Solar Irrigation for Agricultural Resilience (SoLAR) Project Mid-Term Evaluation Final Report – 21 September 2023

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Executive Summary

In this report, the evaluation team assesses the outputs and outcomes of the SoLAR project from its January 2020 start through the mid-term evaluation, completed in August 2023, in relation to the project's goal of contributing to climate resilient, gender and socially inclusive agrarian livelihoods in Bangladesh, India, Nepal and Pakistan by supporting Government efforts to promote solar irrigation. The report considers multiple aspects of project implementation by the International Water Management Institute (IWMI) as well as long-term sustainability, especially in relation to the evaluation criteria of the Organisation for Economic Co-operation and Development's Development Assistance Committee (OECD DAC). Lessons learnt, recommendations for the remainder of SoLAR Phase 1 through June 2024, and guidance for Phase 2 are also presented. Findings and recommendations are provided within the framework of the project's three work packages: WP 1 Generating Evidence, WP 2 Piloting and Testing Solutions, and WP 3 Sharing Knowledge and Strengthening Experience.

Outcomes. The project has achieved the following outcomes, which are discussed in the report.

1) The SoLAR project's greatest overall impact is through training. Also related to WP 3 Sharing Knowledge and Strengthening Experience), the knowledge stakeholders gained through SoLAR is being used for SIPs planning, for example in Bangladesh.
2) A major impact is research and knowledge support (WP 1 Generating Evidence) for the need to tailor solar irrigation pumps (SIP) programs to local and national policies, the socio-economic context, institutional capacities, as well as agricultural, water, energy, and climate conditions
3) SoLAR is successfully providing support for Government implementation of SIP programs in the four countries, considering contextual variables in the following *declining order* of emphasis:
    a. groundwater sustainability (though scaling up challenge are yet to be systematically addressed)
    b. climate (both SIPs for adaptation options and as a carbon mitigation strategy)
    c. gender equity and social inclusion (GESI) targeting, especially of rural women
    d. integrated water-energy-food nexus interlinkages
    e. livelihood support in the locally prevailing food system.
4) SoLAR is providing an appropriate level of regional knowledge integration (WP 1) via:
    a. regional fora and national fora
    b. groundwater sustainability studies
5) The project has achieved good understanding of policy drivers for SIP program adoption, especially diesel/ fossil fuel substitution in Bangladesh, Pakistan, and Nepal. Diesel substitution was less the case in India, where the focus was on large-scale rollout of solar pumps including replacing electric pumps with on-grid SIPs.

IWMI's project implementation demonstrates excellent attention to project timelines and deliverables established at the project's inception, especially considering delays resulting from the Covid-19 pandemic. Greater attention from project leadership is needed to engage the project more meaningfully to assess and diagnose the poor performance of India's PM KUSUM scheme. Additionally, several late-breaking opportunities open the door for the SoLAR project in Phase 1, perhaps requiring a pivot to be agreed upon by IWMI and SDC, that is to specifically engage with the recent national policy declarations supporting SIPs by the prime ministers of both Bangladesh and Pakistan, and the harvesting of lessons learned from the SoLAR project's investments in the Innovation Fund projects, especially those in Nepal.

Sustainability. The long-term sustainability of SoLAR interventions is well established in Gujarat, India, both as a result of the SKY scheme drawing inspiration from IWMI's innovations with the Dhundi Solar Cooperative, and the ongoing, active participation of key state-level functionaries in the India Country Project Management Committee. Additionally, SoLAR has achieved critically important long-term impacts in Nepal via IWMI's GESI-focused influence on AEPC's national policy to reduce the minimum landholding size for SIP program eligibility. In Pakistan, the key achievement in this regard is IWMI's

support for PARC as a key partner in the Government's USD 1.3 billion solarization scheme. Finally, in Bangladesh SoLAR bringing all the major stakeholders to the table and IWMI's support to secure Green Climate Fund support for IDCOL's continuation of its SIPs programs are noteworthy.

Lessons learnt. The evaluation identifies the following principal lessons.

1) SIPs programs remain dependent on subsidies, providing SoLAR the opportunity for evidence-based subsidy design and targeting, as discussed further in the report below
2) The principal GESI benefits of SIPs adoptions are less through direct SIPs adoption by small and marginal farmers and more through spillover benefits of more robust and competitive water markets, and women primarily benefitting through livelihood diversification, for example, livestock rearing
3) While both grid-connected and of-grid, standalone SIPs need promotion, off-grid **currently** provide the greatest opportunity to take solar irrigation to scale in the present context of inadequate infrastructure to evacuate solar power generation and power companies' financial inability or unwillingness to offer competitive incentives for evacuated power, with the following caveats:
    a. major off-grid SIPs programs, in Pakistan and Bangladesh for example, are driven more by motivations to reduce foreign-exchange balance of payments for diesel imports than by solarization policy, *per se*
    b. decarbonization benefits will be achieved only through intentional replacement of fossil-fuel (diesel) pumps
    c. in regions of groundwater depletion risk, SIPs programs must actively seek to replace, not add to, the existing numbers of pumps, and to couple SIPs with water-use reduction through more efficient drip irrigation but also, crucially, crop choice shift
4) Grid-connected SIPs, in general, are the way of the **future** as all four South Asian countries seek to further extend agricultural power grids including to provide power evacuation infrastructure and incentives, or in remote locations to incentivize mini-grids
    a. decentralized solar energy generation (e.g., India's KUSUM-A) that powers existing electrical pumps offers decarbonization promise without the high transactions costs of enrolling farmers in SIPs programs, though for farmers this would represent only a zero-sum switching of power-generation/ fuel source

Recommendations for the coming nine months of SoLAR Phase 1 include:

1) SoLAR 1 project
    a. strengthen WP 3 emphasis on policy support, now that WP 1 and WP 2 are showing results, with greater emphasis on current and short-term future opportunities as touched on for each country below
    b. in the national and regional fora, focus on policy engagement and institutional support
    c. particularly at the South Asia regional level, provide a synthesis of SoLAR results comparing and contrasting national-level findings
    d. hold an international symposium on solar irrigation with both knowledge-generation, research-focused organizations such as other IWMI regional programs (especially in Africa) and other CGIAR partners, as well as with policy and practitioner-oriented organizations and leaders including other bilateral (e.g., GIZ) and multilateral programs (e.g., World Bank, IFAD/FAO, and ISA), potentially linked to other SDC programs

2) SoLAR 1 GESI
    a. in order to better address SoLAR's GESI objectives to demonstrate gender responsive and pro-poor SIP approaches, several concrete actions should be considered in the remainder of Phase 1, including to produce policy and research briefs that identify opportunities and assess how scaling up process could occur of new projects similar to the innovation fund projects that have provided proactive support for women, smallholders, the landless, especially where smallholders and landless are women

b. analyze the remaining data and produce a virtual global symposium with panel experts on gender issues in solar irrigation pumps synthesizing findings from SoLAR Phase 1
c. analyze Innovation Fund results that are GESI relevant and produce research and policy briefs. Promote research to identify women leaders and women's groups who are innovators and can serve as role models in their communities around SIPs
d. in Nepal, plan to develop and to administer interview and survey questions for key stakeholders in government agencies, non-profits and among community members to evaluate the efficacy once AEPC approves its policy that one of every three approved applications for SIPs subsidies must be for women; farmers with 0.339 hectares or above eligible for subsidy; farmers who lease land can also apply for subsidy

3) *SoLAR 1 Nepal*
   a. sharing of SoLAR findings and learnings, especially from GESI work led by IWMI and innovations of group SIPs under Innovation Fund projects, with government and NGO stakeholders
   b. expand the project's good scientific research communication, currently for a more academic audience, with policy makers, local governments and end users
   c. more robust study on why scaling up of solar irrigation is not taking place
   d. robust mechanism for after-sales service and sustainability of the system in the pilot projects
   e. emphasis on policy breakthroughs with NEA regarding net metering. This policy change has the capability of transforming solar irrigation in Nepal in the future

4) *SoLAR 1 Pakistan*
   a. expand the behavioral study to include small, medium, and large farmers, and also applied in canal tail areas end where water stress is greatest
   b. develop and deliver training with KFUEIT and other universities on selection and use of higher-quality SIP components, know-how on installation, operation, and maintenance of SIPs
   c. provide special SIPs and drip/ precision irrigation training sessions for women in agriculture

5) *SoLAR 1 Bangladesh*
   a. more actively identify, develop, and leverage opportunities to provide knowledge input for the policy guidelines of the Prime Minister's declaration to replace diesel with solar pumps
   b. strengthen experience sharing of the two main modalities of SIPs implementation (IDCOL and MoA) by transitioning the CPMC to a SoLAR-led knowledge hub with meaningful broader interactions
   c. provide the knowledge base relevant for groundwater licensing currently overseen by Upazila (Subdistrict) Irrigation Committee, but well spacing norms should be replaced with locally applicable criteria such as groundwater depth, aquifer type, recharge from adjacent water bodies, etc. and not a one-size-fits-all general rule applicable across the entire country
   d. identify sustainable models of SIPs installation and operation that reduce the need for scarce land, while also providing non-irrigation benefits
   e. broaden the training in farm operations, alternate wet-dry (AWD) irrigation, precision water management, etc. as well as repair of SIPs equipment.

6) *SoLAR 1 India*
   a. systematically summarize the large-scale survey conducted of SKY farmers for qualitative and quantitative insights
   b. place more emphasis on addressing groundwater availability using existing data when available, while also considering potential future depletion from solar irrigation adoption (as a 3rd generation question)
   c. IWMI (with GERMI) training of solar technicians and DISCOM engineers is an opportunity

d. formally assess the IF grants to extract lessons learned, especially to assess and recalibrate the IF program for SoLAR Phase 2
e. greater attention can be given to SKY that can help address perceived negative experiences (including DISCOM governance of SKY, support to installers, and planning for the post-7-year handover of SKY SIPs to farmers)
f. help guide the discussions around the insurance availability and sustainability of grid-connected solar irrigation promotion beyond 7-years of government guaranteed support. IWMI should leverage the farmers training to better understand:
    i. are the farmers who are handed over the bills really paying the bills or are there any protests etc. that are not being reported?
    ii. what are farmers' perceptions about the SKY scheme financial outcomes?
g. assess how prepared are other states, and Gujarat, for PM-KUSUM (C but also A and B) considering administrative, infrastructure, policy, finance, and social dynamics factors
h. building on the groundwater sustainability studies, a policy brief should be prepared on socio-economic and agronomic mapping of "safe for solar irrigation" and mapping that informs the suitability of grid-connected solar irrigation superimposing groundwater suitability and quality of grid-connectivity.

Guidance for SoLAR Phase 2 is provided in relation to SDC's own priorities. The evaluation team anticipates these will be useful for the grant agreement with IWMI and other potential implementing partners.

1) SoLAR 2 project

a. Greater emphasis should be provided on SIPs policy engagement and uptake (similar to Phase 1 WP 3). In South Asia, the following are major 'low-hanging fruit' opportunities of government SIPs roll-outs to be addressed in SoLAR 2:
    i. the new Pakistan Solar Water Pumps scheme
    ii. India's PM Kusum C but also A and B with particular attention to implementation
    iii. the Bangladesh Prime Minister's solarization announcement
    iv. in Nepal, SoLAR 2 opportunities exist to coordinate with other bilateral aid programs supporting SIPs
b. pay more systematic attention to integrated approaches including the water-energy-food nexus, especially linked with decarbonization and climate adaptation objectives
c. sharper focus should be placed on subsidy regimes, subsidy delivery, and the role of credit providers as well as insurance providers
d. capacity building should include orientation, management and administration, and trouble-shooting approaches for Government agencies charged with SIPs implementation
e. SDC should continue to support SIPs program in South Asia. The Climate, DRR & Environment Section (CDE) should continue to prioritize SIPs research-supported policy engagement in all four countries, as identified and discussed below
    i. if SDC's Food Systems Section intends to augment support for SoLAR 2, opportunities exist for more integrated water, energy, food WEF Nexus approaches, linked to climate and carbon emphases of the CDE
    ii. if SDC's Water Section intends to augment support for SoLAR 2, opportunities exist for groundwater depletion challenges as well as enhanced groundwater recharge efforts in South Asia in relation SIPs-based and other modes of groundwater development
f. Eastern India, part of Bangladesh, and the Nepal Terai would form a fertile test-bed - a Social-Ecological Observatory for Diversified Livelihoods through Solar Irrigation - with real implications for scaling regionally and for lessons adoption and transfer to Sub-Saharan Africa.

2) *SoLAR 2 GESI*
    a. broaden the SoLAR project to include multiple uses of solar energy and water for food processing
    b. focus on training more women operators, women SIP users on use and maintenance, and identifying key factor in the enabling environment that may limit women becoming SIP users and operators
    c. increase IWMI GESI expertise capacity for the unique, country-specific contexts of Bangladesh, India, and Pakistan
    d. improve IWMI coordination and collaboration with organizations (e.g., UN Women, other UN agencies, bilateral organizations, national and local NGOs, Government agencies, etc.) working on GESI and WEFE nexus to increase policy and program influence
    e. provide financial support to an Innovation Fund that specifically works to benefit women.
3) *SoLAR 2 Nepal*
    a. provide research support on the reasons that SIPs market breakthrough is limited, despite the fact that the technology is already popular
    b. lack of integrated policies for water, energy, and food/ agriculture (WEF Nexus), thus IWMI could facilitate this approach via policy and research briefs and stakeholder meetings
    c. study of groundwater tables in the Terai region to assist the government of Nepal in making policy decisions for SIPs
    d. Innovation fund challenge fund should include various sectors including youth. Not only innovation in technology, but also in supply chain, after sales service , water use optimization, diversified crop pattern and crop calendar information for farmers to make more income.
4) *SoLAR 2 Pakistan*
    a. develop a strategic roadmap for agricultural solarization across Pakistan including technical, financial, and institutional models for the large-scale promotion of SIPs
    b. different universities which have the potential to collaborate in the field of SIPs should be engaged specially for the capacity building of the female members of agricultural communities
    c. innovation fund should be offered every year, commensurate with the project's financial and administrative resources
5) *SoLAR 2 Bangladesh*
    a. conduct research on successful strategies and potential new strategies to replace existing private diesel minor irrigation to solar pumps
    b. consolidate and disseminate findings in existing SoLAR issue briefs stressing that SIPs programs should be based on hydro-geological situations rather than "one size fits all" approach
    c. SIP use for non-irrigation purposes should be explored through applied research and further testing
    d. Promote agricultural and irrigation technology extension services on: drip irrigation, solar trap for pest control, skill enhancement of rural mechanics for SIP maintenance, farmer group formation, formation of Farmers Field Schools (FFS) for horizontal learning, and capacity utilization of pumps
6) *SoLAR 2 India*
    a. consider another state for the development of SoLAR 2 with priority attention to Chhatisgarh or Orissa. In all cases, SoLAR 2 must plan for a consistent and strong field presence as an essential condition for success
    b. plan for the adaptability and transferability of India and South Asia experiences for Africa. For Government and other institutions in Africa considering solarization, a SIPs scheme

planning workflow would be helpful including identifying conditions of suitability for SIPs, identifying institutional mechanisms that are supporting, estimating spillover and secondary effects, and distilling the generalizability of findings and curating this information for broad dissemination and uptake.

c. The Innovation Fund should be continued in SoLAR 2, despite the high transactions costs. Consider a dual-scale model:
    i. Seed Grant IF projects on the order of CHF 10,000 each per year for novel, high-risk, high-reward IF grantees, more oriented to demonstration and deployment than new research per se
    ii. At-scale IF projects on the order of CHF 50,000 each per year for two years for SIPs and WEF(C) deployment that requires a minimum 1:1 leverage of matching funds (especially for other bilateral programs).

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List of Abbreviations

SoLAR: Solar Irrigation for Agricultural Resilience
SDC: Swiss Agency for Development and Cooperation
IWMI: International Water Management Institute
SIPs: Solar irrigation pumps
GHG: Greenhouse Gases
NDCs: Nationally Determined Contributions
UNFCCC: United Nations Framework Convention on Climate Change
WEF(C): Water-energy-food (carbon) nexus

Bangladesh
IDCOL: Infrastructure Development Company Limited
BRRI: Bangladesh Rice Research Institute
SPaRC: Solar Power as a Remunerative Crop
MPEMR: Ministry of Power, Energy and Mineral Resources
SREDA: Sustainable and Renewable Energy Development Authority, SREDA
BADC: Bangladesh Agriculture Development Corporation
BARC: Bangladesh Agricultural Research Centre, BARC
BGEF: Bright Green Energy Foundation
RREL: Rahimafrooz Renewable Energy Limited
DISCOMS: Electricity distribution companies
BARI: Bangladesh Agriculture Research Institute
BAU: Bangladesh Agriculture University
BREB: Bangladesh Rural Electricity Board
DAE: Department of Agricultural Extension
BMDA: Barind Multipurpose Development Authority

India
DISCOMs: Distribution Companies
DSUUSM: Dhundi Saur Urja Utpadak Sahakari Mandali
GERMI: Gujarat Energy Research and Management Institute
GWRDC: Gujarat Water Resources Development Corporation
SKY: Surya Shakti Kisan Yojana scheme
PM-KUSUM: Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan Yojana
MNRE: Ministry of New and Renewable Energy
NDC: Nationally Determined Contribution
NABARD: National Bank for Agricultural and Rural
CEEW: Council for Energy, Environment, and Water
GIZ: Deutsche Gesellschaft für Internationale Zusammenarbeit

Nepal
AEPC: Alternative Energy Promotion Center
DWRI: Department of Water Resources and Irrigation
ICIMOD: International Center for Integrated Mountain Development
IDE: Integrated Development Enterprises
GoN: Government of Nepal
WECS: Water and Energy Commission Secretariat

Pakistan
ONFWM: Agriculture Extension and On Farm Water Management
MNFSR: Ministry of National Food Security and Research
PCRET: Pakistan Council of Renewable Energy Technologies
PARC: Pakistan Agriculture Research Council
CEWRI: Climate Energy & Water Research Institute, NARC/PARC, Islamabad
FWMC: Federal Water Management Cell, Ministry of National Food Security and Research

I. Introduction

As described in the SoLAR Mid-Term Evaluation Inception Report, the widespread adoption of irrigation has transformed agriculture globally, boosting food production, increasing rural employment and secondary economic activities including for women, expanding water supply for drinking and domestic purposes, and enhancing resilience to climate extremes. Irrigation-led agricultural intensification has not come without major tradeoffs, which may (but does not always) include heightened reliance on agro-chemicals, depletion of surface and groundwater, rising salinity, concentration of landholdings and wealth in rural areas, and power grid instability where pumping is powered by electricity. Solar irrigation offers the benefits of irrigation intensification while also posing a unique, more sustainable alternative for many of the tradeoffs. Yet, its widespread adoption is challenged by high investment costs, intermittent insolation and limited pumping hours, land competition, theft, and nascent solar-pump service provision or capacity gap. Ingraining solar irrigation in rural areas thus requires practical experience and further innovation and refinement on the part of farmers (indeed, all members of farming households), input and equipment suppliers, agricultural extension and irrigation department staff, NGOs working on rural development, decision-makers from local to regional and national levels, and donors.

South Asia is the global hotspot of groundwater irrigation and at the same time it is the leader in solar irrigation[1] as measured by area covered by solar irrigation pumps (SIPs) and numbers of adopters, with India leading the way, both for grid-connected solar irrigation as well as off-grid SIPs. Growth in solar irrigation in Bangladesh and eastern India is primarily driven by widespread use of high-yielding varieties (HYV) of rice that have high water demand. In the Middle East- North Africa region, substitution of solar pumping for diesel is a driving factor for adoption. In Sub-Saharan Africa, off-grid solar is more prevalent due to a lack of available grid connections. In Latin America, grid-connected solar for irrigation is more widespread than off-grid; however, adoption levels are comparatively low.

Consistent with the transformative potential of solar irrigation and the importance of South Asia in this regard, the Swiss Agency for Development and Cooperation (SDC) supports the SoLAR project - Solar Irrigation for Agricultural Resilience in South Asia that is implemented by the International Water Management Institute (IWMI) with partners in India, Bangladesh, Pakistan, and Nepal.

The SoLAR Consultation Report (2018) opens by identifying the importance of groundwater for climate resilience in the region.

> *As farmers struggle to cope with increasing climate uncertainty, they must increasingly rely on irrigation. In much of South Asia, the only reliable source of irrigation that offers on-demand water control is groundwater. The last half-century has seen a rapid expansion of groundwater-irrigated area in South Asia. With an annual withdrawal of nearly 300 km^3, more than 60% of irrigation in South Asia is today dependent on groundwater.*

The main goal of the project is to contribute to climate-resilient, gender-equitable, and socially inclusive agrarian livelihoods while developing climate interlinkages in South Asia through the promotion of solar irrigation pumps (SIPs). The project is currently in the first phase (2019 – 2024). Activities are concentrated around solar irrigation adoption with second-generation questions about policy design and setting up the right incentives. Pakistan, most of India, most of Bangladesh, and parts of Nepal are also facing long-term groundwater stress and depleting groundwater caused by the increasing irrigation demand for groundwater. In eastern India, eastern Nepal terai, and some parts of Bangladesh, the volume of groundwater depletion is less of a challenge (except in concentrated areas where over exploitation is visible) but here water quality issues raised by rapid cycling of groundwater and surface recharge include the mobilization of geogenic sources of arsenic as well as agricultural and urban pollutants. Yet, the individual, community, and societal benefits of groundwater irrigation, together with the central role it plays in agrarian livelihoods, call for evidence-based approaches to better understand the management of solar irrigation, training needs, as well as consciousness-raising and evidence for policy on the part of decision-makers at multiple levels in government and civil society.

[1] Lefore, N., A. Closas, P. Schmitter. 2021. Solar for all: A framework to deliver inclusive and environmentally sustainable solar irrigation for smallholder agriculture. *Energy Policy* 154, 2021, 112313, https://doi.org/10.1016/j.enpol.2021.112313.

With this background drawn from the evaluation inception report, we present the evaluation team.

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The team assessed progress to date of the SoLAR project overall, by the GESI dimension, and by country, considering the three work packages (WP) under Phase 1: *WP1 Generating evidence* activities including studies, *WP2 Piloting and testing solutions* interventions including innovation funds, and *WP3 Sharing knowledge* trainings and communications, while also identifying interactions among the three WPs. The evaluation followed a *co-design approach*, building on inputs from SDC (New Delhi, Bern, and Dhaka) and from IWMI (Regional office in New Delhi, program office in Anand, Gujarat, and country offices in Lahore, Pakistan; and Kathmandu, Nepal). In addition to determining and assessing the contribution of outputs and outcomes to delivery of the project's overall aims and objectives in the current Phase 1, the team provides reflections and recommendations for the design and implementation of Phase 2.

We used mixed methods evaluation protocols[2] as follows. For better attribution of SoLAR's impacts, we attempted to use *non-randomized control trial criteria*[3] to select sites and communities where project activities have been implemented (three sites and nine communities in Gujarat, and two sites and three communities in Bangladesh, with only stakeholder interviews instead of field work conducted in Nepal and Pakistan). Formal comparison to similar sites without project implementation proved difficult given the tight timeframes for the Gujarat and Bangladesh field missions. IWMI provided lists of SoLAR project stakeholders, some of whom, but not all, were contacted for the evaluation. The team members, in consultation with the team leader, also contacted other stakeholders based on our knowledge of the field. In some cases, f*ocus groups* of community members, implementation partners, and other stakeholders were also conducted. See Annex 1 for the list of stakeholders and other participants contacted during the evaluation. In the report below, we synthesize the interviews visually in Table 2 and we include direct quotes from the interviews to shed light on the evaluation observations and recommendations.

Additionally, the team conducted a literature review that included the key words 'solar irrigation pumps' in each of the four countries. The results of the literature review were used to inform the design of the principal data collection tool, which were *semi-structured interview guides* (see Annex 2) tailored to the following: Institutional Stakeholders (implementers, public bodies [agriculture, irrigation, etc.], NGOs, donors, service provider [contractor]); SIP Adopters (farmers, rural households), and SIP Non-adopters

[2] Mertens, D. M., & Tarsilla, M. 2015. Mixed methods evaluation. In S.N. Hesse-Biber and R.B. Johnson (eds.), Oxford Handbook of Multimethod and Mixed Methods Research Inquiry. Oxford Academic. https://doi.org/10.1093/oxfordhb/9780199933624.013.27

[3] Arnold, B. F., Khush, R. S., Ramaswamy, P., London, A. G., Rajkumar, P., Ramaprabha, P., ... & Colford Jr, J. M. 2010. Causal inference methods to study nonrandomized, preexisting development interventions. *Proceedings of the National Academy of Sciences*, 107(52), 22605-22610.

(other farmers, rural households). The interviews consisted of, for the institutional actors: five questions with multiple response options pertaining to their assessment of the feasibility (agronomic, social, financial and climate adaptive) of solar irrigation, what is their view of GESI-related access to SIPs, and two open-ended questions regarding their assessment of the impact of Phase 1 and potential for Phase 2 of SoLAR (if they were involved in the project). For SIP adopters, questions centered on how they acquired the pump (e.g. what type of financial support they received), who in the household uses the pump, whether they use the pump on a shared basis, for what purposes each household member utilizes the pump, what type of training was received and by which household member(s) related to the SIP use and maintenance, and whether they believe the SIP benefits justifies the costs in relative terms, ie, not posing specific numbers. Farmers and other stakeholders were asked whether the schemes benefitted them and if they had comments on limitations and possible improvements. In India, 22 interviews were conducted; in Nepal, 14 interviews were conducted; in Bangladesh 14 interviews and in Pakistan 8 interviews were conducted.

Interviews were completed in person, over the phone, or on Zoom, depending on the preference of the interviewee. Each of the interviewers informed participants before the beginning of the interview of the duration of the interview, the assurance of confidentiality, the authenticity of their responses, and the ability to ask for clarification at any time during the interview process. All participants were asked prior to the interview if they were comfortable with the interviewer taking detailed notes of their responses. No visual or audio recordings were used during the interview process. This information was triangulated by comparing and contrasting comments made by interviewees with information gathered through the evaluation team field visits and literature review.

The team coordinated with IWMI to plan the July – August stakeholder meetings and field missions (see Annex 3) to Gujarat, India and Rangpur, Bangladesh by the team leader, GESI expert, and India expert. The field visits were also planned together with IWMI's partners such as NGO Forum in Bangladesh, who have been managing data collection. Finally, the team held *two internal SoLAR project reporting workshops* at IWMI's New Delhi office (August 1, 2023, after the Gujarat field mission and New Delhi appointments) and at SDC (August 7, 2023, after the Bangladesh field mission, with IWMI staff and SDC present in the forenoon and with just SDC in the afternoon). Additionally, the team reviewed project documents and other source material (see Annex 4). As indicated in the terms of reference and the approved proposal for the evaluation, the team conformed to the OECD DAC criteria (2019)[4] as indicated in Table 1, below, as well as the SEVAL (2016)[5] standards.

[4] OECD. 2019. Better Criteria for Better Evaluation. https://www.oecd.org/development/evaluation/qualitystandards.pdf

[5] SEVAL. 2016. Evaluation Standards of the Swiss Evaluation Society. https://www.seval.ch/app/uploads/2018/01/SEVAL-Standards-2016_e.pdf

II. SoLAR Phase 1

The OECD DAC criteria provide an ideal framework in which to present the evaluation team's high-level assessment of SoLAR achievements to date, as summarized in Table 1, which was drawn up by the evaluation team after the completion of data collection, document review, interviews and focus groups, the field missions, and interactions with IWMI and SDC.

Table 1. Evaluation Team's Assessment of SoLAR Project by OECD DAC Criteria

Relevance	• The SoLAR project strategy and approach are highly relevant to solarization policies in Nepal, Pakistan, Bangladesh, and Gujarat State in India; however, greater attention is needed to the PM-KUSUM scheme in India • The project partially addresses local socio-demographic contexts in the countries, noting that SIPs are a blunt instrument to address inequities in farm size, access to credit, and women's roles in farming • IWMI has excellent rapport and coordination with the International Solar Alliance, yet, there was little evidence of ISA's reciprocal support for SoLAR, though opportunities exist in this regard for SoLAR Phase 2, especially considering programming opportunities in Africa • The project is the flagship activity of SDC's CDE in South Asia; however, on-the-ground opportunities and SoLAR's explicit 'GESI agrarian livelihoods' and 'groundwater responsive' objectives offer important Phase 2 programming opportunities to expand support from SDC Food Systems and SDC Water sections, respectively, including for gender-transformative approaches.
Coherence	• SoLAR is in general well aligned to water, energy, and food policies in the four countries, noting, however, that a more integrated water-energy-food nexus approach, especially at the local level, would add considerably to rural livelihood support • As noted, there is partial mismatch between initial objectives and current opportunities in India (PM-KUSUM), Pakistan and Bangladesh (respective Prime Ministers' solarization declarations); however, these can be remedied in the remaining nine months of SoLAR 1 • The evaluation team did not note explicit contradictions of solarization with other development objectives in the four countries; however, opportunities exist for better alignment of SIPs programs with broader development strategies, for example, India's Atal Bhujal Yojana that promotes groundwater recharge in a water security planning framework, rooftop solar programs in Bangladesh, etc.
Effectiveness	• While opportunities exist in the remaining nine months of the present phase, the evaluation team found that the outcomes and outputs achieved to date are satisfactory • There is clearly a rationale for country-level activities within the project, yet greater attention is needed to the regional focus (multi-country, comparative activities) in order to enhance the project's effectiveness in the region and in each country • Similarly, SDC and the Swiss Embassies in the four countries should better coordinate multi-country regional strategies • The project can more meaningfully engage with GESI partners and stakeholders and implement activities including gender training for all project staff

Efficiency	• The scope of work for the evaluation did not explicitly charge the team to assess financial questions on the use of SDC funds, with the exception of the Innovation Funds, which were found to be rather high-value investments (on the order of CHF 60,000 per project) that have to date not been systematically reviewed for lessons learnt • The project management structure consisting of the IWMI Regional team, PMU, CPMC, and IWMI country offices is appropriate; however, IWMI's project leadership transitions appear to have delayed the response to emerging opportunities for project engagement with policy uptake, e.g., the poor uptake of PM KUSUM in India
Impact	• The key outcomes are listed in the executive summary and detailed in the report • The Innovation Fund projects (four total completed in India, two in Nepal, and one in Pakistan) expanded project impacts to diverse partners while also identifying relevant new approaches • Notable successes in India are IWMI's prior inspiration for Gujarat's SKY scheme, leading to active participation, especially of PGVCL, as well as training provided by IWMI and GERMI • The most directly attributable impact is AEPC Nepal's lowering of the landholding threshold • Pakistan impacts include the pioneering farmer preference study and SIPs knowledge dissemination via university partners • In Bangladesh impacts included especially getting all the main stakeholders together in the CPMC
Sustainability	• SoLAR, IWMI, and SDC are now recognized stakeholders in solar irrigation in all 4 countries • The future of SoLAR interventions, including innovation fund-supported solutions, after completion of the project will be limited unless Government champions take these forward • IWMI is at a pivot point with new project leadership set to take charge in September; this is both an opportunity (likely development of new partnerships) and a limitation (inadequate prior experience with SoLAR implementation); however, SoLAR is set to have impact with current and future national and sub-national priorities for solar irrigation. • National and regional fora should exclusively focus on evidence-based policy engagement, given the emerging opportunities in all four countries, including for instance the role of SIPs in countries' climate commitments in agriculture
Next Phase	• Phase 1 lessons learnt have important implications for Phase 2 design, with particular emphasis on expanding to solar irrigation in Sub-Saharan Africa (SSA) via a comparative cross-regional South Asia – SSA comparative approach • Above all, a sound comparative basis for South-South programming must be ensured, with particular emphasis on off-grid, smallholder irrigation, both in groundwater stressed and abundant sub-regions • While some grid-connection opportunities should be kept open, SoLAR 2 should consider SIP implementation by government agencies other than electrical power companies, e.g., via agriculture or horticulture departments, development or infrastructure banks, or by NGOs and the private sector.

Perhaps the best way to capture the results of stakeholder interviews addressing SIPs programs across the project is in the following results dashboard shown in Table 2.

Table 2. Qualitative Results Dashboard of Project Impact by Country Assessed through Semi-Structured Stakeholder Interviews

high / medium / low	Solar Irrigation Feasibility	Solar Irrigation Benefit - Cost	Solar Irrigation GESI Outcomes	Solar Irrigation Climate Resilience/ Mitigation
India	*Extremely high SIPS adoption rates*	*SIPs heavily subsidy dependent*	*GESI effects virtually entirely secondary (via water markets, spill over income)*	*SIPs importance diminished with grid energy from renewables*
Bangladesh	*Moderate SIPs adoption rates despite significant GOB promotion*	*SIPs heavily subsidy dependent*	*GESI targeting is lacking, weak secondary effects (via water markets)*	*Explicit solarization policy to replace diesel pumps*
Nepal	*Significant demand outpacing SIPs program availability*	*SIPs heavily subsidy dependent*	*Strong SoLAR program support and GESI advocacy*	*Incipient SIPs programs yet to make carbon impacts*
Pakistan	*Moderate adoption rates despite growing GOP promotion*	*SIPs subsidy driven, but some self-financed, indicating positive B-C*	*Important but isolated examples of SIPs for kitchen gardens*	*Explicit solarization policy to replace diesel pumps*

It is evident the SoLAR project overall has generated significant achievements and impact. As synthesized in the executive summary, above, ***the SoLAR project's greatest overall impact has been through training*** (WP 3 Sharing Knowledge and Strengthening Experience), especially of SIP implementing agencies of the respective governments. In India, GERMI accompanied by IWMI staff conducted trainings of farmer SIP adopters with a robust training schedule and ample efforts to garner participation. As will be commented, additional efforts to enroll women and youth participants could have extended GESI impacts of the trainings. Additionally, solar installers in the SKY team appear to have training and orientation needs that could yet be met, especially to address SIP operation and maintenance and insurance challenges to be experienced after the initial 7-year period of DISCOM ownership.

A major impact of the project is research and knowledge support (WP 1 Generating Evidence), especially for the need to tailor SIPs programs to local and national policies, the socio-economic context, institutional capacities, as well as agricultural, water, energy, and climate conditions. A more integrated WEF-Carbon Nexus approach would further strengthen SIPs program impacts on rural livelihoods, on climate adaptation and carbon mitigation, and on groundwater sustainability. SoLAR is successfully providing support for Government implementation of SIP programs in the four countries, considering the contextual variables in the following *declining order of emphasis from the project*:

1) South Asia region-wide, SoLAR has established a modeling framework to consider the *impacts to groundwater* of SIPs schemes adoption (which currently are not having a marked impact in this regard, although the impacts of extensive SIPs scaling up are yet to be experienced or systematically addressed
2) *Climate resilience* offered by SIPs is evident in the drought impacts on Boro (dry season) rice cultivation in Bangladesh, by surface water-based SIPs in the canal tail-end areas affected by water scarcity and salinity in Pakistan, and in additional, more flexible pre-monsoon irrigation affected by hot, dry spells in India and Nepal. Additionally, SIPs offer a significant carbon mitigation strategy by potentially replacing fossil fuel (diesel) powered pumps. Although both Bangladesh and Pakistan have recently declared major programs for solarization of diesel pumps, these appear to be motivated less by carbon mitigation imperatives than by foreign exchange balance of payments considerations
3) *Gender equity and social inclusion (GESI) targeting* has been especially effective in SoLAR Nepal, although some evidence of the implementation team's and Governments' attention to GESI challenges is evident in Pakistan and India, though less so in Bangladesh
4) *Integrated water-energy-food (and carbon) nexus interlinkages* receive some attention in SoLAR reports and national and regional fora, yet more meaningful systematic engagement with WEF(C)[6] Nexus and WEF(E)[7] analyses, stakeholder representing these sectors, and integrated policy support remains an opportunity for SoLAR Phase 2
5) Given the prominence of *livelihood support* in the SoLAR project's framing, the evaluation team identifies as a gap the low priority accorded to livelihoods in the project's approach to multiple prevailing local food systems in the locations of SIPs implementation supported by the project.

In the team's assessment, SoLAR is ***providing an appropriate level of regional knowledge integration*** (WP 1), especially via regional fora and national fora (though both were suspended during Covid-19, these have emerged more recently as a signature activity of the project that provides broader visibility to SIPs and thereby to SoLAR, IWMI, and SDC as well as Government implementing partners). Additionally, as commented in the prior paragraph, SoLAR's efforts to assess groundwater sustainability regionally is commended. This is reflective of a consistent modeling and data framework, despite the differences in groundwater monitoring data across the four countries. Yet, consolidating these multi-country regional findings is needed, especially if a Phase 2 will consider a South Asia – Sub-Saharan Africa comparative approach. Finally, the ***project has achieved good understanding of policy drivers for SIP program adoption***, especially diesel/ fossil fuel substitution in Bangladesh, Pakistan, and Nepal, though less so in India.

Despite these and other notable accomplishments of SoLAR in Phase 1, the evaluation identified ***several gaps and opportunities in need of focus and attention in the remaining nine months of Phase 1.***

SoLAR project leadership transitions have hampered the project team's responsiveness to rapidly changing on-the-ground dynamics, although other factors also contribute to the rapid, almost dizzying, pace of change in SIPs programs (e.g., post-Covid-19 dynamics, global price shocks of input costs for

[6] Patel, P.M., C.A. Scott, D.A. Brent. In review. Four Birds with One Stone? Opportunities and Challenges in Adopting Solar Irrigation for a Sustainable Water-Energy-Food Nexus with Carbon Credits. *Water International*.

[7] Shah, T. Accepted. Water-Energy-Food-Environment (WEFE) 1 Nexus in Action: Global Review of Precepts and Practice

fertilizers and energy related to the war in Ukraine, rampant inflation and balance of payment challenges, upcoming elections in India, Pakistan, and Bangladesh, to name a few).

Of special priority for the incoming SoLAR Project Leader are the following:

1) National SIPs schemes in need of policy support (New Pakistan Solar Water Pumps scheme, PM Kusum C in India, PM's solarization announcement in Bangladesh)
2) Systematic review of Innovation Fund projects (WP 2) and lessons learned for scaling of Government and NGO SIPs programs
3) Closer attention to institutions and governance of SIPs programs (especially DISCOMS in Gujarat, IDCOL and Ministry of Agriculture (BADC, DAE and BMDA) in Bangladesh, AEPC in Nepal, and Provincial departments in Pakistan
4) Regional integration in South Asia and beyond (especially Africa, related to SoLAR Phase 2 scoping)
5) Additionally, the following recommendations from the Executive Summary, above, are relevant here:
    a. shift the focus from WP 1 and WP 2 to policy support via WP 3 with greater emphasis on current and short-term future opportunities as touched on for each country below
    b. in the national and regional fora, focus on policy engagement and institutional support
    c. hold an international symposium on solar irrigation with other IWMI regional programs (especially in Africa), with other CGIAR partners, and with other bilateral (e.g., GIZ) and multilateral programs (e.g., World Bank)
6) To support these opportunities, above, and for Phase 2, IWMI may consider a dedicated SoLAR Project Coordinator, allowing researchers to focus on their WP1, WP2 and increasingly WP3 tasks, thereby reducing the time spent on administrative and managerial tasks.

> *"Investment, finance, and marketing are the big challenges for solar in Africa. Governments need policies and the design of schemes." - P.C. Joshi, International Solar Alliance, New Delhi*

II. a. SoLAR GESI Phase 1

SoLAR should be better integrated into IWMI's GESI strategy going forward. In IWMI's GESI Strategy 2020-2023 report there is no mention of energy issues. Furthermore, on IWMI's SoLAR website, the photos, blogs, etc. predominantly show male farmer (from non-minority groups) images with solar panels. In the majority of IWMI publications, policy briefs, research briefs and reports, GESI angle is rare or so minor a discussion is included that they are of very limited utility.

> *"We need to not only evaluate outcomes but also need to make sure that gender transformative research was undertaken where a translator is hired, where there are women researchers in the field talking to women in communities, where questions are developed with and for women in communities" - IWMI Nepal staff*

Reinforced in recommendations for Phase 2, below, in the remaining nine months of Phase 1, IWMI GESI expertise capacity can be increased for the unique, country-specific contexts of Bangladesh, India, and Pakistan which are each different from Nepal where more GESI work has been conducted. It is recommended to improve IWMI coordination and collaboration with organizations working on GESI to increase policy and program influence.

SoLAR Nepal GESI Phase 1 achievements and impact include that the IWMI country representative has GESI training and experience, and she has built a GESI research team. This has produced real GESI relevant results: publications showing, e.g., women and minorities often unaware of 60% subsidy on SIPs; when women did gain access to SIPS, inequities existed: most received by well-networked women; there was a lack of female extension agents despite significant demand for this. There was important IWMI documentation of the transition from dispersed, individual SIPs (wealthier farmers) to community led SIPs (with more diverse farmers benefitting). IWMI's GESI related work influenced policy change within AEPC by means of IWMI policy briefs, research briefs, that included that one of every three applications for SIPs subsidies must now be awarded women, farmers with 10 kattha (0.5 bigha, equivalent to 0.339 hectares or above now eligible for subsidy (before, only farmers with 5 bighas, equivalent to 3.39 hectares were eligible), and farmers who lease land can also apply for the subsidy. One journal article also addresses comparative work on GESI and policy issues between Nepal and Bangladesh.

In the remaining nine months, gaps and opportunities related to SoLAR Nepal GESI include producing policy and research briefs that identify opportunities and assess how scaling up process could occur of new projects similar to the innovation fund projects that have demonstrated pro-women, smallholder and landless achievements, as evidenced by Minergy and Gham Power IF examples. This would include the spread of such opportunities to Nepal among innovation fund projects that were in the other SoLAR countries. Another opportunity in the next nine months is to analyze the remaining data and produce a virtual global symposium with panel experts on gender issues in solar irrigation pumps in Nepal synthesizing findings from SoLAR Phase 1. Lastly, in the remaining months, a recommendation is to develop and begin to administer interview and survey questions for key stakeholders in government agencies, non-profits and among community members to evaluate efficacy of AEPC mandates that one of every three approved applications for SIPs subsidies must be for women; farmers with 0.125 hectares or above eligible for subsidy; farmers who lease land can also apply for subsidy. This process of evaluation should be continued in Phase 2.

> *"Although in Nepal case, there is progress on GESI inclusion in policy, there is still elite capture of subsidies. We still need to work more on awareness raising among marginalized and lobby with the local government for effective subsidy structure so that marginalized women know the policy exit and can benefit from these schemes" - Manohara Khadka - IWMI Nepal country representative*

SoLAR Pakistan GESI Phase 1. GESI was not a focus of IWMI Pakistan for the SoLAR project. However, in the next nine months, IWMI should coordinate the development of a policy brief produced by experts in academia, NGOs and government organizations around the following recommendations:

1) Specialized Training and Extension: Launch comprehensive training and extension programs to educate smallholder farmers, landless and women on modern and sustainable agricultural practices including RDI, and crop diversification. Provide these populations with technical knowledge, best practices, and information on SIPs. This can enhance their productivity, improve crop yields, and promote sustainable farming practices
2) Access to Finance: Draft certain programs in which small farmers especially female farmers can be guided extensively on how they can have access to the established specialized financial institutions in the country for getting the loans and utilizing SIP subsidy
3) Entrepreneurship Support Programs. Establish programs to encourage and support women's entrepreneurship through solar energy programs. These support programs should include material on Market Linkages to Create awareness sessions to educate how to connect these populations directly to markets, reducing the role of intermediaries and enabling farmers to access fair prices for their produce.

SoLAR Bangladesh GESI Phase 1. For GESI related work, IWMI Bangladesh has been conducting research with possible GESI relevant findings that includes SIP effects on land markets including prices and terms of leases (with potential GESI findings). It was found that IDCOL was able to facilitate access

by some sharecroppers to SIP irrigation. Other GESI related work is on possible instruments to control water rates charged by SIP operators. How control over this could be ensured in practice is unclear and whether women and other vulnerable groups are more exposed than, for example, more affluent men in these communities to overcharging for water is also unclear.

Beyond these topics, GESI issues remain largely unexplored in the Bangladesh context thus limiting potential policy impact. Gaps and opportunities in SoLAR Bangladesh GESI include the possibility of IWMI-Bangladesh producing a policy brief within the next two to three months (to inform recent PM announcement on large investment in SIP program rollout) that includes the following recommendations:

1) Paying upfront fees by a farmer or sponsor appears difficult, although the interviews raised concerns about the possible control over water by rich, influential farmers who are able to make down payments; this raises the need to address how farmers organization can manage down payments
2) The government agencies involved should have capacity to: develop user groups (Common Interest Groups, producers' groups or water user groups) to own the SIP, which would allow for users to obtain better bargaining capacity and better voice
3) Women are getting involved in SIP and participating in their operation as individuals or as hired operators. They should be backed by skill enhancing training
4) There is a need to extend the period when SIPs are used to fully utilize this energy source and to better justify the investment. SIPs usefulness year-round including during times of year when irrigation is not needed and their utility for a broader range of activities carried out by women, the elderly, etc. in the household could be achieved by extending SIPs service for household use, for food processing (but machines must be located in the middle of the village) and for microenterprises through additional investments.

In the next nine months, focused sets of interviews should be carried out with female operators to ascertain:

1) What process was followed for them to obtain operators' position, including challenges they faced to obtain the position and how they overcame these
2) What types of challenges they are facing as women in this position and how/if they are resolving these challenges in operation, distribution, and service charge collection, etc.
3) Unique perspectives they may have on SIPs and social equity in the village, multiple uses of SIPs, SIP utility for crops other than paddy, changes they have undertaken themselves as SIP users; effect of SIPs on youth; open-ended questions on effects of SIPs on their village
4) How the buried pipe system of water distribution eases drudgery, allowing female farmers easier access to participate in SIPs irrigation.

SoLAR India GESI Phase 1. IWMI research has included GESI related research on access to SIPs by smallholders and the landless, with findings that SKY program disproportionately benefitted larger farmers. IWMI funds Gujarat Energy Research & Management Institute (GERMI) to provide skills training on SIP use and to a lesser extent maintenance. However, very few women were trained. IWMI has supported alternatives to individual ownership of SIPs, supporting Dhundi village with its solar cooperative, and expanding the solar model village example to Mujkuva village, where grid-connection was piloted by NDDB. SoLAR has few outputs focused on gender related SIP issues in India (Lefore et al, 2021 done under WLE, for example).

> *"Before with diesel pumps, men would break their legs trying to carry the pumps to the fields and back; now the SIPs are light and we women can even carry them" - Anand, Gujarat, woman who took part in a stakeholder meeting where men and women community members were present*

In the remaining nine months it would be useful for IWMI India to explore why more gender related outputs have not been produced under Phase 1.

Also, IWMI India could use available staff with input from IWMI Nepal staff to organize a series of focus group discussions (FGDs) with women farmers, and separately with small and marginal (male) farmers, on barriers to obtaining benefits of SIPs. Each FGD could be organized by women's socio-economic status so that lower income/caste women would not feel impeded in their participation. A policy brief and research brief should be developed synthesizing the findings of the FGDs and disseminated to relevant organizations and agencies.

II. b. SoLAR Nepal Phase 1

For the SoLAR Nepal Phase 1 evaluation a total of fourteen interviews were conducted: five of private sector staff, four of government agency staff, four of non-governmental agency staff and one farmer adopter.

Regarding SoLAR Nepal Phase 1 implementation, prior to SoLAR, the solar irrigation system subsidy was only for those farmers who had 5 or more *bighas* (greater than 3.39 hectares) of land. Now, after continuous policy advocacy by IWMI, AEPC has amended their policies in favor of landless and smallholder farmers. Farmers with 0.339 hectare are eligible for the government subsidy, landless farmers can also apply for subsidy if they can show a lease agreement and one of every three applications need to be for women landowners/farmers. This has been the most important milestone achieved in terms of project impact. This is the impact of Work Package 1 (Generating Evidence).

> *"IWMI's continuous research advocacy has supported us to amend policy on subsidy that is GESI friendly" - Laxman Prasad Ghimire, Assistant Director, AEPC*

In terms of generating evidence and sharing knowledge, the Rapid Assessment Report and Situation Analysis Report sharing in Nepal National Forum has provided a very important lesson learned for the government (AEPC) as well as for the solar irrigation projects of other bilateral organizations such as GIZ DKTI, UK AID NREP. An important learning that led to policy pressure and action was related to the need for a transition from dispersed, individual solar irrigation pumps to community-led solar irrigation pumps. Related to Strengthening expertise, the SoLAR situation analysis of after-sales service and defunct individual solar irrigation pumps has provided important lessons for solar irrigation pump project staff related to the need to plan and the need to introduce innovations to address these important challenges.

> *"IWMI's rapid assessment report and situation analysis shared in the national forum has been pivotal to start our own SIP projects under GIZ funding" - Khem Raj Bhandari, Deputy Team Leader, DKTI Project*

In terms of piloting and testing solution, in the SoLAR demonstration pilots, farmers have experienced increased income due to the addition of one more crop due to availability of water in the dry season in the pilot area. The local government has been very favorably impressed with the outcome of the pilot project and thus allocated 1 crore (10 million NRS = USD 76,000) for a similar system elsewhere in Nepal in this fiscal year (2080/81; 2023/24). There has also been demand from farmers in the same region for the same type of system who do not have access to this system.

> *"We used to have only one paddy in a year, now we could also cultivate spring paddy in the month of April which is only because of SIP as there is no other source of water in this time. We can now have 4 crops instead of two crops. This has helped me to have extra income of 80,000 NRS" (USD 615) - Amin Miya, farmer, SoLAR pilot project*

Two innovation fund projects under SoLAR Nepal were implemented by private companies: Gham Power and Minenergy. Much-needed innovation was accomplished in addressing real time data needs around the efficiency of solar irrigation pumps (Gham Power) and groundwater level trends and optimization of irrigation water (Minenergy) WP 2 Piloting and Testing Solutions. Presentations on the innovations to evaluation team plus SDC (M. Kaufmann) were very positive.

There is a large demand/supply gap for SIPs in Nepal (AEPC claims demand exceeds 10,000 SIPs per year against their provision of 3,000) and Nepal can access all kinds of innovative technologies available globally. Solar irrigation in Nepal, however, remains a subsidy-driven market. Opportunity exists to explore/ innovate with different business/ financial models.
There is an opportunity to engage youth in developing innovations in SIP technologies if IWMI collaborates with different universities. There is an untapped opportunity for IWMI to become a knowledge center for different audience like researchers, policy makers, end users and private sectors.

> *"If all the subsidy is stopped today, SIP market in Nepal will collapse the very next day. We still need subsidy; however, it should be insured that the right people are getting subsidy" - Hari Shrestha, COO, Sun Farmer Solar Company*

> *"Blanket subsidy is killing the market, there must be some innovative financial solution to scale up SIP independently of subsidy. It does not mean we do not need it. We need it for the ones who absolutely cannot afford and is a potential farmer. Rather than this, we need to find different financial solutions as the demand-supply gap is huge." - Gham Power and Mero Micro Finance*

Recommendations for the remaining nine months of Phase 1 in Nepal include the following:

1) Sharing of learnings on innovation to different stakeholders, including cross-regionally
2) Science communication to policy makers, local governments and end users.
3) More robust study on why scaling up of solar irrigation is not taking place
4) Robust mechanism for after-sales service and sustainability of the system in the pilot projects
5) Emphasis on policy breakthroughs with NEA regarding net metering. This policy change has the capability of transforming solar irrigation in Nepal in the future

II. c. SoLAR Pakistan Phase 1

The SoLAR supported behavioral studies on farmers who switched from diesel to SIP pumps and on water extraction behavior was truly novel in Pakistan (WP 1 Generating Evidence). Such evidence will assist the Government in drafting the national SIPs policy, as recently declared by the Pakistan Government. The Executive Committee of the National Economic Council (ECNEC), the highest authority for project approval in Pakistan, sanctioned the Solarization Agriculture tube wells schemes in June 2023, with financing in the amount of Rs377.2 billion and a gestation period of three years. The federal government will contribute Rs139 billion, the provinces will contribute Rs119 billion, and the remaining Rs119 billion will be contributed by the farmers. The scheme aims to replace 50,000 diesel engine tube wells and 50,000 electric tube wells with solar-powered motors[8]. Diesel pump replacement is now actively promoted in Pakistan because SIPs can reduce and stabilize costs for farmers, improve the Government's foreign exchange balance of payments, and reduce carbon emissions.

[8] https://tribune.com.pk/story/2425779/projects-worth-rs11tr-approved

What is rather unique in the SoLAR project perspective is that SIPs adoptions, though limited in number, are largely self-financed by farmers. Very few farmers in Punjab province have received SIP adoption subsidies. However, this is contrasted by the adoption of substandard equipment. Due to limited SIPs experience and farmers' know-how, especially in remote areas, low-grade and poor SIP equipment is used that does not produce the expected results. As a result, SIPs tend to have a negative image among the farming community.

The SoLAR project introduced the groundwater vulnerability index (WP 1), which is also a first in Pakistan. Again, this forms an important basis to roll out future SIPs programs in various provinces. Through workshops and other venues, IWMI has brought this to the attention of national and provincial governments, which are increasingly aware that the promotion of SIPs must be based on groundwater vulnerability zones. The project's groundwater sustainability research involved field instrumentation for groundwater monitoring, soil moisture, and simulation of grid-connected pumps (WP 2 Piloting and Testing Solutions). Twelve sites are being monitored in three districts of Punjab with in-situ instrumentation which includes six SIPs and six non-solar pumps. Pumping and soil moisture data indicate that SIP farmers growing sugarcane in canal-fed areas of Punjab are pumping more compared to other sugarcane growers, potentially due to lower marginal costs of pumping as compared to diesel.

The IWMI SoLAR project team in collaboration with PARC and KFUEIT has conducted trainings, webinars, and other knowledge sharing and capacity-building sessions (WP 3 Sharing Knowledge and Strengthening Expertise). Overall, the SoLAR project has helped in local capacity building for managing SIPs and precision surface irrigation (PSI). Farmers were trained in "Operation and Maintenance of Solar Pumping Unit and Precision Surface Irrigation" and were provided the opportunity to get to know the latest SIPs technology and utilization in their current irrigation system. Additionally, farmers benefited by hiring laser grading equipment at affordable rates from KFUEIT. As a result, a major outcome of SoLAR in Pakistan has been that KFUEIT now has sufficient capacity to become the knowledge hub for SIPs with efficient and precise irrigation systems.

Related to irrigation technology in support of SIPS programs, SoLAR has supported the development, testing, and rollout of responsive drip irrigation (RDI), a novel technique developed and pioneered by the NARC Climate, Energy and Water Resources Institute (CEWRI) via a SoLAR Innovation Fund project. RDI is a low-cost solution that can be efficiently coupled with SIPs. Field experiments of the solution have shown that it has a significant water and energy saving potential of at least 50% compared to conventional drip irrigation.

Although GESI dimensions of SIPs were not explicitly pursued by SoLAR in Pakistan, field trials in multiple remote rural communities have seen women actively managing kitchen gardens irrigated by SIPs using RDI. Women in Pakistan (and in the majority of countries globally) are largely responsible for small-scale agricultural production in kitchen gardens. Also, in Pakistan male household members frequently migrate to work in cities.

In general, the Innovation Fund projects are seen as a positive component of SoLAR, even though there were some issues with payment modalities, such that delayed disbursement of funds affected project timelines.

Recommendations for the remaining nine months of Phase 1 in Pakistan include the following:

- The behavioral study should be expanded to include small, medium, and large farmers with special attention given to including female farmers. It must also be applied in areas at the tail end of canals where water stress is greatest.
- Additionally, training and capacity building of farmers on selection and use of higher-quality SIP components is needed. This can best be achieved by encouraging KFUEIT to lead additional trainings as well as involving more universities in serving as SIPs knowledge hubs. Trainings can focus on providing farmers the know-how on installation, operation, and maintenance of SIPs. Furthermore, special SIPs and drip/ precision irrigation training sessions can be provided for women in agriculture. Very limited focus is evident on GESI issues in SoLAR project Phase 1

activities in Pakistan and steps should be taken by IWMI to correct this in the remaining months of Phase 1.

II. d. SoLAR Bangladesh Phase 1

The stakeholders contacted and interviewed in Bangladesh included 14 in total, with six from the private sector, six from government, one from an NGO, and one farmer (in addition to dozens of farmers the team interacted with during the field mission).

The SoLAR project is especially timely for better understanding and addressing energy use, particularly at a time when global prices for energy, food and other commodities are affecting the economy. Reduction of fossil fuel use that can result from more widespread SIPs adoption at the same time addresses climate change mitigation. However, the current level of SIPs adoption Bangladesh, that has required consistent institutional support by the two main Government partners (IDCOL and Ministry of Agriculture via BADC, DAE, and BMDA), needs significantly greater scaling up with institutional coordination for better skills development and experience sharing in order to have the desired effects on fossil fuel replacement.

The recent announcement by the Prime Minister to replace diesel with solar pumps could be a very significant opportunity for SIPs adoption. According to the Executive Committee of the National Economic Council (20 June 2023), the Prime Minister declared that if private entrepreneurs want to invest in solar power, they will be given governmental support, including waiving of duties and taxes for import of solar panels. However, policy guidelines still need to be framed, and this is an important task for the remaining nine months of SoLAR Phase 1 to provide knowledge-based support for policy development (WP 1). The call to replace more than one million existing diesel pumps with SIPs will be a major challenge and opportunity at present and into the future.

Currently, the two main modalities of SIPs implementation in Bangladesh have used both public (Min. Agriculture MoA's BADC, DAE, and BMDA) and private sector (IDCOL) models. The public sector interventions under MoA are project-based with fixed years of operation in project length, and mostly highly subsidized. The cost-recovery business viability appears unsustainable. Similarly, project-based installations are yet to develop within the SoLAR project that have a high enough demand by the sponsors. Research, extension, rural development, and private service provider companies are involved in SIPs implementation. However, experience sharing through a single platform (SoLAR-led knowledge hub) must be strengthened.

> *"There are no doubts about the benefits of solar irrigation pumps but questions remain about the subsidy, given the current power tariff levels." - Alamgir Morshed, IDCOL*

Surface-water sourced public SIPs (under the MoA model) and groundwater sourced tubewell systems (IDCOL) are different in terms of siting, and crucially, water resources availability and permitting. Field-level operation demands immediate solution of the groundwater licensing issue, which must be based on locally applicable criteria such as groundwater depth, aquifer type, salinity/ quality, recharge from adjacent water bodies, etc. and not a one-size-fits-all general rule applicable across the entire country. Note, the lessons learnt from Bangladesh achieving progress in dry season Boro rice through the opening of groundwater markets using shallow wells through withdrawal of public control over tubewell irrigation are still valid for SIPs today.

> *"Only surface water-based SIP is limiting boundary. Scarcity of water during lean flow of streams constraints irrigation expansion. Confined with riverbank with less fertile land limits further expansion. Portable panel could be a solution for land scarcity. It is available now." - Sarrowar Hossain, Project lead, BADC*

SoLAR Phase 1 activities have been a useful learning experience; however, additional opportunities can be developed and harnessed by expanding SoLAR partnerships in Bangladesh, for example with research, development, and knowledge institutions (including Dhaka University's Institute of Energy, Bangladesh Agricultural Research Institute - BARI), SREDA, UNDP, and reputed public and non-governmental policy research bodies. This could have been realized through the SoLAR Innovation Fund, but the team found that in Bangladesh the Innovation Fund was not utilized to develop knowledge that answers important questions associated with field-level use of SIPs.

SIPs in Bangladesh are a relatively new technology, even though solar rooftop home systems have been implemented for several decades, especially to allow electricity service beyond the grid covered areas. Bangladesh is still to achieve targets and goal of SIPs adoption. There is a clear need to identify sustainable models of SIPs installation and operation that reduce the use of scarce productive land. Opportunities for SIPs to provide important benefits lie not only in irrigation, but also in aquaculture ponds (some of which are supported by public projects), and post-harvest operations (solar powered threshing, drying, milling etc.). New SIP system development may consider keeping space for such operations to broaden the use of solar energy, thus making adoption more effective.

> *"After paying down payments we are yet to be informed of our instalments to be paid, after 5 months the system is not yet handed over. The discharge of well is far below then originally designed, thus cannot meet demand of irrigators." - Juwel Hossain, BREB SIP owner*

The automation of operations and mobile or portable solar panels under a private service provider can be a way to save time and respond to farmers' demands. This allows farmers to pursue non-farm activities for improved livelihoods.

The Boro season rice cropping pattern is the most water intensive and costly in terms of pumping costs, while the alternatives of diversified cropping are relatively easy with lower operational requirements. This is reflected in the SIP irrigation service fees charged to the users (farmers). Additional extension and skill development in operations and maintenance (O & M) at the field level is required. Training in farm operations, alternate wet-dry (AWD) irrigation, precision water management, etc. as well as repair of SIPs equipment like inverters, motors, panels, and in some cases, batteries seem to be inadequate in general. Responses from vendors in servicing the spare parts or pump parts is not well developed. Additionally, monitoring of installed SIPs systems needs strengthening by appropriate local authorities. Further, the command area of existing SIP could be expanded to accommodate more land resulting from improved irrigation efficiency, for example, through farmers groups and sponsoring agencies. All this must be supported by data and knowledge sharing among the agencies to support policy formulation, though this has proven to be difficult.

In sum, for the remaining nine months of SoLAR Phase 1 in Bangladesh, IWMI should:

1) More actively develop opportunities to provide knowledge input for the policy guidelines of the Prime Minister's declaration to replace diesel with solar pumps
2) Strengthen experience sharing of the two main modalities of SIPs implementation (IDCOL and MoA) through a SoLAR-led knowledge hub
3) Provide the knowledge base relevant for groundwater licensing currently overseen by Upazila (Subdistrict) Irrigation Committee, but well spacing norms should be replaced with locally applicable criteria such as groundwater depth, aquifer type, recharge from adjacent water bodies, etc. and not a one-size-fits-all general rule applicable across the entire country
4) Identify sustainable models of SIPs installation and operation that reduce the need for scarce land, while also providing non-irrigation benefits
5) Broaden the training in farm operations, alternate wet-dry (AWD) irrigation, precision water management, etc. as well as repair of SIPs equipment.

II. e. SoLAR India Phase 1

Reflective of the extent of SoLAR activity in India, the evaluation team dedicated the greatest time and effort here as compared to other countries to assess the project's achievements, impacts, gaps and opportunities. Information was sourced via 37 different interactive sessions, 15 farmer interviews, 3 with private sector, 3 with electricity companies, 2 international organizations, 10 academicians or researchers, and 4 Innovation Fund grantees.

Among the four countries in the SoLAR project, India has advantage of early start of programs and schemes dedicated for solar irrigation promotion. The theme requires coordination of key stakeholders/institutions from diverse backgrounds and intentions. In the institutionally complex solar energy space in India, the SoLAR project has been successful in aligning with critical allies such as International Solar Alliance (ISA), some actors in Ministry of New and Renewable Energy, Government of India (MNRE), and Gujarat Urja Vikas Nigam Limited (GUVNL) and Gujarat Energy Research and Management Institute (GERMI). GUVNL and GERMI have in-depth experience in developing and implementing solar irrigation schemes in one of the most proactive states for solar irrigation promotion, Gujarat. At national level MNRE holds reins for implementing PM-KUSUM scheme with high targets for solar irrigation in India. Whereas ISA has interest in developing international consensus for solar energy adoption including agriculture usage, hence solar irrigation. These collaborations can leverage ground implementation experiences and policy formulation in national and global contexts.

> *"Solar water pump promotion is a lonely space" where SDC can be more closely involved – Bilateral agency program officer*

The evaluation team observes that the IWMI SoLAR leadership changes and COVID-19 have impacted the expected broader outcomes of the project, particularly in supporting the government efforts to promote solar irrigation. Nevertheless, SoLAR has made initial progress to address three basic components: 1) impact evaluation (WP1), 2) training of farmers (WP3), 3) groundwater sustainability (WP1).

IWMI's impact evaluation analysis suggests mixed results of the first years of Gujarat's SKY scheme and policy, though SKY and IWMI monitoring are still in progress (WP2). The project research lacks critical ground understanding and perspectives of farmers about SKY and PM-KUSUM scheme. The farmers' perspectives are critical in understanding the current failures of PM-KUSUM scheme at state and national level. PM-KUSUM scheme requires critical course correction and SoLAR project can play pivotal role in providing critical insights for policy formulations.

The project team correctly identified the training needs and played a critical role in developing the farmers' training modules and implementation of trainings. The IWMI-GERMI trainings show very positive uptake by farmers, supported by SKY installers who now interface with farmer adopters. The farmers interviewed still have concerns about the metering company (HPL Electric and Power Ltd.) involved in the SKY scheme. More critical insights about the challenges and setbacks in SKY scheme implementation are compiled by GERMI which shall be leveraged for policy advising for better solar irrigation adoption.

> *"There are still many unresolved issues with SKY Scheme implementation. The farmers' training was helpful but the core challenges related to feeder maintenance causing voltage fluctuation and frequent burnout of the inverters on top of frequent theft of hardware are frustrating us. We requested certain changes in the implementation strategy such as allowing consolidated adoption of the solar systems to reduce maintenance issues, but our requests were neglected. Farmers know their area better than anyone. We shall have been adequately engaged and incorporated in designing, planning, and implementation of solar schemes." - Piyushbhai Bhakta, Rupwada farmer and SKY adopter in DGVCL service area*

The groundwater sustainability component focused on generating primary data for groundwater usage and irrigation water demand in two different geographies. It is premature to claim that groundwater is sustainable with SIPs adoption, given the implementation challenges and limited present scale of current implementation. IWMI shall be cautious in providing early results that can misinform policy makers about the groundwater sustainability aspects. The primary data collection should be extended to more than a few cropping seasons and continuous monitoring can provide short-term and long-term policy implications for groundwater and solar irrigation adoption.

The impact from SoLAR in influencing MNRE, and especially PM-KUSUM, is not currently apparent. Lessons learned from SoLAR work on SKY and with SKY stakeholders in Gujarat are not adequately synthesized or disseminated to drive critical recommendations for PM-KUSUM (C) or SIPs in general. There is critical need to answer the following questions more systematically and effectively, for example, in the final national and regional fora of SoLAR Phase 1:

1) What drove adoption of SKY in Gujarat?
2) Why could Gujarat do what other states seem to not be able to do?
3) What are the experiences and perception of the farmers about SKY and KUSUM that can encourage or discourage further adoption of grid-connected solar/SIPs adoption?
4) What are the critical skill or information gaps needing attention?
5) Why the small and marginal farmers are not able to adopt SIPs?
6) How prepared are others states to adopt grid-connected solar under PM-KUSUM C?

From the broader project design perspective, we find that the project work packages are ambitiously designed with little room for agility. A missed research opportunity was assessment of off-grid SIPs (note, Gujarat alone has >14,000 off-grid SIPs along with a scheme to connect them to the grid). Although it is identified that the subsidy mechanisms are important for SIP adoption, there is a lack of critical understanding about the level of subsidy, and subsidy delivery mechanisms, sufficient for adoption of grid-connected solar irrigation. These could be studies on willingness to pay, farmers behavior (as in Pakistan), GESI focus (as in Nepal), etc. The current mechanisms in India make them very unattractive or unaffordable for the farmers, especially for the small and marginal farmers.

> *"We would like to adopt SKY as it will provide day-time electricity and potential additional income. However, we are not sure why government discontinued this scheme." - Satishbhai Patel, Vishnupura farmer and SKY non-eligible farmer in UGVCL service area*

In terms of project management, strong field presence through field staff and strong personal dialogues between research and field staff can help identify evolving research needs and field insights. Dedicated project management staff shall help reduce workload for the research staff requiring to contribute significant time in project management and organizing fora. This helps researchers to dedicate more time for analyze, compile, and disseminate the learnings. There is a need to identify champions within the government systems (other than Mr R. J. Vala) in Gujarat and other states who can leverage state connections and build enthusiasm in the existing government system.

Regarding identifying and incorporating major stakeholder for SIPs programs, financial sector (banking and insurance) expertise should be better integrated with the project management committees. We find inclusion of IDCOL in Bangladesh providing critical leverage of scalability of SIPs. However, a lack of similar banking or insurance players involved in SoLAR in India leads to limited experience about the scalable financial mechanisms and insurance for SIPs. Clarity around the major stakeholders from the perspective of scalable solar energy and solar irrigation sector in India can help identify roles of stakeholders and their needs. We identify MNRE, DISCOMs, solar installers, O&M service providers, banks, insurance companies, and end-users (farmers) as current major stakeholders for implementing PM-KUSUM or similar schemes.

> *"We are not sure what happens to the solar systems after the end of 7 years of loan repayment period. The Energy Minister then assured us that they will find a way to provide insurance after 7 years as well. If farmers will have to take care of any maintenance cost after 7 years, they will dump the system and go back to grid energy access." - Vinubhai Nadani, Botad farmer, SKY adopter, and cooperative leader in PGVCL service area*

Recommendations by the evaluation team for the next nine months of SoLAR Phase I include:

1) The data from large-scale survey conducted of SKY farmers should quickly and systematically be summarized for qualitative and quantitative insights
2) For WP 1, it is necessary to ask the questions both of groundwater availability during SIPs adoption as well as potential future depletion from solar irrigation adoption (but not focusing solely on the latter as a 3rd generation question)
3) IWMI (with GERMI) training of solar technicians and DISCOM engineers is an opportunity
4) IWMI should formally assess the IF grants to extract lessons learned, especially to assess and recalibrate the IF program for SoLAR Phase 2Greater attention can be given to SKY that can help address perceived negative experiences (including DISCOM governance, support to installers, and planning for the post-7-year handover of SKY SIPs to farmers)
5) Given that SKY adoption is already 5 years old in many cases, it is opportune to understand and guide the discussions around the insurance availability and sustainability of grid-connected solar irrigation promotion beyond 7-years of government guaranteed support. IWMI should leverage the farmers training to better understand:
    a. are the farmers who are handed over the bills really paying the bills or are there any protests etc. that are not being reported?
    b. what are farmers' perceptions about the SKY scheme financial outcomes?
6) A major opportunity is to assess how prepared are other states, and Gujarat as well, for PM-KUSUM (C but also A and B) considering administrative, infrastructure, policy, finance, and social dynamics factors
7) Based on the learnings from the groundwater sustainability studies, a policy brief should be prepared on socio-economic and agronomic mapping of "safe for solar irrigation". Another map can be created that informs the suitability of grid-connected solar irrigation superimposing groundwater suitability and quality of grid-connectivity. The project team must also be cognizant that the questions in PM-KUSUM is not deciding whether to adopt SIPs or not, but rather it is whether to promote grid-connected SIPs or promote off-grid SIPs.

III. SoLAR Phase 2

Based on SoLAR Phase 1 lessons learnt and impacts identified and based on the emerging set of opportunities for SIPs programs in South Asia and other regions, the evaluation team provides the following reflections for SoLAR Phase 2 design. Greater emphasis should be provided on policy engagement and uptake (current WP 3) with only focused new work on evidence and new models (WP 1 and WP 2). In South Asia, at least three major opportunities are offered by government SIPs roll-outs: 1) the new Pakistan Solar Water Pumps scheme, 2) India's PM Kusum C but also A and B with particular attention to implementation in one or possibly two states, and 3) the Bangladesh Prime Minister's solarization announcement. In Nepal, SoLAR 2 opportunities exist to coordinate with other bilateral aid programs supporting SIPs (UK AID NREP Sustainable Energy Challenge Fund, and KfW Office covering Nepal based in Dhaka, Bangladesh). In this context, better understanding is needed of collective action and farmer-group approaches to SIPs deployment.

In general, the evaluation team supports initial efforts to pay more systematic attention to integrated approaches including the water-energy-food nexus, especially linked with decarbonization and climate adaptation objectives. This would entail broadening the understanding of primary and secondary effects of SIPs programs. Particularly from a GESI perspective, solarization is important beyond irrigation pumps and should be seen to encompass multipurpose [non-irrigation] solar energy uses such as cooling and storage. Other energy sector challenges include institutional analysis to better understand opportunities and limitations of power companies as the sector rapidly trends towards renewables. Additionally, water-related opportunities should not be limited to groundwater depletion studies but should include assessment of groundwater sustainability including through managed recharge, SIPs programs tied to precision irrigation (e.g., where pumps are implemented together with drip irrigation), and more systematic understanding of projected climate scenarios. Finally, SoLAR 2 should consider crop diversification and its impacts on livelihoods and nutrition as well as on soil and water resources. SoLAR 2 will benefit from more explicit plans in the coming nine months of Phase 1 for assessing lessons learnt from solar irrigation in South Asia, research scoping, as well as cross-regional comparisons for Africa.

While SIPs programs should continue to receive emphasis in SoLAR 2, the team recommends that sharper focus be placed on subsidy regimes (not just fraction of total cost covered but modalities for investment and fee recovery), subsidy delivery (particularly given the broad social goods objectives, farmers should not be expected to pay the full costs, raising the need for policy analysis of cross-subsidization in line with country NDCs), and the role of credit providers (development or infrastructure banks and private lenders) as well as insurance providers (both public and private) to make SIPs attractive.

Subsidies are a politically sensitive question. 'Perverse subsidies' are blamed for negative behaviors by consumers (e.g., electricity subsidies for over-pumping) while 'incentive subsidies' are seen as investments in positive actions (e.g., training and appropriate water pricing for water conservation). It is recognized that SIPs subsidies tie into broader political economy considerations. Both regular electrical pumps (with coal or fossil-fuel based electricity) and diesel pumps rely on extensive subsidy payments, even if not for the piece of equipment itself. Similarly, water and especially groundwater is subsidized in that there is no charge for use of the resource itself. More broadly, the subsidy for the SIP pump is only a partial picture. How can incentive subsidies be provided to promote a wider shift from diesel pumps to SIPs? Are there external systemic aspects that need to be addressed? In this context, there are virtually no subsidy-free business models. Indeed, agriculture development anywhere depends heavily on subsidies. For example, India spends approximately USD 12B annually for energy subsidy in the agriculture sector, on top of comparable spending on fertilizer, seed, and other inputs. Although subsidy mechanisms vary significantly by state in India, electricity access in most states India is up to 90% subsidized (e.g., Gujarat charges a maximum of INR 0.60/unit to farmers compared to INR 6.00/unit at

the market rate). The political economy of free or subsidized farm power creates significant market distortions towards conventional energy access. Thus, adoption of SIPs significantly depends on the market support (tax-breaks) and subsidies. Additionally, from the DISCOMs' perspective, converting the farmers with subsidized electricity access to solar changes continuous over time subsidy support to one-time upfront subsidy support. Until now, a suitable business model has not been found that does not have any subsidy and is completely market driven, as solar technology is costly and cannot financially compete with conventional electricity access or even diesel pumps, which have higher running costs but limited upfront cost). A major co-benefit of solar irrigation promotion is carbon-emission reduction, which can leverage green credits and tap into green energy development spendings to finance the subsidies.

There is a need to expand the current training mandate, which in SoLAR 1 tends to be targeted towards farmers. SoLAR 2 capacity building should include orientation, management and administration, and trouble-shooting approaches for Government agencies charged with SIPs implementation, including but not limited to power distribution companies, promoters or regulators like AEPC or SREDA, agriculture or horticulture departments, and NGOs (where policies permit their active participation in SIPs implementation).

SDC's Climate, DRR & Environment Section (CDE) should continue to prioritize SIPs research-supported policy engagement in South Asia, with more specific country-level opportunities identified below.

The evaluation team understands that one of SDC's other sections – the Food Systems Section – and possibly a second the Water Section – have interests in SoLAR 2. Food Systems would have ample opportunities to build synergies with and strengthen SoLAR 2 programming related to more integrated water, energy, food WEF Nexus approaches, linked to climate and carbon emphases of the Climate, DRR & Environment Section (CDE). Relatedly, the groundwater depletion challenges as well as enhanced groundwater recharge efforts in South Asia (particularly Pakistan, Western India and regions of Bangladesh and Nepal experiencing over-exploitation) are in need of SIPs-based and other modes of groundwater development that have both some inherent limits to energy supply but also offer tools for better irrigation management practices. Finally, eastern India, part of Bangladesh, and the Nepal Terai would form a fertile test-bed – a Social-Ecological Observatory for Diversified Livelihoods through Solar Irrigation – with real implications for scaling regionally and for lessons adoption and transfer to Sub-Saharan Africa. Given that GESI-relevant livelihood activities are as much post-harvest, marketing, and food consumption (not to discount at all the role of women and marginalized in crop production), it would be useful to conceptually map out alternative, particularly solar, energy use in food processing, storage, and preserving, and then home in on activities and SoLAR 2 emphases that might have the greatest value for women as entrepreneurs and to increase GESI impacts more broadly.

III. a. SoLAR GESI Phase 2

In Phase 2, it is recommended that IWMI broaden the SoLAR project to include multiple uses of solar energy and water for food processing, e.g. and for smaller production systems such as kitchen gardens. There should be a focus on training more women operators, women SIP users on use and maintenance through, e.g., GERMI in India. Handouts should be provided with mostly pictures for trainees to take home to household and community members unable to attend trainings. Another recommendation is that IWMI analyze Innovation Fund results that are GESI relevant and produce research and policy briefs. Another general GESI recommendation for Phase 2 is to broaden SoLAR to Africa. Women and smallholders are the predominant farmers in most African countries. Climate change is significantly increasing irrigation needs in Africa (Shah et al, 2020)[9]; SIPs can offer lower-cost pumping to deal with

[9] Shah, T., Namara, R., & Rajan, A. (2020). *Accelerating irrigation expansion in Sub-Saharan Africa: policy lessons from the global revolution in farmer-led smallholder irrigation*. IWMI.

longer drought periods, grow higher value cash crops, etc. (Gebrezgabher and Leh, 2021)[10]. Smaller agricultural production (kitchen gardens, market gardens, etc.) are critical to include; women are main actors in these spaces (Wong, 2019)[11].

In terms of SoLAR Project GESI Phase 2 design considerations, a recommendation is to increase IWMI GESI expertise capacity for the unique, country-specific contexts of Bangladesh, India, and Pakistan which are each different from Nepal where more GESI work has been conducted. Lastly, it is recommended to improve IWMI coordination and collaboration with organizations working on GESI and WEFE nexus to increase policy and program influence. These include UN Women and other UN agencies, bilateral organizations, national and local NGOs, Government agencies, etc.

SoLAR Nepal GESI Phase 2. For Phase 2 design considerations of GESI activities within SoLAR Nepal we recommend the expansion of research geographically within Nepal. This should include applied research with increased focus on intersectional issues of gender, ethnicity, age, education, geo-political location within the household as well as location within the community to regional level. More qualitative research on SIP issues should highlight marginalized group voices including their concerns, needs and solutions.

IWMI should provide financial support to an Innovation Fund that specifically works to benefit women. Continue applied research that we recommended be initiated in the remaining months of Phase 1 that evaluates on- the-ground effects of AEPC regulations that 1 in 3 SIP applications be women, and efforts to include more smallholders and landless lease holders. Methodologies should include stakeholder meetings. Present policy findings at stakeholder meetings and get feedback; input feedback and research results into a set of policy briefs perhaps divided by each stakeholder groups (i.e., one on women; one focused on smallholders; a third focused on landless leaseholders although of course there will be intersecting issues/actors).

SoLAR Pakistan GESI Phase 2. Phase 2 design considerations for GESI issues in SoLAR Pakistan are that IWMI research with Pakistani collaborators in universities could include:

1) Identify the barriers and bottlenecks for women and other vulnerable social groups to access SIP and access e.g., RDI program including accessing resources, land, credit, and opportunities like SIPs in the agriculture sector.
2) Research on gender-inclusive policies. Analyze impact of existing agricultural policies on vulnerable communities' participation in SIP markets and advocate for gender-inclusive policies.
3) Research on the efficacy of gender-sensitive training programs on SIP use and maintenance to empower women and vulnerable communities in agriculture and improve their skills and knowledge.
4) Research to identify women leaders and women's groups who are innovators in their communities around SIPs or irrigation management who might be able to serve as role models for what other women or women's groups could achieve if provided the right conditions.

SoLAR Bangladesh GESI Phase 2. Phase 2 research needs should include using scenario planning to explore equity issues between upstream and downstream users. This is important with the increasing numbers of SIP user groups along particular rivers.

There is a need to document farmer experiences with SIP use for vegetable production, livestock needs, niche crops (women more involved/gain income from this more than paddy).

[10] Gebrezgabher, S., Leh, M., Merrey, D. J., Kodua, T. T., & Schmitter, P. (2021). *Solar photovoltaic technology for small-scale irrigation in Ghana: suitability mapping and business models. Agricultural Water Management–Making a Business Case for Smallholders* (Vol. 178). International Water Management Institute (IWMI).

[11] Wong, S. (2019). Decentralised, off-grid solar pump irrigation systems in developing countries—Are they pro-poor, pro-environment and pro-women?. *Climate Change-Resilient Agriculture and Agroforestry: Ecosystem Services and Sustainability*, 367-382.

SoLAR India GESI Phase 2. In Phase 2, it is recommended IWMI assess Switch On Foundation's work with women farmers in solar model villages in Jharkhand regarding what are the findings and implications for model expansion within the region and within India. Switch On Foundation wants to collaborate with IWMI and alternative energy related programs and organizations to reach more women. It is also recommended to build on applied research and policy work on GESI issues related to SIPs of Dr. Khadka and her team in Nepal and comparative work in other regions such as by Lefore et al. but through India experts. Also in Phase 2, there should be expanded focus on youth, including female youth, and how/what barriers exist to youth becoming key actors in SIP initiatives. Policy and program analyses should be undertaken of how to reach more women farmers in SIP subsidy programs and related to training opportunities including efficacy of women's groups such as cooperatives in benefitting from SIPs.

III. b. SoLAR Nepal Phase 2

Phase 2 opportunities include research on the reasons that market breakthrough is limited, despite the fact that SIP technology is already popular and there is no doubt about its importance among farmers/adopters, rich technical knowledge, access to latest technologies from global providers, and high demand exists. In Nepal, over 3,000 SIPs have been installed since 2016 by AEPC (which claims demand exceeds 10,000 each year).

Approximately 1,000 SIPs are installed per year by local and provincial governments and other projects. IWMI should examine what the impediments are to solar irrigation scaling up. Although individual and dispersed pumps installation have operation and maintenance (O&M) challenges, options should be devised and tested for these farmers; thus, there is a need for SoLAR 2 to collaboratively innovate with and test solutions for O&M perhaps as part of an Innovation Fund project.

Solar irrigation in Nepal remains subsidy driven. SoLAR Phase 2 open an opportunity for innovating financial/ business models to break through in the market. The private sector is eager to partner with organizations like IWMI for exploring impediments to solar irrigation uptake in the market. Solar irrigation is still expensive for marginalized and low-income farmers, requiring more refined subsidy targeting thus there is scope for IWMI to further work with AEPC on this. There is a need to follow up on whether AEPC's GESI-friendly policies are actually being adopted or not and having the intended impact.

There is a lack of integrated policies for water, energy, and food/ agriculture (WEF Nexus), thus IWMI could facilitate this approach via policy and research briefs and stakeholder meetings. Finally, SDC and IWMI can strengthen partnerships with bilaterals implementing SIPs in Nepal, e.g., UK AID NREP Sustainable Energy Challenge Fund.

There is a need for an in-depth study of groundwater tables in the Terai region to assist the government of Nepal in making policy decisions for SIP. It is recommended to engage youth from agricultural and other universities to innovate related to the integration of WEF Nexus commodities and inputs with local markets. There should be resulting science communication not only as peer reviewed journal articles but also for farmers, local government, policy makers and the private sector to be able to reveal innovation and science-to-practice processes.

IWMI should explore ways to effectively engage high level officers from NEA and related Ministries to have consistent policies for off-grid and grid-connected SIPs in Nepal.

III. c. SoLAR Pakistan Phase 2

The Government of Pakistan has approved solarization of agriculture tube wells in Punjab, Sindh, Khyber Pakhtunkhwa, and Balochistan provinces at a cost of over Rs 377 billion (USD 1.3 billion) over three

years. In the current financial year, Rs 90 billion (USD 0.32 billion) has been targeted to convert 100,000 existing tubewells to solar energy systems. During the remaining nine months of SoLAR Phase 1, IWMI and partners (chiefly PARC) should work closely with government agencies to provide input into the design and implementation of SIPs across Pakistan, including to address the identified problem of low-quality equipment leading to farmers' distrust in SIPs. IWMI should also develop a strategic roadmap for solarization of the agricultural economy across Pakistan. Consideration should be given to recommending a phased approach for rolling out any technical, financial, and institutional models for the large-scale promotion of SIPs. More broadly, greater attention is needed to collaboratively conduct national forums, seminars, and workshops on SIPs implementation, with the provision of follow up. In Phase 2, different universities which have the potential to collaborate in the field of SIPs should be engaged specially for the capacity building of the female members of agricultural communities. The innovation fund should be offered every year as it was reported to have been effective in Phase 1 of the project. The payment system related to remuneration of the researchers working in the innovation fund should be made more efficient.

III. d. SoLAR Bangladesh Phase 2

Grid connection seems a challenge in terms of cost, based on pump location with respect to existing grid infrastructure and power tariffs in place today. Existing grid connections by IDCOL and BADC (as received from local engineers) need more analysis for learning and to devise future strategic planning. The project should have strong linkages with knowledge institutions (universities, research centers) to support critical policy and political decisions through study of farm economy and tariff rates for SIP adoption. IWMI should also conduct research on existing successful strategies and potential new strategies to replace existing private diesel minor irrigation (more than one million) to solar pumps. IWMI should assist by creating policy briefs that stress that policy should be formulated to adapt the model of operation, based on hydro-geological situations, rather than "one size fits all" model. IWMI should conduct research in Phase 2 on irrigation behavior among water users related to irrigation scheduling and water savings. IWMI could act as the coordinator for the three organizations in agriculture (DAE, BADC, BMDA), all of which are confined to surface water schemes, to document lessons learnt for experience sharing and knowledge building. IWMI should examine land ownership dynamics involved in panel installation and irrigation service among user groups. Further, considering demand, organizations may consider continuing SIPs in an integrated manner.

In Phase 2, SIP use for non-irrigation purposes should be explored through applied research and further testing including analysis of what did not function well in the village where grain processing was powered by SIPs.

Other areas IWMI should focus on for Phase 2 are agricultural and irrigation technology extension services to accomplish farmer trainings on: a) drip irrigation, b) solar trap for pest control, c) skill enhancement of rural mechanics for SIP maintenance, d) farmer group formation, e) formation of Farmers Field Schools (FFS) for horizontal learning and f) capacity utilization of pumps. IWMI should co-develop an exit strategy for government agencies for the ongoing projects with the experience gained.

III. e. SoLAR India Phase 2

SoLAR 2 would have multiple opportunities in India, even Gujarat. However, SDC should consider multiple factors for SoLAR 2 expansion or an outright shift to other states with high SIP potential and little uptake to date. Among the multiple factors are not only whether to focus on grid-connected SIPs or distributed solar generation with grid tie-in under the PM-KUSUM C and A, respectively, but also the commitment of the state(s) and DISCOMs or other implementing agencies. As indicated in the Executive Summary and subsequent discussions, off-grid (PM-KUSUM B type) appear not to be the **future** course that states in India are following. In line with the comments above on whether SDC's Climate Change &

Environment Section would go it alone, or whether Food Systems and potentially Water Sections might join SoLAR 2, states that would offer attractive opportunities for high solar energy potential are Tamilnadu, Karnataka, Maharashtra, Rajasthan, Andhra Pradesh, and Telangana. States with high groundwater potential linked to livelihoods include (but lower solar development potential given weather conditions) are West Bengal, and Assam. States with high GESI equity potential, low risk of groundwater depletion, and moderate to high solar potential are Chhatisgarh, Orissa, and Bihar. Considering also these states' political commitment and responsiveness of the administrative service, the better choice would be Chhatisgarh or Orissa. In all cases, SoLAR 2 must plan for a consistent and strong field presence as an essential condition for success. This includes for the training and follow-up of higher-level personnel about SIPs and WEF(C) nexus approaches for resource planning.

> *"I am adopting off-grid solar in my new farm as getting grid-access is a long shot. It will take a few years whereas I need irrigation access soon." - Dr J K Singh, Rajasthan farmer*

With lessons gained from Gujarat's SKY scheme in SoLAR 1, and ongoing experience in Rajasthan, Maharashtra, and Karnataka – all in grid-connected schemes, the SoLAR team may consider adaptability and transferability of experiences for Africa as follows. For Government and other institutions considering solarization, a SIPs scheme planning workflow would be helpful in identifying the necessary and sufficient elements for SIPs deployment. The planning workflow can follow four stages: 1) identifying conditions of suitability for SIPs, 2) identifying institutional mechanisms that are supporting, 3) estimating spillover and secondary effects, and 4) distilling the generalizability of findings and curating this information for broad dissemination and uptake.

The South Asia experience shows that clear, implementable indices and tools that can inform policymakers with actionable items are indispensable. Crucial elements include farmer adopters' choice experiments (willingness to pay for SIPs) for identifying feasible, even ideal, subsidy mechanisms. Other considerations include the sustainability and age of solar systems (especially the panels), after-sales service operation and maintenance questions, and the management and recycling of e-waste at the end of the SIPs lifecycle.

Some of these elements are touched on in the Innovation Fund projects, which must be more systematically assessed for the identification and attribution of solarization impacts. The team considers that, despite their high transactions costs in Phase 1 for SDC and IWMI, the IFs should be continued, in a dual-scale model: 1) Seed Grant IF projects on the order of CHF 10,000 each per year for novel, high-risk, high-reward IF grantees, more oriented to demonstration and deployment than new research per se; and 2) Mainstreaming IF projects on the order of CHF 50,000 each per year for two years for SIPs and WEF(C) deployment that requires a minimum 1:1 leverage of matching funds (especially for other bilateral programs).

Annex 1 – Stakeholders Interviewed as Part of the Evaluation

India			
S.N	**Name**	**Designation, Organization**	**Date**
1	Ujjawal Shah	Engineer, SLS PVT LTD	19 July
2	Dr J K Singh	Farmer from Rajasthan	19 July
3	Farmers from DGVCL	Farmers (SKY Adopters)	20 July
4	Prof Vimal Mishra	Associate Professor, IIT GN	21 July
5	Dhwaneesh Patel	DJ Solar (Solar O&M)	22 July
6	Farmers from UGVCL	Farmers (SKY Adopters)	22 July
7	Dr Deepak Varshney	Regional Researcher, IWMI	24 July
8	Farmers PGVCL (3 Feeders)	Farmers (SKY Adopters)	24-26 July
9	Er R J Vala	Chief Engineer PGVCL, Ex-GUVNL	25 July
10	Surendra Vashisththa	Engineer, RJVCL	26 July
11	Mr Davda and Team	GERMI	27 July
12	PennState SIP Survey Enumerators	N S Patel (Arts) College	27 July
13	Prof Tushaar Shah & Shilp Verma	IWMI-Tata Water Policy Program	28 July
14	Dr Hippu Salk Kristle Nathan	Associate Professor, IRMA	28 July
15	Dr S S Kalamkar	Director, Agro-Economic Research Centre	29 July
16	IF Grantees (4 Orgs)	-	30 July
17	Farmers MGVCL	Farmers (SKY Adopters)	30 July
18	P C Sharma	Joint Director, International Solar Alliance	31 July
19	Nilanjan Ghose	Sr Advisor, GIZ	31 July
20	Dhundhi Farmers	Secretary, Dhundhi Surya Urja Utpadak Sahakari Mandali	31 July
21	Farmers MGVCL	Farmers (SKY Adopters)	31 July
22	IWMI-SoLAR Team	IWMI	1 August
23	Faiz Alam	Regional Researcher, IWMI	8 August
24	Dr Nitin Bassi	Sr Programme Lead, CEEW	8 August
25	Dr Avinash Kishore	Sr Research Fellow, IFPRI	12 August
Nepal			
S.N	**Name**	**Designation, Organization**	**Date**

1	Shisher Shrestha	National Researcher, IWMI	23 May
2	Labisha Upreti	National Researcher, IWMI	23 May
3	Manohara Khadka	Country Representative, IWMI	11 August
4	Laxman Prasad Ghimire	Assistant Director, AEPC	27 June
5	Dinesh Rajouria	Joint Secretary, WECS	28 July
6	Sagar Mani Gyawali	Assistant Manager, NEA	3 July
7	Anjal Niraula	CEO, Ghampower	21 July
8	Prem Sagar Subedi	Deputy Team Lead, NREP	12 July
9	Avishek Malla	Expert, ICIMOD	24 July
10	Dr Bharat Raj Poudel	Deputy Team Leader, GIZ	7 July
11	Khem Raj Bhandari	Deputy Team Leader, AEPC-DKTI	5 July
12	Manoj Gupta	Chair, Chhipaharmai RM	23 July
13	Amin Miya	Farmer, Adopter	24 July
14	Jeevan Baidya	Director, SunBridge/Minergy Pvt	18 July
15	Madhav Neupane	Head Project, Research & Development, Mero Micro Finance	28 July
16	Haro Shrestha	COO, Sunfarmer	31 July
Pakistan			
Sr.	**Name**	**Designation, Organization**	**Date**
1	Dr. Bashir Ahmad	Director, Climate Energy and Water Resources Institute (CEWRI), Pakistan Agricultural Research Council (PARC)	8 June
2	Mr. Khalid Jamil	Scientific Officer, CEWRI PARC	8 June
3	Dr. Muhammad Ashraf	Assistant Professor, Khawaja Fareed University of Engineering and IT	8 June
4	Dr. Andrew Bell	Assistant Professor, Boston University	8 June
5	Mr. Muhammad Muzzamil	Director Technical, Buraq Integrated Solutions/Capital Technologies	2 June
6	Mr. Raza Narejo	Deputy Country Manager, Islamic Relief Pakistan	30 May
7	Mr. Atif N. Khan	Technical Director, Renewable Stars Pvt Limited	30 May
8	Mr. Abbas Ali	Technical Officer, GIZ	31 May
Bangladesh			
S.N	**Name**	**Designation, Organization**	**Date**
1	Sarwar Hossain	BADC, PD	30 April

2	Ashok Biswas	DAE, PD	30 April & 22 May
3	Habibur Rahman Khan	BMDA	22 May
4	Nazmun Nahar Karim	BARC	31 July
5	Saidur Rahman	BAU	24 April
6	Tariqul	Manager, Kushtia	30 May
7	Juwel Hossain	Manager, Operator, Dinajpur	19 June
8	Ariful	Manager, Kushtia	30 May
9	Abdur Rashid	ED, BMDA	6 June
10	Khalid Hassan	Mechanic, BMDA	6 June
11	Ahsan	Researcher, Dhaka	24 July
12	Liton Molla	Manager, Jhalokathi	26 July
13	Nazrul Islam	Farmer, Kushtia	26 July
13	Shahin	Farmer/operator, Barisal	26 July
14	Said	Owner, Satkhira	28 July

Annex 2 – Semi-structured Interview Guide

**Clarify which of the three main categories of stakeholders you are interviewing:*

I. Institutional Stakeholders (implementers, public bodies [agriculture, irrigation, etc.], NGOs, donors, service provider [contractor])
II. SIP Adopters (farmers, rural households)
III. SIP Non-adopters (other farmers, rural households)

I. SoLAR Institutional Stakeholders

A. Introduction of evaluation *(Swiss Development Cooperation SDC supports the SoLAR project and has engaged an external Evaluation Team not part of the project; explain your role in the Team)*

B. Stakeholders' name, position, institution:
Tick the box: __Govt. agency, __NGO, __IWMI, __SDC, __Other SIP donor, __Other
Familiarity with solar irrigation (SoLAR in particular) __High, __Low, __No knowledge
Background with the SoLAR project, if any.

C. What is your assessment of the feasibility (agronomic, social, climate adaptive) of solar irrigation, and why? *(First ask this open-ended question, make notes, then ask the following)*
__High (it is being replicated widely and should expand further)
__Medium (it is context specific and possibly has potential for wider adoption)
__Low (it has some unique factors but is unlikely to expand)
__Nil (SIPs only adopted because it was project implemented)

D. What is your opinion of the cost and investment requirements of solar irrigation, particularly with cost sharing (if any), and why? *(First ask this open-ended question, make notes, then ask the following)*
__High (it is profitable and the returns justify the investment in 5 years or less)
__Medium (returns justify the investment in 5-10 years)
__Low (returns justify the investment in 10+ years)
__Nil (SIPs only adopted to capture subsidies)

E. What is your view on the gender dimensions, age, class/wealth equity, and caste/community access to solar irrigation, and why? *(First ask this open-ended question, make notes, then ask the following)*
__High (it is adopted and provides benefits to all, regardless of gender, age, class or caste)
__Medium (mostly adopted by male, middle age to older in age, wealthy, upper caste, but provides broader benefits)
__Low (adoption and benefits for male, middle to older age, wealthy, upper caste)
__Nil (SIPs only adopted because government or donor required it)

F. Does solar irrigation improve climate resilience, and how? *(First ask this open-ended question, make notes, then ask the following) (Note the major climate change related concerns?)*
__High (it is resilient to extremes like drought/flood and it is carbon neutral)
__Medium (it may be carbon neutral)
__Low (it does not offer much of any climate resilience)
__Nil (it is less resilient than other irrigation practices)

G. Which aspect of Solar Irrigation are you/your organization concerned about?
__ Irrigation Access (Sustaining Agriculture)
__ Green Energy (Mitigating Carbon Emission)
__ Additional Income Generated through Selling Solar Energy
__ Climate Resilience (Building Climate Adaptation for sustainability)

H. What is the existing policy/ programmatic framework for SIPs in the country? How, if at all, has this changed over the past 3-5 years or longer?

I. Please comment on any specific challenges, problems or opportunities in SIP adoption.

J. If you are involved in, or if you are familiar with the SoLAR project and its activities or findings, has the SoLAR project and its findings in any way contributed to national or subnational (state or regional level) policy changes?

K. If you are involved in the SoLAR project, please comment on Phase 1 outcomes and impacts, or other aspects of Phase 1.

L. Even if you are not involved in the current Phase 1 of the SoLAR project, but you commented positively on solar irrigation potential above, what should be included in Phase 2, if this is to go forward?

II. SIP Adopters

A. Part of SoLAR (or other project)
B. What is your primary motivation? Irrigation using solar energy ___, cash income from energy feed-in___, both of these___.

Questions for Solar Irrigator Adopters

1. How many cropping seasons are followed and what are the typical crops in each season?
2. Has there been any significant changes in agriculture practices in recent years?
3. Do you think the irrigation needs are increasing? Why?
4. When did you acquire your solar pump?
5. How did you come to decide to acquire the solar pump? Under which scheme or agency, department or NGO?
6. What are the primary challenges faced in acquiring/ operating solar pump?
7. Would you advise your neighbor/ friend/ relative to acquire a solar pump? Why?
8. Which household members participated in the decision to acquire the pump and what were the reasons each of these was interested in acquiring it?
9. What purpose is the water pumped by the solar pump used for by each household member? (for each activity, list mother, father, son, daughter, grandmother or grandfather, aunt, uncle, etc.)

a. Irrigation water_____
b. Water for kitchen garden_____
c. Water for household use_____

8. What factors made it possible to purchase the solar pump?
    a. What was the purchase price?
9. Which household members use the pump?
10. Is the SIP providing enough income for you to feel that the price justified the cost?
11. Do you use other sources of irrigation water? Yes___ No___
    a. If Yes, then how do you access each source? diesel pump____gravity fed system from canal___ Other (explain)_____(check all that applies and explain Other)
    b. If Yes, then why do you use each of these other type(s) of these sources?
12. Did you receive training in how to use the pump? (including irrigation distribution for greater efficiency)? Yes___No___
    a. Did you receive training in how to maintain the pump?
    b. Which organization provided the training?
    c. Who within your household received the training?
13. Do you use water for irrigation on a shared basis? Yes___ No___

a. If yes explain the source of the irrigation water and how you have access to the water_____
b. If yes, does your group have a shared SIP?
c. If yes, how is the cost of the SIP shared?
d. Did your group receive support for
   i. The cost of the SIP? Yes___No___
   ii. Training in how to use the SIP? Yes___No___
   iii. Training in how to maintain the SIP? Yes___No___

III. SIP Non-adopters

Questions for Non-Solar Irrigator Adopters (only those who have a pump should be included)

1. How many cropping seasons are followed and what are the typical crops in each season?
2. Has there been any significant changes in agriculture practices in recent years?
3. Do you think the irrigation needs are increasing? Why?
4. What type of irrigation pump(s) do you use? (name all types of pumps used)? How did you come to decide to acquire that type of pump(s)?
5. Which household members participated in the decision to acquire the pump and what were the reasons each of these was interested in acquiring it?
6. What purpose is the water pumped used for by each household member? (for each activity, list mother, father, son, daughter, grandmother or grandfather, aunt, uncle, etc.)
   a. Irrigation water_____
   b. Water for kitchen garden_____
   c. Water for household use_____
7. What factors made it possible to purchase the pump(s)?
   a. What was the purchase price?
8. Which household members use each type of pump?
9. Is the pump providing enough income for you to feel that the price justified the cost?
10. Do you use other sources of irrigation water? Yes___ No___
    a. If Yes, then how do you access each source? diesel pump____gravity fed system from canal___ Other (explain)_____(check all that applies and explain Other)
    b. If Yes, then why do you use each of these other type(s) of these sources?
11. Did you receive training in how to use the pump?
    a. Did you receive training in how to maintain the pump?
    b. Which organization provided the training?
    c. Who within your household received the training?
12. Do you use water for irrigation on a shared basis? Yes___ No___
    a. If yes explain the source of the irrigation water and how you have access to the water_____
    b. If yes, does your group have a shared irrigation pump?
    c. If yes, how is the cost of the irrigation pump shared?
    d. Did your group receive support for
       i. The cost of the pump? Yes___No___
       ii. Training in how to use the pump (including irrigation distribution for greater efficiency)? Yes___No___
       iii. Training in how to maintain the pump? Yes___No___
13. Have you heard or experienced about Solar irrigation? What are your thoughts about the feasibility of solar irrigation for your farm and your region?

Annex 3 – SoLAR Evaluation Field Mission Timetable

Date	Base Location	Members	Visit
July 17	Anand	Praharsh	IWMI-ITP, INREM
July 19	Anand	Praharsh	Meetings in Anand
July 20	Anand	Praharsh	South Gujarat
July 21	Ahmedabad	Praharsh	Ahmedabad, IIT GN
July 22	Madhav Kampa (North Gujarat)	Praharsh, Chris	North Gujarat (Madhav Kampa, Vishnupura Kampa)
July 23	Madhav Kampa (North Gujarat) - Rajkot	Praharsh, Chris	North Gujarat (Hirapur Kampa, Badera Kampa, Dehgamda Feeder)
July 24	Rajkot (Western Gujarat/Saurashtra)	Praharsh, Chris, Manfred	IWMI-India Updates, FV: Targhadi Feeder
July 25	Rajkot (Western Gujarat/Saurashtra)	Praharsh, Chris, Manfred	Meeting with Er R. J. Vala, FV: Devgam Feeder
July 26	Rajkot (Western Gujarat/Saurashtra)	Praharsh, Chris, Manfred	FV: Botad (Parameshwar Feeder)
July 27	Gandhinagar-Anand	Praharsh, Chris, Manfred	Meeting with GERMI, Meeting with PennState SIP Survey team
July 28	Anand	Praharsh, Chris, Manfred	Meeting with ITP team and Prof Dr Hippu Salk Kristle Nathan (IRMA)
July 29	Anand	Praharsh, Chris, Stephanie, Manfred	Meeting with AERC, Internal caucus
July 30	Anand-Delhi	Praharsh, Chris, Stephanie, Manfred	Zoom Calls (IF Grantees), FV: Mujkuva (Central Gujarat)
	Delhi	Praharsh, Chris, Manfred	ISA & GIZ
July 31	Anand-Delhi	Stephanie	FV: Dhundi and Golaj Feeder
Aug 1	Delhi-Dhaka	Praharsh, Chris, Stephanie, Manfred	IWMI SoLAR team presentations
Aug 2	Dhaka	Praharsh, Chris, Stephanie, Wais	Meeting with BADC, BMDC, BARC, BAU, DAE representatives, Meeting with IDCOL
Aug 3	Dhaka-Rangpur	Praharsh, Chris, Stephanie, Wais	Meeting with KFW, FV: Birganj
Aug 4	Rangpur	Praharsh, Chris, Stephanie, Wais	FVs: Rangpur-Hathibanda, Rangpur-Lalmonirhat
Aug 5	Rangpur-Dhaka-Delhi	Praharsh, Chris, Stephanie, Wais	Travel Day
Aug 6	Delhi	Praharsh, Chris, Stephanie	Debriefing and plan for stakeholder meeting

Aug 7	Delhi	Praharsh, Chris, Stephanie	SoLAR Team Debriefling, SDC Debriefing
Aug 8	Delhi	Praharsh	Meeting with Faiz Alam and Archisman Mitra, Meeting with CEEW

Annex 4 – SoLAR Project Documents (reviewed by evaluation team)

Geographical Scope - IN, NP BD, PK, Regional (RE), Global (GL)	Document Title	Year	Document Focus
RE	About SoLAR (Solar Irrigation for Agriculture Resilience)	2020	Background
RE	SoLAR India Consultation Report	2018	India
RE	SoLAR Scoping Study Report 2019	2019	Background
RE	SoLAR Project: Main Credit Proposal/(SoLAR Project Contract) [IWMI+SDC]	2019	Background
RE	SoLAR Inception Workshop Report	2020	Background
RE	SoLAR Progress Report. Year 1: Jan-Dec 2020	2020	Background
RE	SoLAR Progress Report. Year 2: Jan-Dec 2021	2021	Background
IN	ATREE Grant Agreement	2021	India
RE	SoLAR Progress Report. Year 3: Jan-Jun 2022	2022	Background
RE	SoLAR Change of Credit Duration	2022	Background
RE	Promoting Solar Irrigation Service Providers in Ganga Basin	2018	India, Nepal, Bangladesh
IN	Solar Irrigation in India: A Situation Analysis Report	2021	India
IN	Role of Kisan Credit Cards in Development of Dairy and Fishery Sector in India	2023	India
IN	Training Completion Report of 66 Batches in 46 SKY Feeders for Farmers in Gujarat	2023	India
RE	Innovation Fund RFP 2020	2020	India
RE	Innovation Fund RFP 2021	2021	India
RE	Innovation Fund Selection Details 2020	2020	India
RE	Report on Selection of Innovation Funds Grantees-Round 2	2021	India
RE	Innovation Fund 2020: Scoring Excel Sheet	2020	India
BD	Bangladesh Consultation Workshop Report	2019	Bangladesh
BD	Solar Irrigation in Bangladesh: A Situation Analysis Report	2021	Bangladesh
BD	Impact Assessment of Solar Irrigation Pumps (SIPs) in Bangladesh: A Baseline Technical Report	2023	Bangladesh
NP	Nepal Consultation Workshop Report	2019	Nepal
NP	A Rapid Assessment of AEPC's Subsidy Delivery Mechanism for Solar Irrigation Pumps (SIPs) in Nepal	2020	Nepal
NP	Solar Irrigation in Nepal: A Situation Analysis Report	2021	Nepal
PK	Pakistan Consultation Workshop Report	2019	Pakistan
PK	Solar Irrigation in Pakistan: A Situation Analysis Report	2021	Pakistan
PK	The National Forum: Sustainable Solar Irrigation-What do we know?	2022	Pakistan
PK	Training of Professionals on SoLAR Powered High Efficiency Irrigation Pumping Systems and Other Uses-Pakistan	2022	Pakistan

Management response to the External Review of the Solar Irrigation for Agricultural Resilience (SoLAR) Project, Phase 1 (1st December 2019 to 30 June 2024)

Management Response

The Management Response (MR) states the position of the SDC on the recommendations of the external review of the Phase 1 of the Solar Irrigation for Agricultural Resilience (SoLAR) Project. The MR provides a basis for strategic steering of the project's implementation during the remaining period of the first phase and offers inputs for the design of the second phase of the project.

Assessment of the review

Being a multi country evaluation, the exercise was conducted by a team of 2 International and 4 national/country experts under the lead of Dr. Christopher Scott, Goddard Chair and Professor, Dept. of Ecosystem Science and Management, Pennsylvania State University, USA. The evaluation was conducted as per the terms of reference and in accordance with the OECD/DAC Criteria viz. relevance, coherence, impact, effectiveness, efficiency, and sustainability. The evaluation process, despite being complex, was well managed both by evaluators with support from SDC and the project partner (International Water Management Institute, IWMI). The evaluation entailed close involvement of the SDC's reference group comprising Ms. Divya Sharma (SDC India), Ms. Corinne and Dr. Jonathan Demenge (Co-Heads of SDC India), and Dr. Cornelia Hett and Dr. Manfred Kaufmann (SDC Bern).

The main objectives of the review were to – (i) provide an objective independent assessment of the overall performance of the Phase I of SoLAR project Dec 2019 to the present (July 2023); (ii) highlight potential areas of improvement so that the project can fully achieve its planned objectives before the end of the project (till 30 June 2024), for the overall project as well as the four project countries; and (iii) provide ideas and guidance for the focus of next phase of the project.

The overall approach adopted in the review process was discussed with SDC during the inception as well as briefing meetings. The external review was carried out successfully and in a timely manner between April and August 2023. During this period, semi structured interviews and discussions were held with a large number of key stakeholders in all the project countries. This included government officials, practitioners and researchers at the national, provincial/state and local levels, farmers and community groups, other donors active in the domain, innovation fund grantees, irrigation service providers, NGOs, solar irrigation pump (SIP) adopters (farmers, rural households), and SIP non-adopters (other farmers, rural households) and the project team in person. Interviews were conducted over the phone, or on Zoom, depending on the preference of the interviewee. Between 17th July and 5th August 2023, the reviewers conducted field visits in the parts on Gujarat in India and Barind tract in Bangladesh, where the SoLAR project is active and held meetings and consultations with national level stakeholders in Dhaka.

The review report, structured around the project's three work packages, is comprehensive and provides an in-depth assessment of the performance of the phase 1 of the SoLAR Project, both overall and country specific. The report provides strategic recommendations to further strengthen the positive results by the end of the present Phase i.e. June 2024. Findings in the draft report were presented and discussed with SDC and IWMI – giving IWMI an opportunity to offer responses and offer additional explanations – and compiled in the final report.

The report's analysis and resulting recommendations are considered to be useful for strengthening the impacts of Phase 1 of the SoLAR Project, and for the design of a second phase.

Key findings and recommendations

The reviewers have noted that the SoLAR project strategy and approach are **highly relevant** to solarization policies in Nepal, Pakistan, Bangladesh, and Gujarat State in India. In their view, the outcomes and outputs achieved by the SoLAR project to date are satisfactory and overall, the **pro-**

ject has generated significant achievements and impact. The report suggests that **SoLAR project's greatest overall impact has been through training**, especially of SIP implementing agencies of the respective governments. **A major impact of the project is research and knowledge support,** especially for the need to tailor SIPs programs to local and national policies, the socio-economic context, institutional capacities, as well as agricultural, water, energy, and climate conditions.

SoLAR is **providing an appropriate level of regional knowledge integration**, especially via regional fora and national fora (though both were suspended during Covid-19, these have emerged more recently as a signature activity of the project that provides broader visibility to SIPs and thereby to SoLAR, IWMI, and SDC as well as Government implementing partners). Additionally, SoLAR's efforts to assess groundwater sustainability regionally is commended. This is reflective of a consistent modeling and data framework, despite the differences in groundwater monitoring data across the four countries. Finally, the **project has achieved good understanding of policy drivers for SIP program adoption**, especially diesel/ fossil fuel substitution in Bangladesh, Pakistan, and Nepal, though less so in India.

SoLAR has achieved critically important **long-term impacts in Nepal via IWMI's gender and social inclusion** (GESI) focused influence on AEPC, Nepal's national policy to reduce the minimum land-holding size for SIP program eligibility. **In Pakistan, the key achievement in this regard is IWMI's support for** PARC as a key partner in the **Government's USD 1.3 billion solarization scheme**. Finally, **in Bangladesh IWMI's support to secure Green Climate Fund support for IDCOL's continuation of its SIPs programs was found to be noteworthy**.

With regard to overall project management, the reviewers observed that the **project management structure** consisting of the IWMI Regional team, IWMI country offices, Project Steering Committee and Country Project Management Committees **is appropriate.**

IWMI's project implementation has demonstrated excellent attention to project timelines and deliverables established at the project's inception, especially considering delays resulting from the Covid-19 pandemic. The review however also highlights that greater attention from project leadership is needed to engage the project more meaningfully to (a) assess and diagnose the poor performance of India's PM KUSUM scheme and to (b) engage in several late breaking opportunities that open the door for the SoLAR project in Phase 1. The latter include specifically (1) to engage with the recent national policy declarations supporting SIPs by the leadership of both Bangladesh and Pakistan, and (2) the harvesting of lessons learned from the SoLAR project's investments in the Innovation Fund projects, especially those in Nepal.

Despite the notable accomplishments of SoLAR in Phase 1, the evaluation identified **several gaps and opportunities in need of focus and attention in the remaining 10 months of Phase 1.** While there is clearly a rationale for country-level activities within the project, yet greater attention is needed towards strengthening the regional focus - **multi-country, comparative activities** - in order to enhance the project's effectiveness in the region and in each country. Of special priority is the **need to focus on extending policy support to the National SIPs schemes** (New Pakistan Solar Water Pumps scheme, PM Kusum in India, PM's solarization announcement in Bangladesh); and systematic review of Innovation Fund projects and lessons learned for scaling of Government and NGO SIPs programs.

All the seven key recommendations for SoLAR Project, Phase 1, are 'fully agreed' (see Table 1). SDC agrees to seize this opportunity to improve the results of Phase 1 of SoLAR by taking specific measures in line with the recommendations as detailed in the following section. The **ideas and guidance for the phase two of the project** (see Table 2) **will be taken into consideration during the design stage of the next phase of the project.** The options to integrate selected ideas for Phase 2 depend on the active interest expressed by SDC's sections Food System and Water in partnering with the project as well as opportunities presented by country developments and regional programmes (e.g.: West, East or Southern Africa).

Table 1: Key Recommendations for the Remaining Period of Phase 1

1.	Shifting the focus of the project's work from **research and innovation to policy support** with greater emphasis on current and short-term future opportunities in each of the partner countries.	
2.	Formally **assess the Innovation Fund (IF) grants** to extract lessons learned, especially to assess and recalibrate the IF program for SoLAR Phase 2	
3.	**Groundwater - Strengthening management and governance:** Building on the groundwater sustainability studies, work on mapping of "safe for solar irrigation" regions.	
4.	**GESI:** Sharing insights on GESI impacts of SIP adoption with policy makers in each of the partner countries.	
5.	**Inter-Regional Outreach:** The project should explore potential for out-scaling project findings to other countries, while strengthening the Water, Energy, Food, Environment (WEFE) Nexus	
6.	**Capacity Building:** Strengthening and expanding the ambit of SIP adoption related trainings.	
7.	**Project Management:** Ensuring plugging of gaps in a situation of project leadership transition	
Fully agree	Partially agree	Disagree

Table 2: Ideas and guidance for the phase two of the project provided by the review

1.	Greater emphasis should be provided on **SIPs policy engagement and uptake** (similar to Phase 1 WP 3). In South Asia, at several major opportunities are offered by government SIPs roll-outs.	
2.	Augment support for **integrated approaches including the water-energy-food-environment (WEFE) nexus**, especially linked with decarbonization and climate adaptation objectives under the SIPs programme.	
3.	Plan for the adaptability and **transferability of South Asian experiences for Africa**. For African countries considering solarization, it would be helpful to develop a SIPs scheme planning workflow including identifying conditions of suitability for SIPs, identifying supporting institutional mechanisms, estimating spillover and secondary effects, and distilling the findings for broader dissemination and uptake.	
4.	**Capacity building** should include orientation, management and administration, and trouble-shooting approaches **for Government agencies** charged with SIPs implementation	
5.	**Explore groundwater depletion challenges** in relation to SIPs-based and other modes of groundwater development as well as strengthen interventions on enhancing groundwater recharge in South Asia	
6.	Observe **socio-ecological impact of SIP adoption** on diversification and resilience of agrarian/rural livelihoods in parts of eastern India, Bangladesh, and the Nepal Terai with real implications for scaling regionally and for lessons adoption/transfer to Sub-Saharan Africa.	
7.	Sharper focus should be placed on understanding the **subsidy regimes, subsidy delivery, and the role of credit providers as well as insurance providers**.	
8.	SDC's Climate, DRR & Environment Section (CDE) should continue to prioritize SIPs research-supported policy engagement in South Asia, with more specific country-level opportunities identified below.	
Fully agree	Partially agree	Disagree

Overview of recommendations, management response and measures for Phase 1

Recommendation 1			
Shifting the focus of the project's work from research and innovation to policy support with greater emphasis on current and short-term future opportunities in each of the partner countries.			
Management response: IWMI is in the process of collating its research and is now in a position to offer policy insights based on this research to all the countries.			
Fully agree	Partially agree	Disagree	
Commitment under the Credit Proposal, therefore we fully agree.			
Measures		Responsibility	Timing
1. Develop a comprehensive policy engagement strategy, identifying the most appropriate modalities for this in the various partner countries.		IWMI	Dec 2023
2. Develop policy and research briefs that identify challenges and opportunities of the existing government schemes within every country, and assess how they can be strengthened and possibly adapted and how scaling up processes could be facilitated.		IMWI	Apr 2024
3. Organize the next set of national and regional fora, and focus on policy engagement and institutional support. Use these events to strengthen experience sharing of the different modalities of SIPs implementation in the partner countries		IWMI	Jun 2024
4. Focus on policy breakthrough regarding net metering for transforming solar irrigation in Nepal		IWMI	Jun 2024
5. Undertake a study on barriers and challenges to wider adoption or scaling up of solar irrigation in India, Nepal and Bangladesh		IWMI	Jun 2024
6. Present /disseminate project results at various targeted (international) fora		IWMI	Jun 2024

Recommendation 2			
Formally assess the Innovation Fund (IF) grants to extract lessons learned, especially to assess and recalibrate the IF program for SoLAR Phase 2			
Management response: Execution of IF grants has been an intensive exercise. SDC is interested in getting insights into the value of this modality.			
Fully agree	Partially agree	Disagree	
Measures		Responsibility	Timing
1. Prepare detailed case studies documenting the impact of the various interventions funded through the IF grants.		IWMI	Feb 2024
2. Prepare most suitable, short communication products (briefs, blogs, and short videos) on the case studies and widely disseminate the same.		IWMI	Apr 2024
3. Present the case studies at various national and regional for a (by leveraging events of partner including ISA, FAO).		IWMI	June 2024
4. Identify sustainable models of SIPs installation and operation that reduce the need for scarce land, while also providing non-irrigation benefits		IWMI	Jun 2024
5. Prepare a "lessons learned report" with recommendations for changes to the operational management of the IF in order to make processes more efficient		IWMI	Jun 2024

Recommendation 3			
Groundwater – Strengthening management and governance Building on the groundwater sustainability studies, work on mapping of “safe for solar irrigation” regions.			
Management response: Groundwater responsive SIP promotion is a primary objective of the project, and efforts towards that were initiated. It is important to systematically strengthen this aspect in the project, while also accepting that not all aspects can be addressed in the remaining period of phase 1			
Fully agree	Partially agree	Disagree	
Measures		Responsibility	Timing
1. Prepare a policy brief on socio-economic and agronomic mapping of “safe for solar irrigation” zones in the partner countries		IWMI	Apr 2024
2. Superimpose groundwater availability and quality of grid-connectivity to inform the suitability for grid-connected solar irrigation		IWMI	Jun 2024
3. Broaden the training in water efficient farm operations - alternate wet-dry (AWD) irrigation, precision water management etc. as well as repair of SIPs equipment		IWMI	Jun 2024
4. In Bangladesh, provide the knowledge base relevant for groundwater licensing (beyond the well-spacing norms).		IWMI	Jun 2024
5. Place more emphasis on addressing groundwater availability using existing data when available, while also considering potential future depletion from solar irrigation adoption (as a 3rd generation question)		IWMI	Jun 2024
6. Developing regional spatial models for groundwater sustainability based on ground water potentials and ground-water use scenarios.		IWMI	Jun 2024

Recommendation 4			
GESI – Sharing insights on GESI impacts of SIP adoption.			
Management response: GESI was the primary objective of the project, but was not systematically focused on, except in Nepal. It is important to strengthen this aspect in each country under the project.			
Fully agree	Partially agree	Disagree	
Measures		Responsibility	Timing
1. Analyze the country specific data, produce policy briefs documenting GESI impacts of SIP adoption		IWMI	Apr 2024
2. Share project results on GESI at other events on GESI and agriculture. Host a virtual symposium/ session with panel of experts on GESI issues in solar irrigation pumps synthesizing findings from SoLAR Phase 1		IWMI	Jun 2024
3. Identify opportunities to scale up innovation fund projects that have demonstrated pro-women, smallholder and landless impacts		IWMI	Apr 2024
4. Explore opportunities to strengthen GESI in solar irrigation adoption through a pilot intervention with womens’ self help groups.		IWMI	Apr 2024
5. Provide special SIPs and drip/precision irrigation training sessions for women in agriculture		IWMI	Jun 2024
6. Integrate SoLAR into IWMI’s GESI strategy going forward. SoLAR website to reflects the GESI focus of the project through the photos, blogs and policy briefs etc.		IWMI	Apr 2024

Recommendation 5		
Inter-Regional Outreach- Explore potential for out-scaling project findings to other countries, while strengthening the Water, Energy, Food (WEF) Nexus		
Management response: The project in the next phase will look at exploring the opportunities for enhancing the water-energy-food-environment(WEF) nexus approach and expanding the project's regional outreach beyond South Asia, to Africa, MENA or Central Asia. The remaining time in the current phase could provide an opportunity to start establishing grounds for the same.		
Fully agree	Partially agree	Disagree
While efforts may be initiated to start exploring potential south-south cooperation possibilities in Africa, it is important to ensure that the project's valuable research and policy-oriented work in South Asia is continued and not abandoned prematurely.		
Measures	Responsibility	Timing
1. Hold an international symposium on solar irrigation with other IWMI regional programs (especially in Africa), other CGIAR partners, and bilateral and multilateral programs (e.g., World Bank) to start understanding the landscape, opportunities and challenges	IWMI	Jun 2024
2. Work on identifying countries and contexts therein (off-grid/grid-connected, farming environment etc.) as well as potential partner organisations in Africa where the SoLAR project could provide valuable thematic inputs based on the project work conducted thus far.	IWMI	Jun 2024

Recommendation 6		
Capacity Building: Strengthening and expanding the ambit of SIP adoption related trainings.		
Management response: Capacity building is an important part of the project, and efforts to strengthen and institutionalize the same should be explored.		
Fully agree	Partially agree	Disagree
Besides enhancing the participation of women in training programmes, the project should actively work on developing training modules and knowledge briefs and disseminate the same through research and training partners and platforms like STAR C of the International Solar Alliance, UN and CGIAR		
Measures	Responsibility	Timing
1. Broaden the training in farm operations, alternate wet-dry (AWD) irrigation, precision water management, etc. as well as repair of SIPs equipment.	IWMI	Jun 2024
2. Develop and deliver training with KFUEIT and other universities on selection and use of higher-quality SIP components, know-how on installation, operation, and maintenance of SIPs.	IWMI	Jun 2024
3. Produce training modules on selected sustainable models of SIPs installation and operation that reduce the need for scarce land and at the same time provide non-irrigation benefits to users.	IWMI	Jun 2024

Recommendation 7
Project Management- Ensuring plugging of gaps in project management in a situation of project leadership transition
Management response: This was also identified as a possible challenge during the partner risk dialogue at the beginning of the project, where SDC had requested IWMI to institute a position of a Deputy. IWMI was asked to ensure that there are no gaps during the transition, and if possible the previous team lead continues to be part of the project for the remaining duration of the phase 1, but this was not adhered to by IWMI.

Fully agree	Partially agree	Disagree
The six-month gap between the transitions from one project leader to the next affected the project and added to the burden of the research staff. This hampered the timeliness and quality of the operational reports as well as development of policy outputs and policy level discussions.		

Measures	Responsibility	Timing
1. A new project leader has recently joined the project. It is critical that she quickly comes on board and takes active charge of project interventions at the earliest possible.	IWMI	Oct 2023
2. The new project lead must focus attention on finalizing the policy outputs as well as initiate and further policy dialogues at appropriate levels in all the partner countries.	IWMI	Sep 2023
3. In the phase 2, IWMI should ensure that the SoLAR project team has both project leader and her deputy positions in place.	IWMI	Phase 2

Overview of recommendations, management response and measures proposed for the Phase 2

1. Greater emphasis should be provided on **SIPs policy engagement and uptake** (similar to Phase 1 WP 3). In South Asia, at several major opportunities are offered by government SIPs roll-outs.
Management Response: This would be an important intervention to be continued and further strengthened from the phase 1 of the project. In South Asia, at least three major opportunities are offered by government SIPs roll-outs: 1) the new Pakistan Solar Water Pumps scheme, 2) India's PM Kusum with particular attention to ease implementation in one or possibly two states, and 3) the Bangladesh Prime Minister's pump solarization announcement; 4); in Nepal, by coordinating with other bilateral aid programs supporting SIPs as well as working on financially viable models of SIP adoption and grid feed-in policy.
2. Augment support for **integrated approaches including the water-energy-food-environment (WEFE) nexus**, especially linked with decarbonization and climate adaptation objectives under the SIPs programme.
Management Response: We acknowledge the importance to pay more systematic attention to integrated approaches including the WEFE nexus. The project shall provide evidence of WEFE related primary and secondary effects of SIPs programmes. SDC's section CDE will explore interests and possibilities for internal collaboration with the sections Food Systems and Water to incorporate an integrated WEFE approach for phase 2.
3. Plan for the adaptability and **transferability of South Asian experiences of SoLAR in phase 1 to similar contexts in Africa**. For African countries considering solarization, it would be helpful to develop a SIPs scheme planning workflow including identifying conditions of suitability for SIPs, identifying supporting institutional mechanisms, estimating spillover and secondary effects, and distilling the findings for broader dissemination and uptake.
Management Response: the project's experience in South Asia can certainly provide valuable insights for countries in Africa or other parts of the world that are considering solarising irrigation services. Of course, the learnings of the SoLAR project are contextual and hence there may be limits to the transfer of findings and knowledge from phase 1 to new countries in phase 2. The project will take efforts to develop appropriate instruments (such as checklists, workflows or an online portal) that capture relevant information critical for SIPs promotion that could support a country government to make informed choices on models or approaches of SIP services most relevant for their context. In addition, IWMI should actively explore partnering with relevant local/regional agencies to support the project's plans to foray into another geographical region beyond South Asia.

4. Capacity building should include orientation, management and administration, and trouble-shooting approaches for Government agencies charged with SIPs implementation.	
Management Response: SoLAR 2 capacity building should include orientation, management and administration, and trouble-shooting approaches for Government agencies charged with SIPs implementation, including but not limited to power distribution companies, promoters or regulators, agriculture or horticulture departments, and NGOs (where policies permit their active participation in SIPs implementation).The project should also look at supporting relevant government entities to define technical specifications for SIPs to ensure quality control.	
5. Explore groundwater depletion challenges in relation to SIPs-based and other modes of groundwater development as well as strengthen interventions on enhancing groundwater recharge in South Asia	
Management Response: The project in phase 2 should explore models of at scale SIP promotion that lead to adoption of groundwater recharge and/or more water efficient irrigation practices. These efforts, should of course be developed after due consideration of learnings and challenges from other projects that have worked on promoting adoption of efficient irrigation practices. The project must also not directly invest too much effort in monitoring groundwater abstraction which can be very costly especially in case of large unconfined aquifers, but instead look to work with data collected by other agencies or with proxies.	
6. Observe socio-ecological impact of SIP adoption on diversification and resilience of agrarian/rural livelihoods in parts of eastern India, Bangladesh, and the Nepal Terai with real implications for scaling regionally and for lessons adoption/transfer to Sub-Saharan Africa.	
Management Response: Solarization is important beyond irrigation pumps and should be seen to encompass multipurpose [non-irrigation] solar energy uses such as cooling and food processing. SoLAR 2 should also look at crop diversification and its impacts on livelihoods and nutrition as well as on soil and water resources.	
7. Sharper focus should be placed on understanding the subsidy regimes, subsidy delivery, and the role of credit providers as well as insurance providers.	
Management Response: Subsidies are a politically sensitive question. 'Perverse subsidies' are blamed for negative behaviors by consumers while 'incentives' are seen as investments in positive actions. It is important to understand and offer recommendations on how incentives can be structured to promote a wider shift from diesel pumps to SIPs as well as check over-exploitation of ground water. How can government work towards reducing the amount of subsidies and gradually move towards financially attractive models of SIP promotion (e.g. agri-voltaics).	
8. The research-supported policy engagement in South Asia on SIP services should be continued in SoLAR phase 2, however with targeted approaches in the project countries which take into account identified specific country-level opportunities and entry points.	
Management Response: The phase 1 of the project was heavily focused on basic research. In phase 2, the project needs to shift from research to action and policy advocacy. The phase 2 should have limited and punctual research inputs, with a view to address very specific policy questions of the partner country governments.	

Fully agree	Partially agree	Disagree

The management would like to thank the review team for the successful completion of the external review of the Phase 1 of the Solar Irrigation for Agricultural Resilience (SoLAR) Project, and sharing a very high-quality report with detailed recommendations. The management further takes note of the

ideas and guidance for the next phase of the project. These will be taken into account during the design of the next phase and related exchanges and co-design with other sections of SDC.

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