International Copper Association India
Copper Alliance

IIEC
International Institute for Energy Conservation

Evaluation and Impact Assessment of Solar Irrigation Pumps

A deep dive in Haryana & Chhattisgarh

June 2022

Supported by:

Alliance for Solarised Irrigation

Disclaimer

Table of Figures:

FIGURE 1: PM-KUSUM SCHEME ... 8
FIGURE 2: AGRICULTURE PUMP SETS IN INDIA ... 11
FIGURE 3: NUMBER OF SOLAR PUMPS INSTALLED DURING LAST 10-YEARS ... 12
FIGURE 4: FORECAST UNTIL 2030 FOR INSTALLATION OF SOLAR PUMPS ... 13
FIGURE 5: IDENTIFICATION OF TARGET REGION ... 15
FIGURE 6: SELECTED DISTRICTS ... 16
FIGURE 7: AGRO-CLIMATIC ZONES OF HARYANA ... 16
FIGURE 8: DISTRICT WISE NUMBER OF SOLAR WATER PUMPS IN HARYANA ... 18
FIGURE 9: SELECTED DISTRICTS ... 19
FIGURE 10: AGRO-CLIMATIC ZONES OF CHHATTISGARH ... 19
FIGURE 11: NUMBER OF SOLAR WATER PUMPS INSTALLED UNDER SSY ... 20
FIGURE 12: ECOSYSTEM AND STAKEHOLDERS FOR SOLAR PUMP SCHEME ... 23
FIGURE 13: COST LIFE CYCLE COST COMPARISON OF DIESEL AND SOLAR PUMPS ... 24
FIGURE 14: FARMER’S COMMENTS ... 25
FIGURE 15: STAKEHOLDER CONSULTATION OF BOTH THE STATES ... 32

Table of Tables:

TABLE 1: STATE-WISE AND COMPONENT-WISE IMPLEMENTATION OF PM KUSUM SCHEME TILL 2020-21 ... 9
TABLE 2: PROJECTED TRENDS OF SOLAR PUMP INSTALLATION TILL 2030 ... 12
TABLE 3: CLASSIFICATION OF FARMERS ... 16
TABLE 4: SOIL AND CROPPING PATTERN OF HARYANA ... 17
TABLE 5: SELECTION CRITERIA AND SELECTED DISTRICTS ... 18
TABLE 6: PUMP COST TO BE PAID BY THE FARMERS UNDER SSY ... 20
TABLE 7: SOIL AND CROPPING PATTERN OF CHHATTISGARH ... 20
TABLE 8: SELECTION CRITERIA AND SELECTED DISTRICTS ... 21
TABLE 9: COMPARATIVE ANALYSIS OF LEVEL OF SUBSIDIZATION ... 22
TABLE 10: CROP WISE IRRIGATION REQUIREMENTS ... 25
TABLE 11: MAPPING OF RECOMMENDATIONS ... 29
TABLE 12: LIST OF PARTICIPANTS OF STAKEHOLDER CONSULTATIONS ... 33

Table of Contents:

1 EXECUTIVE SUMMARY 5
1.1 IMPACT ASSESSMENT STUDY IN TWO STATES 5
1.2 KEY FINDINGS 5
1.3 CONCERNS OF FARMERS 6
1.4 FUTURE OUTLOOK AND WAY FORWARD 7
2 BACKGROUND 8
3 SOLAR PUMP SCHEMES IN INDIA AND STATUS OF INSTALLATION 9
3.1 SCHEMES PROMOTING SOLAR PUMPS IN THE COUNTRY 9
3.2 CURRENT STATUS OF INSTALLED SOLAR PUMPS 11
3.3 PROJECTED TRENDS OF SOLAR PUMP INSTALLATION UNTIL 2030 12
4 GAPS AND SCOPE FOR IMPROVEMENT 14
5 IMPACT ASSESSMENT IN TWO STATES 15
5.1 SELECTED STATES 16
5.1.1 Haryana 16
5.1.2 Chhattisgarh 19
6 KEY OUTCOMES 23
6.1 KEY FINDINGS 23
6.2 CONCERNS OF FARMERS 26
7 RECOMMENDATIONS 27
7.1 TECHNICAL RECOMMENDATIONS 27
7.2 Financial RECOMMENDATIONS 27
7.3 POLICY RECOMMENDATIONS 28
8 FUTURE OUTLOOK AND WAY FORWARD 30
8.1 THE ALLIANCE FOR SOLARIZED IRRIGATION (ASI) 30
8.2 OBJECTIVES OF THE ALLIANCE 30
9 ANNEXURES 32
9.1 STAKEHOLDER CONSULTATION 32
9.2 MAPPING OF VARIOUS SOLAR PUMP SCHEMES IN INDIA 34

1 EXECUTIVE SUMMARY

The solar pumping segment in India has seen significant growth in recent years which is primarily driven by both Central and State Government subsidies, ranging from 30 to 95%. The initial thrust emerged from the target of 1 million pumps (by 2020-21) set by the Central Government in 2014-15. Agricultural electricity consumption has increased from 81,673 GWh in 2001-02 to 228,172 GWh in 2019-20. Ministry of New and Renewable Energy (MNRE) has launched the Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahaabhiyan (PM-KUSUM) scheme in 2019 to provide support to 20 Lakh farmers to set up solar pumps. The scheme has three major components as illustrated in the figure. In the Budget for 2020-21, expansion of the scheme was announced, which was later approved by Government with the inclusion of feeder level solarization as a new variant under Component-C, with the expansion, the targeted solar capacity addition under the scheme has increased to 30.8 GW.

India has the world's most arable land at 17.5 lakh / sq. km. These lands are irrigated via over 30 million agriculture pump sets, out of which, 20 million pump sets are connected to the grid and around 10 million pumps are diesel pumps. The number of solar pumps installed is very negligible compared to the grid-connected ones and the diesel ones. The total number of solar pumps installed today is about 3,90,000 pumps which have been mostly deployed in the last five years.

Majorly, the solar pumps are installed by State Renewable Energy Development Agencies with capital subsidy assistance from the Ministry of New & Renewable Energy (MNRE) and the state government. Further, the solar pumps installed in India is concentrated in a few states namely Chhattisgarh, Rajasthan, Andhra Pradesh, Uttar Pradesh, Haryana, and Bihar. Figure-3 shows the number of pumps installed over the years in India.

1.1 IMPACT ASSESSMENT STUDY IN TWO STATES

For better understanding about the gaps in adoption and penetration of solar pumps in different states, an impact assessment study was conducted. The objective was to understand and document the achievements and the challenges faced by the states in attaining their targets. The solar pump market needs different business models to flourish and achieve stability. For greater penetration and uptake, a better understanding is required of the factors that are adversely affecting the current market. The impact assessment conducted in two states helped in documenting the ground reality and the challenges faced by all the stakeholders including the farmers. Haryana and Chhattisgarh were identified for the impact assessment study. Haryana was selected based on having a greater number of prosperous farmers with larger landholdings. Chhattisgarh was considered due to having greater number of small and marginal farmers.

Both the states offer subsidy for installation of solar water pumps. However, in Haryana the pumps are deployed under the PM KUSUM scheme while in Chhattisgarh it is mostly due to the state-run Saur Sujala scheme. The amount of subsidy varies depending upon the state and the program being run to promote solar water pumps.

1.2 KEY FINDINGS

- Limited awareness and knowledge: More than 85% of the farmers lacked awareness of the working procedure for the solar pumps and were only able to switch on and switch off the pump.

The farmers did not know the solutions to small maintenance problems that could be easily corrected at the farmer's end.

- Greater Cost-benefit: As there is no operational cost associated with the solar pumps and availability of subsidy, the effective overall cost is lower than the annual cost of irrigation through a diesel pump set. Further, the solar pump can be used for other allied agriculture works along with exporting the excess generated electricity to the grid which again is beneficial to the farmers.
- Unrestricted Water usage: One of the major concerns of solar pump is unrestricted use of ground water. It was observed that after the installation of the solar water pump groundwater is being used judiciously, and about 85% of the farmers switched off the pump on completion of irrigation. This is majorly because previously the farmers used electric pumps which did not have any fixed time of electric supply and the pumps were kept on throughout the day to overcome the erratic power supply system of agriculture feeders.
- Improved crop yields: Farm yields have increased, and solar irrigation enabled more than 80% farmers in Chhattisgarh and 61% farmers in Haryana to grow three crops per annum and rotate crops to grow nutritious and cash crops.
- Improved food security & income: As per the study an average 36% of farmers in Chhattisgarh and 14% in Haryana have reported increase of over 50% in their annual incomes. 82% of farmers confirmed that their earnings have increased by around 25% after the installation of solar water pumps.
- Lack of after sales service report support: 72% of the farmers have reported that they do not get after sales services easily from the service provider. 65% reported that their service provider is more than 15 km away from the solar pump installation site and the resolution of problems takes a lot of time impacting the farm yields.
- Decarbonization / Environmental Impact: In India, it is estimated that 5 million solar pumps can save 23 billion kilowatt-hours of electricity or 10 billion liters of diesel. This translates into an emissions reduction of nearly 26 million tons of CO2. Thus, in Haryana and Chhattisgarh with an installation of 22 thousand and 1.05 lakh pumps respectively the potential carbon emission reduction is in tune of 0.12 million and 0.55 million tons of CO2 respectively.

1.3 CONCERNS OF FARMERS

As per the study and the feedback of the farmers, there are factors hindering the use of solar pumps which is affecting the livelihood of the farmers. The list of pain points is highlighted below:

- Theft and Vandalism: Theft is a major issue in rural areas and about 20% of the farmers reported missing panels, wires, and components.
- Bore collapse and Pump Blockage: Many farmers complained that in the monsoon season; due to heavy rain and waterlogging soil sedimentation occurs over the pump rendering it incapable to work. Sometimes the bore collapses due to wet soil and the pump gets stuck similar to electric pumps. In case of SWP additionally the controller card is also damaged in the process requiring extra servicing and cost.
- Low water tables: 45% farmers complained that the output from the pumps reduces in summer months as the water table decreases in the region. This creates a reduced rate of flow from the pumps hindering agriculture work. Further, lesser flow or lower heads lead to clogging of pumps, damaging the machine and increasing the maintenance cost. This is generally caused due to improper survey of groundwater table at the time of installation.
- Shrub Shadow: The increase in shrubs near the solar pumps, reduces the solar panel and pump's efficiency. To avoid such incidents many farmers have installed the panels on higher platform, which again hinders panel maintenance and cleaning, creating a conundrum.

- **Knowledge disbursement:** Many farmers complained that the system integrators at the time of installation do not provide basic working instruction on the pumps to the farmers.
- **Insurance claims:** In case of damage / theft the minimum damage for claiming insurance is INR 10000. Furthermore, the minimum time for resolution of insurance claim is thirty days, which is a very long time considering the cropping cycle. In remote areas this time for resolution of claim increases exponentially.

1.4 FUTURE OUTLOOK AND WAY FORWARD

Interacting with the stakeholders, peers and delving through the major recommendation it was observed that many organizations/ entities are working in the common interest to promote the use of solar water pumps. The major goal for the promotion is the development of the agriculture sector and the sustainable growth of the WEF nexus. Thus, the requirement of the hour is to assimilate the individual efforts. To facilitate the same IIEC and ICA are forming an alliance of like-minded organizations and experts to accelerate the usage of solar irrigation pumps in India. The **'Alliance for Solarized Irrigation'** is envisaged as a coalition where organizations and individuals work together to develop increased and sustainable use of solar energy for agriculture and horticulture practices in India.

The Alliance will drive active dialogue with all stakeholders to ensure the development and implementation of standards and best practices. It will support the national and state governments in better regulatory enforcement of standards. The alliance will drive mass awareness and sensitization to create public demand for safe and sustainable agricultural and horticultural infrastructure. It will work to strengthen the knowledge pool of the food, water, and energy sectors through evidence-based policy guidance, data-driven research, and industry reports.

2 BACKGROUND

The government of India under the "Indian Agriculture Towards 2030[1]" aims to double farmers' income by increasing irrigated land by at least 20%. Agriculture is the primary source of livelihood for approximately half of the Indian population and, half of the cultivation is heavily dependent on rainfall. Erratic weather, irregular rainfall patterns, low access to irrigation for smaller farms, erratic and unstable power supply to the already electrified pump, and the ever-increasing price of fuel have prompted the farmers to adopt enhanced technologies and methods in agriculture, dairy, fisheries, and livestock to meet the diversified food needs of the people. As a result, the electricity demand for irrigation has been steadily increasing over the years driven by subsidized, and in many cases unmetered supply. Availability of subsidized, often free power which at the same time, is of poor quality and unreliable, causes farmers to over-consume energy for irrigation, which has led to an alarming depletion of groundwater levels. To deal with the twin issues of reducing agriculture subsidies and meet rising power demand for irrigation, the Government has been promoting solar irrigation pumps for the past few years.

The solar pumping segment in India has seen significant growth in recent years which is primarily driven by both Central and State Government subsidies, ranging from 30 to 95%.[2] Agricultural electricity consumption has increased from 81,673 GWh in 2001-02 to 228,172 GWh in 2019-20.[3] Ministry of New and Renewable Energy (MNRE) has launched the Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahaabhiyan (PM-KUSUM) scheme in 2019 to provide support to 20 Lakh farmers to set up solar pumps. The scheme has three major components as illustrated in the figure. In the Budget for 2020-21, expansion of the scheme was announced, which was later approved by Government with the inclusion of feeder level solarization as a new variant under Component-C, with the expansion, the targeted solar capacity addition under the scheme has increased to 30.8 GW.

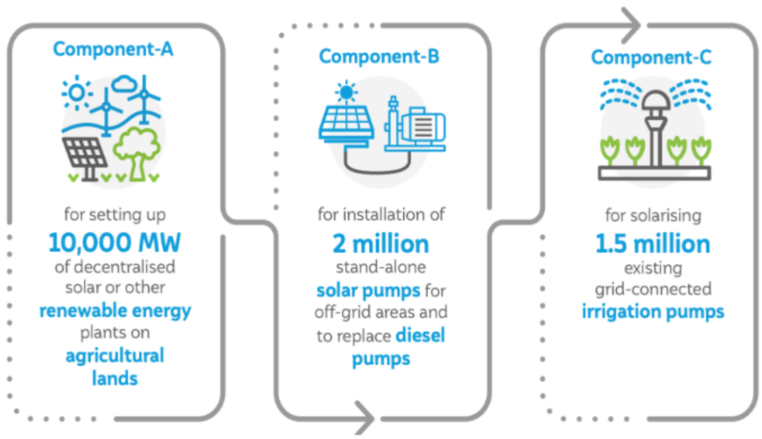


FIGURE 1: PM-KUSUM SCHEME

[1] GoI, Pathways for Enhancing Farmers' Income, Nutritional Security and Sustainable Food Systems, 2021
[2] cKinetics, Designing Financing Interventions to Catalyze Solar Pumps market in India, 2017
[3] cKinetics, Designing Financing Interventions to Catalyze Solar Pumps market in India, 2017

3 SOLAR PUMP SCHEMES IN INDIA AND STATUS OF INSTALLATION

3.1 SCHEMES PROMOTING SOLAR PUMPS IN THE COUNTRY

The major driving framework behind the support for solar pumps is the declining costs of solar modules and the Government's strong focus on renewable energy. The Government via Jawaharlal Nehru National Solar Mission (JNNSM) set a target of 100 GW of solar energy by 2022. According to National Electricity Plan (CEA, 2018b), a further 50 GW of solar energy capacity was to be added from 2022 to 2027. The main scheme promoting the uptake of off-grid solar pumps and other forms of solar irrigation today is the Central Government scheme PM-KUSUM. Apart from PM-KUSUM, there are various state-run schemes which are promoting solar irrigation via various forms of incentivization and subsidies. States like Bihar, Andhra Pradesh, Chhattisgarh, Haryana, Karnataka, Madhya Pradesh, Maharashtra, etc. are prime examples. As an example, Maharashtra in 2017 had announced its ambitious plans to install 100,000 off grid solar in three years from FY 2018-19 to FY 2020-21 under Mukhyamantri Saur Krushi Pump Yojana after discontinuing its solar agriculture pump scheme in 2016 and opted for a feeder-based solar energy scheme. Further, the Maharashtra government increased the electricity tax by INR 0.10 per unit for commercial and industrial consumers to meet the fund requirements for subsidization of the program. Andhra Pradesh government in the state budget of 2018-19, announced that it will provide 60% (previously 56%) of the cost of solar pumps as a subsidy through the DISCOMs and the central government will arrange for 30% as central financial assistance. The following table shows the component wise achievements of the PM-KUSUM scheme till FY 2020-21[4].

TABLE 1: STATE-WISE AND COMPONENT-WISE IMPLEMENTATION OF PM KUSUM SCHEME TILL 2020-21

S. N.	State	Component A	Component B	Component C	
				Individual Pump Solarization	Feeder Level Solarization
		MW	No.	No.	No.
1	Andaman & Nicobar	-	-	-	-
2	Andhra Pradesh	-	-	-	-
3	Arunachal Pradesh	-	50	-	-
4	Assam	-	-	-	-
5	Bihar	-	-	-	-
6	Chandigarh	-	-	-	-
7	Chhattisgarh	-	20,000	-	-
8	Dadra & Nagar Haveli	-	-	-	-
9	Daman & Diu	-	-	-	-
10	Delhi	62	-	-	-
11	Gujarat	500	2,199	7,000	-
12	Goa	10	200	7,000	-
13	Haryana	65	37,000	468	-

[4] MNRE, Annual Report, 2021

S. N.	State	Component A	Component B	Component C	
				Individual Pump Solarization	Feeder Level Solarization
		MW	No.	No.	No.
14	Himachal Pradesh	20	1,550	-	-
15	Jammu & Kashmir	5	5,000	-	-
16	Jharkhand	50	11,000	500	-
17	Karnataka	500	10,500	1,000	50,000
18	Kerala	40	100	100	-
19	Ladakh	-	600	-	-
20	Lakshadweep	-	-	-	-
21	Madhya Pradesh	300	60,000	-	25,000
22	Maharashtra	500	1,00,000	-	50,000
23	Manipur	-	150	-	-
24	Meghalaya	5	700	-	-
25	Mizoram	-	-	-	-
26	Nagaland	-	50	-	-
27	Odisha	500	6,000	-	-
28	Puducherry	7	-	-	-
29	Punjab	220	9,500	-	12,500
30	Rajasthan	1,200	75,000	37,500	-
31	Sikkim	-	-	-	-
32	Tamil Nadu	75	6,500	20,000	-
33	Telangana	500	-	-	30,000
34	Tripura	5	3,900	2,600	-
35	Uttar Pradesh	225	23,000	-	-
36	Uttarakhand	-	-	200	-
37	West Bengal	-	-	700	-
38	**Total**	**4,789**	**3,72,999**	**77,068**	**1,67,500**

A detailed analysis of other government schemes promoting solarized irrigation is provided in Annexure-1.

Various non-governmental organizations, as well as donor agencies, are also promoting solar irrigation and solar pumps in India through different programs. Global Green Growth Institute (GGGI) through collaboration with International Solar Alliance (ISA) is assisting ISA member countries in mobilizing financial support for the deployment of one million solar irrigation systems[5]. Denmark's Ministry of Foreign Affairs is the primary donor agency, and the project is operational from 2020 to 2025. German Federal Ministry for Economic Cooperation and Development through GIZ is promoting the use of solar Water Pumps under its Indo-German Energy Program. The project has

[5] https://gggi.org/project/in25-gggi-isa-partnership-for-one-million-solar-pump-initiative

facilitated an acceleration in the deployment and adoption of solar water pumps for productive use in a sustainable manner in India. The project has been implemented in a few selected groundwater-rich but energy-poor states in the eastern and north-eastern parts of India.

Further, the Syngenta foundation for sustainable agriculture has developed a CSR program for Solar-powered Lift Irrigation systems[6]. The project is based in the village of Chandrapur, in Jharkhand, India, and aims to encourage smallholder farmers to switch from rain-fed paddy production to vegetable cultivation with the help of a solar-powered lift irrigation system. The project, supported by Syngenta India Limited and the Syngenta Foundation India is working with a farmer's group called the Five Brothers Irrigation Committee, consisting of 23 members with a collective irrigated area of 10.65 acres. The Water Foundation through the installation of new solar-powered irrigation systems in Andhra Pradesh, India aims to improve the irrigation systems for agricultural purposes in lands belonging to farmers with limited financial resources in the Andhra Pradesh district. The project targets the installation of solar-powered drip irrigation systems to increase agricultural productivity & empower farmers for the irrigation of arable land in the Utakallu, Mandlipalli and Dugumarri villages. The VNV Advisory Services with Grassroots Trading Network for Women Sewa is running a program aiming to install 1000 solar pumps in the salt farms of Rann of Kutch. The farmers generally used diesel for pumping out water/ brine into the salt pans. With the installation of the solar PV systems, the majority of the diesel usage is replaced by a renewable energy source. A unique feature of this project is that a majority of the salt farmers are women who gain energy independence through the project. Transform Rural India Foundation is developing a pilot program to install solar irrigation systems in 12 hectares of land in Tukutoli, Jharkhand to promote sustainability and improve the economic condition of the local farmers.

3.2 CURRENT STATUS OF INSTALLED SOLAR PUMPS

India has the world's most arable land at 17.5 lakh / sq. km[7]. These lands are irrigated via over 30 million agriculture pump sets, out of which, 20 million pump sets are connected to the grid and around 10 million pumps are diesel pumps. The number of solar pumps installed is very negligible compared to the grid-connected ones and the diesel ones. The total number of solar pumps installed today is about 3,90,000 pumps which have been mostly deployed in the last five years which is depicted in the following figure.

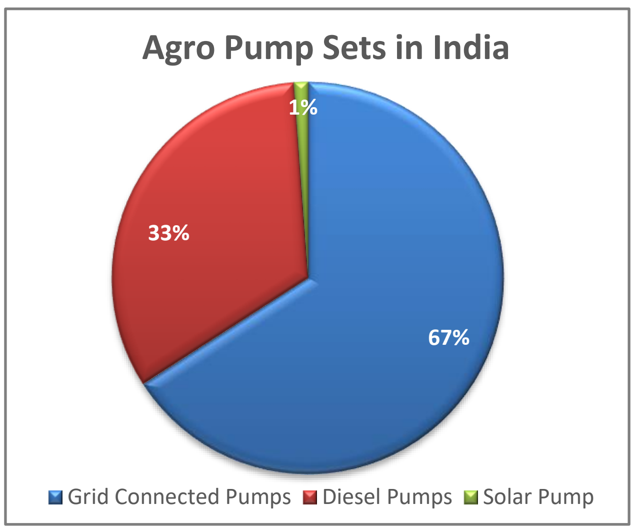


FIGURE 2: AGRICULTURE PUMP SETS IN INDIA

Majorly, the solar pumps are installed by State Renewable Energy Development Agencies with capital subsidy assistance from the Ministry of New & Renewable Energy (MNRE). These pumps are financed via capital subsidy by the Ministry of New & Renewable Energy (MNRE) coupled with state subsidy. Historically the subsidy ranges from 30% to 60%. The remaining 15% to 40% is paid by the farmer depending upon the scheme and state. Further, the solar pumps installed in India is concentrated in a few states

[6] https://www.syngentafoundation.org/agriservices/whatwedo/irrigation/solarpoweredliftirrigationsystem
[7] https://www.pv-magazine-india.com/2022/01/21/solar-water-pumps-redefining-farmers-lives

namely Chhattisgarh, Rajasthan, Andhra Pradesh, Uttar Pradesh, Haryana, and Bihar. Figure number 3 shows the number of pumps installed over the years in India[8].

3.3 PROJECTED TRENDS OF SOLAR PUMP INSTALLATION UNTIL 2030

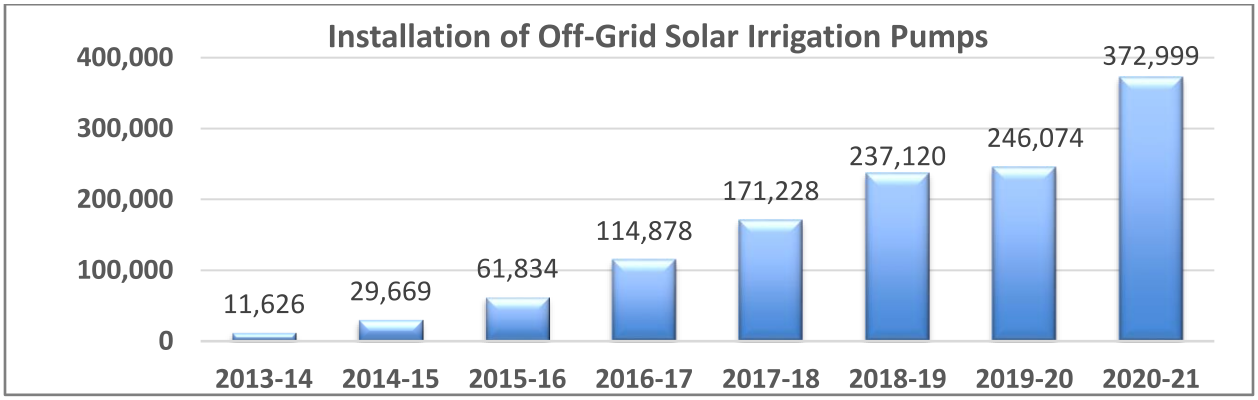


FIGURE 3: NUMBER OF SOLAR PUMPS INSTALLED DURING LAST 10-YEARS

Using the triple exponential smoothening method, the number of pumps to be installed up till 2030 is forecasted. This process of forecasting uses a weighted average method where the weights of the past values are reduced exponentially such that the recent years have better weightage in the forecast model. The following table and figure show the number of pumps forecasted till 2030 and include the band for the margin of error of the forecast model.[9] The forecast of solar pump installation in India until 2030 also shows slow penetration compared to the desirable rate of uptake. Thus, there is need for identification of gaps and ways overcome them

TABLE 2: PROJECTED TRENDS OF SOLAR PUMP INSTALLATION TILL 2030

S. N.	Year	Actual	Forecast	Margin of Error
		Nos	Nos	± Nos
1	2013-14	11,626	-	-
2	2014-15	29,669	-	-
3	2015-16	61,834	-	-
4	2016-17	1,14,878	-	-
5	2017-18	1,71,228	-	-
6	2018-19	2,37,120	-	-
7	2019-20	2,46,074	-	-
8	2020-21	3,72,999	-	-
9	2021-22	-	3,92,584	49,856
10	2022-23	-	4,42,475	55,763
11	2023-24	-	4,92,366	61,122
12	2024-25	-	5,42,256	66,066
13	2025-26	-	5,92,147	70,684

[8] IEEFA: Powering up solar irrigation effort will support India's renewable energy targets, 2021
[9] IIEC Research

14	2026-27	-	6,42,038	75,034
15	2027-28	-	6,91,928	79,161
16	2028-29	-	7,41,819	83,099
17	2029-30	-	7,91,710	86,873

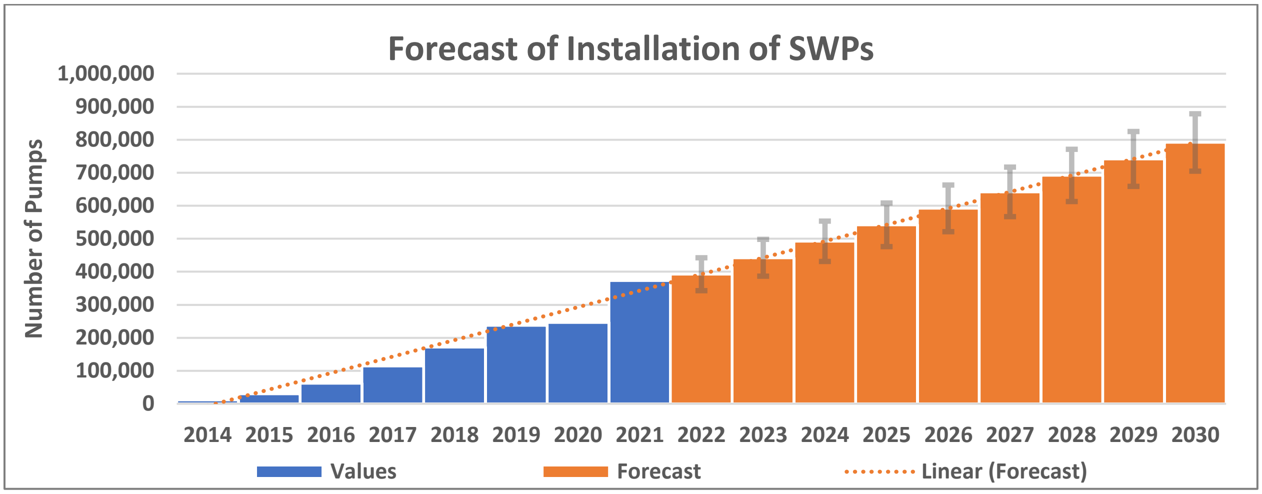


FIGURE 4: FORECAST UNTIL 2030 FOR INSTALLATION OF SOLAR PUMPS

4 GAPS AND SCOPE FOR IMPROVEMENT

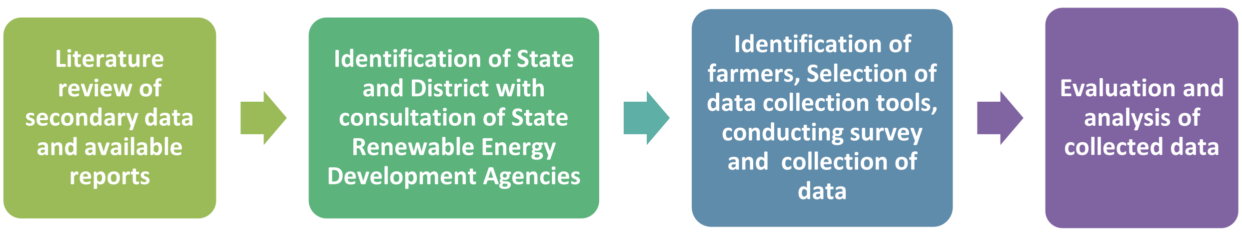
The sustainable growth of the agriculture and horticulture sector depends majorly on the development of this solar water pump sector. India had a target of deploying two million off-grid solar pumps but in reality, the progress has been sluggish, and India has managed to achieve only 10% of the target. There are various reasons why states are unable to implement the solar water pump scheme to its full potential. Data on the performance and impact assessment of these solar pumps are not available for any state, except for a few independent studies. Further, the performance of the scheme in a few states is exceptional compared to others. There might be various reasons for which there is disparity between the adoption and penetration of solar pumps in different states.

For better understanding about the gaps in adoption and penetration of solar pumps in different states, an impact assessment study was conducted. The objective was to understand and document the successful examples and the challenges faced by the states in achieving their targets. The solar pump market needs different business models to flourish and achieve stability. For greater penetration and uptake, a better understanding is required of the factors that are adversely affecting the current market. The impact assessment conducted in two states helped in documenting the ground reality and the challenges faced by all the stakeholders including the farmers. Haryana and Chhattisgarh were identified for the impact assessment study. Haryana was selected based on having a greater number of prosperous farmers with larger landholdings. Chhattisgarh was considered due to having greater number of small and marginal farmers.

5 IMPACT ASSESSMENT IN TWO STATES

While analyzing the state level data, varying performance has been observed in different states. Some of the states have been implementing the solar water pumps successfully others not so much. So, it is evident that there are some variable factors that are affecting the uptake of solar water pumps in the states. Thus, a deep dive study was required to understand and analyze the factors affecting the uptake of solar water pumps and document the measures taken by the successful key States and the challenges faced by not-so-successful States, to achieve their targets. The findings need to be shared with all States so as to maximize the yields of the efforts of Governments at the State and at the National levels. The following methodology was identified for undertaking the impact assessment study:

Literature Review: A detailed analysis and literature review of the challenges and nuances of the current and past schemes was performed, which resulted in the identification of gaps and the scope of improvement.



Identification of Target States: Via literature review and consultation with stakeholders, various states were identified that had successfully implemented solar water pumps and some which were not so successful. The major basis of the selection of region for the impact assessment study was:

- Agroclimatic zones
- Prosperity of the farmers (both prosperous and marginal farmers need to be targeted)
- Nature of crop & the diary activity in the region
- Level of solar water pump penetration in the state

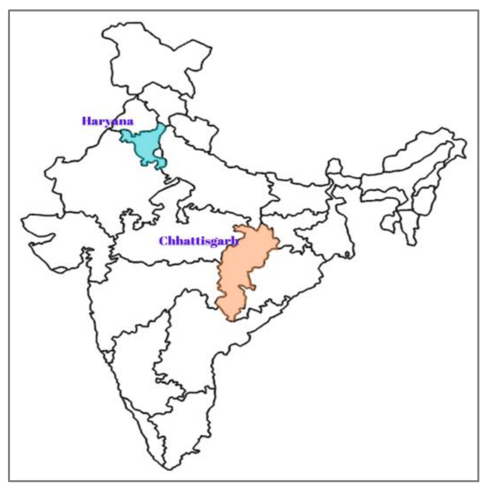


FIGURE 5: IDENTIFICATION OF TARGET REGION

Haryana is one of the major producers of wheat and has a greater number of prosperous farmers. In the recent years Haryana has seen greater penetration of solar water pumps such that it is amongst the top 5 states in the installation of solar pumps. Whereas Chhattisgarh is the largest producer of rice, the number of marginal farmers is more in the state of Chhattisgarh. Chhattisgarh is successfully running *"Saur Sujala Scheme"* for the promotion of solar water pumps, in which it is offering 95-98% of subsidy for 3HP and 5HP pumps. Agriculture is the major source of employment in both of these states. To understand the success of these states and the factors affecting greater uptake Haryana and Chhattisgarh were selected as the target states for conducting the study.

TABLE 3: CLASSIFICATION OF FARMERS

Category	Land
Marginal	Below 2.5 Acres
Small	2.5 Acres to 5 Acres
Semi- Medium	5 Acres to 10 Acres
Medium	10 Acres to 25 Acres
Large	Above 25 Acres

Identification of Farmers, Data Collection Methodology, and Collection of Data: The method of random sampling was adopted for the selection of farmers. The study was undertaken in a participative manner combining qualitative and quantitative data analysis of 100 farmers in each of the states. Before the selection of the farmers, they were categorized into groups according to their landholdings. The table above shows the categories of the farmers. Secondary data was collected by reviewing various government reports, census data, meteorological data, maps, policies and programs, reports of the agricultural department of the states, and websites of selected areas. The collection of primary data was done by field visits to assess the impact on the beneficiaries. An intensive questionnaire to assess the impact of solar pump installation on beneficiaries, System Integrators, and State Nodal Agencies was developed. Various forms of data collection like focused group discussions, survey questionnaires, and in-depth interviews were performed.

Evaluation and Data Analysis: In-depth analysis of the collected data was collated and evaluated via statistical methods.

5.1 SELECTED STATES

5.1.1 Haryana

FIGURE 6: SELECTED DISTRICTS

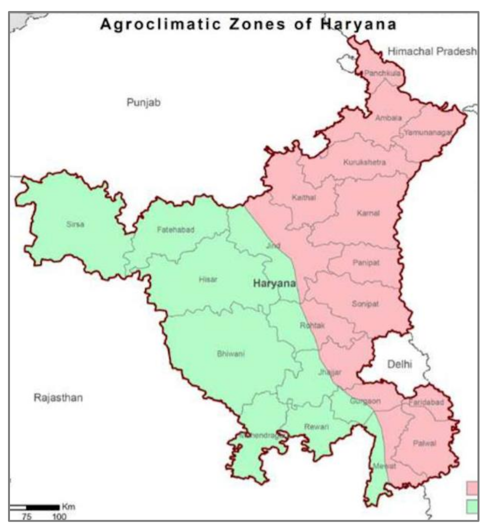


FIGURE 7: AGRO-CLIMATIC ZONES OF HARYANA

Haryana is often called the "Food Mine" of the country and about 80% of the population in the state is directly or indirectly dependent on agriculture.[10] Haryana has two major physiographic regions: the flat alluvial plain covering most of the state and, a strip of the highly dissected Siwalik (Shiwalik) Range (including the narrow foothill zone) in the northeast. Southern parts of Haryana have the remnants of the Aravalli Range. Haryana experiences a tropical climate and is similar to other states that lie in the northern plains. The crop production of Haryana can be broadly classified into Rabi consisting of sugarcane, groundnut, maize, paddy, etc., and Kharif consisting of chilies, bajra, jawar, pulses, and vegetables. The North-Western part of the state is suitable for the cultivation of rice, wheat, vegetable, and temperate fruits and the south-western part is suitable for high-quality agricultural produce, tropical fruits, exotic vegetables, and herbal and medicinal plants. The following table shows the soil and cropping pattern based on the climatic zones.

TABLE 4: SOIL AND CROPPING PATTERN OF HARYANA

#	Soil Climate Zone	Area	Features	Cropping Pattern	
				Kharif Season	Rabi Season
1	Dry Zone	Bhiwani and Sirsa District	Lesser Irrigation Facilities	Pearl millets, Cotton, Moog, Guar	Gram, Taramira/ Mustard & Barley
2	Semi-Dry Zone	Rewari, Jhajjar, Hisar, Fatehabad and Bhiwani District	Fewer Irrigation Facilities	Pearl millets, Cotton, Moog, Guar and Maize in some areas	Gram, Mustard & Barley, Raya
3	Slightly Dry Zone	Dadri, Mahendragarh, Rewari, Gurugram, Jind, Hisar, and Rohtak District	Irrigation required for successful Kharif Cropping	Jowar, Bajra, Guar	Gram, Mustard & Barley, Raya
4	Slightly Moist Zone	Jind, Sonipat, Nuh, Palwal, Karnal, Kaithal and Kurukshetra District	Kharif Crops successful without moisture stress	Bajra, Groundnut, Maize, Sugarcane	Wheat, Green Gram, Safflower Cowpeas, Fodder
5	Moist Zone	Gurugram, Faridabad, Panipat, Ambala, Karnal and Kurukshetra District		Sugarcane, Maize, Groundnut, Bajra	Wheat, Gram, Mustard, Fodder Cowpeas
6	Wet Zone	Yamuna Nagar, Karnal, Panchkula and Ambala District	Double Cropping under rainfed conditions	Sugarcane, Maize, Groundnut, Bajra	Wheat, Gram, Mustard, Fodder Cowpeas

The promotion of solar pumps in the state of Haryana is being done through the PM-Kusum scheme. Till December 2021, 22,408 nos. solar irrigation pumps have been installed under the Scheme. The following figure shows the district-wise distribution of installed solar pumps in the state.

[10] Haryana State Farmer Guide Website

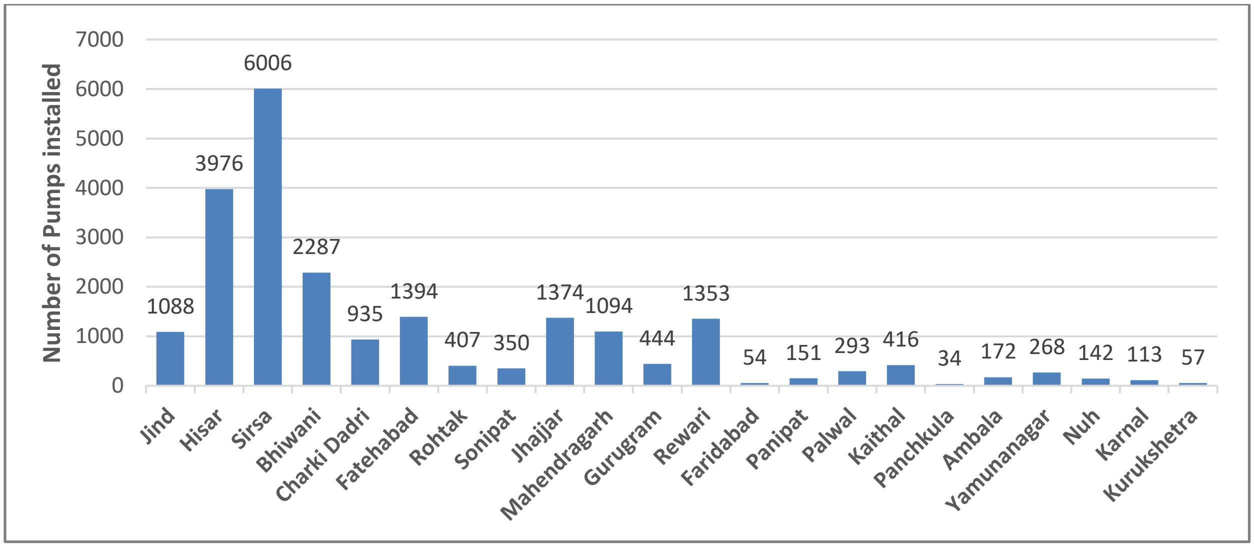


FIGURE 8: DISTRICT WISE NUMBER OF SOLAR WATER PUMPS IN HARYANA

On the basis of rainfall, demography, soil, and the number of solar pump installation data in the state, 8 districts were selected for the study. The below figure and table highlight the selected districts and the selection criteria for the study.

TABLE 5: SELECTION CRITERIA AND SELECTED DISTRICTS

Zone	District	No. of Pumps	Selection Criteria
Northeast Zone	Panchkula	34	Siwalik Hills Area: Lowest no. of pump installed
	Kurukshetra	57	Indo Gangetic Alluvial plains
	Sonipat	350	Yamuna Alluvial Plain & dry zone
	Palwal	293	Normal rainfall in 2021 (-20%)
Southwest Zone	Bhiwani	2287	Aeo-Fluvial Plain; Lowest Rainfall in 2020 (-47%)
	Fatehabad	394	No. of pumps is low; Minimum Rainfall
	Sirsa	6006	Highest No of Pump installed and receives minimum Rainfall
	Hisar	3976	Excess rainfall in 2021 (-33%)
Note	Bhiwani, Palwal, Kurukshetra, Sirsa is Dark Zone where Water level decreases 1 meter every Year		

5.1.2 Chhattisgarh

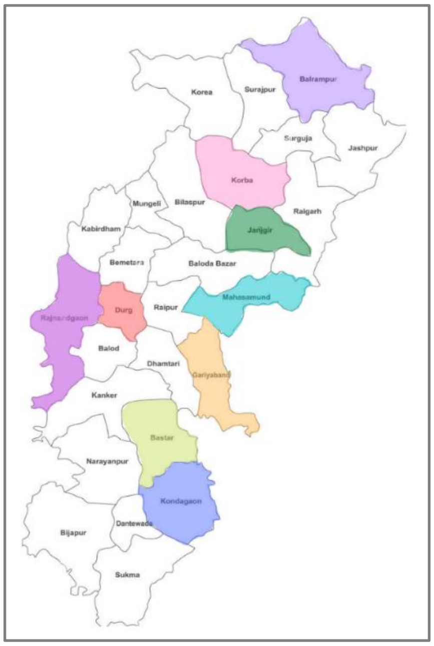


FIGURE 9: SELECTED DISTRICTS

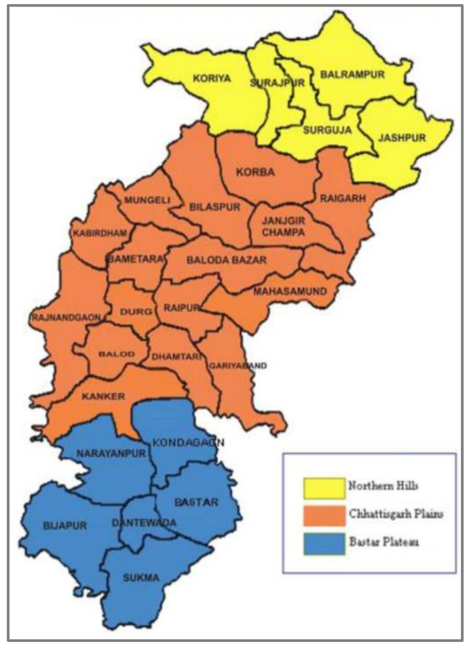


FIGURE 10: AGRO-CLIMATIC ZONES OF CHHATTISGARH

Chhattisgarh is called "the rice bowl of central India" and around 80%[11] of employment in the state is dependent on agriculture. Chhattisgarh has allocated 17.2% of its total expenditure towards agriculture and allied activities i.e., nearly three times of the average allocation for agriculture by other states. Non-Basmati Rice is the most exported commodity from the state and its exports reached US$ 257.67 million in FY 2020 and US$ 474.82 million in FY 2021.

The state is divided into three Agroclimatic zones viz, plains, Bastar plateau, and Northern hills covering 51.0%, 28.0%, and 21.0% of geographical area, respectively. Rice is the main crop of Chhattisgarh and covers almost 77% of the produce. Only 30% of the agricultural land i.e., 89300 hectares is irrigated amongst that almost 80000 Hectare land is irrigated by solar water pumps and the rest 70% is dependent on rains only, as a result the farmers are unable to obtain the economic benefits from agriculture.

<u>Saur-Sujala Yojana</u>

The major reason for the large penetration of solar pumps is the state-run program Saur-Sujala Yojana. Prime Minister Narendra Modi in November 2016 launched the Saur-Sujala Yojna (SSY) in Chhattisgarh to provide solar power Irrigation Pumps to the farmer at a Subsidized Price under the implementation of State Nodal Implementing Agency CREDA (Chhattisgarh State Renewable Energy Development Agency).

[11] http://answers.gkplanet.in/2018/01/which-indian-state-is-known-as-rice-bowl-of-india.html

Under this scheme 3 and 5 HP surface and the submersible pump were distributed to the farmers to improve their economic and financial condition. The SSY scheme provided subsidy of 85% to 90% to the farmers and priority was given to the unelectrified areas first. The scheme is being implemented phase wise and till date approximately 1.05 lakh pumps has been installed till 2021 (including drinking water pumps). The above figure shows the phase wise installation status of the pumps in the state of Chhattisgarh. These 1.05 lakh pumps are irrigating approximately 80 to 90 thousand hectares of land. Further, the State Government is also paying subsidy and arranging finance for the farmers such that the pumps are affordable and actually can be installed by the farmers. The effective price that a farmer has to pay for availing a solar water pump is given in the table below[12]:

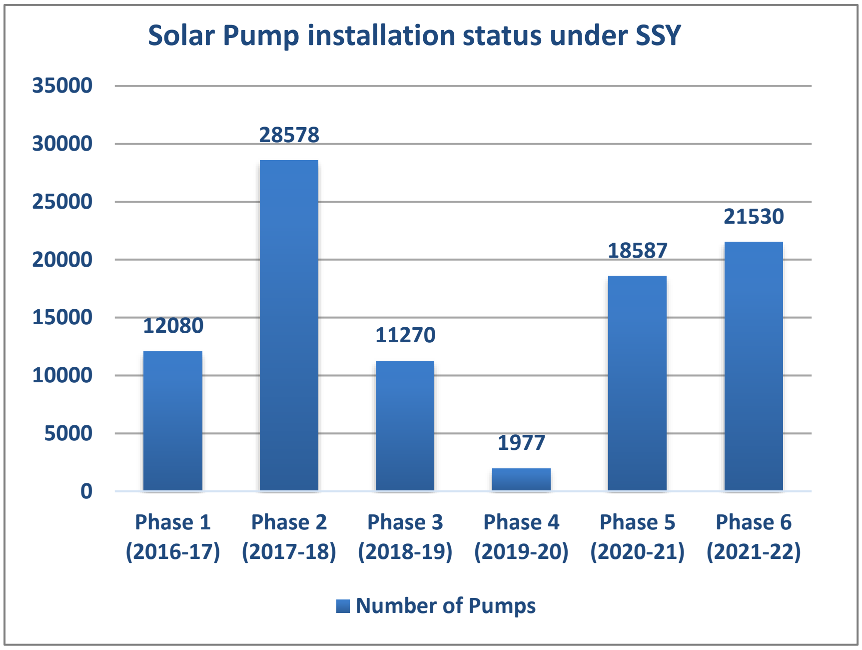


FIGURE 11: NUMBER OF SOLAR WATER PUMPS INSTALLED UNDER SSY

TABLE 6: PUMP COST TO BE PAID BY THE FARMERS UNDER SSY

Beneficiary Category	Amount in INR for 3 HP Pump	Amount in INR for 5 HP Pump
SC/ST	7,000	10,000
OBC	12,000	15,000
General	18,000	20,000

The entire state has been divided in to five major categories namely very high rainfall zone (rainfall >1600 mm), high rainfall zone (1500-1600 mm), medium rainfall zone (1400-1500), low rainfall zone (1300-1400) and very low rainfall zone (<1300mm). Due to varying topography, the type of soil is different across the state. The following table shows the soil and cropping pattern based on the climatic zones:

TABLE 7: SOIL AND CROPPING PATTERN OF CHHATTISGARH

#	Agro Climate Zone	Area	Soil Features	Cropping Pattern	
				Rainfed	Irrigated
1	Plains	Raipur, Gariyaband, Balodabazar, Mahasamund, Dhamtari, Durg, Balod, Bemetara,	Entisol 36 %, (Bhatha) Alfisol 21 %, (Matasi) Inceptisol 22 %, (Dorsa) Vertisol	Rice - Fallow, Rice - Lathyrus, Rice - Lathyrus, Rice - Gram / Wheat Soybean - Gram /	Rice - Gram / Wheat / Sunflower, Rice - Rice / Maize, Maize - Urd,

12 http://www.creda.in/

#	Agro Climate Zone	Area	Soil Features	Cropping Pattern	
				Rainfed	Irrigated
		Rajnandgaon, Kabirdham, Bilaspur, Mungeli, Korba, Janjgeer, Raigarh & a part of Kanker Districts (Narharpur & Kanker Block)	18 %, (Kanhar) Alliuvial 3 % (Kachhar)	Wheat Soybean + Arhar Kodo / Urd / Moong / Til + Arhar Maize - Mustard	Vegetable - Vegetable, Soybean + Arhar, Sugarcane
2	Plateau	Jagdalpur, Narayanpur, Beejapur, Kondagaon, Dantewada, Sukma and the remaining part of Kanker Districts	Entisol 26 %, Alfisol 25 %, Inceptisol 34 %, Vertisol 10 %, Alliuvial 5 %	Rice - Fallow, Maize - Fallow, Millets / Niger - Fallow, Arhar + Moong / Urd - Fallow	Rice - Wheat / Gram Maize - Gram / Mustard Rice - Maize Vegetable - Sugarcane
3	Northern Hills	Sarguja, Surajpur, Balrampur, Koria, Jashpur & Dharamjaigarh Tehsil of Raigarh Districts	Entisol 13 %, Alfisol 29 %, Inceptisol 28 %, Vertisol 28 %, Alliuvial 2 %	Rice - Fallow, Maize - Fallow, Fallow - Horse Gram/Niger (Horsegram and niger are midseason crop sown during Aug.to mid Sept.) Arhar - Fallow Rice - Wheat Maize - Mustard Sugarcane	Rice - Wheat, Maize - Wheat / Mustard, Vegetable - Vegetable Sugarcane

On the basis of rainfall, demography, soil, and the number of solar pump installation data in the state, 9 districts were selected for the study. The below figure and table highlight the selected districts and the selection criteria for the study.

TABLE 8: SELECTION CRITERIA AND SELECTED DISTRICTS

Zone	District	No. of Pumps	Selection Criteria
Northern Zone	Balarampur	5400	Cropping Intensity 117 %
			Hilly Areas
	Korba	6780	Power hub of CG; diversity of soil and rainfall.
Plain Zone	Janjgir Champa	2790	Flat area with scanty vegetation. No. 2 in paddy production, sub-tropical climate
	Mahasmund	4700	No. 3 in paddy production, near Mahanadi River;
	Durg	1300	Drought-prone area with the lowest rainfall
	Rajnandgaon	3000	No. 1 in paddy production. Cropping intensity: 126%
	Gariyaband	9765	Cropping intensity: 119%

Zone	District	No. of Pumps	Selection Criteria
Plateau Zone	Bastar	6950	70% Tribal Population
			Forest-based economy
			Lowest Cropping Intensity-101 %
			Lowest Fertilizer use-5kg/ha
	Kondagaon	7552	Cropping Intensity 104 %

Level of Subsidy

Both the states offer subsidy for installation of solar water pumps. The amount of subsidy varies depending upon the state and the program being run to promote solar water pumps. Haryana is implementing the central PM-KUSUM scheme, prior to that a separate program was being operated in the state of Haryana which was absorbed into KUSUM after its notification in 2019. Whereas the state of Chhattisgarh is implementing Saur Sujla Scheme as the primary solar water pump program. The following table provides a comparative analysis of level of subsidization, compares the amount of subsidy being offered in both the states.

TABLE 9: COMPARATIVE ANALYSIS OF LEVEL OF SUBSIDIZATION

State	Level of Subsidy	Amount to be Paid by Beneficiary	
		3HP AC/DC	5 HP AC/DC
Haryana	75%	58,750	83,250
Chhattisgarh	95-98%	18,000	20,000

6 KEY OUTCOMES

On analysis of the data collected it was found that there are various reasons and markers for which the uptake of solar pump is inconsistent across the nation. It was observed that the PM-Kusum Scheme as well as the SSY scheme of Chhattisgarh is designed such, that a lot of stakeholders are associated with the implementation part. These stakeholders are directly connected to the success of the scheme and penetration of solar water pumps. The following figure summarizes the ecosystem of these stakeholders and how they are connected.

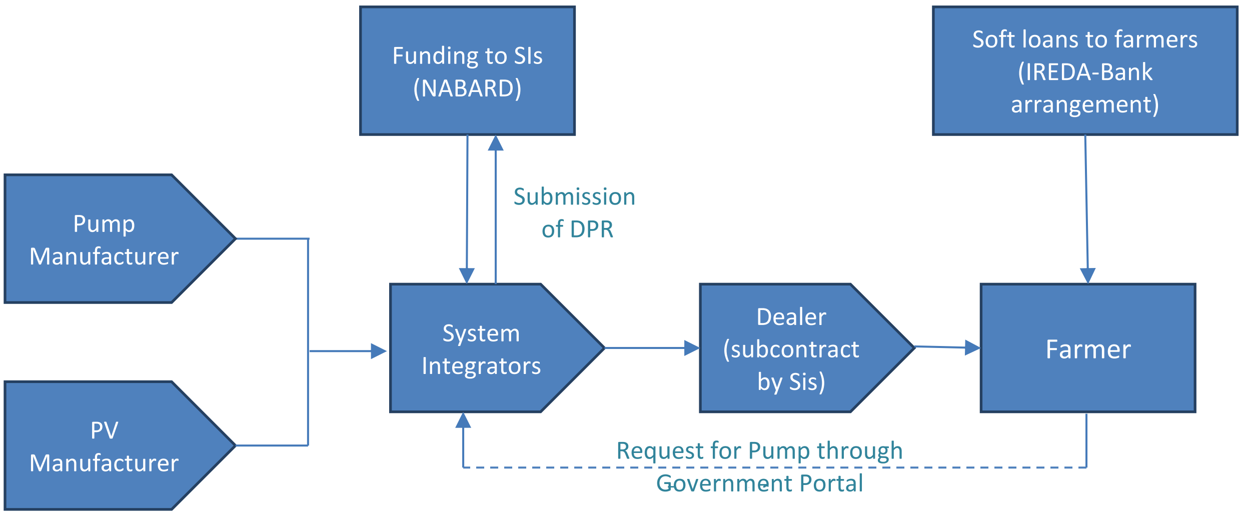


FIGURE 12: ECOSYSTEM AND STAKEHOLDERS FOR SOLAR PUMP SCHEME

6.1 KEY FINDINGS

These stakeholders are an integral part of the implementational success of the schemes. The impact assessment study highlighted various key findings which affect the solar pump ecosystem and the larger WEF nexus. The following are the key findings of the impact assessment study based upon analysis of the data gathered:

- Limited awareness and knowledge: It were observed that more than 85% of the farmers [13] lacked awareness of the working procedure for the solar pumps and were only able to switch on and switch off the pump. The farmers did not know the solutions to small maintenance problems that could be easily corrected at the farmer's end. Further, the majority of the individuals are unaware of the cost advantages, the environmental benefits, and improved solar-powered pump efficiency, and this adds to adverse views of solar-powered pumps. This is largely attributed to a lack of knowledge and access to renewable sources of energy.

- Greater cost-benefit: As there is no operational cost associated with the solar pumps and availability of subsidy the effective overall cost is lower than the annual cost of irrigation through a diesel pump set. Further, the solar pump can be used for other allied agriculture works along with exporting the excess generated electricity to the grid which again is beneficial to the farmers. The following figure shows a comparison of the costs associated with Solar Pumps and Diesel Pumps.

[13] IIEC Research

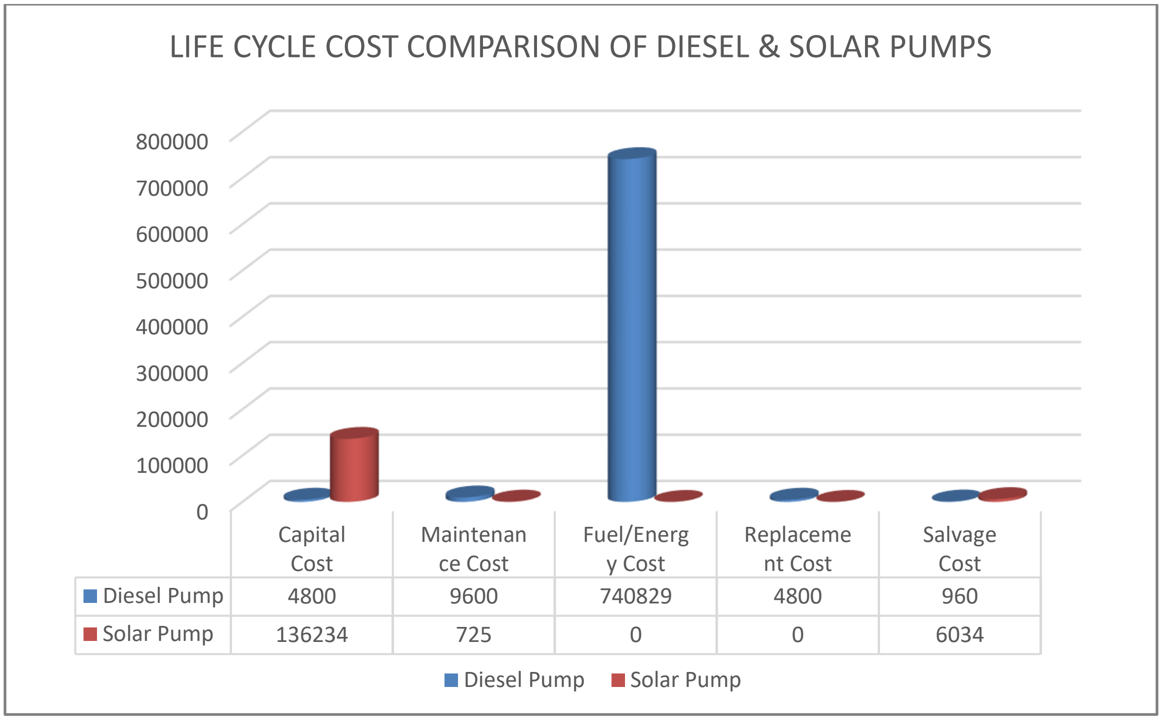


FIGURE 13: COST LIFE CYCLE COST COMPARISON OF DIESEL AND SOLAR PUMPS

Although the initial cost of the solar system is higher compared to the diesel system, in the long run, due to no energy/ fuel cost the solar pump is much more cost-effective. In spite of this the uptake of solar pump is not up to the mark and is affected by various factors given below as per the analysis of the collected data.

- Economic viability of pumps
- Farmers access financing for the initial cost
- Installation, operation, and maintenance of new technology
- Quality control
- Water management

- Unrestricted water usage: Water resource management is a growing priority for the Central Government, and the National Water Policy sets high-level objectives for water management nationally, including the need to improve water-use efficiency for irrigation. One of the major concerns of solar pump is unrestricted use of ground water. Analysis of Central Ground Water Board data on well depth by the Vasudha Foundation shows that, in the pre-monsoon period, groundwater levels are close to drought-like conditions in many regions and that most regions are likely to be included in the "water-stressed" category by 2040. It was observed that after the installation of the solar water pump groundwater is being used judiciously, and about 85% of the farmers switched off the pump on completion of irrigation. This is majorly because previously the farmers used electric pumps which did not have any fixed time of electric supply and the pumps were kept on throughout the day to overcome the erratic power supply system of agriculture feeders. 70% of the farmers had been seen to be sharing water with neighboring farms. But there are still gaps in the ecosystem and there is a need to work with other stakeholders and promote the holistic development of the scheme by focusing on crop diversification, water-efficient practices and groundwater recharging.

➢ **Improved crop yields:** Farm yields have increased, and solar irrigation enabled more than 80% farmers in Chhattisgarh and 61% farmers in Haryana to grow three crops per annum and rotate crops to grow nutritious and cash crops.

➢ **Improved food security & income:** During the dry season the solar irrigation system provides a safety net for farmers, coupled with micro irrigation techniques the solar pumps reduce the daily workload of the farmers enabling and improves productivity around the year and leading to increased income. As per the study an average 36% of farmers in Chhattisgarh and 14% in Haryana have reported increase of over 50% in their annual incomes. 82% of farmers confirmed that their earnings have increased by around 25% after the installation of solar water pumps. Thus, transitioning to solar pumps increased farmers' income due to an increase in productivity for the rain-fed farmers, and a reduction in irrigation costs for the diesel and electric pump owners.

Farmer Name: Balram

Village: Kulina

District: Palwal

State: Haryana

Feedback: I am very happy since the installation of the solar pump on my farm. My income has doubled since then and I am very happy. I thank you for the installation of the solar pump

FIGURE 14: FARMER'S COMMENTS

➢ **Lack of after sales service report support:** 72% of the farmers have reported that they do not get after sales services easily from the service provider. 65% reported that their service provider is more than 15 km away from the solar pump installation site and the resolution of problems takes a lot of time impacting the farm yields.

➢ **Decarbonization / Environmental Impact:** Solar irrigation pumping solutions have a substantially lower environmental footprint compared to traditional options. As per a study in In India, it is estimated that 5 million solar pumps can save 23 billion kilowatt-hours of electricity or 10 billion liters of diesel. This translates into an emissions reduction of nearly 26 million tons of CO_2. Thus, in Haryana and Chhattisgarh with an installation of 22 thousand and 1.05 lakh pumps respectively the potential carbon emission reduction is in tune of **0.12 million and 0.55 million** tons of **CO_2** respectively.

TABLE 10: CROP WISE IRRIGATION REQUIREMENTS

Type of Crop	Irrigation Requirement (Hours/Day)
Rice	8-9
Wheat	7-8
Cotton	4-5
Paddy	6-7
Sugarcane	2-3
Maize	4-5

➢ **Mitigation of climate change**: As the consequences of climate change become more real, improved irrigation will become an increasingly important mechanism for sustainable and drought-resistant farming, rapidly removing the need for fossil fuels. The above table shows the average number of hours water is being used for the major 6 crops in India. This shows that the majority of crops can be serviced by solar pumps with better water management and uses.

- **Support to Government:** Adaption of solar pumps for the government results in subsidy savings on diesel and farm electricity, forex savings which can release the current national deficit, agricultural output increase, and development of the relevant industry. Farmers can enjoy increased income at a minimum cost, through enhanced crop productivity, higher-value crops, and multiple cropping cycles.
- **Socio-economic impact:** In India, the marginal farmers are in general dependent on rainfall. Due to drought or short seasons of rain. Solar pump systems improve the farmers' standard of living by providing reliable, predictable, and affordable energy for irrigation. It also contributes to addressing health, education, and gender issues. With the growing utilization of these systems, the costs have decreased substantially, making them an efficient, convenient, and cost-effective solution for grid-isolated rural areas.

6.2 CONCERNS OF FARMERS

As per the study and the feedback of the farmers, there are factors hindering the use of solar pumps which is affecting the livelihood of the farmers. The list of pain points is highlighted below:

- **Theft and vandalism**: Theft is a major issue in rural areas and the farmers are also affected by it. Almost 20% of the farmers reported missing panels, wires, and components.
- **Bore collapse and pump blockage:** Many farmers complained that in the monsoon season; due to heavy rain and waterlogging soil sedimentation occurs over the pump rendering it incapable to work. Sometimes the bore collapses due to wet soil and the pump gets stuck similar to electric pumps. In case of SWP additionally the controller card is also damaged in the process requiring extra servicing and cost.
- **Low water tables:** 45% farmers complained that the output from the pumps reduces in summer months as the water table decreases in the region. This creates a reduced rate of flow from the pumps hindering agriculture work. Further, lesser flow or lower heads lead to clogging of pumps, damaging the machine and increasing the maintenance cost. This is generally caused due to improper survey of groundwater table at the time of installation.
- **Shrub shadow:** The increase in shrubs near the solar pumps, reduces the solar panel and pump's efficiency. To avoid such incidents many farmers have installed the panels on higher platform, which again hinders panel maintenance and cleaning, creating a conundrum.
- **Knowledge dissemination:** Many farmers complained that the system integrators at the time of installation do not provide basic working instruction on the pumps to the farmers. Due to this, there is very limited understanding of the impact of dust on panels and other aspects of operating efficiency. Thus, over the years the efficiency of the pump decreases, increasing the inhibition of the farmer toward the solar pumps.
- **Insurance claims:** In case of damage / theft the minimum damage for claiming insurance is INR 10000. Furthermore, the minimum time for resolution of insurance claim is thirty days, which is a very long time considering the cropping cycle. In remote areas this time for resolution of claim increases exponentially.

7 RECOMMENDATIONS

7.1 TECHNICAL RECOMMENDATIONS

- Survey and type of pump: The size and type of pump should be decided at the time of the site survey based upon the size of landholding, prevalent water table, and depth of water at the block level. AC or DC pumps should be decided on the basis of intended applications, their relative price, availability of maintenance services, their quality, and performance. Further, depleting groundwater is a major issue in India awareness program is necessary to educate the farmers on the consequences of groundwater depletion. Therefore, there is a need to work with other stakeholders and promote the holistic development of the scheme by focusing on crop diversification, water-efficient practices, and groundwater recharging.

- Application of power generated for other uses: The major recommendation in the consultation process and interviews were the ability of the farmers to be able to use the idle generation capacity for namely operating lighting equipment and fans in the agriculture sheds in the fields. Therefore, a Home Lighting System can also be connected to the pump which will give additional benefits to the farmers. Currently, the farmer has an option to use a universal controller in the pump, but the power generated can only be used for allied agricultural works and including this universal cost increases the pumps installation cost exponentially. Thus, it is recommended that the farmers should use the idle generation to run small domestic loads in the sheds located in the farms. Also, the pumps should come with a pre-fitted universal controller to run small domestic loads.

- Agriculture allied activities: Development of new models to capitalize on prevailing farmer activities to encourage the use of the water for cattle rearing, aquaculture, storage of water for 24-hour irrigation as per requirement, etc.

- Universal solar power controller: It was observed during the course of the study, the majority of the farmers and some System Integrators lacked the knowledge of the universal solar pump controller and the availability of the same under the scheme. This highlights the necessity for creating more awareness about the USPC and its benefits to the farmers

- Battery backup: In the daytime, solar energy is available to operate the pumps but for having a 24-hour irrigation availability there is a requirement for adding battery backup to the solar pumping system. As per the study, irrigation in the nighttime requires on an average 40-45 units of power. Thus, arises an opportunity for integration of batteries in the system for 24X7 access to power. The major challenge in this scenario is integrating the cost of the batteries in the solar water pump system. Thus, there is a need to create innovative business model where these batteries can be utilized and capitalized in the daytime. This creates an opportunity to club battery swapping of electric vehicles in this business model of solar water pump which will lead to additional source of income for the farmers.

7.2 Financial RECOMMENDATIONS

- Financing of pumps: Innovative financing mechanism is required to fund the pumps. Easy agriculture loan disbursement for purchase of solar water pumps is the need of the hour, thus requiring knowledge sharing activity to both farmers and lending institutions.

- Insurance: The farmers who have installed solar pumps are not properly aware of the insurance claim process leading to mismanagement and delay in the resolution of problems. Training on how to claim insurance is required for simplification of the process and ease for the farmers. Further, keeping stock of spare pumps in the local distribution centers will solve the issue of time-consuming repairing process. The solar water pumps should have dedicated insurance programs designed in tune with “Fasal Bima Yojana”.

7.3 POLICY RECOMMENDATIONS

- Small and marginal farmers: The small and marginal farmers in the states face a lot of problems to acquire the initial investment amount of solar pumps. Thus, there is a requirement for creative subsidies or special financing for the small and marginal farmers. Innovative business models can be developed which promote community ownerships and water as a service, which will benefit especially the small and marginal farmers.

- After-sales service market: As the utilization of assets will depend on timely services and maintenance activities. Proper maintenance of solar pumps can help keep their water yields consistent and extend the lifecycle of the product. Regular cleaning of panels with the right materials, checking wires, cleaning pipes, and replacing inverters (every 8-10 years) can help ensure the high investment in a solar pump pays back a farmer over its entire guaranteed lifetime (25 years). A service market at the local level will solve the issue of dependence and will generate local employment. These local employments can be clubbed with existing schemes like Surya Mitra of NISE.

- Theft and damage: In view of arising numbers of theft and vandalism strong measures need to be taken as the creation of fences, camera surveillance, and GPS monitoring for pumps at subsidized rates.

- Micro-irrigation techniques: A major challenge for implementing solar water pumps is ground water exploitation. Unrestricted pumping may cause severe irreversible damage to the water table creating imbalance in the local ecosystem. To tackle this implementation of micro irrigation technique is a must. GOI is promoting micro-irrigation techniques through various finance mechanisms. By linking these schemes to the solar water pumps schemes the water-energy-food nexus will see many improvements. Examples can be taken from the program being run by Gujarat Green Revolution Company Limited where installation of drip irrigation is a must for availing solar water pump subsidies. This will also lead to promote water conservation.

- Specialized training programs: A requirement is there for improving the technical capacity of farmers and local institutions to use and maintain pumps, and to attain the highest capacity and efficiency of solar pumps. This training should aim for multi-level development from farmers to local vendors and authorities like gram panchayats. The government can help in building farmer and local institutional capacity by mobilizing its service network and providing technical expertise. Gram panchayats, Krishi Vigyan Kendras (KVKs), and local agricultural universities are examples of government institutions allied with agriculture that can offer their human resources to support training programs for farmers and State agricultural universities and agricultural block offices have existing repositories of information on agricultural technologies and adding solar pumps to their knowledge packs should not be difficult.

TABLE 11: MAPPING OF RECOMMENDATIONS

What	How	Why
Improve impact potential by integrating with Govt. policies on allied agricultural technologies	Focus on merging policies at the state level. Ensuring farmers get information on multiple allied policies at the time of application and are able to apply for them through one window. Incentivize co-application to other irrigation policies primarily, National Mission on Micro-irrigation and PM Krishi Sinchai Yojana.	Benefits of standalone solar pumps have been minimal – integrating with agricultural productivity schemes can help diversify multiple areas of impact. Integration with policies that support micro irrigation systems can improve agricultural returns per additional drop of water.
Develop of Service market for solar pumps	Either farmer should be educated and trained to take over day-to-day maintenance activities or Gram Panchayat should take a training program and train 10 to 20 people in each village for the work. Such kind of a service market will also help to generate local employment.	Regular cleaning of panels with the right materials, checking wires, cleaning pipes, and replacing inverters (every 8-10 years) can help ensure the high investment in a solar pump pays back a farmer over its entire guaranteed lifetime (25 years).
Battery Backup	Swapping of batteries during the peak time for charging should be allowed and farmers should be trained accordingly. Persons in hardware shops or technical officials can give minimal training to the farmers.	With the additional battery bank, a Home Lighting System can also be connected giving additional benefits to the farmers. Additionally swapping of batteries can also lead to an additional source of income.
Raising awareness and undertaking capacity building	Technical assistance programs can improve the utilization of solar pumps and additional water. These programs can be conducted by existing information networks like agricultural universities, Krishi Vikas Kendras, and field service officers to provide ongoing assistance to farmers.	New farm technology requires upgrading farmer capabilities and changing behaviors.
24*7 readiness for operation & Maintenance	At least 5 pump components should be kept ready for replacement in any damage complaint that arises at the end of the farmers. The spare part should be given, and the pump should be made functional within 24 hours of the complainant's received.	Insurance and other formalities can be done later within a week or two as farmer's crops cannot weight. This will lead to an increase in the trust of farmers in the authority.

8 FUTURE OUTLOOK AND WAY FORWARD

Interacting with the stakeholders, peers and delving through the major recommendation it was observed that many organizations/ entities are working in the common interest to promote the use of solar water pumps. The major goal for the promotion is the development of the agriculture sector and the sustainable growth of the WEF nexus. Thus, the requirement of the hour is to assimilate the individual efforts. To facilitate the same IIEC and ICA are in process of forming an alliance of like-minded organizations and experts in order to accelerate the usage of solar irrigation pumps in India. This alliance will provide handholding support to all the stakeholders of the solar pump ecosystem. This Alliance is envisaged as a coalition where organizations and individuals work together to develop increased and sustainable use of solar energy for agriculture and horticulture practices in India. This alliance will create a platform for all the stakeholders to assimilate technology, funds, and thoughts to support the government of India and the farmers of the Nation.

8.1 THE ALLIANCE FOR SOLARIZED IRRIGATION (ASI)

The Alliance for Solarized Irrigation is bringing together some of the country's leading solar pump and other equipment manufacturers, infrastructure think tanks, experts, and decision-makers from industries, consultants, RESCOS, designers, utilities, and civil society on one platform. The Alliance is much-needed assimilation of thoughts of stakeholders who bat for the solarization of irrigation to improve the Agriculture and Horticulture cropping intensity along with addressing the food, water, and energy nexus.

The Alliance will drive active dialogue with all stakeholders to ensure the development and implementation of standards and best practices. It will support the national and state governments in better regulatory enforcement of standards. The alliance will drive mass awareness and sensitization to create public demand for safe and sustainable agricultural and horticultural infrastructure. It will work to strengthen the knowledge pool of the food, water, and energy sectors through evidence-based policy guidance, data-driven research, and industry reports.

8.2 OBJECTIVES OF THE ALLIANCE

Some of the major activities performed by the alliance will be:

- Initiate active dialogue with key stakeholders at the national and state level to ensure effective implementation of the PM-KUSUM Scheme.
- Facilitate the knowledge transfer to state agencies on new and innovative mechanisms to improve the penetration of solar pumps and other equipment for energizing agriculture and for meeting the targets under the PM-KUSUM Scheme.
- Support state Governments in their endeavor for better regulatory enforcements as per the national and global standards with enabling policy environment.
- Continued and sustained engagement with members on issues of importance; update them about the latest developments in India and in other developing countries where solar irrigation or solarization of agriculture programs are being implemented.

- Drive awareness and sensitization to create demand at both farmer and market levels for improved penetration of solar energy for energizing the services in the agriculture and horticulture sectors.

- Strengthening the knowledge pool on energizing agriculture through evidence-based policy guidance, data-driven research, and industry reports.

9 ANNEXURES

9.1 STAKEHOLDER CONSULTATION

In the course of the impact assessment study, IIEC and ICA along with local support organizations conducted large-scale stakeholder consultations in both the states. Where all stakeholders of the solar pump ecosystem starting from farmers, financers, system integrators, and state renewable agency members participated, the findings of the study were shared with the stakeholders, and views and suggestions were taken on the possible ways of improving the schemes and the ecosystem. The recommendations received can be broadly classified into three types, technical recommendations, financial recommendation and policy recommendations. All three recommendations were developed on the basis of interviews with farmers, as well as consultations with pump manufacturers, System Integrators and agricultural experts, and state nodal agencies. The following lists shows the stakeholders present in the consultation process.

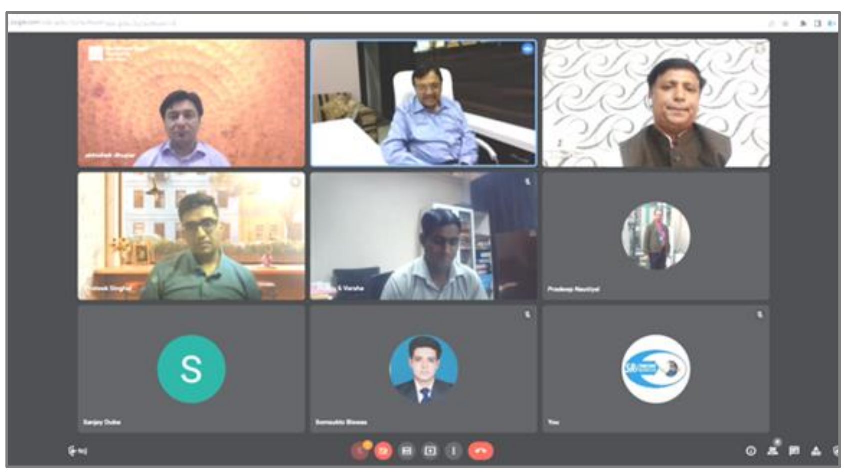


FIGURE 15: STAKEHOLDER CONSULTATION OF BOTH THE STATES

TABLE 12: LIST OF PARTICIPANTS OF STAKEHOLDER CONSULTATIONS

S.No	Name of Participants	Name of Organization
1	Pratik Singhal	ECOZEN Solutions
2	Piyush Patidar	Shakti Pumps
3	Dhirendra Mani Tiwari	CG Electrical Infra
4	Mukesh Jain	Unique Associate
5	Hari Narayan Gupta	Laxmi Agency
6	Jai Kishan Bajaj	RBP Energy
7	Rajesh Agrawal	Avni Traders
8	K.S. Khurana	Rawmatt Solution
9	Shailendra Kumar Shukla	Ex-CREDA, HAREDA Chief
10	Kamlesh Kumar Sen	KY Energy Solution Private Limited
11	A Keshav Rao	Neat Nature Solution Private Limited
12	Pradeep Kumar Nautiyal	HAREDA
13	Suyash Singh Rajput	Neat Nature Solution Private Limited
14	Dinesh Kumar	Tridots ventures Private Limited
15	Abhishek Dhupar	International Copper Association India
16	Sanjay Dube	International Institute for Energy Conservation
17	Somsuklo Biswas	International Institute for Energy Conservation
18	Bhanu Pratap Bharti	SR Corporate Consultant Private Limited
19	Ritu s Jain	SR Corporate Consultant Private Limited
20	Varsha Choraria	SR Corporate Consultant Private Limited

9.2 MAPPING OF VARIOUS SOLAR PUMP SCHEMES IN INDIA

#	Name of policy/ scheme	Nodal agency	Year of Inception	State/ Central	Objective	Target	Subsidy	Other Nuances	Achievements
1	Kisan Urja Suraksha Evam Utthaan Mahaabhiyan (KUSUM)	MNRE	2018	Center	Incentivize farmers to run solar farms and water pumps for generating solar power for extra income	28.25MW solar power over 10yrs: a) 10GW solar generation on barren farmlands b) 1.75 mn pumps c) solarization of grid-connected farm pumps 7.25GW (sell surplus solar power to DISCOM) d) solarization of tube-wells 8.25GW	a) 60% for solar pumps (30% MNRE and 30% states) b) In 30%, 10% upfront by farmer and 90% debt to farmer	No subsidy for solar farms but 50 paise/unit for buying power from farmers for 5 years;	-
2	Scheme for Solar Pumping Program for Irrigation and Drinking Water (under Off-grid and Decentralized Solar Application Scheme)	MNRE; Carried out via State Nodal Agencies	2012	Center	Subsidize 1 million solar pumps by 2021	a) Develop models to foster scalable deployment of solar power for pumping in rural areas. b) Address and support rural development, over and above basic service of water c) Energy access	Below 3HP 25%. 3-5HP 20%	-	-
3	CFA for Solar Pumping (part of Scheme for Solar Pumping Program for Irrigation and Drinking Water)	MNRE; carried via NABARD	2012	Center	Promote solar pumps in agriculture via credit inked-subsidy scheme	Initial target 10,000 solar pumps; later revised to 30,000 and further revised to 1,00,000 in 2015	40%	20% upfront by the farmer; 40% subsidized loan from RRBs and other rural FIs	1,744 pumps till Dec 2016
4	Rashtriya Krishi Vikas Yojana	Ministry of Agriculture	2007	Centre	Incentivize states to draw a comprehensive plan for the agriculture sector;	pumps component aims to promote reliable power for irrigation by subsidizing solar pumps	State + center 75% 2HP and 50%	The state is eligible only if it maintains or increases % expenditure on agriculture and allied sectors w.r.t state plan expenditure	
5	Andhra Pradesh Solar PV Water Pumping Program	New & Renewable Energy Development Corporation of Andhra Pradesh	2014	State	Subsidize solar pumps to improve irrigation via reliable power	10,000 in 2016-17	3HP 86%; 5 HP:85%	-	2014-2015 and 2015-16: 6725
6	Solar pump scheme Andhra Pradesh		2018	State		NA	3 HP 82%	Only areas where groundwater is within 75mts	
7	Bihar RE policy	Bihar Renewable Energy Development Agency	2017	State	Improve irrigation access	10,000 pumps by 2022	-	-	-
8	Bihar Saur Kranti Sichai Yojna		2012	State	Subsidize solar pumps to improve irrigation via reliable power	2,85,000 pumps over 2012-2017 (phase 1 pilot 2012-13: 560 pumps)	90% (40% MNRE + 50% state)	-	527
9	Mukhyamantri Navin & Navnirman Urja Yojna		2016	State		3,300 pumps till 2021-22 (2016-17 target 1,000)	-	-	993 (2016-17)

#	Name of policy/ scheme	Nodal agency	Year of Inception	State/ Central	Objective	Target	Subsidy	Other Nuances	Achievements
10	Saur Sujala Yojana Scheme	Chhattisgarh Renewable Energy Development Agency	2016	State	Empower farmers by providing them with solar irrigation patps on subsidized rates	51,000 farmers till 31 March 2019 (including 11,000 in 2016-17)	3HP and 5HP: 95-98%	-	Cumulative 7,448 till FY2016, rising to 18,586 till Jan 2018
11	Solar Water Pumping Scheme	Haryana Department of Renewable Energy	2016	State	Subsidize solar pumps to improve irrigation via reliable power	2016-17 – 885 2017-18 - 2,195 2018-19 - 25,000	90%	-	-
12	Surya Raitha Scheme	Karnataka Renewable Energy Development Agency	2014 pilot; 2018 extended to all	State	a) Reduce use of conventional source in power generation – pumps to supply 1/3rd of total energy generated to the nearby grid b) promote solar energy for uninterrupted power to farmers during the day and increase farmers' earnings by enabling the sale of excess electricity to DISCOMs	310 pumps in phase 1 pilot	90% (this includes part interest-free debt from DISCOM to the farmer; part of payments from DISCOM to a farmer for electricity used to pay off that loan)	Pump installed 1.5 times the capacity; Government purchases power at Rs 7.8/unit, if subsidy not availed and Rs. 6.3 if availed	250 5-7HP pumps in pilot phase 1
13	Mukhyamantri Solar Pump Yojana Madhya Pradesh	Madhya Pradesh New & Renewable Energy Department	2015	State	Subsidize solar pumps	a) arrange irrigation in off-grid areas. b) reduce pollution by diesel. c) reduce financial burden on farmers by using diesel	90% below 3HP, 85% 3- 5HP	-	-
14	Solar Pump Scheme Maharashtra	Maharashtra Energy Development Agency	2015	State	Subsidize solar pumps to improve irrigation via reliable power	2,600 solar pumps	80% (22% MNRE + 58% state)	Eligible for only 1- 5HP pumps	-
15	Hi-tech Technology/ For Agriculture Solar Powered Pump Scheme	Rajasthan Horticulture Development Society	2018	State	Supply, Commissioning and maintenance of solar pumping infrastructure and after-sales services for 10 years (Includes 5 years guarantee period).	7500 nos. solar pump	70%	The implementing firm is also required to establish a customer care center, farmer training service center, and toll-free number	-
16	Rajasthan solar pumps program	Rajasthan Renewable Energy Corporation Limited	2014	State	Subsidize solar pumps to improve irrigation via reliable power	2014-15: 2,900 2015-16: 4,702 2016-17: 7,500 2017-18: 5,000 2018-19: NA	2014-15: 70% 2015-16: 60- 75% 2016-17: 60- 75% 2017-18: 50- 70% 2018-19: 55% 3HP and 60% 5HP	a) Subsidy varies by access to electric pumps: b) no additional state subsidy for	-

#	Name of policy/ scheme	Nodal agency	Year of Inception	State/ Central	Objective	Target	Subsidy	Other Nuances	Achievements
							(draft) (includes MNRE component)	farmers already using electric pumps c) Highest subsidy for farmers who have applied for electric pumps and willing to surrender connection	
17	Solar Pump Scheme Tamil Nadu	Tamil Nadu Energy Development Agency	2017	State	Improve irrigation scenario in the agriculture sector (about 4.3 lakh farmers waiting for free power connections,	1,000 5-10HP pumps in phase 1	90% (MNRE 20%, State 40%, TANGEDCO 30%)	Farmers to pay 10% upfront and forfeit free power connection (or application for it)	-
18	UP Solar Pump Yojna	UPNEDA	2016	State	Subsidize solar pumps to a) reduce cost of irrigation b) 24x7 power to all and c) environment conservation	10,000 pumps in 2016-17; total target 50,000 pumps till 2022	70% on 2 HP; 65% on 3HP and 40% on 5HP	-	2016-17: 5,458 pumps