International Journal of Environment and Climate Change

Volume 13, Issue 9, Page 1183-1192, 2023; Article no.IJECC.103301
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Factors Militating against Adoption of Solar Water Pump Sets in the Selected Area of Chhattisgarh, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2023/v13i92344

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/103301

Original Research Article

Received: 12/05/2023
Accepted: 14/07/2023
Published: 15/07/2023

ABSTRACT

In the agricultural sector, the highest electricity use goes to irrigation pump sets. Solar pump sets are a renewable source of energy that can replace existing diesel- and electricity-based pump sets. The Sour Sujala Yojna was launched by the Prime Minister to provide solar-powered irrigation pumps to farmers at a subsidized price. 56362 solar water pump sets were installed from 2016 to 2019 in Chhattisgarh state. In the study area, sample farmers were facing two major problems: the solar pump was not working during cloudy days, and second "low farm income". Rank 3 was "small land holdings," and through the solar pump irrigation, less area was covered, ranking 4. There is a maintenance problem that is minor or negligible. To solve the problem, a battery charge system with a solar pump should be added. and the water tank was fixed and stored above 20 meters. A solar pump is a renewable source of energy. So it does not affect nature. It is the best source of irrigation for future energy savings.

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Keywords: Solar; pump; constraints; garret ranking; farmer.

1. INTRODUCTION

Agriculture plays an important role in the Indian economy. Nearly 70 percent of India's population depends either directly or indirectly on agriculture, while 44 percent of the 140 million sown hectares depend on irrigation, and the remainder rely on the monsoon. Irrigation is essential for crop production [1-6]. There's a growing demand for water to irrigate the crops. In the agricultural sector, the highest electricity use goes to irrigation pump sets. India has announced plans to replace many of its 26 million groundwater pumps for irrigation with solar pumps [7]. This will lead to large savings in installed electric power capacity and diesel and will reduce huge amounts of CO2 emissions. However, it is recognized that solar-based pumping poses a new risk to water resources [6,8]. Several studies have shown that solar energy use in agriculture generates impressive returns for farmers [9-14]. For enhancing farmers' income, groundwater irrigation has to play a major role. Groundwater extraction for irrigation largely depends on electric and diesel sources of energy. It has been estimated that the replacement of existing diesel and electricity-based pump sets with solar pump sets can lead to a reduction of 62 billion kilograms equivalent of carbon dioxide (kg CO2) emissions and savings of USD 11.5 billion per year [15]. To meet the energy demand for irrigation, solar photovoltaic (PV) pumps were introduced under the National Solar Mission (NSM) off-grid power generation category with a power target and phases as shown in Table 1. SOUR SUJALA YOJNA was launched by the Prime Minister to provide solar-powered irrigation pumps to farmers at a subsidized price. Chhattisgarh is the first state to implement the scheme [16-19]. 2 hp, 3 hp, and 5 hp solar pumps were installed under this scheme. In this scheme, 56362 solar water pump sets were installed during 2016 to 2019 in Chhattisgarh state. In the Raipur district, 917 solar water pump sets are installed. CREDA (Chhattisgarh State Renewable Energy Development Agency) provides solar water pump sets at a subsidized price to the farmers. The benefits received by the farmers through the Sour Sujala Yojna is provided by the agricultural department [20-23]. The specific objectives of this study are to identify the constraints on the adoption of solar water pump sets.

Table 1. National solar mission targets

S. No.	Application segment	Target for Phase – I (2010-13)	Target for Phase – II (2013-17)	Target for Phase - III (2017-22)
1	Grid connected solar power generation	1100MW	4000MW	100000MW
2	Off-grid solar applications (includes solar PV pump)	200MW	1000MW	2000MW
3	Solar thermal collectors	7 million sq. m.	15 million sq. m.	20 million sq. m.
4	Solar lighting systems	5 million	10 million	20 million

Source: Ministry of Renewable Energy Sources, Govt. of India

2. MATERIALS AND METHODOLOGY

It represents the elaborated methodological framework and the background of the study area. The methodology is divided into four sub-sections: sampling design, data collection, analytical procedure. The methodological framework is presented under the following headings:

2.1 Sampling design
2.2 Collection of data
2.3 Analytical tools and techniques

2.1 Sampling Design

A multi-stage sampling technique was used for the selection of sample farmers in the present study. The detailed sampling framework that will be adopted for accomplishing the objectives of the present study is given as follows:

2.1.1 Selection of district

The purposively-cum-random sampling technique was employed for the selection of samples in the present study. Chhattisgarh State consists of 33 districts. Raipur district was purposefully selected for the study in the first stage, as the district was assigned the highest target for solar water pumps. In Raipur districts, a total of 917 solar pump sets were installed among all blocks of the district during the years 2016–17 to 2018– 2019.

2.1.2 Selection of blocks

The Raipur district has four blocks, namely Arang, Tilda, Dharsiwa, and Abhanpur. Arang Block was selected purposefully because the highest number of solar pumps were installed. Block-wise, the number of solar water pump sets installed in Raipur districts is given in Table 2.

2.1.3 Selection of villages

The selection of villages is in accordance with the corresponded villages of solar pump farmers. Villages are Kunda, Badgaon, Chandkhuri, Godhi, Tekari, Parsada, Chhatera, and Borid.

2.1.4 Selection of farmers

For research purposes, 49 farmers were selected randomly from the eight villages with solar pump sets.

2.2 Collection of Data

In order to address the objectives of the study, primary as well as secondary data were collected.

2.2.1 Primary Data

Primary data for the study will be collected from solar pump set users and farmers. Information regarding the problems facing adoption of solar water pump sets will be collected from farmers.

2.2.2 Secondary Data

Secondary data relevant to the objectives of the study was collected from the CREDA (Chhattisgarh State Renewable Energy Development Agency) and the Agriculture Department in Raipur, etc.

Table 2. Block wise number of solar water pump set installed in Raipur districts

S. No.	Block Name	No. of solar water pump set 2016-17	No. of solar water pump set 2017-18	No. of solar water pump set 2018-19	Total no. of solar water pump set installed
1	Abhanpur	83	40	57	179
2	Arang	118	105	74	297
3	Dharshiwa	65	63	56	184
4	Tilda	87	94	75	256
Total		353	302	262	917

(Source: Agriculture Department Raipur)

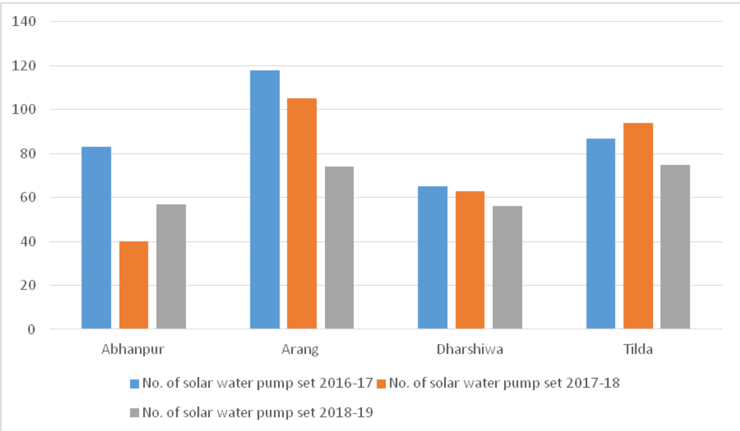

Fig. 1. Block wise number of solar water pump set installed in Raipur districts

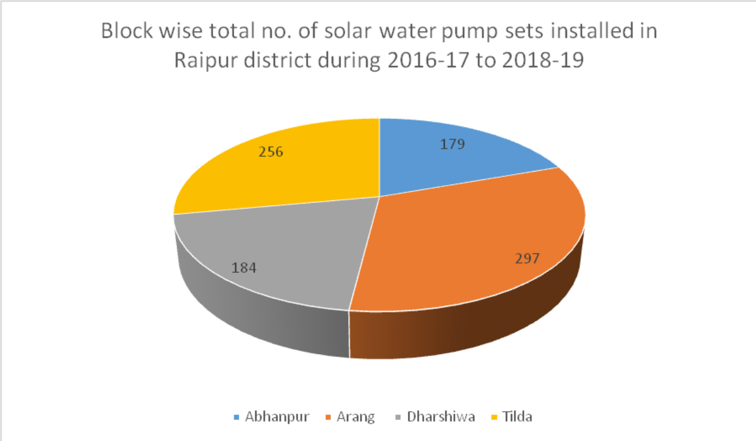

Fig. 2. Block wise total no. of solar water pump sets installed during 2016-17 to 2018-19

2.3 Analysis Tools and Technique

2.3.1 To understand the constraints in adoption of solar water pump sets

Constraints in the use of solar water pump sets have been identified based on the literature reviews and farmer's opinion. These constraints were evaluated by 3 experts in the field and a final list of constraints was drawn up for pre-testing after proper addition and deletion.

Garret ranking technique was used to find out the significant constraints that affect the respondents. According to this process, respondents were asked to assign the rank for all constraints and the result of such a rank was transformed to the score value by using following formula:

Per cent position = 100∗(Rij−0.50)÷ Nj

Where, Rij stands for rank given for the ith constraints (i= 1, 2……10) by the j th individual (j = 1, 2 …..48)

Nj stands for number of constraints ranked by jth individual.

When the percentage positions were found, by referring to the table given in Garrett and Woodsworth (1969), the percentage position of each rank was transformed to scores. The scores for each constraint were then summed up over the number of sample farmers that ranked those constraints. In this way, for each of the constraints, total scores were reached, and mean scores were determined by dividing the total score by the number of respondents who gave ranks. Lastly, the overall ranking of the constraints was achieved by assigning rank to the decreasing order of the mean scores.

Table 3. Constraints in adoption of solar pump sets

Constraints no.	Constraints
F1	Small land holding
F2	Lack of knowledge about solar pump
F3	Delay in installation of solar pump
F4	Low farm income
F5	Lack of demonstration
F6	Inadequate subsidy
F7	Problem of starter
F8	High ground water
F9	Less area irrigate
F10	Not working during cluody days
F11	Compare to disel pump
F12	Maintenance

3. RESULTS AND DISCUSSION

On the basis of the outcome of the pilot study, only problems like Small land holding, Lack of knowledge about solar pump, Lack of knowledge about solar pump, Low farm income, Lack of demonstration, Inadequate subsidy, Problem of starter, Problem of starter, High ground water, Less area irrigate, Not working during cloudy days, Compare to diesel pump and Maintenance have been used in the Final Interview Schedule. By way of giving these factors in the Final Interview Schedule, sample farmers have been called to assess each problem on its own significance. Each farmer is instructed to indicate the problem in adoption of solar pump by giving rank 1 to the main problem, rank 2 to the second main factor and so on. Based upon the ranks assigned by the sample farmers, the order of facing problem during the installation of solar pump. To find the most significant problem, the sample farmers were selected because they were facing problems. Garrett's Ranking Technique was employed. It is calculated as a percentage score, and the scale value is obtained by employing Scale conversion. The table given by Henry Garrett is shown in Table 4.

The percentage score for each rank from 1 to 12 was calculated. The percentage score thus obtained for all ten ranks was converted into scale values using the Scale Conversion Table given by Henry Garrett. The scale values for first rank to twelfth rank were 83, 73, 66, 62, 55, 52, 48, 44, 40, 34, 27, and 17, respectively. The score value (fx) is calculated for each factor by multiplying the number of respondents (f) with the respective scale values (x). The total scores were found by adding the score values (fx) of each rank for every factor. The mean score was calculated to determine the order of preference given by the respondents for the factors. Based on the mean score, the overall ranks were assigned for each. The ranking analysis of the factors in the adoption of solar water pumps by farmers through Garrett's Ranking Technique is shown in Tables 4 and 6.

Table 7 reveals shortcomings in the study area regarding the adoption of solar water pump sets. In the study area, sample farmers were facing two major problems: 'the solar pump is not working during cloudy days and "low farm income". Rank 3 was "small land holdings," and through the solar pump irrigation, less area was covered, ranking 4^{th}. Rank 5 was "delay in installation of solar pump". "Problem of starter", "high ground water", "Inadequate subsidy", "Lack of demonstration", "Lack of knowledge about solar pumps," and "compare to diesel pumps" were assigned ranks 6th, 7th, 8th, 9th, 10th, and 11th, respectively. There were maintenance problems, but they were minor or negligible.

Table 4. The ranking analysis of the factors in adoption of solar water pump

Constraints no.	Formula (100∗(Rij−0.50)÷ Nj)	Calculation	Table value(x)
F1	100*(1-0.5)/12	4.166667	83
F2	100*(2-0.5)/12	12.5	73
F3	100*(3-0.5)/12	20.83333	66
F4	100*(4-0.5)/12	29.16667	62
F5	100*(5-0.5)/12	37.5	55
F6	100*(6-0.5)/12	45.83333	52
F7	100*(7-0.5)/12	54.16667	48
F8	100*(8-0.5)/12	62.5	44
F9	100*(9-0.5)/12	70.83333	40
F10	100*(10-0.5)/12	79.16667	34
F11	100*(11-0.5)/12	87.5	27
F12	100*(12-0.5)/12	95.83333	17

Table 5. Garrett ranking conversion table

The conversion of orders of merits into units of amount of "socres":

Percent	Score	Percent	Score	Percent	Score
0.09	99	22.32	65	83.31	31
0.20	98	23.88	64	84.56	30
0.32	97	25.48	63	85.75	29
0.45	96	27.15	62	86.89	28
0.61	95	28.86	61	87.96	27
0.78	94	30.61	60	88.97	26
0.97	93	32.42	59	89.94	25
1.18	92	34.25	58	90.83	24
1.42	91	36.15	57	91.67	23
1.68	90	38.06	56	92.45	22
1.96	89	40.01	55	93.19	21
2.28	88	41.97	54	93.86	20
2.69	87	43.97	53	94.49	19
3.01	86	45.97	52	95.08	18
3.43	85	47.98	51	95.62	17
3.89	84	50.00	50	96.11	16
4.38	83	52.02	49	96.57	15
4.92	82	54.03	48	96.99	14
5.51	81	56.03	47	97.37	13
6.14	80	58.03	46	97.72	12
6.81	79	59.99	45	98.04	11
7.55	78	61.94	44	98.32	10
8.33	77	63.85	43	98.58	9
9.17	76	65.75	42	98.82	8
10.06	75	67.48	41	99.03	7
11.03	74	69.39	40	99.22	6
12.04	73	71.14	39	99.39	5
13.11	72	72.85	38	99.55	4
14.25	71	74.52	37	99.68	3
15.44	70	76.12	36	99.80	2

Percent	Score	Percent	Score	Percent	Score
16.69	69	77.68	35	99.91	1
18.01	68	79.17	34	100.00	0
19.39	67	80.61	33		
20.93	66	81.99	32		

Table 6. The ranking analysis of the factors in adoption of solar water pump by the farmers through Garrett's Ranking Technique

Constraints	F1 81	F2 73	F3 66	F4 62	F5 55	F6 52	F7 48	F8 44	F9 40	F10 34	F11 27	F12 17	total score	mean score	rank
Small land hoding	1215	657	198	310	165	260	192	44	80	34	27	17	3199	65.89796	III
Lack of knowledge about solar pump	810	219	198		110		192		40				1569	32.02041	X
delay in installation of solar pump	972	730	511	248		52	48	176		68	27		2832	57.79592	V
Low farm income	972	584	292	310	220	156	240	220	160	129	81	17	3381	69	II
Lack of demonstration	567	219	132	186	220		240		40	34	27		1665	33.97959	IX
Inadequate subsidy	648	511	330	248		104	144		120	34	27	17	2183	44.55102	VIII
problem of starter	810	438	396	310	165	104	48	44	120	102	54	17	2608	53.22449	VI
high ground water		876	528	186	330	208	240		120	34	27		2549	52.02041	VII
less area irrigate	1053	584	264	248	275	156	96	88	80	68	27		2939	59.97959	IV
not working during cluody days	1296	657	528	434	110	260	144	176	160	102	27	17	3911	79.81633	I
compare to disel pump				310	165	208	192	88	80		27		1070	21.83673	XI
Maintenance											27	17	44	0.897959	XII

Table 7. The ranking of constraints in adoption of swps in the study area

S. No.	Constraints	Mean value	Rank
1	Not working during cloudy days	79.81633	I
2	Low farm income	69	II
3	Small land holding	65.89796	III
4	less area irrigate	59.97959	IV
5	delay in installation of solar pump	57.79592	V
6	problems of starter	53.22449	VI
7	high ground water	52.02041	VII
8	Inadequate subsidy	44.55102	VIII
9	Lack of demonstration	33.97959	IX
10	Lack of knowledge about solar pump	32.02041	X
11	compare to diesel pump	21.83673	XI
12	Maintenance problem	0.89795	XII

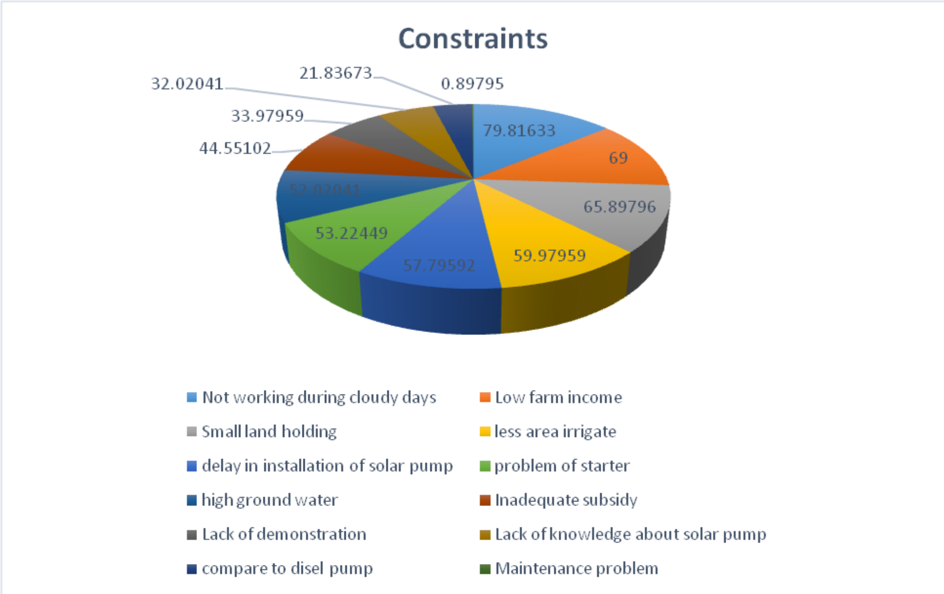

Fig. 3. Constraints faced by the respondents

4. CONCLUSION AND SUGGESTION

In the study area, many problems were identified militating against the adoption of solar pumps, such as Solar pumps not working during cloudy days, low farm income, small land holdings, irrigation covering a smaller area through solar pumps, and delays in the installation of solar pumps. Problems of starter, high ground water, inadequate subsidy, lack of demonstration, lack of knowledge about solar pumps compared to diesel pumps, and maintenance problems above the problems of "Solar pump not working during cloudy days", "low farm income", "small land holding," and "through the solar pump irrigation, less area was covered" were major constraints facing the sample farmers. In the area of study, solar pumps with low pumping capacity backed by water harvesting techniques and micro-irrigation can enable farmers to change their crop patterns to higher-value and more remunerative crops.

During cloudy days, the solar pump is not working. To overcome this problem, a battery charging system should be added with a solar pump. Traditional methods of water harvesting should be adopted and stored at a height of 20 meters for use on cloudy days.

Large farmers do not adopt solar pumps because of their lower discharge capacity. And solar pumps are costly, so farmers can’t install them without subsidies. But because solar pumps are renewable sources of energy, they overcome the electric and diesel problems. A solar pump is a renewable source of energy. So it does not affect nature. It is the best source of irrigation for future energy savings. It is required by the government to promote the use of solar pumps.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
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