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India’s Irrigation-Energy Nexus: Examining the Potential of Solar Water Pumps in Transforming Agriculture

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India's Irrigation-Energy Nexus: Examining the Potential of Solar Water Pumps in Transforming Agriculture

Akshita Sharma

Given the developing prospects of SIPs for India's sustainable future, this issue brief studies the potential and viability of SIPs in solving the perverse nexus between groundwater depletion and power subsidy burden in Indian agriculture.

ABSTRACT

The irrigation-energy nexus in India's agricultural sector is characterised primarily by depleting groundwater and a growing power subsidy burden[1]. To address the burden, the Government of India [GOI] promoted solar irrigation pumps [SIPs] by offering substantial investment subsidies. Solar water pumps promise a low carbon footprint, consistent energy availability, zero fuel costs, and low operational costs. Given the developing prospects of SIPs for India's sustainable future, this issue brief studies the potential and viability of SIPs in solving the perverse nexus between groundwater depletion and power subsidy burden in Indian agriculture. The piece

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[1] This refers to the burden of debt on power distribution companies (or DISCOMs) due to massive power subsidies that remain underfunded by the state governments.

concludes by identifying barriers to farmers adopting SIPs, critically analysing government policies for promoting them, and makes recommendations to address this nexus.

INTRODUCTION: INDIA'S IRRIGATION-ENERGY NEXUS

Agriculture alone employs 42.5% of the Indian workforce, the largest portion by far and one that is primarily composed of rural workers (Ministry of Statistics and Programme Implementation [MOSPI] 2020: 55). Between 2019-2020, agriculture and its allied sectors, contributed 17.8% of the total Gross Value Added [GVA][2] in the economy (Ministry of Finance 2021: 232). Thus, agricultural development is integral to India's economic progress.

Irrigation is central to agricultural development and it plays a crucial role in determining production yield. Thus, the GOI's vision to double farmer's income by 2022 and increase agricultural productivity requires steady and sustainable access to irrigation. However, 55% of the farmers surveyed in Uttar Pradesh flagged insufficient irrigation as the "biggest bottleneck" to increasing incomes from farming (Jain and Shahidi 2018: 2).

Farm subsidies have been central to agricultural policies in India. In 2013-14, the government granted irrigation subsidies worth INR 17,500 crores and in 2015-16, massive power subsidies worth INR 90,000 crores were granted to the agricultural sector, which has reduced the cost of extracting water to almost zero (Indian Statistical Institute 2019: 1). Thus, due to the wide prevalence of electric groundwater pumps and cheap subsidised power, the value attached to extracting water is much lower than what it ought to be for a scarce resource. This has led to negative externalities such as overexploitation of groundwater and overuse of fuel-based pumps.

The water crisis only worsens in states like Punjab and Haryana which heavily depend on groundwater pumps for irrigation. Furthermore, recording 1.75 million tonnes, the carbon footprint of Indian agriculture is one of the highest in the world because of its rampant use of diesel pumps (Bassi 2015: 1). Meanwhile, India's power subsidy burden looms large as subsidised electricity continues to push power distribution companies into a financial crisis. On average, an electric tubewell[3] in south-west India "imposes a power subsidy burden of Rs 56,000/ year on the DISCOM, and emits 5,660 kg/ year of carbon" (Shah, Verma, and Durga 2014: 1).

It's imperative to note that the DISCOMs crisis[4], the groundwater depletion, and

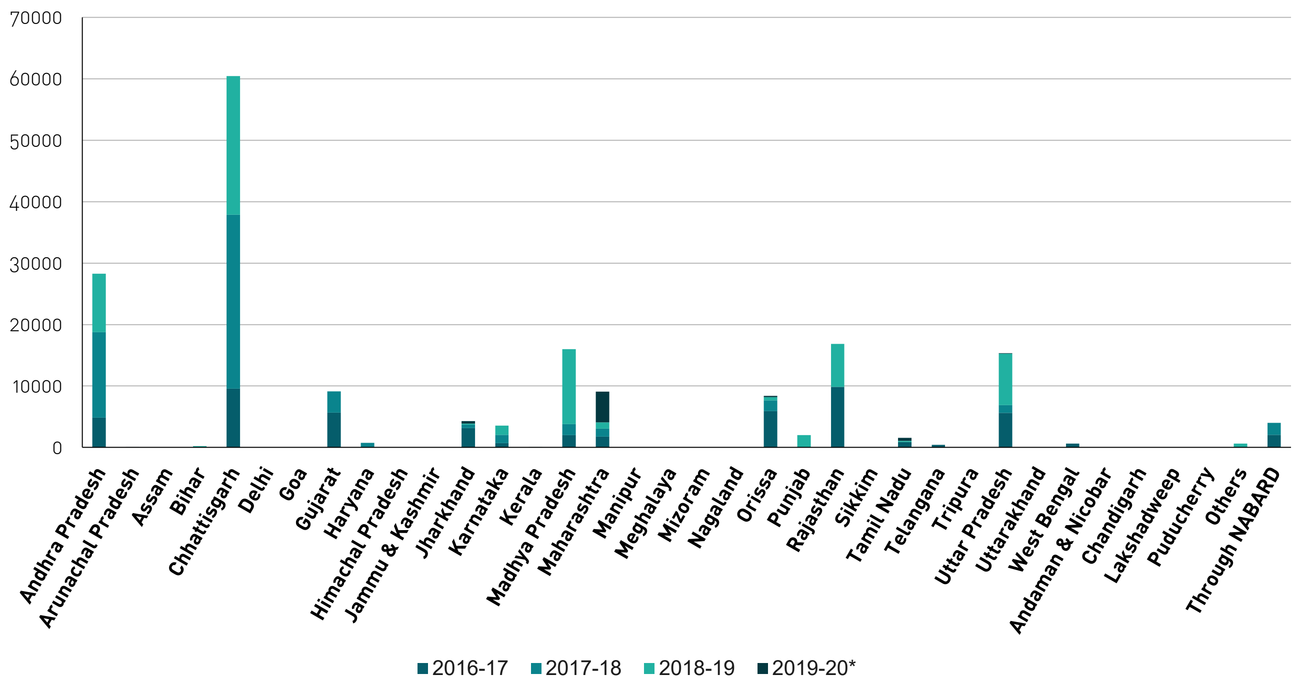
[2] GVA is the measure of the value of goods and services produced in an area, industry, or sector of an economy. It reflects the contribution made by an individual producer, industry, or sector to economic growth.

[3] A tube well is a type of well with a long 100–200 mm wide stainless steel tube or pipe that bores into an underground aquifer for water. The top of the tubewell holds a pump which lifts water through a strainer fitted at the bottom.

[4] DISCOM's crisis is the high debt burden on power distribution companies which rendered many of them non-performing assets in the energy sector in India.

air pollution can be mitigated if groundwater extraction is metered. Metering, that is attaching a price to the water use, encourages more prudent use of groundwater and also allows DISCOMs to earn a higher revenue. However, the government has not adopted this method in order to avoid political backlash due to increased input costs in agriculture. Instead, the GOI has been promoting the adoption of solar irrigation pumps through huge investment subsidies to help reduce the power subsidy burden. As a result, the Ministry of New and Renewable Energy's [MNRE] schemes encouraged the installation of 1.81 lakh standalone solar pumps throughout the country by October 2019 (MNRE 2019: 1).

Figure 1: **State-wise Year-wise Installation of Solar Pumps**



Source: MNRE (2019: 2)

This issue brief studies the potential and viability of SIPs in solving the 'perverse nexus' (Verma, Durga, and Shah 2018: 1) between groundwater depletion and power subsidy burden in Indian agriculture. It also identifies barriers to adopting SIPs by farmers, analyses policy frameworks in place of promoting them, and makes recommendations to address this irrigation-energy network.

THE RISE OF GROUNDWATER IRRIGATION

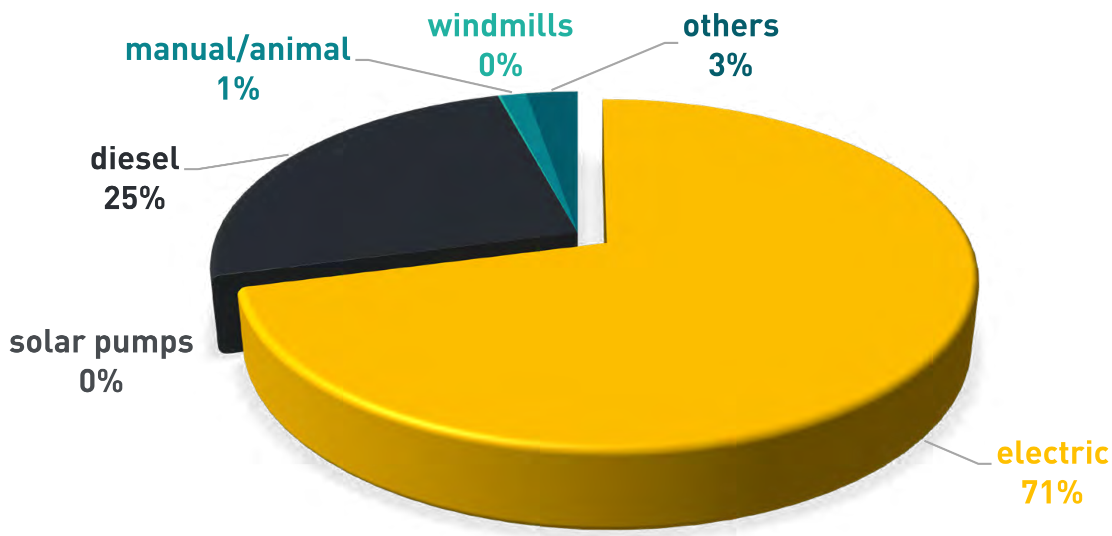
India witnesses a wide variation in precipitation from more than 11,000 mm annually in Cherrapunji to less than 100 mm in western Rajasthan. While the subcontinent receives about 4000 billion cubic meters in annual rainfall [bcm], maximum precipitation occurs during the monsoon season, leaving the utilisable surface water only at 690 bcm (Jain, Kishore, and Singh 2019: 2).

The country's annual replenishable groundwater resource stands at 433 bcm, while the yearly groundwater draft stands at 231 bcm, out of which about 92%

is used for irrigation (India-WRIS n.d.). Canal water and groundwater together provide for 87% of the net irrigated area in India, out of which groundwater alone covers 63% (ICRIER 2019: 10). However, up till the early 1970s, canal water was the primary source of irrigation. Still, due to inefficient governance, inadequate maintenance, and cost overruns, the canal irrigation system became unsuitable for a fast-growing agricultural sector's increasing water demand. Thus, despite massive public investments equivalent to 4000 million US dollars (Jain 2019: 3), the Compound Annual Growth Rate [CAGR][5] for canal systems stood at 0.52% in 2014-15, a substantial drop from 7.29% in 1974-75 (ICRIER 2019: 5).

Canal irrigation systems in India shrunk simultaneously with the rise of groundwater irrigation. In 2019, 9% of the country's GDP could be attributed to groundwater extraction (ICRIER 2019: 6). Due to heavily subsidised power, lack of efficient regulations, and instant water availability from the ground, groundwater pumps have become the preferred source of irrigation. The 5th Minor Irrigation Census shows that 70.9% of total lifting devices for minor irrigation use electricity as the source of energy, while only 24.8% use diesel (MoWR, RD, and GR 2017: 19).

Figure 2: **Percentage of various energy sources in 5th Minor Irrigation Census**



Source: Ministry Of Water Resources, River Development And Ganga Rejuvenation (2017: 19)

[5] Compound Annual Growth Rate [CAGR] is a measure of how much one has earned on one's investments every year during a given interval.

TOWARDS SOLVING THE IRRIGATION-ENERGY NEXUS: DEBATES ON POTENTIAL AND VIABILITY OF SOLAR IRRIGATION PUMPS

The groundwater economy in the west-south corridor that spans from Punjab to Tamil Nadu differs in many ways from the east-north passage, which constitutes the Ganga-Brahmaputra basin. Therefore the west-south corridor is dominated by electric water pumps for irrigation since it holds lesser groundwater availability. This domination led to severe water table depletion, eventually snowballing into the DISCOMs crisis (Figure 2). Farmers in this corridor also face frequent power cuts, low voltage, and receive stable electricity only during the night.

Table 1: **Electricity tariffs and subsidies to the agriculture sector for 2014-15**

State	Power Tariff - Agricultural Consumer [INR]	Subsidy to Agricultural Power [INR million]
Haryana	0.08 - 0.10	52,840
Punjab	0	44,540
Maharashtra	2.1	35,000
Andhra Pradesh	0.50 - 1.0	43,000
Tamil Nadu	3.22	32,600
Gujarat	0.6	11,010
Madhya Pradesh	3.20 - 4.05	59,050

Source: Dhawan (2017: 20)

The west-south corridor will benefit significantly from the introduction of SIPs since the region has many solar hotspots and receives peak sunlight hours, ensuring a regular and efficient supply of electricity to farmers. It will also help relieve the DISCOMs subsidy burden from INR 30,000 to 35,000 per year, per SIP (Shah, Verma, and Durga 2014: 11). Additionally, SIPs will also help move towards zero carbon footprint in the groundwater economy by decreasing reliability on fossil fuel-based electricity production. The only possible drawback of SIPs could be the risk of the over-exploitation of groundwater since on-demand cheap power will always be available post introduction of SIPs in the corridor.

The government has introduced several solar irrigation schemes, such as PM-KUSUM [Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan], Surya Raitha Scheme in Karnataka and Suryashakti Kisan Yojana [SKY], to increase the uptake of SIPs and disincentivise overuse of groundwater. Another programme called Solar Power as a Remunerative Crop [SPaRC] was initiated in Gujarat by the International Water Management Institute (IWMI). These schemes provide subsidies to farmers by covering the capital cost of SIPs with a capacity of up to only 7.5 horsepower [HP] because such SIPs extract less water per minute. The preference in these schemes are given to those farmers who are already using water-saving micro-irrigation systems or are open to doing so. However, this criteria for availing subsidies may benefit only medium and large farmers as they are more likely to have a micro-irrigation system[6] in place. This means that on top of the 50% to 90% subsidy for micro-irrigation (Dhawan 2017:15), they may also benefit from the subsidies for solar irrigation (Bassi 2015: 64).

Another factor which may make SIPs more affordable is the falling price of solar photovoltaic [PV] cells, used in SIPs to convert light energy into electrical energy. However, with their increasingly cost-effective prices, one can expect an expansion of non-subsidy markets for SIPs in the private sector, which can make it difficult for the government to keep groundwater exploitation in check. The state would be unable to ensure that people use lower capacity SIPs or responsibly use micro-irrigation systems (Shah, Verma, and Durga 2014: 12). For example: a study in Uttar Pradesh showed that less than 25% of 1600 surveyed farmers had heard of micro-irrigation, and none used it (Jain and Shahidi 2018: 3). If these farmers adopt SIPs via private markets but not government schemes, they will be free from the conditions of government subsidies that require micro-irrigation adoption or low capacity SIPs.

The shortfall of government-provided high capital cost subsidies is that it can discourage the development of non-subsidy markets because farmers will always look forward to the cheapest alternative to shift to solar irrigation. In addition, it can create solar photovoltaic [PV] oligopolies that try to increase their revenue share by increasing the SIP price and obstructing the entry of new players into the market. These profit-motivated oligopolies tend to use high subsidies to promote SIPs among farmers and refrain from any real benefits-based promotion of solar irrigation and hence, SIPs (ibid).

Despite subsidies, the initial capital investment remains high, raising questions about the viability of SIPs. The operation and maintenance of solar PV systems require trained professionals and machine components which may be hard to find in rural areas. Bassi (2015) explains that such constraints may hinder the long-term performance and efficiency of SIPs. To overcome the obstacle, the Suryamitra Skill Development Programme by the MNRE aims to upskill youth for employment opportunities in the growing Solar Energy Power Project in India and abroad (Suryamitra Skill Development Programme n.d.).

However, the continued use of diesel pumps instead of solar pumps poses a serious concern. While usage of the former may aggravate groundwater depletion, farmers practically have no incentive to switch to solar pumps because of existing power subsidies schemes and the negligible cost of extracting water.

SELLING SOLAR POWER AS A REMUNERATIVE CROP

To curb the usage of diesel pumps in the west-south corridor, the International Water Management Institute (IWMI) has proposed incentivising farmers to sell solar power as a remunerative crop. Under the SPaRC programme, farmers

[6] Micro-irrigation is a modern method of irrigating through drippers, sprinklers, foggers, and other surface or subsurface emitters. This method increases yields and decreases water usage.

can sell surplus solar power produced back to the power grid. This alternative will incentivise farmers to conserve groundwater and energy, increase farmer income, and enable more efficient irrigation by encouraging farmers to adopt crops with high returns to irrigation. The programme includes a balanced incentive, comprising a capital cost subsidy and Feed-in Tariff [FiT][7] paid to the farmers for the energy they sell back through grid-connected solar pumps.

The Surya Raitha solar irrigation scheme in Karnataka has provisions for buying back surplus solar power from SIP owners at an attractive FiT. Shah, Verma, and Durga (2014) show that the capital-cost subsidy and buy-back of surplus power combo earn a farmer a "net additional income INR 76,000 by the sale of surplus solar energy and abolishes the carbon footprint of groundwater irrigation", while the DISCOM saves INR 56,000 annually. However, a higher than optimal FiT could lead to malpractice where farmers may continue using diesel and electric pumps while selling all of the solar power generated or may only grow solar power, forgoing other crops. Nonetheless, evidence from Dhundi in Gujarat shows that even though farmers had been offered a high FiT as part of the SPaRC programme, there was no sign of a fall in agricultural production. The study concludes that higher FiT is more likely to improve incomes and help farmers grow more crops (Verma, Durga, and Shah 2018: 2).

Meanwhile, the Ganga-Brahmaputra Basin in the eastern corridor is a water-rich and flood-prone area dominated by diesel water pumps. The recent rise in diesel prices has naturally increased the costs of irrigation. Thus, the benefits of adequate irrigation have not been fully realised in this region which threatens to stagnate groundwater irrigation altogether. According to Jain and Shahidi's (2018: 2) study in Uttar Pradesh, out of 86% of all farmers with irrigation access on all lands, 51% were dissatisfied with irrigation because of the depleting water table and high diesel expenses.

Therefore, introducing SIPs in this region may boost agricultural growth while curbing the need to lay rural electric networks (Shah, Verma, and Durga 2014: 11). However, practices that work efficiently in the west-south corridor may not translate to Eastern India due to the latter receiving less sun time. This may make solar power generation more expensive for farmers in the east-north corridor. Moreover, subsidies on electricity make renting diesel pumps or cheap pumps imported from China a more economical option. Whereas purchasing SIPs cost farmers INR 1,00,000 or 1,12,500 per unit even after subsidies (Bassi 2015: 64). Therefore, for small and marginal farmers in the Ganga-Brahmaputra Basin, the costs of installing SIPs are unaffordable. About 40% of all farmers surveys in Uttar Pradesh expressed that SIPs are too expensive (Jain and Shahidi 2018: 25). The intensity of cropping and irrigation is comparatively high in the east-north corridor, which means that less barren land is available for installing solar arrays.

Bassi (2015) indicates that the absence of a decision on how many wells will be installed with grid-connected solar power presents serious concerns around selling solar power back to the grid. He also estimates the financial costs associated with grid connection to be enormous. For instance, installing a

[7] Feed-in tariffs (FIT) are fixed electricity prices that are paid to renewable energy (RE) producers for each unit of energy produced and injected into the electricity grid

100-kilowatt solar-powered system to an electricity grid costs around INR 0.85 crore. This estimate includes the cost of the solar PV device, power conditioning equipment, safety equipment, meters, and installations. Citing their non-viability, the Centre for Science and Environment (2019) stated that SIPs might not be the silver bullet to solve the irrigation-energy nexus.

Despite these reservations, SIPs are being viewed as the answer to erratic power supplies, the DISCOMs crisis, and a more sustainable source of irrigation by the government. However, SIPs have faced limited uptake by farmers despite substantial capital cost subsidies and new government programmes.

POLICY RECOMMENDATIONS: MITIGATING DRAWBACKS AND IMPROVING ADOPTION OF SIPs

Cancelling power subsidies to push farmers towards solar irrigation may result in political backlash and could be devastating for small and marginal farmers. Therefore, the government must encourage farmers to adopt solar irrigation over fuel-based pumps by educating them about the advantages of solar water pumps and the long-term benefits farmers stand to gain from them.

In conclusion, solar irrigation entails consistent and on-demand power supply, low maintenance costs, and the opportunity to sell back excess solar power. While diesel costs remain high, the price of SPVs is falling and may become more affordable over time. Upfront capital costs of SIPs are unaffordable despite subsidies, but there is always the option of joint ownership. A report by KPMG (2014) shows promising benefits of switching to solar irrigation. Further, replacing diesel pumps with solar water pumps can have a high internal rate of return [IRR[8]] of 19% currently and 33% in the next five years and offer a break-even[9] period of a short 4.1 years.

Table 2: **Electricity tariffs and subsidies to the agriculture sector for 2014-15**

	Break-even period and IRR for a farmer using diesel pump w/out taking into consideration crop yield improvement	Break-even period and IRR for a farmer using diesel pump taking into consideration crop yield improvement
Current break-even period and IRR for solarisation (2.2 kW Pump)	Beyond 15 years; IRR 10%	8 years; IRR 19%
Break-even period and IRR five years hence[10] (2.2 kW Pump)	7 years; IRR 21%	4.1 years; IRR 33%

Source: KPMG (2014: 10)

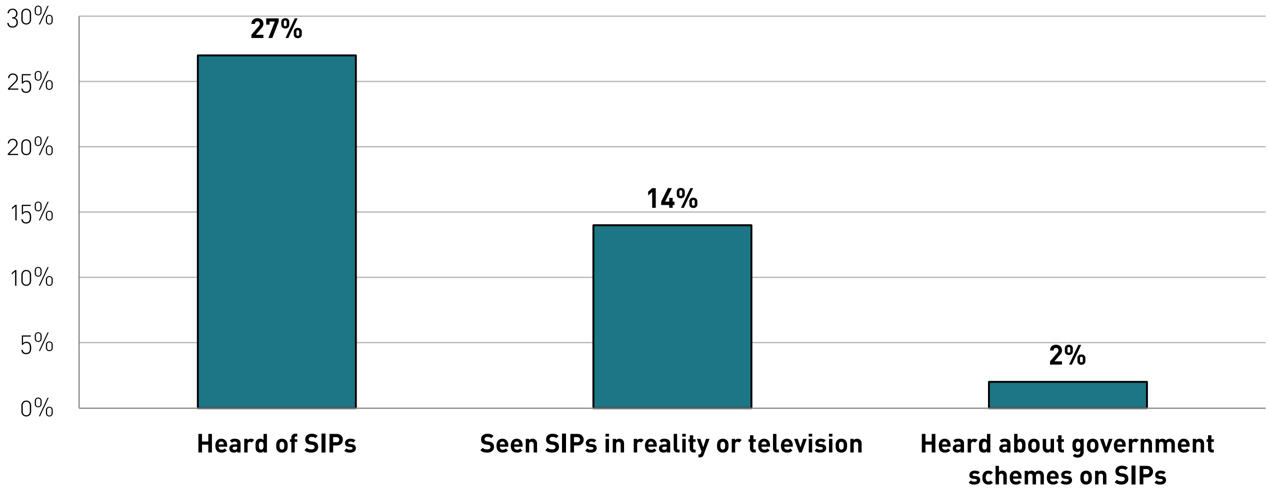
8 Internal Rate of Return (IRR) is the annual rate of growth that an investment is expected to generate.

9 Break-even period refers to the amount of time it takes to recover the cost of an investment.

10 Inputs: 1) Solar pump price reduction of 30%, diesel price increase of 3% per annum, crop price increase of 3% per annum.

A study by the Council of Energy, Environment and Water [CEEW] found that awareness about SIPs is low among farmers in Uttar Pradesh (Jain and Shahidi 2018). However, farmers who had positive views about SIPs were twice as likely to adopt it than those who were unaware. About 41% of surveyed farmers were interested in adopting SIPs due to the convenience it provides and its negligible operational costs (ibid).

Figure 2: **Awareness about SIPs among farmers**



Source: Jain and Shahidi (2018: 2)

Financing SIPs is a significant hurdle for farmers. For example, for a 5 HP pump, the willingness-to-pay is 17% of the quoted price. Similarly, for a 10 HP pump, the willingness is only about 12% of the quoted price (ibid: 29). Most farmers said they would prefer tapping into their savings or taking loans from the bank to purchase SIPs. It is important to note that even farmers who were not interested in buying SIPs are willing to adopt one under the joint-ownership model.

The following are recommendations for improving adoption, viability and benefits from the solar irrigation move:

1. Deploy awareness programmes about efficient water management practices and benefits of SIPs through existing networks of farmers via the Ministry of Agriculture and Ministry of Water Resources (Jain and Shahidi 2018: 3).

2. Promote Joint Liability Groups [JLG] among small and marginal farmers constrained by resources to invest in SIPs. Through JLGs, farmers can jointly take a loan and purchase solar pump/s to own and share collectively. JLGs will also build collective trust to not engage in any malpractices (Shah, Durga, and Verma 2014: 13) and make it an easy point for surplus power monitoring by DISCOMs.

3. Assess the best FiT and capital cost subsidy balance to ensure that SIPs are economically viable to not only farmers but also the government while warranting equity in access to all (Bassi 2015: 66).

4. The government must consider altering existing solar irrigation schemes to include marginal farmers, as well. Jain and Shahidi (2018) recommend promoting smaller (sub-HP to 3HP) solar pumps through capital subsidy for marginal farmers and strengthening the financial ecosystem rather than offering capital subsidy support to medium and large farmers.

BIBLIOGRAPHY

Bassi, Nitin. (2015). "Irrigation and energy nexus: Solar pumps are not viable." *Economic and Political Weekly* 50: 63-66.

Centre for Science and Environment. (2019). "CSE releases its new report on use of solar-powered water pumps in agriculture". Accessed 2 July 2021, https://www.cseindia.org/cse-releases-its-new-report-on-use-of-solar-powered-water-pumps-in-agriculture-9644.

Dhawan, Vibha. (2017). "Water and agriculture in India: background paper for the South Asia expert panel during the Global Forum for Food and Agriculture (GFFA) 2017". Hamburg, Germany: German Asia-Pacific Business Association. Accessed 2 July 2021, https://www.oav.de/fileadmin/user_upload/5_Publikationen/5_Studien/170118_Study_Water_Agriculture_India.pdf.

Indian Council for Research on International Economic Relations [ICRIER]. (2019). *Getting More from Less Story of India's Shrinking Water Resources.* New Delhi, India: ICRIER.

Indian Statistical Institute. (2019). *Agricultural Subsidies.* New Delhi, India: Indian Statistical Institute.

India-WRIS. (n.d.). "CGWB Ground water resources". Accessed 2 July 2021, https://indiawris.gov.in/wiki/doku.php?id=cgwb_ground_water_resources.

Jain, Abhishek, and Tauseef Shahidi. (2018). *Adopting Solar for Irrigation: Farmers' Perspectives from Uttar Pradesh.* New Delhi, India: Council on Energy, Environment and Water.

Jain, Rajni, Prabhat Kishore, and Dhirendra Kumar Singh. (2019). "Irrigation in India: Status, challenges and options." *Journal of Soil and Water Conservation* 18 (4): 354-363.

KPMG. (2014). *Feasibility analysis for solar agricultural water pumps in India.* India: KPMG Advisory Services Private Limited.

Ministry of Finance. (2021). *Economic Survey 2020-21 Volume 2.* New Delhi, India: Ministry of Finance.

Ministry Of New And Renewable Energy [MNRE]. (2019). *Lok Sabha Unstarred Question No. 4045.* New Delhi, India: Government of India.

Ministry of Statistics and Programme Implementation [MOSPI]. (2020). *Annual Report Periodic Labour Force Survey (PLFS) 2018-19.* New Delhi, India: Ministry of Statistics and Programme Implementation.

Ministry Of Water Resources, River Development And Ganga Rejuvenation [MoWR, RD, and GR]. (2017). *5 Census Of Minor Irrigation Schemes Report.* New Delhi, India: MoWR, RD, and GR.

Shah, Tushaar, Shilp Verma, and Neha Durga. (2014). "Karnataka's smart, new solar pump policy for irrigation." *Economic and Political Weekly* 49: 10-14.

Suryamitra Skill Development Programme. (n.d.). "About Suryamitra". Accessed 10 June 2021, N.I.S.E - Suryamitra Skill Development Programme (nise.res.in).

Verma, Shilp, Neha Durga, and Tushaar Shah. (2018). *Solar Irrigation Pumps and India's Energy-Irrigation Nexus.* Gujarat, India: International Water Management Institute (IWMI)

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