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Low-Cost Mobile Solar Operated Lift Irrigation System: A Case Study

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Abstract

Effective and judicious use of irrigation water contribute a lot for the management of crop growth and increase in productivity. In the light of increasing demand for irrigation in the state of Assam and to cover the non irrigated area as well as to continue the supplies for the irrigated command area, it becomes imperative to look for a holistic and people centric Low Cost Innovative Irrigation technique. Irrigation water can be assured at every crop field provided we set our mind and put concerted efforts to address it. This paper highlights the Irrigation scenario in Assam with a case study on Low Cost Solar Operated Mobile Lift Irrigation in Assam(India),for its continuance and contribution towards growth in Agricultural Productivity. This innovation in Irrigation Sector can cause social transformation by bringing in the development of Agriculture and other allied Sectors. An attempt was also made to establish the economic and operational benefits of the system by making a comparison amongst the different lift Irrigation Schemes in the State. The Study advocates for utilization of the non conventional solar energy for irrigating the multiple crops by lifting the surface water sources in the State by using the Low Cost Solar Operated Mobile Surface Lift Irrigation System. The paper also presents the financial analysis and key performance indicators of the system with a highlight on its diversified application for disaster preparedness and mitigation on the part of Stakeholder Departments with a primary aim to increase irrigated agriculture productivity..

Keywords: Agriculture, Surface Water, Ground Water, Irrigation Potential, Solar Power, Productivity, Cropped Area)

Introduction:

The Brahmaputra and the Barak along with numerous tributaries contribute the rich surface water resources of North Eastern Region of India, particularly Assam. The ground water availability and extraction in the state of Assam(India) are presently under safe category. Land use pattern in Assam indicates that out of the total geographical area of 78.50 lakh hectares, the Gross Cropped Area of Assam is 38.88 Lakh hectares during 2022-23. Against this, the ultimate irrigation potential i.e. the ultimate Gross Irrigation Potential (Annual Irrigable Area) has been estimated about 27 Lakh hectares (net sown area) which constitutes 69.45 percent of Gross Cropped Area. Out of the estimated ultimate irrigation potential of 27 Lakh hectares, State Govt's plan is to irrigate 10 Lakh hectares through Major and Medium Irrigation Projects from Surface Water Sources and 17 Lakh hectares through Minor Irrigation Schemes which include both Surface Water lift or Surface Flow (Estimated IP: 10 Lakh hectares) and Ground Water Lift Irrigation Schemes(Estimated IP: 7 Lakh hectares).

The development programme for improvement of Irrigation facility in Assam has been taken up under two broad heads, namely 1.Major and Medium Irrigation and 2. Minor Irrigation. While the Irrigation Schemes are broadly classified as Major, Medium and Minor, they are sub categorized as Surface Flow, Surface Lift(for Major/Medium and Minor) and Ground Water lift (for Minor only).

Irrigation Scenario in the State:

Out of 27.00 Lakh Hectares of net sown area in Assam, till March 31,2023, the State Government has created a gross irrigation potential of 10.24 Lakh hectares (AIA) through 18 Major/Medium(14 Flow Irrigation Schemes and 4 Lift Irrigation Schemes) with a creation of 2.74 Lakh hectares and 3864 Minor Irrigation schemes creating 7.50 Lakh hectares. Till Marh 31,2023, 7.51 Lakh Hectares of Net Irrigation potential had been created out of Ultimate Irrigation Potential of 27 lakh hectares. Out of 3864 Minor Irrigation Schemes, 1992 nos. are Flow, 622 nos. are Lift, 1037 nos. are Deep Tube Wells and 213 nos. are Shallow Tube Well Schemes.

As a part of green and climate friendly initiatives, the State Irrigation Department, during 2021-23 installed 9662 nos. of Tube Well points (Solar 3587Nos. & Electrical 6075Nos.) in two phases under Pradhan Mantri Krishi Sinchayee Yojana-Har Khet Ko Pani (PMKSY-HKKP) creating irrigation potential of 38,648Ha.

Lift Irrigation Projects:

In Assam, 622 Surface Lift and 1659 Ground Lift Irrigation Schemes including the one with 9662 Tube well points installed under PMKSY had been developed till 31 July, 2023, creating about 2.0 lakh Irrigation potential in the state . All the Surface Lift and maximum of Ground Water Lift Irrigation schemes are electrically operated and are very useful in providing assured irrigation for sustaining the multiple cropping. Electrical Lift Irrigation Schemes are dependent on reliability of Power Supply and are often associated with periodical maintenance issues which require timely interventions to sustain the Irrigation Supplies during cropping season. Moreover, during the idle period, the Water Users have to bear the financial burden for payment of rental charges for the Power reserves that were sanctioned for the electrical installations , mostly for the tube well and lift points . Further, the electrical installations require continuous maintenance for proper upkeep and functionality. Therefore, considering the increasing maintenance as well as the operation cost associated with consumption of electricity in the Irrigation Schemes, it has become an essential need of the hour to tap the nonconventional green solar energy and use it for operating the Lift Irrigation System to be designed as the Low Cost and water use efficient system.

Ground water scenario in the state is so far in the safe zone. Presently the Ground Water Draft is 12.38% with a total extractable Ground Water availability of 21.40 BCM whereas the total potential is 26.53 BCM. Considering the abundant surface and ground water potential in the state, eco friendly solar operated lift irrigation system may be developed to ensure multiple cropping. The following case studies illustrate the viability of Low-Cost Solar Operated Irrigation Systems in the State.

Low-Cost Solar and Electrically Operated Ground Water Irrigation Scheme:

The Low Cost Solar Operated Ground Water scheme comprises of a tube well assembly that draws ground water from a shallow depth within 45 m bgl with the help of a solar operated submergible pump of 3 HP capacity. PVC ribbed screen filters of 150mm OD are used at suitable depth of water bearing

stratum for the bored well to give an average yield of 0.25 cusec (7 lps). A set of 9 nos. of solar panels, each with 330 W rated capacity, are installed on a Galvanized MS framed sections, supported on a RCC column. The solar panel assembly generates DC power of 3000 Watt considering 7.15 kWh /sq m /Day under standard test condition on horizontal surface with tolerance (+, -) of 15% . DC power gets converted to AC output the help of a converter fitted in the Control Panel. Depending on the available sunshine hours, the tube well can be operated to give an average output discharge which is conveyed to farmers' fields to irrigate about 4 hectares of cultivable land (CCA) and average AIA may be 12 hectares based on consideration that 3 crops are grown in the command area of each tube well point .The cost of development of such a well is about Rs 6.0 lakh i.e. @ Rs 1.50 lakh/hect of CCA or 0.5 Lakh/ hect of AIA.

Similar tube wells may be constructed at other locations where the electricity is readily available for 24 x 7. Ground Water from such tube well, drawn by 3 HP submergible pump requires an installed Electrical Power of 3KW. The yield of the tube well may be same as 0.25 Cusec under stabilized Electrical Voltage. The Average Cost of Electrical Tube Well may be Rs 5.9 lakh. Fig 4.1 shows a solar operated tube well irrigation scheme in a farm field of Assam (India).

The merits and demerits of Solar and Electrically Operated Tube wells are given in Table 4.1

Sl No	Indicators	Solar Tube Well	Electrical Tube well
1	Cost/ No	Rs 6.0 Lakh	Rs 5.9 Lakh
2	NIA/No	4 Hect	4 Hect
3	Power	3.0 KW	3.0 KW
4	Operational Flexibility	5-6 Hrs. of Operation subject to Sunshine Radiation	24 Hrs. of operation subject to availability of Power
5	Recurring O & M Cost /No/Month	Nil	Rs 3000- Rs 5000
6	Benefit Cost Ratio at 10% annual rate of interest	1.91	2.71
8	Environmental Aspects	Green Energ., Eco-Friendly	Electrical Lines pose a risk to Lives
9	Revenue Generation	Contributes to generation of electricity that may be put on Power Grids	No Revenue Generation
10	Other Uses	May be used for illumination and small-scale industry during idle Period	May be used for other purposes against payment of Electric Charges

Table 4.1: Comparative Statement: Solar & Electrical Tube Well for a bored depth of 45 m with 150 mm dia PVC Casings/Filters

Literature Survey and Background Study :

R.Nandhini. et al. [4] highlighted the importance of automation techniques for effective water

efficient irrigation system. The survey by the Bureau of Electrical Energy in India (2011) [6] reveals that there are around 18 million agricultural pump sets and around 0.5 million new connections are installed every year with average capacity of 5HP. Total annual energy consumption in agriculture sector is 131.96 billion KWh (19% of total electricity consumption). Durai, CR [7] presented an overview of a system utilizing solar power for irrigation purposes with Soil Moisture sensors

Sl. No	Item Description	Solar Tube Wells	Electrical Tube wells
1	Cost	Rs 6.0 Lakh	Rs 5.9 Lakh
2	NIA	4 Hect	4 Hect
3	Power	3 KW	3.0 KW
4	Operational Flexibility	5-6 Hrs. of Operation subject to Sunshine Radiation	24 Hrs. of operation subject to availability of Power

recording the water content of the field soil and giving the information to the user via the GSM module through SMS, thereby the system controls the water pump/motor to regulate the supply to the field. This system, however lacked the facilities for pesticide spray to the field. Therefore, solar powered irrigation technique with time to time updated innovative technological features is the future for the agriculture farmers and an alternative reliable solution for energy crisis situation. So for current irrigation scenario in the state of Assam (India), the new innovative solar mobile irrigation technique, as outlined below, can be an easy and low cost irrigation solution to the farming community.

Solar Powered Mobile Lift Irrigation Scheme: System Description

It is a Lift Irrigation Scheme where the Pumping System can be moved easily from one place to other, to irrigate the farm land for raising crops. The Pumps are mounted on a floating platform, supported on UPVC Barrels with the solar panels mounted as roof, on MS Angle posts fixed on the base plates of the platform. Size of the platform can be increased easily based on the design requirement of the Pumping System. Self-priming DC surface Pumps are used to allow maximum running hours for operation in a day. Remote Monitoring System (RMS) integration is also made to allow real time monitoring of the system in terms of operational voltage, discharge, current and time (hours) etc. The system, being very light in weight, floats quite easily and is very cost effective. Unlike the conventional electrically operated Lift Irrigation schemes with stationary Pump house, where there are risks due to flood damages, this non-conventional system mitigates the damage risks due to seasonal floods. Fig 6.1 shows a Solar Operated Mobile Lift Irrigation scheme installed on a natural surface source near Guwahati in Assam (India).

Fig 4.1 : Solar Powered Tube well Irrigation Scheme

Fig 6.1 : Solar Powered Mobile Lift Irrigation Scheme(LIS)

Salient Features: The salient features of a solar powered small Mobile LIS showing the detail configuration of Pump, Solar Panels and Floating Barge etc. are presented at Table 5.1 below.

Table 5.1: Specifications of a small Mobile LIS

Sl. No	Technical Specifications	Pump Specifications	Barge Design Specifications	Advantages of a DC Surface Pump
1	Size of Platform: 4m x 3m	Type: DC surface pump	Size (L x B) : 4 m x 3 m	1. DC pump is more efficient than AC pump because it can be operated with lesser number of solar panels 2.DC solar pump has longer life as it uses motor coils, manufactured from pure copper. 3. Zero energy costs provide a very fast return on investment 4. Longer pumping duration
2	Load capacity of Barrel Barge: 3800 kg	Power: 3 HP / 2.2 KW	Capacity: 3800 KG	
3	Solar Panel Capacity: 3300 W (10 nos. of PVC panels)	Pump Head: 20 meter	Number of Barrel: 20 Nos.	
4	Pump: 3 HP, DC surface Pump	Voltage: 230 V	Material used: MS sheet of 5 mm size	
5	Discharge: 700 LPM	Current: 9 A	MS Angle of Assorted size	
6	Command Area: 6-8 Hectares (From a single suction point)	Delivery: 3 inch	GI Pipe	
7	RMS: Yes	Pump Make: Standard (Sileaf/Kirloskar/KSB etc.)	MS flat	
8	Mobility: Yes			

Key Highlights / Novelty of the Project:

The key performance indicators (KPIs) of a Solar Operated Mobile Lift Irrigation Scheme are -

- Low Cost of Construction .
- Low Maintenance Cost.
- Ease of installation.
- Eco friendly System .
- Anti-Theft Protection
- Remote Monitoring System.

Table 5.2 : KPIs and flexibilities of a typical Mobile Solar Irrigation Scheme.

Sl. No	Low-Cost of Construction	Low Maintenance Cost	Ease of installation	Eco-friendly	Anti-Theft Protection	Remote Monitoring System
1	Use of low cost UPVC Barrels	Powered by Solar Panels, No additional operational cost. Return of investment is very good.	Entire set up can be assembled in an hour manually .	Use of solar Panels and recycled barrels make it eco-friendly	As the system uses DC pump , it can't be used for any domestic or other industrial purposes, thereby reducing risk for thefts .Provision may be made to emboss the Solar Panels and branding. Install Motion sensor CC camera for live monitoring of the pump	IoT based Remote Monitoring System, can be installed in the Barge/ Pump Controller. The schematic data can be linked directly to the Digital Web portal, providing a transparent, clear image/documentation of delivery of service.
2	Fabrication can be done easily at workplace	In case of damage, replacement of barrels is easy and does not require high skills.	Size of the platform along with complete set up can be increased easily as per Pump Sizes.			
3	Can be transported to the location and Maneuver.					
4	No separate supporting structure needed as panels can be easily mounted on the Super-structure of the barrel barge platform.					

					station.	

Other Benefits:

During flood, the Floating Barge can be used to carry men and materials here and there. The Solar Panels can provide power to the relief camps for pumping and other purposes. Portable RO system can also be installed on it to supply pure drinking water to the people affected during the flood. Solar operated Mobile LIS may be introduced to provide irrigation facility to the farmers in flood prone remote areas, where there is availability of water in surface tanks/ponds etc but no readily available electricity to lift water. As the system makes use of solar power to operate, it reduces the operational cost . Depending on the needs, its capacity may be increased to the required level and thereby help in dewatering and thus mitigates the problem of water logging. As the complete set up is flexible and modular in nature, we can easily increase its size and number. Its mobility allows to pump out the water from different suction points. Considering at least 3 to 4 suction points by a single moveable scheme, the total command area will get multiplied accordingly. The scheme can easily be integrated to capture the water content data from Soil Moisture Sensors in the field and accordingly regulates the Pump to supply required irrigation water to the crops. Adding distribution system and integrating Drip/ Sprinklers (Smart Irrigation System) to the Mobile LIS will facilitate the system to increase the Water Use Efficiency by about 30-40%, thereby reducing the Capital Expenditure.

Comparison of different LIS:

The following table shows the comparison among different type of Ground and Surface Lift Schemes**.**

Type of LIS	CCA (Hect)	Discharge (lpm)	Power Source	Mobility	Project Cost(lakh)	Cost/Hect	Remarks
Hybrid STW (Solar & Electrically Operated)	4	400	Solar/Electrical	No	10	2.5	In the long run, Borehole may require redevelopment
Surface Centrifugal (20HP)	6	3600	Electrical	No	160	4.0	Includes cost of canals etc.
Mobile LIS	8	700	Solar	Yes	6.8	0.85	By shifting the pumping location to other points, CCA may be increased 3 times

The above data implies that the Mobile LIS is very cost effective with no Land Acquisition issues . The number of units may multiply as per actual requirements.

Financial Analysis:

Benefit Cost Ratio: For a selected cropping pattern of Sali Paddy, Early Ahu, Mustard, Potato, Pulses, Rabi Vegetables etc. in a cultivable area of 8 Hectares with a 150% of cropping intensity, the B C ratio was calculated at price level of 2023-24 and it was found that at 5%,10% and 15% of Interest Rates, the corresponding values of BC Ratio are 6.86, 5.57 & 4.52 respectively.

Net Present Value (NPV) and Expected Commercial Value (ECV): Considering a total capital cost of Rs 6.80 Lakh with a maintenance cost @ 10% of Project Cost per year and the value of additional yields due to benefits of scheme was found to be Rs 8.1046 Lakh as assessed for the selected cropping pattern on a cultivable area of 8 Hectares. The NPV assessed for the project life of 15 years comes out to be Rs 412.29 Lakh and Expected Commercial Value (ECV) is found Project is Rs 302.12 Lakh.

Action Research:

As an experimentation, a field trial run with the Solar Mobile LIS, powered by a 3 HP pump was made to lift water from a natural water body in a study area nearby Guwahati, Assam (India). By making use of WARABANDI system, the scheme was found to benefit a total about 9.5 Hectares of land belonging to 4 farmers for the period 31/03/ 2023 to 31/1/2024. Total pump operation during the period was for 496.45 hours. Daily Average of pumping by the scheme was for 3 hours 30 minutes. As the farmers were using the system locally with an ease of operation and flexibility, practically there was no any operational and maintenance cost for the scheme.

Conclusion:

Application of Solar Power in Irrigation Sector can create a remarkable growth in Agriculture Productivity due to less humane effort, easy monitoring by remote control configuration with mobile phones . It is a good and reliable alternative solution to sustain crop yield during energy crisis situations. Solar Powered Mobile LIS is quite cost effective, flexible, sustainable, user and eco-friendly. It is recommended to consider more installation of this type of schemes to cover maximum cultivable area for assured irrigation, which will not only increase the Agriculture Productivity of the farmers but also contribute significantly in catering to the water needs of fish farmers to promote the fish production. Moreover, the low-cost innovation technology would also boost the development of small-scale industry in Animal Husbandry and Dairy Sector. Especially in flood prone areas**,** the Mobile LIS may be useful for relief distribution, dewatering, meeting the power needs for street lighting, internet and mobile connectivity etc.

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