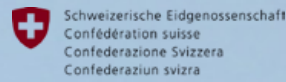


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Financing Solar for Irrigation in India

Risks, Challenges, and Solutions

SHALU AGRAWAL AND ABHISHEK JAIN







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A Policy Brief on 'Financing Solar for Irrigation in India: Risks, Challenges, and Solutions'.

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In over seven years of operations, CEEW has engaged in more than 180 research projects, published well over 110 peer-reviewed books, policy reports and papers, advised governments around the world over 400 times, engaged with industry to encourage investments in clean technologies and improve efficiency in resource use, promoted bilateral and multilateral initiatives between governments on more than 50 occasions, helped state governments with water and irrigation reforms, and organised more than 210 seminars and conferences.

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the International Solar Alliance; modelling long-term energy scenarios; energy subsidies reform; decentralised energy in India; energy storage technologies; India's 2030 renewable energy roadmap; solar roadmap for Indian Railways; clean energy subsidies (for the Rio+20 Summit); clean energy innovations for the rural economy; solar for health care; and renewable energy jobs, finance, and skills.

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CEEW's major projects on water governance and security include the 584-page National Water Resources Framework Study for India's 12th Five Year Plan; irrigation reform for Bihar; Swachh Bharat; supporting India's National Water Mission; collective action for water security; mapping India's traditional water bodies; modelling the water–energy nexus; circular economy of water; participatory irrigation management in South Asia; domestic water conflicts; modelling decision making at the basin level; rainwater harvesting; and multi-stakeholder initiatives for urban water management.



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Over the past four years, Shalu has worked on diverse research topics concerning renewable energy policy and finance, renewables for irrigation and community services, fossil-fuel subsidies reform and future energy scenarios for India. Most recently, she conducted primary research on barriers to diffusion of solar irrigation pumps in Ethiopia, and the role of suitable business models in solar pump diffusion. Currently, Shalu is working as a Research Associate with the Initiative for Sustainable Energy Policy (ISEP) at John Hopkins SAIS. At ISEP, she is profiling rural electricity demand and customer attitudes towards alternative electricity solutions, particularly mini-grids.

Prior to joining CEEW, Shalu had short term project stints with organisations such as Centre for Science and Environment, Schlumberger Asia Services Ltd. (Wireline segment) and Control & Switchgears Ltd. Shalu holds an M.Sc. in Economics and Policy of Energy and Environment from University College London (Chevening Scholar) and a B. Tech in Electrical Engineering from Indian Institute of Technology Roorkee.

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Over the past six years, Abhishek has worked on multiple issues at the confluence of energy, economics, environment and sustainable development. Most recently, he has co-led the largest energy access survey in India. He also conducted the first independent evaluation of the world's largest direct benefit transfer scheme. He has researched and published in the areas of energy access, clean cooking energy, rationalisation of LPG and kerosene subsidies, deployment strategies for solar pumps, and electricity sector reforms for India, to name a few. He regularly presents at various national and international forums, and writes in leading national dailies.

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Executive Summary

Solar-powered irrigation systems (SPIS) offer significant opportunities to facilitate irrigation access in an environmentally-sustainable manner. In India, with a substantial government support in form of capital subsidies, over 100,000 solar pumps had been installed by December 2016. But a subsidy-led approach would be fiscally unviable to achieve deployment of SPISs at scale, given their high upfront cost. It is argued that availability of credit for different delivery models would be crucial for large-scale deployment of solar pumps in the country. However, several risks and operational challenges often constrain flow of long-term finance for agriculture in developing countries.

In view of the need for long-term finance to enable widespread adoption of SPIS, this study investigated the key risks and challenges affecting financing of solar pumps in India. It also explored how different delivery models (individual ownership and water-as-a-service) compare in terms of ease of financing, and the measures required to address perceived risks. For this purpose, semi-structured telephonic interviews with 10 financiers from different institutions, including NABARD, scheduled commercial banks, regional rural banks, and non-banking financial institutions, were conducted. Following are the key insights from the study.

Key insights

Focus on awareness generation about SPIS and its economic benefits amongst field-level staff of financial institutions. The study found that limited awareness among bankers about the economic benefits of SPIS to the farmers, raises the risk perceived by the financiers, particularly the field-level staff, in financing SPIS. Efforts are warranted for awareness generation, particularly through field visits, to build financiers' confidence.

Streamline policy support for SPIS promotion. The study found that the availability of high capital subsidies (of up to 90 percent) for solar pumps had been a barrier to SPIS uptake under erstwhile credit-linked scheme.



Also, while subsidy support improves investment viability, this approach is not sustainable in the long run. It poses risks related to policy uncertainty and constraints to deployment at scale. In order to facilitate a supportive ecosystem for SPIS financing, there is a need for i) gradual phase-out of subsidy support, ii) measures to bring down the cost of SPIS, and iii) encouraging financing support through interest subsidies while avoiding competition between different policies. For the latter, the government could restrict the high-capital subsidy support to small and marginal farmers, and facilitate long-term loans with interest subsidy for medium and large farmers. Such targeting can be facilitated through limited capital subsidy support to smaller pump sizes.

Support financial institutions in developing a sound investment appraisal system. In order to appraise SPIS loan applications, financiers need to estimate the additional income that will accrue to the farmer from the proposed investment. But this process is challenging due to uncertainties related to farming practices, water availability and crop prices. Financing SPIS at a large-scale would require measures to assist the investment appraisal process. These could entail development of investment evaluation tools along with databases to provide updated information on parameters such as groundwater resources, crop prices, etc.

The appraisal process is also constrained by the shortage of trained staff, which is essential for economic appraisal, field-verifications and advising farmers about better farming and crops. Along with new recruitments and training exercises, financiers could outsource preliminary assessment of SPIS loan applications to suppliers, to reduce the efforts required at the financiers' end. A sound appraisal system would also encourage lenders to reduce the collateral requirements - a common challenge faced in agriculture financing.

Enhance confidence in long-term sustainability of SPIS performance. Financiers expressed concerns about the quality and long-term performance of SPIS, as well as timely availability of after-sales service, which influence their risk-perception and willingness to finance SPIS. Measures such as periodic monitoring of past installations, sharing farmers' experiences, and enforcing service warranty (through earnest money deposits or first-loss agreements with suppliers), could help overcome these concerns.

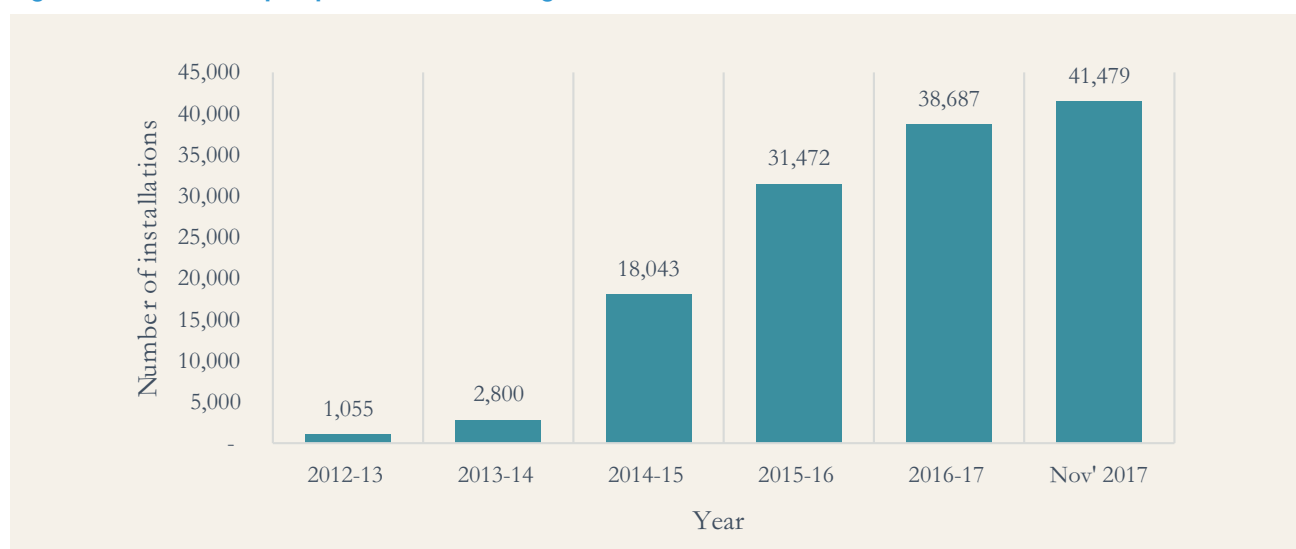
Give due importance to the sustainability of water sources, while financing SPIS. Even though SPIS could reduce production risks related to lack of irrigation access, the risks due to reduced water availability in the long-run would remain, which could affect investment viability. Thus, while supporting SPIS deployment at scale, adequate efforts for water conservation measures would be essential, particularly in areas with constrained ground water resources. This could entail linking of financial support and incentives for solar pumps to adoption of efficient irrigation practices and groundwater management.

Support future research on alternative delivery models, such as water-as-a-service. The study found that financiers perceive the water-as-a-service model cost-effective to reach small and marginal farmers, but they perceive it to be riskier, and would prefer the individual ownership model. This is due to the difficulty in appraising the farmer's economic viability, concerns about the sustainability of water sources, and the potential for social conflicts in this model, when managed by a group of farmers or community organisations. Future research on alternative delivery models is required to build financiers' confidence in such models.

1. Introduction

Solar-powered irrigation systems (SPIS) offer significant opportunities to facilitate irrigation access in an affordable and environmentally-sustainable manner, while decoupling irrigation from the rising power subsidy burden (Agrawal & Jain, 2015). For these reasons, SPIS have received increasing policy focus and government support in India. Figure 1 depicts the growth in yearly solar pump installations over 2012-17. As of November 2017, India has a cumulative installation of 1,42,000 solar pumps (PIB, 2017).

Figure 1: Annual solar pump installations during 2012-17



Source: CEEW analysis based on MNRE (2017) and PIB (2017)

This growth has received impetus from huge capital subsidies of up to 90 per cent, offered by various state governments in tandem with the Ministry of New and Renewable Energy (MNRE). For example, in order to promote solar water pumping for irrigation, MNRE provides 30 per cent of the benchmark costs as subsidy for solar pumps (henceforth known as ‘capital-subsidy scheme’), (MNRE, 2014). However, a subsidy-led approach seems unviable to achieve the set target of 1 million solar pumps by 2021. Even the provision of 30 per cent capital subsidy would entail an outlay of nearly INR 135 billion,¹ which is more than twice the annual budget of MNRE (INR 54.73 billion in 2017-18) (Popli, 2017).

Given the high capital cost of solar pumps as compared to its alternatives, scaling up their deployment would be highly contingent on the availability of credit for farmers in the country (Agrawal & Jain, 2016). In recognition of this imperative, in 2014, MNRE launched a ‘credit-linked capital-subsidy’ scheme (MNRE, 2014). Under the scheme, the beneficiary farmer has to contribute 20 per cent of the solar pump cost upfront, the government contributes 40 per cent as subsidy, while the remaining 40 per cent is made available to the farmer as debt from the banks, payable over 10 years (NABARD, 2014). In view of the high solar pump cost², the repayment period of the debt was kept at 10 years. Despite several efforts, only 1,744 systems were installed under the scheme until December 2016, as against the targeted deployment of 30,000 solar pumps by June 2016 (MNRE, 2017). On account of the limited uptake, the scheme was discontinued with effect from April 2017 (NABARD, 2017). One of the commonly cited reasons behind this slow uptake has been the

¹ Rough estimates, assuming solar pumps of 5 HP capacity and capital costs of INR 500,000/unit.

² INR 500,000 for a 5 horsepower (HP) system

parallel implementation of the capital-subsidy scheme, under which farmers could avail much higher subsidy, reducing their total contribution. However, the potential supply-side challenges constraining the financing of solar pumps remain unexplored.

Past studies on adoption of solar lighting and home systems have found that limited access to credit is a critical barrier to adoption (Yoon et al, 2016; Scarpa & Willis, 2010). Studies have also highlighted the importance of credit for adoption of solar pumps (IRENA, 2016; Kelley et al, 2010). Given their high upfront cost and distributed revenue inflows over long time-periods, solar pump adopters would require access to long-term finance. However, agriculture financing is fraught with several risks inherent to agriculture in general, such as risks related to natural hazards (rain failure, floods, crop diseases), price or demand fluctuations, poor cropping practices, and macro-economic environment or policies (Hollinger, 2004). Agriculture financing also faces operational challenges and higher transaction costs due to inadequate rural infrastructure and dispersed populations (IFAD, 2009). Further, these risks and challenges worsen with the loan term, as it becomes difficult to appraise the agricultural investment due to increased uncertainties and information asymmetry—for instance, lack of knowledge and certainty about the profitability of the investment.

In India, long-term loans are not very common in rural areas. As per All-India Debt and Investment Survey data, in 2012, only 10 per cent households reported outstanding debt of duration five years or more (NSSO, 2014). The majority outstanding dues (65 per cent) had been contracted for short durations of less than two years. At the aggregate level, long-term credit accounted for less than a fourth of the total direct credit advanced to agriculture and allied activities in 2011-12.^{3,4} This is despite the fact that institutional credit for agriculture can contribute towards priority sector lending targets of commercial banks (Hoda & Terway, 2015). Given the risks and challenges associated with term-finance in general, and for agriculture in particular, it is likely that financing of solar pumps is facing supply-side constraints, which need to be explored and addressed.

Another issue associated with the financing of solar pumps, is that of credit availability for different deployment models. Until recently, efforts for promotion of solar pumps have been focused on individual ownership of solar pumps. However, most of such state support is being availed by medium/large farmers (Kishore et al, 2014). Small and marginal farmers find even subsidised solar pumps inaccessible due to low savings and limited access to credit (Agrawal & Jain, 2016). It has been argued that alternative delivery or business models, such as water-as-a-service, might suit the latter's needs and capacity better (IRENA, 2016; Nederstigt & Bom, 2014). Solar pump deployment under these models would also require access to appropriate financial products. However, the same might not be forthcoming due to supply-side constraints, such as information gaps, risks perceived by financiers, or operational challenges.

In view of the opportunities that solar irrigation holds for Indian agriculture and the need to facilitate access to finance for solar pump uptake under different delivery models, this study was conducted to bridge the existing knowledge gaps. It does so, by exploring answers to the following research questions:

1. What risks and challenges constrain the financing of solar pumps in India?
2. How do different delivery models for solar pumps compare in terms of ease of financing, and what factors might constrain flow of finance under each?
3. What measures could mitigate the risks and challenges affecting financing of solar pumps?

³ Analysis based on the data from Handbook of Statistics on the Indian Economy, Reserve Bank of India

⁴ In this analysis, long-term loans (for a period of 3-15 years) include medium-term loans as well. Short-term credit is typically for six months, but covers credit up to one year.

2. Methodology

In view of the limited research on the subject, this study adopted semi-structured interviews as the preferred research strategy, as it allows greater flexibility for securing additional and previously-unknown information (Saunders et al, 2016).

Scheduled commercial banks (SCBs), regional rural banks (RRBs) and cooperative banks are the key financing institutions in India, for extending direct institutional credit to agriculture and allied activities (Hoda & Terway, 2015). In 2011-12, these respectively accounted for 88.63 per cent, 5.64 per cent and 5.72 per cent of the long-term loans issued to agriculture and allied activities.⁵ Therefore, to explore the risks, challenges and potential solutions for financing solar irrigation pumps, this study targeted key informants from different financial institutions, ranging from NABARD⁶, SCBs, RRBs, and non-banking financial institutions (NBFCs). Informants were identified using purposive sampling, with the objective to obtain maximum heterogeneity in responses.

Overall, 10 telephonic interviews with key informants were conducted during 3-25 August 2016. Annexure A contains the details of the respondents interviewed. Questionnaire for guiding the interviews was prepared and shared with the participants before the interviews, in order to facilitate a more informed discussion (see Annexure B). These focussed on the following themes, in response to the research questions.

1. Risks perceived in financing solar pumps and factors influencing the same
2. Operational challenges in financing solar pumps
3. Outlook towards financing alternative delivery models
4. Potential measures to address the perceived risks and challenges

All the interviews were manually recorded, and thematic analysis was employed to evaluate the information and data received.

⁵ Handbook of Statistics on the Indian Economy, Reserve Bank of India

⁶ National Agriculture Bank for Agriculture and Rural Development is an All-India development financial institution.



3. Findings and Discussion

3.1 Risks perceived in financing solar pumps

This study found that several risks are afflicting the flow of finance for solar pumps in India. These have been classified into risks related to information asymmetry, technology, production and policy, and are discussed below.

3.1.1 Risk of information asymmetry

While India has more 19 million electric and 9 million diesel irrigation pumps, only 0.1 million solar pumps have been deployed till date, comprising a mere 0.35 per cent share of total irrigation pumps. Moreover, majority (99 per cent) installations took place over the past five years (see Figure 1). Being a relatively new technology, financiers, particularly the field-level staff, lack adequate awareness about the economic benefits of solar pumps to the farmers, raising concerns about payback. Some respondents pointed out that lack of knowledge and familiarity with solar pumps increases financiers' risk perception towards them, and significantly affects their willingness and level of comfort in financing the same.

There is a need for awareness generation amongst field level staff at the financial institutions/banks regarding the technology and its economic benefits to farmers, such as savings on fuel and improved agricultural performance, which could alleviate risks pertaining to lack of information. As per the respondents, physical demonstrations would be most effective, to build confidence in solar pumps. Suppliers can play a crucial role in this regard by acting as a link between the financiers and the farmers. They can fill the information gaps regarding the technology by organising field visits and awareness sessions. Further, it would be useful to educate the field staff of government line departments such as irrigation, agriculture, revenue, etc., with whom financiers' often interact and liaison with to get feedback on companies, performance of systems deployed, and farmers' experiences.

3.1.2 Technology-specific risks

Even though the respondents acknowledged that solar pump technology has been field-tested, they expressed apprehension about the sustainability of solar pump performance over long terms. This was mainly on account of concerns regarding the system quality and after-sales service support, which are discussed below.

Box 1: Empanelment of solar pump suppliers

Based on a list of criteria, MNRE approves a state-wise list of *channel partners*⁷ (component manufacturers or PV system integrators), who can supply/install solar pump systems under the relevant government scheme. This list is periodically revised by the ministry.

MNRE channel partners have to strictly follow the prescribed technical specifications and quality standards for each component to be used in the solar pump system. The rate of the system that suppliers have to bid for, to secure projects under the schemes, have to be inclusive of transportation, installation and maintenance for 5 years from the date of commissioning.

7 As of August 2016, there were 58 suppliers selected by MNRE for empanelment under its Solar Pumping Program all across India. <http://mnre.gov.in/file-manager/UserFiles/off-emp170816.pdf>

3.1.2.1 *Concerns about system quality and performance*

In order to regulate the quality of solar pump systems being installed under government-supported schemes, MNRE has established a system of empanelment of solar pump suppliers (refer to Box 1 for details).

Respondents acknowledged that till date they have financed solar pump systems by MNRE-approved channel partners only and have not experienced any performance-related issues. However, all the systems financed by them are less than two years old, which is too short a timeframe to comment on the reliability of system quality, particularly when the payback time of the loans is 10 years. The quality of the systems is a significant determinant of the viability of investment, and hence a point of concern for financiers.

Respondents emphasised upon the importance of system quality by recounting their past experience with tractor and solar home systems' (SHS) finance, wherein failures on account of poor quality were observed. The default rates in case of farmers, who received tractors from established companies, were lower than that in cases where farmers received tractors from lesser-known companies. Similarly, in a few cases involving financing of SHS, manufacturers provided poor quality systems that stopped working much before their technical life, leading to investment failure. Such experiences increase the risks perceived by financiers in financing new technologies, including solar pumps. Measures such as periodic monitoring and information sharing about solar pump installations, along with a robust credit rating system for solar pump companies, could contribute towards trust and confidence in solar pumps amongst financiers.

Respondents also highlighted that several solar pump companies, who are not MNRE channel partners, are supplying low-cost systems. Financiers' conversations with farmers yielded that 5 horsepower (HP) pumps are available in the market at INR 350,000, as against INR 540,000 quoted under the MNRE schemes. This difference raises concerns about lack of competition amongst the channel partners and inflated system costs under the government scheme. One potential reason for this cost difference could be that lack of adherence to quality standards by the suppliers, who are not channel partners, in which there is need to regulate the quality of systems entering the market. Given these concerns and high technology cost, there is an urgent need to stimulate competition amongst the solar pump suppliers, along with a quality certification and robust enforcement mechanism, for out-of-scheme installations as well.

3.1.2.2 *Concerns about after-sales service support*

Respondents stated that availability of timely repair services after solar pump installation is a significant concern, as delays can adversely affect crop productivity and hence, farmers' payment capacity. Even though there is a provision of five-year service warranty under government schemes (refer to Box 1), there is no mechanism to ensure that services will reach the farmers, when they need it. It was suggested that measures, such as earnest money deposit, could help ensure both asset warranty and after-sale services. For instance, a few banks are signing agreements with suppliers, wherein they deposit 10-15 per cent of capital payments for 1.5 years, as a security against service warranty.

3.1.2.3 *Risk of physical damage or theft*

As solar pumps are kept in the open, there are concerns related to theft, physical damage, and loss due to natural disasters (such as floods, storms, etc.). As per the respondents, neither the suppliers nor the insurance companies are forthcoming in covering these risks. Further, solar pumps also run the risk of disuse, if the groundwater levels fall beyond the serviceable level of the installed pump. This challenge is not on the radars of either the suppliers or the financiers, but can certainly affect the project's viability in the long run.

3.1.3 Production risks

Several factors such as the dependency of Indian agriculture on the monsoon, lack of reliable access to irrigation, shortage of other inputs, and vulnerability to natural calamities (droughts, floods, pest attacks, etc.) influence the production risks and hence the farmer's ability to service his debt. All the respondents acknowledged that solar pumps can facilitate access to reliable irrigation services in unirrigated areas and mitigate the irrigation challenges due to lack of, or poor supply of, agricultural power. To this extent, solar pumps could reduce the production risks related to lack of reliable access to irrigation. However, the risks due to reduced water availability for irrigation in the long run and the lack of other input resources, would still remain. In order to reduce the production-related default risk for solar pump finance, it would be imperative to consider sustainability of water sources, while extending finance for solar pumps.

This in turn would require access to information on current water levels and potential future trends, in easily accessible formats. However, at present, assessment reports by the Central Groundwater Regulatory Board (CGRB) are the only data source on water levels, which lack granularity and are published after a huge time-lag (Saha et. al., 2017). Pilots to record real-time groundwater data, such as those carried out in a few districts of Uttar Pradesh, could offer the way forward on making it easily accessible to diverse users, including financiers (Chauhani, 2015). Linking financial support and incentives for solar pumps to water conservation measures such as equipment for efficient irrigation, could also help address the sustainability concerns.

3.1.4 Policy risks

As per our interviews, financiers perceive several policy risks while extending finance to solar pumps, which are listed below.

3.1.4.1 Availability and impact of capital subsidy

The high upfront cost of solar pumps is a major barrier to their adoption, particularly for small and marginal farmers. Respondents emphasised upon the role of capital subsidy in improving the viability of solar pump investment and hence, in mitigating the risk of default by the farmers. However, this might not be a sustainable strategy in the long run, as once the government extends subsidy support, it is difficult to withdraw it later without adverse consequences. For instance, in case of SHS, the demand for loans for the latter significantly plummeted post the withdrawal of capital subsidy on these systems. As one respondent quoted:

“Subsidy is required for giving the initial push. However, it is not sustainable in the long term and there is a need for a phase-out plan. Focus should also be on cost reduction through innovation or economies of scale.”

This underscores the need for progressively decreasing subsidy support for solar pumps, as the technology costs decline. In parallel, measures such as mass procurement of solar pumps by the government could bring down the system costs by ensuring economies of scale, as has been observed in the case of light-emitting diodes (LEDs). Supporting alternative delivery models such as group-sharing, renting or water-as-a service could also make solar irrigation affordable for farmers.

3.1.4.2 Parallel and multiple programmes to promote solar pumps

Respondents confirmed the earlier hypothesis that parallel implementation of two government programmes (capital-subsidy and credit-linked capital-subsidy schemes) with varying subsidy support has been a barrier in the uptake of solar pumps under finance-backed schemes. Even though the number of solar pumps under the 'capital subsidy' scheme were limited, farmers used to prefer to wait for their turn, rather than opting for the 'credit-linked subsidy' scheme when the latter was in service until recently. The variation in subsidy

component and farmers' contribution often led to confusion as well as mistrust amongst financiers, farmers, and solar pump suppliers. The respondents, therefore, emphasised upon the need for policy consistency to ensure smooth deployment of finance-backed solar pumps. For instance, the government could restrict the high-capital subsidy approach to small and marginal farmers, and support medium and large farmers through long-terms loans with interest subsidy.

3.1.4.3 Policy of subsidised electricity connections

Agriculture power consumption (for irrigation purposes) is heavily subsidised by the state governments in India. The typical tariff paid by farmers in 2013-14 was INR 1.8 per unit of electricity, as against the cost of supply of INR 5.9/kWh (Planning Commission, 2014). Despite a capital subsidy of 40 per cent under the credit-linked capital-subsidy scheme, solar pumps are economically less attractive than subsidised agriculture connections. As per the interviews, financiers perceive subsidised agriculture connections under the current power-tariff regime as a significant policy challenge. In the states where agricultural power is highly subsidised and state governments are proactively awarding new agriculture connections, the demand for solar pumps under the credit-linked capital-subsidy scheme has been negligible.

Respondents also expressed concerns about the fate of the loans awarded for solar pumps, in the event that the farmers, who have availed the loans, also secure subsidised electricity connections. This would undermine the utility of solar pumps for the farmers, and hence the viability of investment by the financing agencies. One potential measure to overcome such concerns could be that farmers obtaining financial support for solar pumps be considered eligible for subsidised electricity connections only after paying back a certain portion of their loans.

3.2 Operational challenges

Besides identifying risks perceived in financing solar pumps, respondents also pointed towards several operational challenges in the appraisal, approval and disbursal of credit for solar pumps, as discussed below.

3.2.1 Difficulty in investment appraisal

Due to the high upfront costs, loans for solar pumps are for long terms (3-10 years). Therefore, the viability of investment in solar pumps needs to be carefully assessed, in order to avoid default and the associated costs (Hollinger, 2004). Many respondents stated that appraising solar pump investment is a challenging task, as it involves estimation of additional income accrued to the farmer due to the proposed investment.

Even though there are standard templates available for appraising solar pump loan applications, the viability of investment can significantly vary from case to case, and requires substantial due diligence by the financier. It was highlighted that two important factors influence a solar pump's viability. These are i) source of water; and ii) crops being grown. The viability would be lower if the groundwater level is lower (as capacity of system required increases) and/or if the farmer is growing low-value crops (such as paddy). As part of the loan application process, not only do the bankers have to physically verify these factors, but they also have to advise farmers about increasing the share of high-value crops (such as vegetables and fruits) in the cultivated area to improve the income generation potential. Further, the uncertainty about future variations in groundwater depth and the profitability of the crops being grown, also influences the risks perceived by the financiers. These challenges could be addressed by supporting the financiers in appraisal processes and facilitating access to information on groundwater variations and crop price trends, in easily accessible formats.

Further, appraisal of solar pump credit applications is found difficult in cases where farmers already possess subsidised electricity connections and are seeking solar pumps as a replacement/back-up. In such cases, electricity access to irrigation already exists, and it is difficult to estimate additional benefits due to solar pumps. On the contrary, in cases where farmers have been using diesel pumps or had no prior electricity

access to irrigation, it is easier to assess economic viability. This is because there would either be direct savings on account of avoided expenditure on diesel fuel or concrete expectations of higher revenue due to better yields and adoption of high-value crops. This points towards the opportunity of focussing solar pump deployment efforts towards farmers lacking electricity connections or those using diesel pumps for irrigation.

3.2.2 Shortage of trained staff

Few respondents emphasised upon the lack of adequate staff at the field level, particularly in the public-sector banks in rural areas, as a critical barrier in credit disbursal. It was noted that institutions serving rural customers should employ an adequate number of agriculture-assistants. These are trained to conduct economic appraisals of agriculture investments, pre- and post-sanction validations through field verifications, and also advise farmers about better farming practices and crops. But currently, this ratio is quite skewed. In the absence of trained staff, financiers find it difficult to properly appraise the viability of loans, which in turn increases the financing risks. This also leads to delays in sanctioning of loans, preventing farmers from getting timely access to finance. Thus, there is an urgent need to upgrade the staff capacity at the branch level, through new recruitments and training exercises.

Some banking institutions have employed innovative strategies to appraise the loan applications for solar pumps. For instance, outsourcing the preliminary risk validation to the suppliers, who scrutinise the applications by farmers, based on the criteria specified by the bank, which can considerably reduce the efforts required at the financiers' end. In all the applications forwarded by the suppliers, lenders also conduct independent appraisals, which includes physical verification of the site as well as economic appraisal of the farmers' ability to service the loans. Similar measures could also be adopted by other financing institutions.

3.2.3 Challenges related to collateral availability

Financiers require security for long-term loans to cover production and price risks faced by the farmers, and to cover the risks due to information asymmetry and moral hazards. Even though the solar pump, being an asset, is the primary security for the loan taken by the farmers, it is not treated as sufficient, as the technology is new and the resale market is un(der)-developed. Further, additional costs would have to be incurred for dismantling, transporting and re-installing solar pumps, making the second-hand market less attractive. Hence, respondents emphasised on the need for collateral security to cover the risk of default. It was stated that limited awareness and experience of financing solar pumps further influences financiers' perception about the collateral requirements.

However, inability of farmers to offer proper collateral was cited as the biggest constraint in lending, including for solar pumps. Majority farmers in India have already mortgaged their lands, typically for short-term (crop) loans. Under such scenarios, a new lender is quite wary to extend long-term credit of high value to already indebted farmers, without any security.

Few respondents downplayed the collateral requirement as an issue, citing that the farmers approaching them for solar pump loans also hold Kisan Credit Cards⁸ from their bank, which in turn are linked to farmers' details such as credit history and land ownership. Thus, a potential solution to overcome the constraints related to collateral could be that either the existing lender extend the new credit (for the solar pump) or the new lender, which is keen to extend the credit, also takes over the existing loan component from the previous lender. This would allow the farmers to secure new loans without pledging new security, while also addressing the lenders' concerns. Another potential measure could include waiving off the collateral requirement for solar pumps.

⁸ Kisan Credit Cards (KCC) are aimed at simple and hassle-free sanction of credit to farmers. Farmers can use KCCs to obtain short-term as well as term loans, depending upon the crops cultivated. As of 2012-13, 128.4 million KCCs have been issued.

While loans below INR 100,000 don't require collateral⁹, it is a bank's discretion to waive off the collateral requirement for the rest. In case of solar pumps, some banks have waived off the collateral requirement for loans up to INR 500,000, based on their experience of working in the renewable energy sector and the confidence that solar pumps will stimulate the demand for more financial services from farmers. It was highlighted that with a sound investment appraisal process and risk management strategy, lenders can safely waive off the collateral requirement for solar pumps.

3.3 Perspectives on financing alternative delivery models

In view of the opportunities for extending irrigation access to small and marginal farmers, this study also explored financiers' comfort levels and concerns related to financing alternative delivery models for solar pumps. Their views were invited regarding water-as-a-service models owned and operated by i) entrepreneurs, ii) a group of farmers, and iii) community/farmer associations. Given that financiers might have only limited experience with such approaches, their responses were graded against the case of financing individual ownership models.

Even though all the respondents acknowledged that the water-as-a-service model would be more cost-effective for farmers, they expressed a higher confidence in financing individually-owned solar pumps. They found the latter attractive, as it is easier to appraise the economic viability of the investment where the responsibility for debt-service payment and the system's maintenance is fixed. However, the viability of the former would depend on the number of farmers to be served, average field size, distance of the fields from the source of water, crops to be grown, and water availability. The presence of so many variables would make investment appraisal complicated, increasing the risk of financing. They also pointed out the risk related to the sustainability of the water source, questioning the number of years for which one well could be used to service several farmers, and mechanisms to ascertain the same.

In case of an entrepreneur-owned solar pump, respondents raised doubts about the fate of the investment, in case the clients (farmers taking water on rent) decide to opt for individual ownership of solar pumps in the future. This could significantly affect the entrepreneur/group's ability to service loan payments, thus increasing the risk of default for financiers.

In the case of group or community ownership models, the group dynamics would be a critical factor for the success of the investment. There is always likelihood of conflicts within the group or of the group falling apart, which would increase the risk of default. Further, default by one member can affect the creditworthiness of the whole group. Cooperation between the group members and the terms of agreement for water sharing would be essential for investment in such models to be viable. Respondents cited that several joint liability groups (JLGs) have been unsuccessful in the past, precisely on these accounts. In case of community solar pump models serving a large number of farmers, a robust institution with strong leadership for enforcement of rules, and effective group management and conflict resolution would be a crucial determinant of the viability of investment.

While respondents identified potential socio-economic challenges in financing the water-as-a-service model under different operational and ownership patterns, they also conceded that if viability of such models could be proven, financiers would be happy to invest in them. Besides pointing towards important issues to be addressed, this finding also underscores the need to share experiences and learnings from existing models. For instance, Vaishali Area Small Farmers Association (VASFA), has been using solar pumps for servicing irrigation water to its member farmers (GIZ, 2015). In another example, Claro Energy has piloted trolley-mounted solar pumps to provide on-demand irrigation service in-lieu of a fixed rental fee (Kakkar, 2017). Assessing the economic viability, social feasibility and environmental sustainability of such models could yield insights to address the concerns raised and risks perceived by the financiers in financing such models.

⁹ As per the guidelines by the Reserve Bank of India.

4. Conclusion and Policy Recommendations

Over the past five years, India saw installation of around 100,000 SPIS, making it the largest solar pump market in the world. As the deployment of solar pumps gathers pace in India, the present study investigated the risks and challenges constraining flow of finance for solar pump technology. Based on 10 semi-structured interviews with financiers from varying financial institutions such as NABARD, SCBs, RRBs and NBFCs, the study found that several perceived risks influence the flow of finance for solar pumps. These are summarised in Table 1.

Table 1: Risks perceived in financing solar pumps

Type of risk	Factors influencing the risk
Risk of information asymmetry	Limited awareness about solar pumps amongst financiers, particularly the field staff
Technology-specific risks	Concerns about system quality and long-term performance
	Concerns about after-sales service support
	Risk of physical damage or theft
Production risks	Risk of reduced availability of water for irrigation
Policy risks	Uncertainty in availability of and impact of capital subsidy
	Parallel and multiple programmes with varying subsidy support
	Availability of subsidised electricity connections, even for farmers taking loans for SPIS

Source: CEEW Analysis, 2017

Simultaneously, the study investigated the operational challenges faced by financiers in financing SPIS and found two key hurdles. First, financiers face difficulty in appraising the solar pump loan applications due to factors such as the shortage of trained staff, information gaps, and uncertainty about future water availability and crop profitability. Second, inability of farmers to provide proper collateral, as banks find solar pumps insufficient as primary security.

While exploring how different delivery models compare in terms of ease of financing, it was found that financiers would prefer financing individually-owned SPIS as against the water-as-a-service model. The latter were perceived riskier due to difficulty in appraising their economic viability, assessing the sustainability of water source, and potential for social conflicts.

In order to facilitate financing of SPIS and their adoption at scale, this study puts forward the following recommendations, which could help mitigate some of the perceived risks and operational challenges faced by the financiers.

1. Focus on awareness generation about the solar pump technology and its benefits amongst staff of financial institutions, particularly through physical demonstrations. In this regard, engagement and collaboration with solar pump suppliers could be an effective strategy, as the latter could act as a link between farmers and financial institutions.
2. Facilitate a supportive ecosystem for SPIS financing through i) a gradual phase-out of subsidy support, ii) measures to bring down the cost of SPIS, and iii) encouraging financing support through interest subsidies while avoiding competition between different policies. For the latter, the government could restrict the high-capital subsidy support to small and marginal farmers, and facilitate long-terms loans

with interest subsidy for medium and large farmers.

3. Develop innovative means to assist lenders in conducting investment appraisals for solar pump investment under individually-owned as well as water-as-a-service models. These could entail development of databases to provide information on water availability, crop price, and likely future trends in easily accessible formats. A sound appraisal system, along with risk management strategies, would also encourage lenders to reduce the collateral requirements, which was one of the most frequently cited challenges.
4. Upgrade the staff capacity of financial institutions at the branch level, through new recruitments and training exercises, in order to enable sound appraisal of solar pump applications in an accelerated manner. As this is a time-intensive process, lenders' efforts could be supplemented by outsourcing of preliminary risk validation to suppliers, as is being practised by some banks.
5. In order to strengthen financiers' confidence in the quality and performance of solar pumps, undertake measures such as periodic monitoring, sharing information about successful installations, setting up robust credit-rating systems for solar pump companies, and enforcing service warranty through earnest money deposits or first-loss agreements with suppliers.
6. While supporting SPIS deployment at scale, ensure adequate efforts for water conservation measures, particularly in areas with constraining ground water resources. This could entail linking of financial support and incentives for solar pumps to adoption of efficient irrigation practices.

It has been well-documented that a stable macro-economic environment, along with “political stability, a profitable agricultural sector, rural credit culture, and a legal and institutional framework for contract enforcement are indispensable” conditions for the feasibility and success of long-term finance (Hollinger, 2004). While these factors would have significant bearings over the supply and success of finance for solar pumps as well, exploring these aspects was beyond the scope of this study. The findings of the study should, therefore, be interpreted accordingly. The study also lacks the perspective of financiers from cooperative banks, due to the inability to obtain participation from them. This study was the first of its kind to explore the risks and challenges in solar pump financing and therefore, it adopted a qualitative approach to capture all potential issues. Future studies could adopt quantitative means to identify the priority issues and measures to address them. Future research could also assess and establish the economic viability, social feasibility and environmental sustainability of new delivery models such as water-as-a-service, which are crucial to build financiers' confidence in such models.

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Annexure 1

Table A: List of respondents interviewed

S.No.	Category of financial institution	Name of the institution	Name of the respondent	Designation
1	Development Financial Institution	NABARD	A. R. Khan	Deputy General Manager (DGM), Irrigation
2	SCBs	State Bank of India	M. Krishna Rao	General Manager, Rural & Agri Banking
3		State Bank of Hyderabad	Ajit Singh	Deputy General Manager, FI (retired)
4		Syndicate Bank	B. R. Hiremath	Associate General Manager
5		RBL Bank	Manoj Kumar Rawat	Head, Agri Business
6	RRBs	Baroda Rajasthan Kshetriya Grameen Bank	Sanjiv Agrawal	Incharge, Loan Department
7		Gramin Bank of Aryavrat	R. P. Kushwaha	Senior Manager, Credit Department
8		Paschim Banga Gramin Bank	Joydeb Choudhury	General Manager, DIT
9		Karur Vyasa Bank	Panduranga Kurupatti	Deputy General Manager, Agriculture
10	NBFCs	Maanaveeya Development & Finance Private Limited	Gouri Sankar Gollapudi	Managing Director

Annexure 2

The following are the questions used as a reference for conducting the semi-structured interviews:

1. Are you aware about solar pumps and have you been involved in financing them?
2. Do you perceive any key risks in financing solar pumps? Kindly elaborate.

Prompts:

 - a. Production risks
 - b. Technology risks
 - c. Risk of policy uncertainty
3. What factors influence the risk of lending for solar pumps?

Prompts:

 - a. Lack of confidence in technology's performance or issues of system quality
 - b. Lack of understanding about economic viability of solar-based irrigation
 - c. Uncertainty/delay in subsidy disbursal
 - d. Risks of technology breakdown or disuse
4. Apart from the risks involved, do you perceive any operational difficulty in financing solar pumps?

Prompts:

 - a. Appraising the investment viability
 - b. Lack of or poor quality of collateral
 - c. Poor infrastructure and staff capacity
 - d. Financial illiteracy of farmers
5. New deployment models for solar pumps are emerging these days, such as water-as-a-service model (explain). Would the risks and challenges in financing solar pumps increase/decrease, if the investor (loan applicant) is i) an entrepreneur, ii) a group of farmers, or iii) a community organisation, as compared to lending to an individual farmer?
6. What measures (policies/market development) would be required to boost financiers' confidence in solar pumps?

Prompts:

 - a. Waiving off collateral requirements for solar pumps
 - b. Availability and extent of capital subsidy
3. From a demand-side perspective, what challenges prevent farmers from availing loans?









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