar pumps on the farmers.

Solar water pumps promise enormous income to farmers through increase in income generated through an increased agricultural productivity[1]. The key assumption made here is that there is improved agricultural productivity from using solar powered irrigation and the weather patterns did not vary from baseline scenarios. All the solar pumps in the sample study was bought by the farmers without any subsidy.

2

To understand the environmental impacts after the installation of solar pumps

There is ample research evidence to prove that solar water pumps have created significant savings in carbon emission. In this study we have calculated the abatement of carbon emissions from replacing diesel and electric pumps as well as few climate-resilient practices promoted along with solar pumps.

3

To understand the social impact of solar pumps on the quality of lives of farmers.

Research evidence shows that DRE installations[2] could be linked to significant social impact in areas of education, women empowerment, healthcare, safety, and increase in quality of life, among others. The beneficiary assessment carried out through in-depth interviews included understanding any significant changes in the quality of lives of the farmers after adoption of solar pumps.

METHODOLOGY

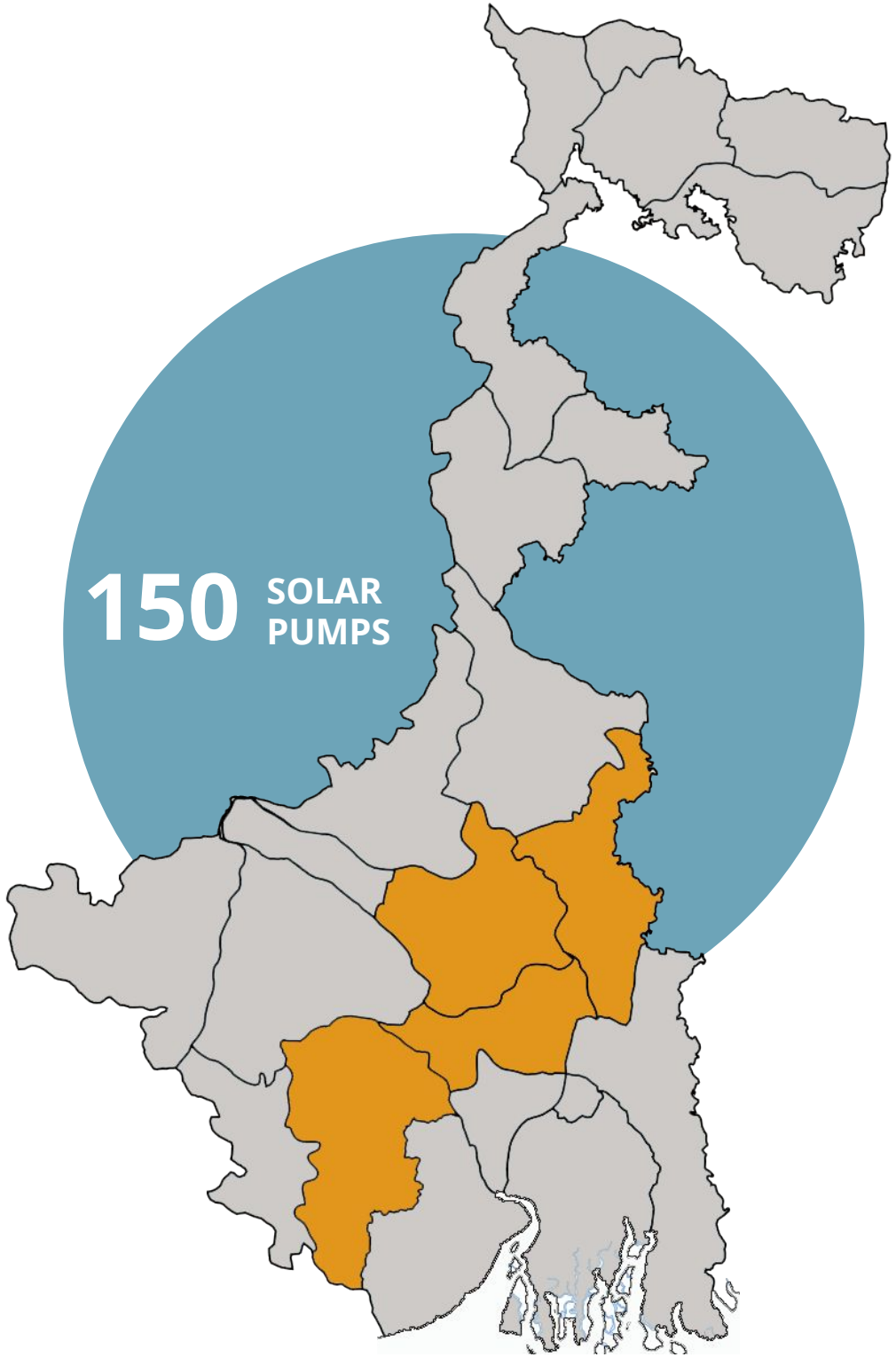
STUDY AREA

The entire study was situated in West Bengal, in 4 districts, namely **Purba Barddhaman, Nadia, Paschim Medinipur and Hooghly distributed across 11 blocks**.

Till 2021, **SwitchON has facilitated the financing of 150 solar pumps in the fields of small and marginal farmers across West Bengal.** However, for an in-depth assessment, a statistically representative sample of 25 farmers have been selected out of 150 solar pump holders.

Area of Impact

- **Purba Barddhaman**
- **Paschim Medinipur**
- **Nadia**
- **Hooghly**



SAMPLING FRAME

A sampling frame of **25 farmers** were identified using **purposive sampling** with the objective to obtain maximum heterogeneity in responses. **The condition on which the sample of respondents was constructed was that all the 25 farmers had installed a solar pump at least one year back.** This helped us to represent the change in income through all the 3 cropping seasons - Summer, Monsoon and Winter. In our sample of 25 farmers, **13 of them used diesel pumps, 8 farmers irrigated through electric cum diesel pumps, 1 practiced rain fed agriculture and 3 farmers used to purchase water before transitioning into solar**. The solar pumps provided to the farmers ranged from 3 HP to 5HP. We employed an in-depth approach in the collection of data, each nuances were understood and noted down. A semi-structured questionnaire and farmers were probed further to understand the realities on ground.

While we attempted to collect good quality data, we acknowledge that the estimates provided by the farmers of annual expense and income could be influenced by their bias. Although the absolute values reported might not be equal to the actual values, the relative trends for income and expenditure are fairly consistent.

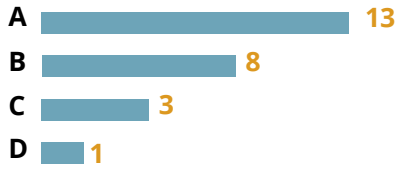
25

Farmers

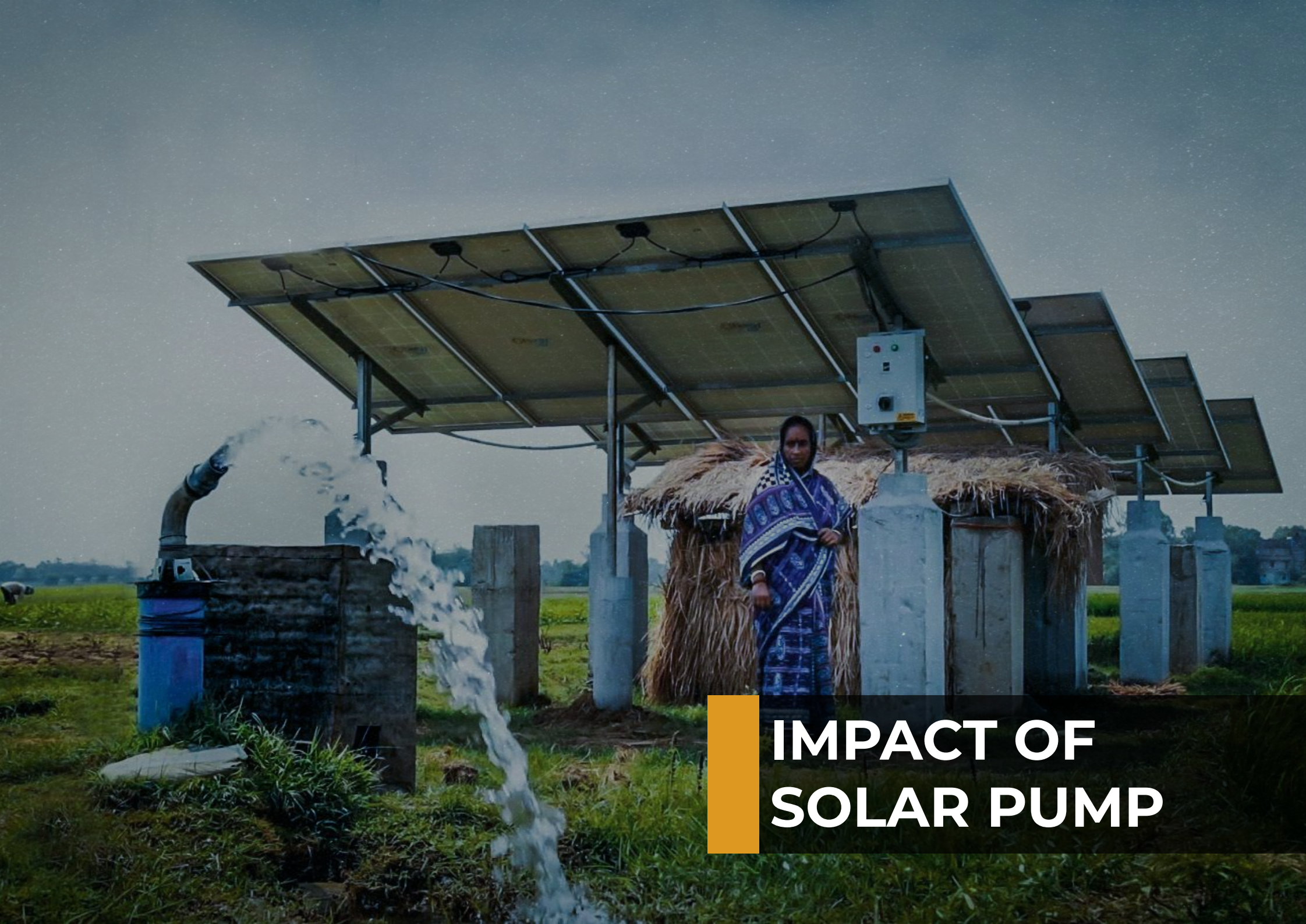
Purposive Sampling

A form of non-probability sampling in which researchers rely on their own judgment when choosing members of the population to participate in their surveys

Before Transitioning into SOLAR



A - used diesel pumps
B - electric cum diesel pumps
C - used to purchase water
D - rain fed agriculture



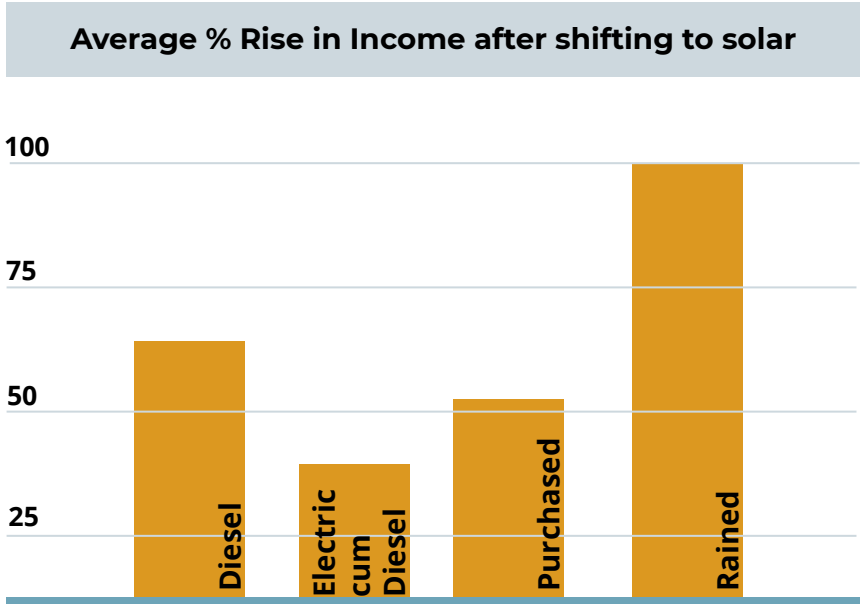
IMPACT OF SOLAR PUMP

ECONOMIC IMPACT OF SOLAR PUMP

It is well-established that solar pumps can have a positive impact on farmers pockets; in this regard the Indian government aims to push solar pumps in the market. In this section, we dig deeper to understand the economic impact and the reason behind the increase in farmer's income. Before the solar pump, farmers from our sample study primarily got irrigation water from either of the four sources - diesel, electric, rainfed irrigation and water market. In the following, we have written down the energy cost from various sources of irrigation:

Sources of IRRIGATION	Average ANNUAL ENERGY COSTS (INR)
Diesel Pump	45,000
Electric cum Diesel Pump	25,000
Purchased Water	50,000
Rain fed	0

Our sample shows that purchasing water is one of the most expensive ways of procuring water for irrigation. It also means that these farmers did not own any pump previously, and had the ability to easily pay off their solar pump loans from saving the water cost. Although rain fed farmers had zero energy cost earlier they had to forgo 2 season's cropping. Moreover, irrigated land has better yield than rain fed. Farmers who used electric pumps had to pay INR 25000, but they often resorted to diesel pumps when electricity was unavailable.



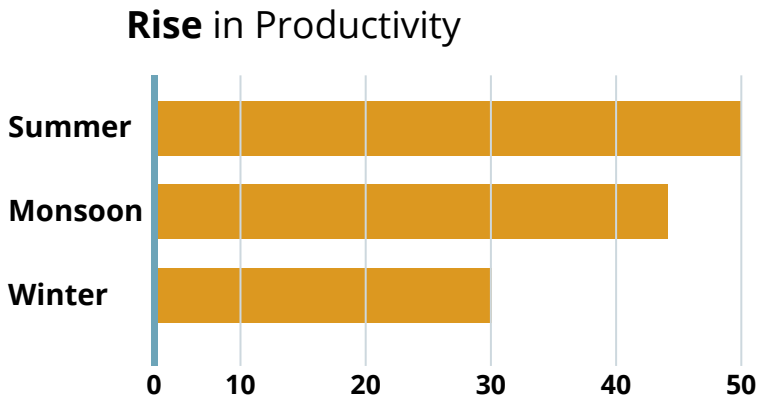
The above graph shows that the average percentage rise in income among diesel farmers is 65%, 45% among electric cum diesel pump users and 55% among those who purchased water. The highest rise **(100%)** is seen among **rain fed farmers because their income drastically improves as they can crop twice or thrice a year compared to once previously.** The second highest percentage rise in income is seen among diesel farmers as they get to save a significant amount of money from the fuel cost.

STREAMS OF INCOME

Project interventions studied over a period of time show that there are **four major streams of income** which farmers can tap into with solar based pumping. Not all farmers tapped into the four streams but nonetheless, there was a rise in income even if they tapped into one of those streams, which itself proves that solar based pumps are profitable. We understand the different streams of income through which the 25 farmers from our sample study helped increase their income quotient. The four streams of income are: increase in productivity, cropping intensity and diversity, water selling and adopting aquaculture.

Increase in Productivity:

Adequacy and reliability of irrigation water significantly influence crop productivity [3,4]. Considering the baseline was as normal[5] as of the current year, 18 out of the 25 farmers from our sample reported an increase in the per crop productivity. Irrigation via diesel or grid-electricity powered pumps faces both the challenge of fuel inadequacy and unreliability. The farmers reported that the high cost of diesel forces them to under-irrigate their farms in a bid to reduce costs, thereby affecting crop yields. But with solar pumps, they completely irrigated their land and their crop production increased. It is important to note here that farmers could tell about their production change only if they get it measured. In some case of subsistence farming, the total production is not measured. Out of the 7 farmers, who reported no rise in production said that they are not aware of the rise in production, if any.



Average **Rise in Productivity** (%)

The above graph shows that the highest % rise in production is seen during summer season (50%), this is because most of the farmers could not irrigate their entire tract of land due to unavailability of water during summer. Although the sample farmers practiced rainfed irrigation during monsoon season and did not face water crisis before solar, the productivity significantly improved when they irrigated using solar pumps. The production rise during the winter season is comparatively less than other seasons (30%).

Cropping Intensity & Diversification

Another major reason behind the rise in income among the farmers is their ability to diversify their crops, using solar pumps**. In case of rain fed farmers [6], they used to grow one crop (paddy), during Monsoon season. The introduction of solar pumps helped to grow another crop in summer season.** This led to an increase in income, having also found the market linkages to sell their produce.

The maximum number (10 farmers) of crop diversification is noticed during Winter season as it is a suitable time to grow various seasonal fruits and vegetables. During the summer season, 4 farmers have seen crop diversification and 2 of them left their lands vacant due to heat and lack of water. During Monsoon, there has been no crop diversification seen among the farmers because most of them grew paddy which they could previously even with rainwater. But it is important to note that erratic rainfall often affected their crops previously, but with solar pump, even if the monsoon is late, they can irrigate their land successfully.

Summer

Paddy, Brinjal, Pointed Gourd.

4

Winter

Wheat, Flower, Pointed Gourd, Sweet Lime, Brinjal.

10

"Before solar, we used to plant crops like brinjal, ridge gourd but they could not survive due to unavailability of sufficient water. Now with solar, we have started cultivating these crops and my income has doubled."

Ganesh Biswas
Panduah

Farmers in the sample study who subscribed to horticulture and began growing vegetables - brinjal, cabbage, cauliflower, ridge gourd, flowers and high value fruits such as strawberry and guava. These are farmers who had prior experience with horticulture and were now able to grow their produce with a reliable electricity source to pump water.

Crop diversification does not only depend upon availability of reliable sources of irrigation alone. It also depends upon the farmer's ability to adapt and shift to new crops which would give better returns.

Water Selling

In West Bengal, informal water markets are prevalent and the prices are standardized to a large extent. Water selling is a lucrative business and it can improve equity by expanding the scope of groundwater access among those who do not own a pump. Even before solar pumps, water was sold by electric or diesel pump owners. But over the years, high electricity tariffs and high fuel prices have dampened the water market. With the introduction of solar pumps, the water market has revived in a few pockets of West Bengal.

In our study sample, the farmers sold water typically for paddy in 2 seasons and potato during winter. Land in West Bengal is measured in units of 'bigha' which equals to 0.33 acres and one season approximates for 3-4 months. The water prices are described below:

Table: *Water Prices charged by Solar Waterpreneurs among our sample farmers*

₹ 3600 - 4500	₹ 2400 - 3000	₹ 3000 - 3600
Summer	**Monsoon**	**Winter**
PRICE (acre/season)		

In our sample study, 17 out of 25 farmers sold water after shifting to solar.
Out of those 17 farmers, 12 started selling water for the 1st time.

The average income from water selling was INR 25000 annually of a diesel pump owner, but post installation of solar pumps it increased to INR 35000 among the farmers in our study. **This shows that there is almost 40% average rise in income from water selling after shifting to solar pumps. But in some cases, the water market is also dependent on demand forces.**

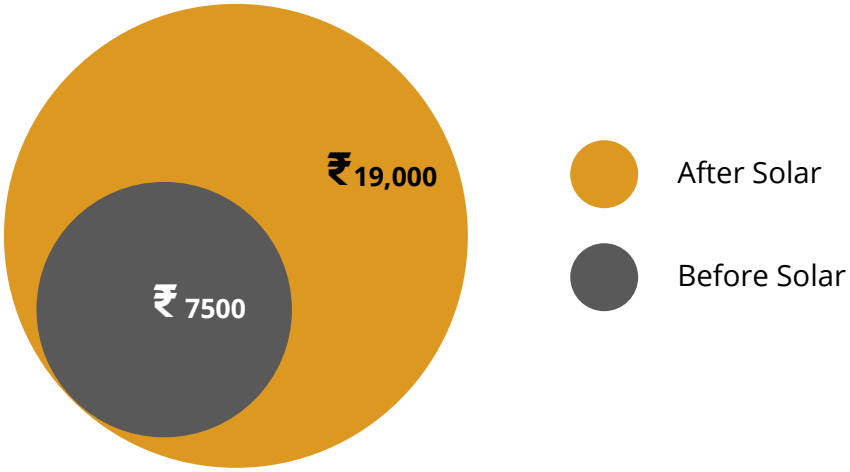
The demand from nearby farmers might reduce if the neighbour owns an electric/solar pump. But this case is rare because getting electricity connection is often hard to find and 2 solar pumps are not encouraged in the same area. Instead a Water User Group is encouraged to form so that the farmers can mutually benefit and pay their quarterly EMIs.

Adopting Aquaculture

Agriculture remains the mainstay of the people in rural Bengal but many farmers practice fishing in their small ponds during Monsoon season when adequate rainfall helps in the breeding of fish. **The average size of a pond among such farmers is 0.33 acres.**.

Previously, farmers used their ponds for subsistence fishing and practiced aquaculture only during monsoons. With the introduction of solar pumps, the farmers are able to engage in aquaculture throughout the year and earn a reliable income from it.

Average Income from **Aquaculture**



In our sample, 4 farmers practiced aquaculture of which **two of them started commercial fishing after shifting to solar**.

2.5x ↑

SOCIAL IMPACT OF SOLAR PUMP

Solar powered pumps have the potential to lift rural families from subsistence agriculture and poverty, which has been exacerbated by climate induced water shortage. Solar irrigation brings immense benefits including better nutrition, higher incomes and greater climate resilience [7]. From our research study, we have identified the following key social impact on the life of 25 farmers.

> *"Previously, we used to plant paddy seeds during monsoon season, hoping for a fruitful harvest. But due to the late arrival of monsoons, we have lost a lot of money and suffered loss. With solar, we can irrigate our crops even with the late arrival or erratic rainfall."*

Nigam Chaitanya
Memari, Hooghly

Faith and Pride in Agriculture:

Ramesh Biswas of Nadia said "I almost gave up farming due to high diesel cost and low returns from agriculture. But after shifting to solar, my faith in agriculture has regained. I can grow crops all throughout the year, sell water and even practice aquaculture." Farmers constitute an important share in India's GDP, but with high irrigation prices, most of them face huge losses throughout the year. Through solar irrigation, most of the farmers reported that they could diversify their crops and earn maximum profit.

Increase in Assets:

10 out of 25 farmers reported that they could buy assets from a rise in income. The increase in assets were as small as repairing the house through my savings from the fuel cost to buying a new land after paying off the loans. Undoubtedly, solar has brought a change in the farmer's living standards either sooner or later.

Anxiety due to rising prices and fall in the trap of money lenders:

Solar pumps provide reliable and affordable energy, potentially reducing energy costs for irrigation. They are a promising alternative technology, where diesel is expensive or where reliable access to the electricity grid is lacking. In one of the focus group discussions held at Purba Bardhaman one of the farmers quoted that *"Before solar we used to buy water from our neighbors and we had to wait till midnight for our turn. Now with solar, we are not dependent on anyone and we can water our crop based on its requirement".* **Farmers are relieved from rising prices, they do not have to chase money lenders or fall for diesel mafias from the irrigation market.** 80% of the farmers in our sample study practiced rainfed agriculture during Monsoon season. But often due to late monsoons, they suffered from crop damages. After solar, there is no crop damage as it can be supplemented by solar irrigation.

Improved physical and emotional health from better health:

On the quality of life of the beneficiaries adopting solar pumps, all the farmers expressed that their transition from diesel or electric pumps to solar powered irrigation systems have overall impacted the time spent in operating the irrigation systems, their diet and lifestyle through improved food security and health status of the beneficiaries.

"After the installation of solar pumps, I was able to practice fishery as a result of improved access to water. With more water being available after the installation of solar pumps, I was able to build a farm pond for fishing and also include fish consumption in our diet for two times in a day"

Mihir Mondal
Shimlagar, Hooghly

Reduced hours of water management:

Access to energy in the form of solar pumps brought water to their doorsteps and saved them both time and effort.

"The time saved from operating a diesel pump has helped me relax and spend my leisure time driving an auto rickshaw. I had purchased an auto rickshaw last year and also earned some amount by transporting passengers in that."

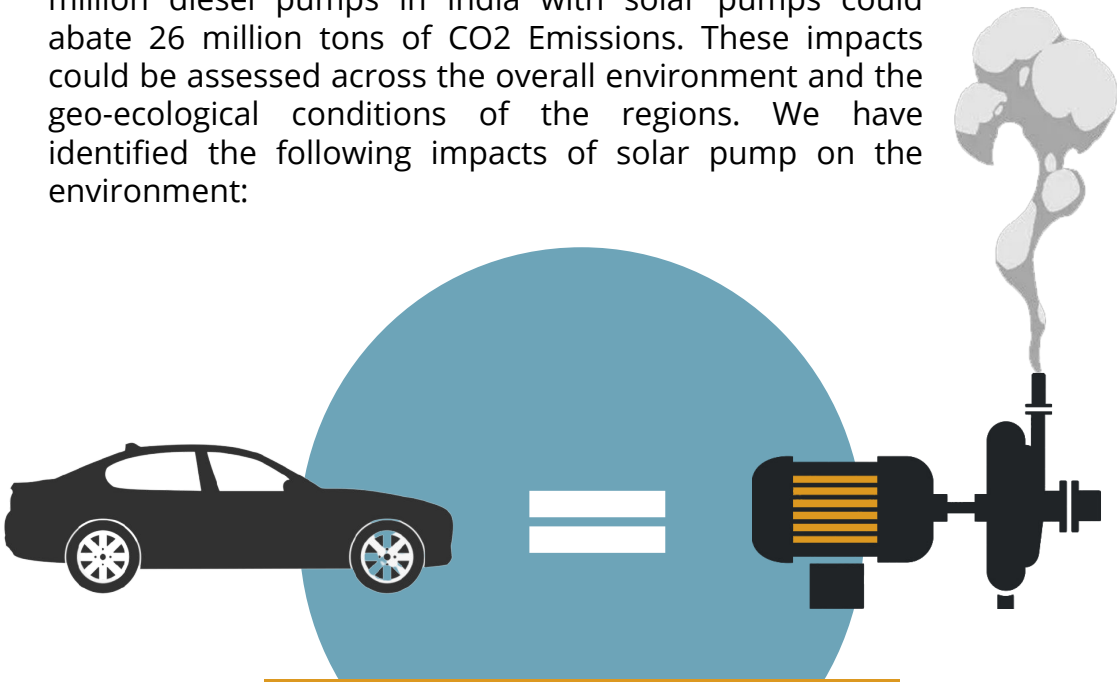
Ganesh Biswas
Champakdanga, Hooghly

"The time saved from using solar pumps for irrigation helped me in getting easy access to water for irrigation at affordable prices. The time saved from operating diesel pumps has allowed me to spend more time with my family, especially my children."

Sk. Based Ali
Ilsora, Purba Bardhhaman

ENVIRONMENTAL IMPACT OF SOLAR PUMP

Solar irrigation pumping solutions have a substantially lower environmental footprint compared to traditional options. The potential environmental advantages from solar pumping, compared to conventional methods, is impressive. In India, it is estimated that replacing five million diesel pumps in India with solar pumps could abate 26 million tons of CO2 Emissions. These impacts could be assessed across the overall environment and the geo-ecological conditions of the regions. We have identified the following impacts of solar pump on the environment:



Replacing **1 5HP Diesel or electric pump** for 1 year = **Replacing 1 car from road for 1 year**.

Abatement of Carbon Emissions:

Replacing 1 5HP diesel or electric pump for 1 year is equal to replacing 1 car from road for one year. A total of 77 tonnes of CO2 [9] per year have been abated by replacing the 8 electric and 13 diesel pumps from the sample**. This is equal to removing 16 cars for a year from road**, considering a car releases 4.6 tons of carbon dioxide per year [10]**.** Solar energy is key to achieving SDG 7 – "Ensure access to affordable, reliable, sustainable and modern energy for all" and building resilient, equitable and sustainable economies. India's pledge as per Nationally Determined Contribution (NDC) Paris Agreement on 2 October 2016 is a 33-35% reduction in CO2 emissions associated with each unit of economic output by 2030. It plans for 40% of its installed electricity capacity to be renewable by 2030.

Encouraging water conservation

Solar pumps by their very design can **check water-wastage, as they work only when the sun shines, providing peak output during peak sunlight hours. This limits the daily amount of groundwater that can be extracted.** In cases where the groundwater is very deep and falls under Black Zones [(11)], SwitchON has taken some necessary steps to prevent overexploitation. They are motivated to install micro irrigation systems which can increase yields and decrease water requirement. **SwitchON is also promoting solar pumps along with micro irrigation systems to increase the water use availability as well as efficiency**. It is quite evident that the importance of micro-irrigation to achieve sustainability in solar irrigation systems cannot be neglected. But it's a long way ahead and requires extensive demonstrations, training and awareness programs to bring Indian farming community abreast with micro-irrigation practices.

Lastly, in the context of climate change, solar pumps not only offer an opportunity for mitigating greenhouse gas emissions, but help to make farmers more resilient against the erratic rainfall patterns caused by climate change.

Promotion of solar pumps along with micro irrigation systems to increase the water use availability as well as efficiency.

RECOMMENDATIONS

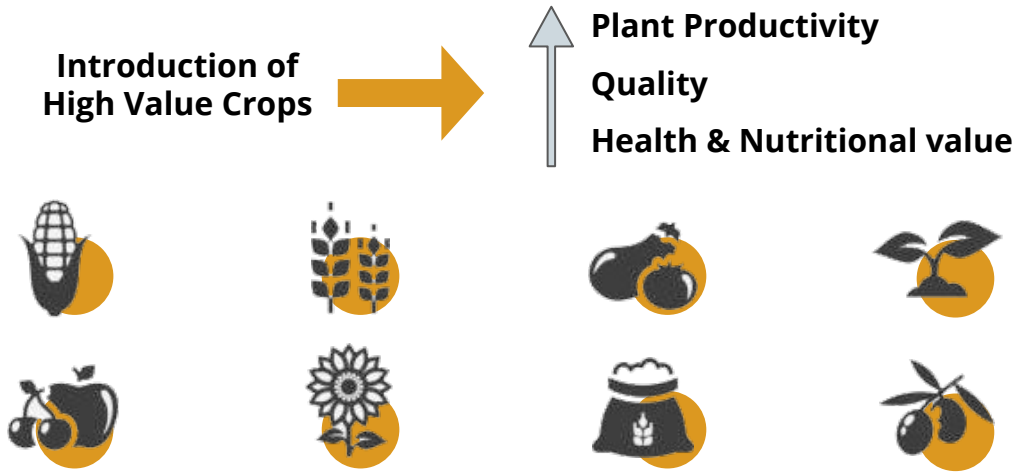
FUTURE POTENTIAL OF SOLAR PUMPS:
RECOMMENDATIONS

In a developing country whose economy is centered around agriculture, and which is rapidly transitioning into the realm of renewable energy, the future of **solar pumps** seems brighter than ever. The government's ambitious target to initiate widespread usage of solar pumps is a positive indication of the growth of the solar pump industry, which is likely to flourish in the coming years and aid in accelerating the sustainable development of our country. But it is important to adequately address the issues of groundwater overexploitation while giving cheaper and more reliable sources of irrigation. Therefore, there is a need to have effective monitoring, policy and agreements, enforcements through regulations to prevent over-extraction of precious water resources, while maintaining equity in access to renewable energy driven irrigation systems. In this section, we discuss a set of recommendations whose uptake would ensure a sustainable scale up of solar powered irrigation systems.

In a developing country whose economy is **centered around agriculture**, and which is **rapidly transitioning into the realm of renewable energy**, the future of solar pumps seems brighter than ever.

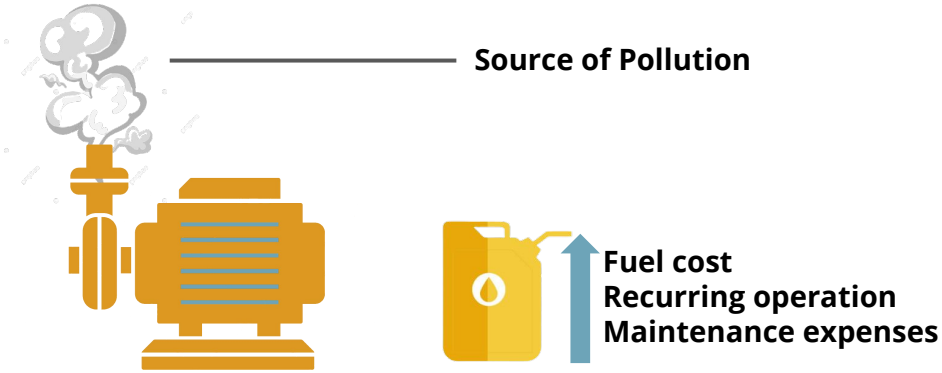
Encourage crop diversification:

From the study it is evident that crop diversification has helped in increasing the farmer's income significantly. The farmers who cultivated single crop or same crop were likely to benefit less compared to those who went for crop diversification. Moreover, **the introduction of new and improved varieties of crop can enhance plant productivity, quality, health and nutritional value** and/or build crop resilience to diseases, pest organisms and environmental stresses. Thus it is important to train farmers to make the best use of solar pumps and earn profits to pay back the loan EMIs.



Focus on Diesel Pump and Rainfed Farmers:

As evidenced by the study, diesel and rainfed farmers are likely to benefit more from solar pumps than electric pump users. The Government Program should focus on replacing off-grid pumps than grid connected pumps as the diesel pump users are overburdened with rising fuel cost and recurring operation and maintenance expenses.



Water Selling:

Water Selling is a lucrative business for farmers and helps them earn significant income out of it. So wherever possible, farmers should be encouraged to sell water by forming a Water User Group, instead of installing a new pump in the neighbourhood. This will help them earn income as well as provide access to irrigation among those farmers who do not have the economic capacity to afford irrigation pumps.

Energy-Water-Agriculture Nexus:

Farmers should be encouraged to grow low water-intensive and high value crops to earn profit and adopt micro-irrigation practices. Given the cross-sectoral nature of intervention, solar pumping systems should be promoted keeping in mind the water, energy and agriculture nexus to enable the mitigation of potential trade-offs.

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1. Eshita Gupta, The impact of solar water pumps on energy-water-food nexus: Evidence from Rajasthan, India, Energy Policy, Volume 129, 2019, Pages 598-609, ISSN 0301-421

2. Shakti Sustainable Energy Foundation (2017). Impact Assessment and Reporting for Decentralized Renewable Energy (DRE).

3. Crop productivity of the farmers are measured only when they go and sell the produce in the market. So in cases where farmers went for subsistence farming, their crop productivity could not be measured and they were unable to say whether there was a rise in productivity or not.

4. Tahir, Z., & Habib, Z. (2000). Land and Water Productivity: Trends across Punjab Canal Commands

5. Normal here refers to the fact that there was no abnormalities like drought, flood or late monsoons, which usually impact agricultural productivity.

6. In this case, we are referring to Alpana Pal from Purba Barddhaman. She is the only rainfed farmer from our sample.

7. Agrilinks (2020). Solar Powered Irrigation Could Boost Climate-Resilience for Millions.

8. Agrawal, S., A. Jain A. 2018. "Sustainable deployment of solar irrigation pumps: Key determinants and strategies." *WIREs Energy Environ,* e325. https://doi.org/10.1002/wene.325.

9. The emissions are calculated by assuming that a 5 HP diesel pump running for 1200 hours a year releases 4.5 tonnes of CO2 and a 5 HP electric pump running for 1200 hours a year releases 4.07 tonnes of CO2. The calculation has been derived from multiple sources:
Simmons, T.CO2 Emissions from Stationary combustion of fossil fuels. Lik:
https://www.ipcc-nggip.iges.or.jp/public/gp/bgp/2_1_CO2_Stationary_Combustion.pdf
Heat Values of various fuels. Link: https://world-nuclear.org/information-library/facts-and-figures/heat-values-of-various-fuels.aspx
U.S. Information Administration. Link: https://www.eia.gov/tools/faqs/faq.php?id=667&t=6

10. A typical passenger vehicle emits about 4.6 metric tons of carbon dioxide per year. Source:
https://www.epa.gov/greenvehicles/greenhouse-gas-emissions-typical-passenger-vehicle#:~:text=typical%20passenger%20vehicle%3F

11. A zone of aquifer is termed as a Grey Zone or a Dark Zone by the Centre Ground Water Board (CGWB)if the pumping out of underground water exceeds 100%. The installation of solar pumps in these regions requires an approval from the State Water Investigation Department (SWID) for a sustainable planning and implementation of groundwater extraction and sustainable agricultural practices using less water intensive crops and surface as well as groundwater recharge programmes.


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