Integrated Research and Action for Development (IRADe) — 20 Years

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Discussion Paper

Assam

IRRIGATION SECTOR

ENABLING STATE LEVEL CLIMATE MITIGATION ACTIONS

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1. Introduction

Irrigation is an integral part of agriculture. Access to water is a precondition for irrigation. Water can also be accessed through boreholes, or if the land is located close to a river or canal, lake or wetland, farmers can use this as a water source. Farmers are using three types of irrigation techniques. Flood irrigation is the most common one. This irrigation can be used for all crop types, and it usually requires little equipment and maintenance. Hence, this irrigation technique is an attractive option for smallholders, mainly for subsistence farming, where cash flows are limited. Sprinkler and drip irrigation is primarily used for high value due to the investments in equipment. Drip and sprinkler irrigation are technically more complicated than flood irrigation, and maintenance requires technical knowledge. Irrespective of the irrigation techniques and water source, extraction typically involves using a pump powered by diesel, grid electricity, or solar PV. Solar-powered irrigation systems are a clean technology option for irrigation, allowing solar energy for water pumping, replacing fossil fuels as energy sources, and reducing greenhouse gas (GHG) emissions from irrigated agriculture.

To this aspect, the objective of this work is to explore economically attractive approaches for the farmer to promote the adoption of the solar water pump (SWP) for irrigation in Assam. The slow adoption of SWP in the recent past establishes the need to understand better factors that impact farmers' irrigation options and research possible alternative strategies to promote SWP. In this analysis, we have developed an economic model of the variables influencing the costs and revenues of different irrigation pumps. However, beyond economic factors, there are other factors such as perceptions of solar pump performance and reliability vis-a-vis conventional pumps, availability of capital or different options available to farmers for capital finance, and the expected future grid connectivity that may impact a farmer's choice of irrigation techniques. To account for these non-economic factors, we have also integrated stakeholder perception in the analysis by capturing it through personal interviews.

The rest of the report is organized across several sections. In section 2, a brief background of Assam agriculture and the status of SWP in Assam. Section 3 estimates the required number of irrigation pump to meet the irrigation requirements of the farmers followed by section 4 compares the cost of irrigation using different (diesel, electricity and Sola PV) available irrigation techniques. Stakeholders' perceptions captured through personal interviews are presented in section 5. Business model for upscaling uptake for SWP in Assam is discussed in Section 6. Section 7 present the key findings emerging from the analysis and a set of policy recommendations to promote the adoption of SWP at a large scale in Assam.

2. Background of the selected State

Assam is situated in the North-Eastern part of India. It has a population of about 3.09 crores, and about 70% of the total population resides in rural areas[1]. The State has abundant fertile land and water resources with a total geographical area of 78,438 sq. km, out of which 98.4% area is rural. Assam shares about 2.4% of the country's total geographical areas and provides shelter to the 2.6% population of the country. Almost 27 lakh farmer families in Assam, about 67% have marginal farmers (Table 1).

Table 1. Classification of farm families in Assam

Classification of Farm Families (Agriculture Census, 2010-11)			
Class	**Landholding size**	**No. of farm families**	**Percentage of total farm families**
Marginal	Less than 1 hectare	1831115	67.31%
Small	1.0 - 2.0 hectares	496574	18.25%
Semi Medium	2.0 - 4.0 hectares	303528	11.16%
Medium	4.0 - 10.0 hectares	84869	3.12%
Large	10.0 hectares & above	4137	0.15%
	Total	**27,20,223**	**100%**

Source: Agriculture Census, 2010-11 [3]

Rice is the major crop in Assam, accounting for 60.87 percent of the total cropped area during 2015-16. Rice covered is about 24.95 lakh hectares. The rice crop in Assam is classified into three categories depending upon the crop harvest season, i.e., winter rice, autumn rice, and summer rice. Winter rice occupied the highest area (18.84 lakh ha), followed by summer rice (4.07 ha). Total cereals, including rice, wheat, and maize, occupied about 74.50 percent of the total cropped area in the State. Pulse accounted for 3.59 percent by occupying 1.47 lakh ha land.

Table 2. Cropping pattern in Assam (Area in lakh ha)

Crops	2003	2013	2016
Autumn rice	5 (15.89)	2.76 (8.92)	2.04 (6.61)
Summer rice	3.27 (10.39)	3.95 (12.77)	4.07 (13.19)
Winter rice	17.47 (55.51)	18.64 (60.27)	18.84 (61.05)
Jute	0.69 (2.19)	0.64 (2.07)	0.71 (2.30)
Rape mustard	2.69 (8.55)	2.57 (8.31)	2.82 (9.14)
Potato	0.79 (2.51)	0.93 (3.01)	1.02 (3.31)
Wheat	0.7 (2.2)	0.4 (1.29)	0.25 (0.81)
Black gram	0.4 (1.27)	0.5 (1.62)	0.53 (1.72)
Sugarcane	0.26 (0.83)	0.29 (0.94)	0.29 (0.94)
Masur	0.2 (0.64)	0.25 (0.81)	0.29 (0.94)
Total cereals	26.74	26.01	25.52
Total pulses	1.25	1.33	1.47
Total food grains	27.64	27.73	26.99
Total oilseed	3.38	2.79	3.04

Source: Directorate of Economics and Statistics, Assam

Note: Figures in parenthesis the percentage share to total crop area in the cropping season

There is good potential for agricultural growth in the State by increasing cropping intensity, raising crop yield, and diversifying into pulses and oilseeds through increasing irrigation capacity. Due to the uncertainties in the production of Kharif crop due to flood and high rainfall, the State Agriculture Department has laid greater emphasis on Rabi crops by assigning top priority in developing assured irrigation facilities through installation of Pump Sets (Shallow Tube Well (STW) & Low Lift Pump (LLP)[1].

Table 3. Number of STWs and LLPs Installed

Component of Irrigation	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	Total
Shallow Tube Wells	4463	17549	42320	102042	29310	38735	39496	55590	329505
Low Lift Pumps	6195	3462	5302	14867	500	9368	0	5066	44760

Source: Directorate of Agriculture, Assam

2.1. Irrigation system in Assam

As an agricultural state, Assam exhibits quite a different agro-climatic conditions, particularly in terms of water resources, compared to other parts of India. Brahmaputra and Barak's rivers are the two significant sources of water in Assam, which recharge the groundwater aquifer and various ponds and lakes. Assam has bountiful rainfall, which also restores the groundwater table. Figure 1 shows the monthly rainfall in Assam for the year 2015. The highest rainfall is in June and August. However, rain is very scarce during the rabi season, indicating the importance of irrigation.

Assam experiences flood almost every year during the rainy season. Table 2 shows that Autumn and winter rice which are the critical rice season, gets severely damaged due to flood. An FAO[2] study suggests scope for cropping area expansion by bringing the chronically flood-affected and deep-water rice areas under boro rice cultivation by creating irrigation facilities. The development of groundwater irrigation facilities in the flood-prone area will enhance the access to irrigation and reduce the occurrence of flood events by drawing down on aquifer through irrigation.

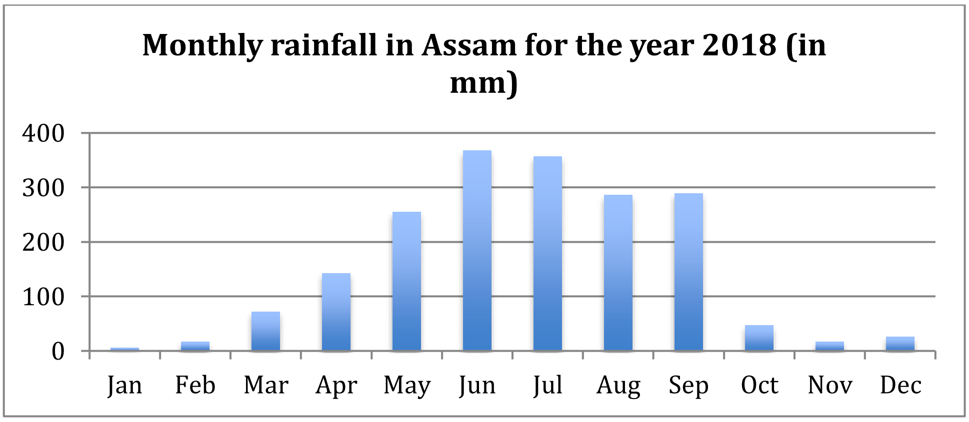

Figure 1. Average monthly distribution of rainfall of Assam in 2015

[1] https://diragri.assam.gov.in/portlets/irrigation
[2] http://www.fao.org/3/x2243t/x2243t07.htm

Source: Rainfall Statistics of India, IMD, 2018

About 80% of the groundwater is recharged from the rainfall during the monsoon season and the rest from the non-monsoon and other sources. The agriculture sector is the predominant consumer of groundwater resources. About 70% of the groundwater is extracted for irrigation purposes. As per CGWB, the net annual water availability in the State is 25.79 BCM, and the yearly replenishable groundwater resource is about 28.52 BCM[3]. Table 4 shows that the State had an irrigation potential of 11.27 lakh hectares (40% of the net cropped area). Only 7.33 lakh hectares (26% of the net cropped area) were under utilizable assured irrigation.

Table 4. Details of land use in Assam (2016) [8]

1	**Gross Cropped area**	**4075871 Ha**
2	Net Cropped Area	2817500 Ha
3	Irrigated area	748530 Ha
4	As of 31st March 2015, Irrigation potential was created in Assam	11.27 Lakh Ha (40% of the net cropped area)
5	The net cropped area brought under utilizable assured irrigation	7.33 Lakh (26% of the net cropped area)
6	Crop water demand	29065 MCM
7	Water potential requirement	29065 MCM
8	Existing water potential	9008 MCM

Source; Directorate of Agriculture

Assam has a unique indigenous irrigation system and water conservation system. In most cases, the water systems are managed by farmers or communities. The irrigation projects are primarily constructed and controlled by the government. However, in hilly areas, it is mainly minor irrigation. National Water Policy emphasized strengthening Water Users Associations (WUAs) in the State through providing financial support or awareness and capacity building (National Water Policy 2012)[5]. Each WUA has a committee for carrying out the activities of the WUA for three years.

Many farmers in Assam still depend upon rainfall directly for crop cultivation. In Assam, seasonal rainfall influences crop cultivation to a great extent. Further, the heavy rain during the Kharif season affects rice cultivation due to the flood. Barring monsoon months, the rest of the agricultural year is relatively dry [6]. According to a study by IWMI, shallow tube wells powered with 4-5 HP pumps formed a popular irrigation mechanism in the Kamrup district of Assam. This was an initiative by the government in the 90s, where large diesel pumps were supplied at subsidized rates[4]. However, this led to the issue of larger withdrawals of groundwater for growing paddy. This problem can be solved by selecting small pumps and irrigating crops in the non-Kharif season. However, in some regions where farmers could not afford the rising diesel price, they have opted to do off-farm work or leave their land to the large farmers (as sharecropping)[7]. At present, the government of Assam has introduced a solar pumping system under the "The Rural Infrastructure Development Fund (RIDF)" to

[3] http://cgwb.gov.in/State-Profiles/Assam.pdf
[4] https://publications.iwmi.org/pdf/H041807.pdf

install SWPs for irrigation. However, there remains a sizeable gap between the potential and availability of irrigation facilities in the State.

2.2. Present policies and schemes for irrigation

The Assam government has come up with several new plans and programmes for the State's agricultural sector. In the year 2018, the government implemented the surface minor irrigation scheme named "**Har-Khet-Ko-Pani**" (HKKP) under Pradhan-Mantri-Krishi-Sinchayee-Yojana (PMKSY). The primary objective of HKKP is to create new water sources through Minor Irrigation (both surface and groundwater). Under the HKKP program, 2344 Solar and 2435 electric in phase 1 and 3862 solar and 11288 electric pumps in phase 2 were provided to the farmers with an outlay of 246 and 896 crores, respectively. In phase 1, 18,577 farmers had 19 116 hectares of land, and in phase 2, 17,216 farmers with 19,664 hectares were covered. Erratic power supply in rural areas is also a challenge hampering irrigation. Under the Borlah scheme, a pilot project was initiated to provide farmers with solar-powered deep tubes. The project covered about 30 ha at Borlah near Hajo[8]. The Rural Infrastructure Development Fund (RIDF) is utilized to install STW using Solar PV for irrigation. The fund commenced in 2016-17 has a target to implement 1 Lakh Shallow Tube Wells" and "10,000 Solar PV Powered STW will be implemented. Under this, small or marginal farmers or groups with a minimum of 2 hectares (15 bighas) of contiguous cultivable agricultural land shall be eligible for subsidy [12]. Subsidy for solar-powered STW includes 50% of the total cost of STW civil work and 85% of the solar PV set[5].

The present policies indicate that the government has given lots of effort to provide irrigation to rural areas. However, only 15% of the total agricultural land is under irrigation. Hence in this study, we will assess the potential of solar irrigation in Assam, considering the present irrigation scenario. It will also look into the state policies to install solar PV pump set and their impact on the environment.

[5] http://www.rkvyassam.in/ridf/RIDF-Guideline.pdf

3. Irrigation pump requirement in Assam

This section estimates the number of pumps required based on efficiency, area, crop water requirement, and crop cycle in Assam for irrigation. The study utilizes both qualitative and quantitative methods. The qualitative method includes interviews with Assam researchers, solar developers, farmers, and policy makers. Farmer's interviews were conducted telephonically. A selected number of farmers who have installed the solar pump in their fields were interviewed for their experiences with solar water pumps. This section provides information on the data collection process analysis of electric and diesel pump usage.

3.1 Pump sizing and number of pumps required

Water requirement for crop production: for this study, we developed an economic model to assess the annual cash flow for croplands irrigation depending upon crop cultivation under different pump capacities and government schemes. The model is an MS-excel-based model based upon different physical, geographical, and economic factors. To calculate the water requirement for crop production, we used the formula specified by ICAR[6], which is given below:

$$\text{Water requirement (WR)} = A \times C_r \times W_c \qquad (1)$$

Where,

WR= Water requirement (cu.m)
A = Cultivated area (in hectare)
C_r = Crop cycle (days)
W_r = Water requirement for crops (in mm)

To calculate the water requirement for each crop, we assumed that the area cultivates about 4 ha. However, to assess the number of diesel pumps, we assumed the cultivated area to be 4 ha the land size holding of farmers in Assam, which is given below:

Table 5. Land size holding, area, and number of landholdings in Assam

Landholding size		Number of land holdings	Area (ha)
Marginal	(<1)	1860000	785000
Small	(1-2)	495000	696000
Semi-medium	(2-4)	295000	806000
Medium	(4-10)	79000	410000
Large	(>10)	4000	279000

Source: Agricultural Statistics, 2018-2019

Rice is one of the major crops cultivated in almost all the parts of Assam. The water required for each crop is taken from a report published by Assam Agricultural University (AAU) [13]. The crop water requirement (in mm) data considers the rainfall water and the type of existing agriculture in Assam.

[6] http://www.iiwm.res.in/pdf/Bulletin_67.pdf

3.2 Estimation of irrigation pump size

The size of a pump exclusively depends upon the flow rate required to meet the irrigation needs for an agricultural field. The flow rate is estimated as the maximum flow needed to complete a crop's water demand within a given time period, which is determined by the number and duration of irrigation periods in a crop's growing cycle. We considered it the optimum water requirement in the whole cycle of crop cultivation in a year and assumed that each irrigation cycle requires the same amount of water. Thus, the pump flow rate is calculated by using the equation given below:

$$\text{Pump flow rate (Q) (m}^3\text{/hr)} = \frac{Area\ (ha) \times water\ requirement\ (Wr)}{Crop\ cycle\ (Cr) \times Hours\ of\ pumping\ (hrs)} \qquad (2)$$

The pumping hour for our calculation is assumed to be about 6.8 hrs[7].

Finally, assuming the pump efficiency to be 75% and the motor efficiency 65%, with a head of 16m, using equation 3[8], we calculated the pump size.

$$\text{Pump size:} \frac{Pump\ flow\ rate \times head \times Specific\ gravity}{3960 \times Pump\ eff. \times Motor\ eff.} \qquad (3)$$

Based on our interview with stakeholders, we found that the civil cost for boring is about Rs. 2.5 lakhs. The approximate cost of the solar PV panel set is about Rs. 85000 per hp. By including the subsidized amount given by the government, we calculated the total cost of the whole model.

3.3 Operating cost of diesel-powered irrigation pump

Ranganathan et al. [14] methodology was adopted to assess the diesel usage for irrigation in Assam. From the CACP data, we identify the farmers using diesel pumps for irrigating different crops. There are four crops produced in Assam, namely, paddy, potato, rapeseed, mustard oil, and jute. Paddy and potato are mostly irrigated out of these four crops [15]. Then we identify the number of hours the diesel pump was used during cropping. Thus, assuming the average efficiency of a pump with a power rating, we assess the amount of diesel required to run the pump for a scheduled time. Following, we multiply the diesel usage with the average cost of the diesel to estimate the amount of money spent by the farmer. The flowchart of the methodology is given below:

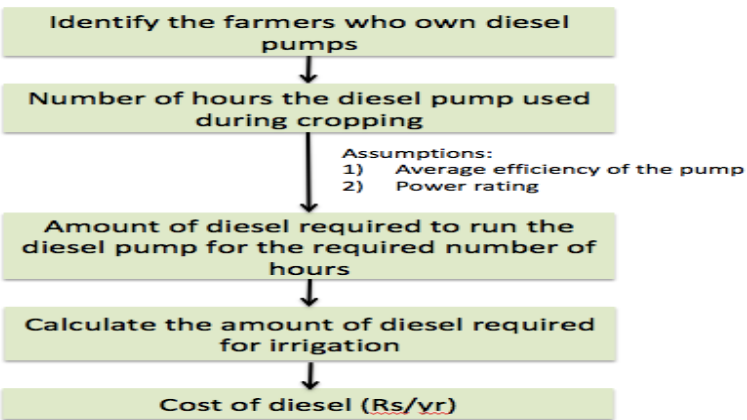

Figure 2 Flow Chart of Methodology

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7 https://www.villagesquare.in/2017/05/10/solar-pumps-bring-relief-smallholder-farmers-rayagada/

8 http://riograndewater.org/media/1064/b-6011-calculating-horsepower-requirements-and-sizing-irrigation-supply-pipelines.pdf

3.4 Pumps required to irrigate the agricultural field in Assam

The size of the pump used in irrigation depends upon parameters like crop cycle days, type of crop, and area cultivated. The farmers in Assam irrigate their land for paddy, potato, and mustard crops. Table 6 provides the estimates of water requirements to irrigate 4 ha of farmland, where crops like paddy, potato, and mustard are cultivated during the Kharif, Rabi, and winter seasons.

Table 6. Season-wise crop cultivation in Assam and the required water

Seasons	Crops	Crop cycle (days)	Area (in Hect)	Water requirement of crop, total (in mm)	Water required (cu.m)	Water required (cu.m/day)
Kharif	Paddy	120	4	300	12000	100
Winter	Paddy	100	2	1250	25000	250
	Potato	120	1	700	7000	58
	Mustard	90	1	200	2000	22
Summer	Paddy	120	4	300	12000	100

We calculated the number of pumps required for different cropping seasons concerning the landholding size. Assuming the model pump size of 3 hp, we found that the maximum number of pumps is needed for the autumn season. The reason behind this is the large amount of land involved in the autumn cropping season. Figure 3 shows that the maximum number of pumps required is for farmers holding marginal and small farmers.

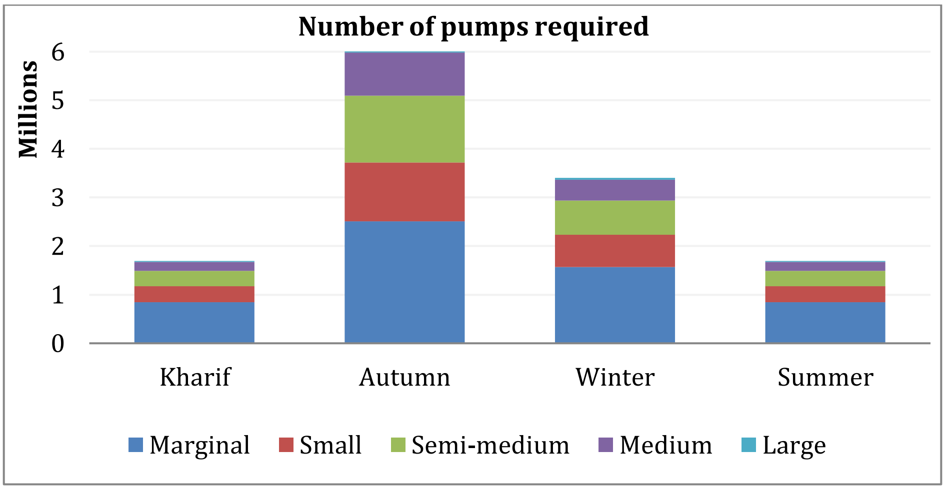

Figure 3. Number of pumps required in Assam

4. Comparing the cost of different irrigation systems

Presently, Assam uses three types of pumps: diesel, electrical and solar. There is a considerable variation in the three pumping systems' technology, efficiency, and costing. Thus, in this section, we compared different pumping systems considering the output and maintenance involved. This included operating costs (diesel consumption, electricity), maintenance costs (machinery, labor, etc.), and replacements (diesel engine, electrical pump, motor, and solar pumps). This analysis provides an insight into the overall cost incurred over the project life of the irrigation system. The critical parameters considered in the calculations are given below:

a) Pump specification: Head and flowrate
b) Capital cost
c) Operating cost
d) M&R cost

4.1 Pump specification

The sizing of the pumps is based on the head, area, and the crop area cultivated. The diesel pump is sized by calculating the actual power required to lift water i.e.

$$\text{Hydraulic power (W)} = \rho \text{ (roh)} * g * \text{head} * \text{flow}$$

Where ρ (roh) = density of water (kg/m^3)

g = gravitational acceleration (m/s^2)

head = total dynamic head (m)

flow = flowrate (m^3/s)

4.2 Capital cost

The capital costs occur once in a lifetime of the project. It consists of the cost of the pump and its relevant accessories, and the installation. The solar pump cost is taken from the standardized price provided by MNRE for North-Eastern states. The electrical and diesel pump cost is taken from the manufacturer's list. Here, we have considered the Kirloskar pump.

4.3 Operating cost

The operating cost for each pump is different, as it depends upon the energy source it is using. In the case of the diesel pump, the liters of diesel consumed per annum is calculated from the running time of the diesel pump. The fuel cost is considered constant along the project's lifetime. In the case of the electric pump, the energy source is viewed from the grid. The cost of the electricity is taken from the electricity board of Assam.

4.4 Maintenance and Replacement cost

The maintenance and replacement cost of the pumping system is evident in all the three-pumping systems. The M&R cost depends upon the maintenance schedule, type of pumps, and technology. The replacement schedule depends on the ruggedness of the system, operating environment, and the level of maintenance performed.

4.5. Life cycle cost comparison of three available irrigation techniques

The life cycle costs of different pumping systems are shown in figure 4. We have considered that at the end of every 5 yrs pumps require a substantially large amount of capital for repair and maintenance. The cost is high in the 6th and 11th years. It can be seen that the LCC of the solar pumping system increases every five years due to the maintenance charges. The LCC analysis of the three readily available irrigation pumps suggests that diesel pumps have a very high operating cost, followed by electric pumps.

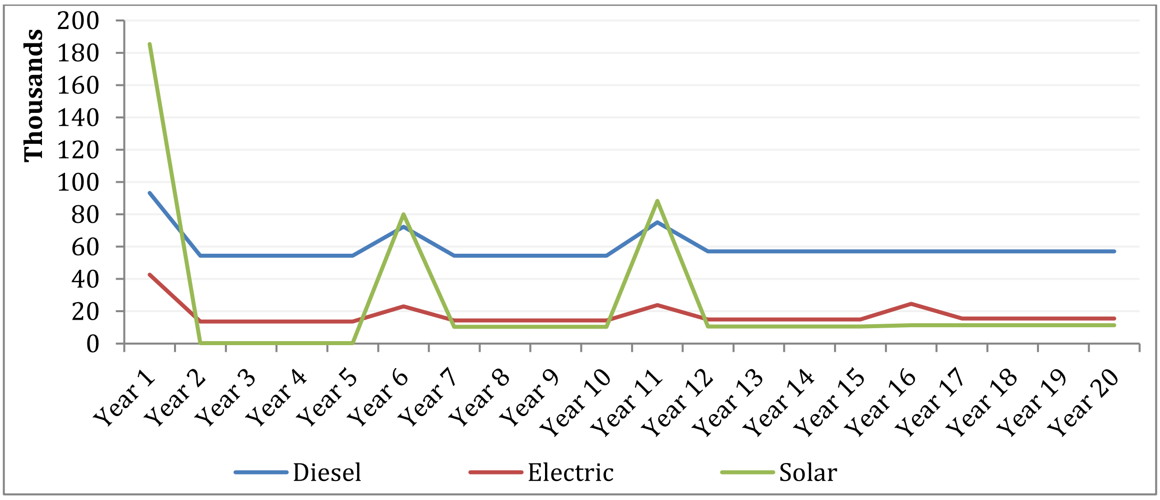

Figure 4. Life cycle cost analysis of diesel, electric and solar pump

The average annual irrigation cost (includes capital, operation, and maintenance costs) for five hp or equivalent capacity Solar, electric, and diesel pumps is Rs. 26,770. 28,098 and Rs. 54,443 respectively. The solar pump is a commercially more economical option for the farmer. Electric pump, the other best alternative for the farmers, requires an extension of grid infrastructure to the agriculture field.

5. Farmer's perception about solar pumps

There is a general perception among the farmer that solar is a good and viable irrigation solution while they think it is beyond their reach. There is a gap in farmers' understanding of the operation and maintenance, any financial support mechanism to procure the pump etc. land holding of farmers is fragmented. End-user economic linkage is entirely missing. There is a need to have state-specific policies to promote the transition from traditional (diesel or electric) pumps to Solar water pumps. Bring SLDC to monitor end-user finance for the water pump. A commercial bank or other financial institutions are not forthcoming to finance solar water pumps.

In the last few years, farmers in Assam have used electrical pumps. The problem with electric pumps is that there is inconvenience in irrigation due to irregular electricity supply. The farmers cultivate rice in the rabi season, which requires good irrigation. Unavailability of electricity supply or lack of electric transformer maintenance in case of break down forced them to use diesel pumps.

The government has started schemes for solar PV pumps set to farmers in Assam. However, the scopes of those schemes are very limited, and only a small number of farmers can get solar water pumps under the system. Farmers have given positive reviews after using solar PV pump sets. The pumps can range from 5 hp to 20 hp with 960 rpm. The solar PV pump sets are mostly subsidy-driven, making it easier for farmers to buy. The government provides solar pumps sets to a group of farmers, managing the water distribution timetable among themselves. The farmers deliver their land to the government for solar panel installation.

6. Business Model Scenarios for Potential Up-scaling of Solar Pumps in Assam

The acceleration of the SWP in Assam can be facilitated by creating enabling frameworks that include a supportive institutional, innovative financing schemes and a viable market-driven mechanisms. Increased access to irrigation water is based on a need to increase water supply to smallholder farmers for irrigated agricultural production. The business models can be viewed from the perspective of an individual farmer (or group of farmers) or a supplier (e.g., solar pump service provider). We propose three models: 1) Individual purchase, 2) Community irrigation model, 3) Irrigation entrepreneur model.

6.1 Individual purchase

The business model is designed for a standalone SWP where a farmer invests in a pump for agricultural production. This model will be suitable for the farmers having shallow ground water region. The model assumes that farmers is be motivated to invest in solar irrigation technology, if it will maximize the farmers profit from the farming. In addition to generating income from crop sales, farmers can consider selling excess water to neighboring farmers. Since water for irrigation is only needed for a certain number of hours per day, using the solar pump to abstract additional water for sale could be a way to increase the use of the solar panels. Thus, instead of matching the amount of solar power generated to meet the maximum ('peak') irrigation pumping needs, the solar power generation could match the demand of nearby farmers.

Financing and government upfront subsidy to promote the clean energy for irrigation will minimize the effective cost of acquisition for the farmer. Financial institutions may come forward to provide loan to the farmer against the SWP at a concessional rate. Policies to set lower interest rate ceilings would reduce farmers' capital investment costs and likely catalyze the adoption of solar pump irrigation.

6.2 Community irrigation model

To address the capital investment challenge faced by most smallholder farmers, the business model can adapt to a cost-sharing model where a group of farmers pool their funds to invest in a solar irrigation pump. The inherent sustainability driver for a cost-sharing model is mitigated investment risk for individuals. Joint partnership investments allow smallholder farmers a better negotiation for lower interest rate loans from financial institutions. All the farmers having their respective land parcel situated in such a way that a SWP can cater their farms without requiring much additional capital expenditure on pipe for transportation of water.

6.3 Irrigation entrepreneur model

This is a pay-as-you-go (farmers pay for use) model and supplier/entrepreneur retains ownership and responsibility for maintenance. Under this model farmers do not have to arrange the capital for SWP. Solar irrigation is the cheapest technology among the available options therefore, farmers may also benefit by getting water at relatively cheaper rate.

7. Key Findings

Solar irrigation has enormous potential to provide cost-effective and reliable irrigation solutions to farmers relying heavily on polluting diesel and subsidized electricity. A shift to solar irrigation will help reduce air pollution and GHG emission to support country climate commitment. Our analysis found that solar water pump is an economically more viable option for the farmers in Assam. In Assam, we have many small and marginal farmers who would require irrigation pumps. This group of farmers generally don't have the financial strength to purchase capital-heavy irrigation pumps. The costs-benefits analysis of the irrigation system as a whole suggests that farmers generally profit from using SWP. Given the potential benefits of solar pumps, this report proposes three business model scenarios based to supply water to smallholder farmers for irrigated agricultural production. It describes the benefits to be gained from the different scenarios, noting that direct farmer purchase of solar pumps is feasible, but community irrigation and irrigation entrepreneur offer promising alternatives. However, given the limitation of factors considered in this model, the business model scenarios should be analyzed further to consider context-specific viability. At present, farmers, governments, private sector actors and development investors show much interest in solar pump irrigation as a solution to improving food security and resilience. That interest needs to be matched with systematic study and business models that support the expected outcomes.

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Annexure 1

District-wise Number of WUAs formed upto31/03/2016[9]

Sl.no.	District name	Number of WUAs formed		
		Registered	**Unregistered**	**Total**
1	Barpeta	35	23	58
2	Bongaingaon	12		12
3	Chirang	5	9	14
4	Cachar	33	7	40
5	Darrang	44		44
6	Udalguri	14	15	29
7	Dhemaji	7	9	16
8	Dhubri	52	20	72
9	DIbrugarh	28	11	39
10	Goalpara	49	17	66
11	Golaghat	49	17	66
12	Hailakandi	23	4	27
13	Jorhat	59	64	123
14	Kamrup	65	65	130
15	Kamrup Metro			
16	Baksa	10	16	26
17	KarbiAnglong	16	32	48
18	Karimganj	6	4	10
19	Kokrajhar	30	14	44
20	Lakhimpur	3	23	26
21	Morigaon	45	30	75
22	Nagaon	121	58	179
23	Nalbari	5	86	91
24	Dima Hasao		37	37
25	Sivasagar	41	18	59
26	Sonitpur	31	38	69
27	Tinsukia	21	5	26
Total		**794**	**613**	**1407**

9 https://irrigation.assam.gov.in/sites/default/files/swf_utility_folder/departments/irrigation_webcomindia_org_oid_3/do_u_want_2_know/wuas.pdf