



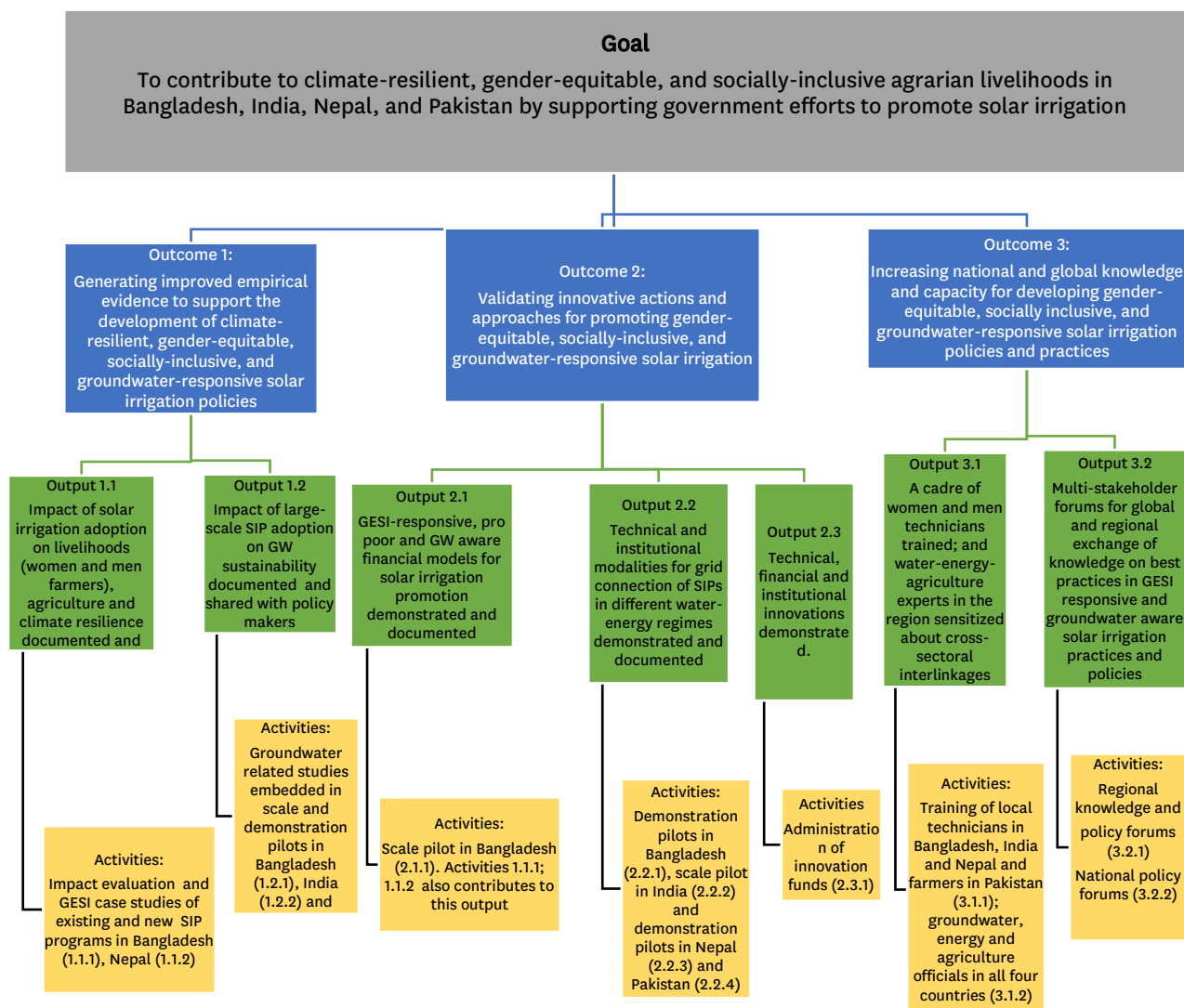
Solar Irrigation for Agriculture Resilience (SoLAR)

YEAR 4 WORK PLAN
MARCH 2023

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SoLAR Logical Framework



1.1.1 (IE&GESI) Impact evaluation and GESI case studies of existing and new SIP programs in Bangladesh

Brief background:

The Bangladesh government envisages solar irrigation as a cheaper and cleaner substitute for expensive diesel-based irrigation currently prevalent in the country. IDCOL is the primary organisation for the promotion of Solar Irrigation Pumps (SIP) with the “fee-for-service” model, where IDCOL provides loans and grants to sponsors, who install SIPs and sell water to farmers in exchange for a fee. Given this background, it becomes imperative to understand the impact of solar pumps on irrigation accessibility and agricultural outcomes at the farmer level, GHG emissions and groundwater sustainability.

Achieved in Year 1

- Preliminary field visits
- Impact assessment methodology finalised
- Design of the SIP survey finalised (questionnaire, sample)
- Collection of the 1st round (Kharif 2) of SIP level primary data using phone interviews
- Translation of relevant policy documents from Bengali to English

Achieved in Year 2

- [Situation analysis report](#) based on literature reviews secondary IDCOL data completed
- Design of the household survey (sample and questionnaire)
- Collection of the baseline household survey
- Collection of the 2nd (rabi), 3rd (Kharif 1) and 4th (Kharif 2) rounds of SIP level primary data using phone interviews
- Analysis of policy documents through a GESI lens
- Opinion piece published in the Daily Star: [When sun can dispel smoke: Solar irrigation and climate change in Bangladesh](#)
- Presentation in conferences: International Association of Energy Economics 43rd Conference, 7 June 2021, Concurrent Session 17: Climate Change Mitigation - Case Studies

Achieved in Year 3

- Collection of the 5th (Rabi 2022), 6th (Kharif 1 2022), and 7th (Kharif 2 2022) rounds of SIP-level primary data using phone interviews
- Baseline technical report – “*Impact assessment of solar irrigation pumps (sip) in Bangladesh*” completed based on SIP survey till 2021 and baseline household-level data collected in 2021
- 3 Policy Issue briefs published
 - o “*Institutional modalities for decarbonizing irrigation in Bangladesh* ([link](#))”
 - o “*Mitigation and beyond: Multiple co-benefits of solar irrigation in Bangladesh* ([link](#))”
 - o “*Making renewable energy investments sustainable through grid-connected solar pumps in Bangladesh* ([link](#))”

- 1 Research brief published
 - Buisson, Marie-Charlotte; Mitra, Archisman; Hounsa, T.; Habib, A.; Mukherji, Aditi. 2022. *Adaptation co-benefits of solar irrigation: evidence from Bangladesh. New Delhi, India: International Water Management Institute (IWMI). CGIAR Initiative on Transforming Agrifood Systems in South Asia (TAFSSA); Solar Irrigation for Agricultural Resilience (SoLAR). 9p.*
<https://cgspace.cgiar.org/handle/10568/127850>
- Presentation in conferences:
 - ADB Asia Water Forum 2022, August 10, 2022, Session Title: Opportunities for financing and private sector involvement
 - ‘Beyond climate change mitigation: the impact of solar irrigation on farmers’ poverty, time allocation and equity in accessing groundwater in Bangladesh’ at the International Conference on ‘Groundwater, key to the Sustainable Development Goals’, Paris, 18-20th May 2022.
- First draft of a descriptive paper done, currently being finalized - “State of solar irrigation in Bangladesh: learnings for solarization in off-grid areas of South Asia”
- Econometric analysis of baseline data done for identifying the adaptation co-benefits of solarizing agriculture for farmers
- Research results shared with ADB team based on their request for contributing to the SIP roadmap being prepared for Bangladesh. Shared reports and issue briefs with Barind Multipurpose Development Authority (BMDA) based on their request to contribute to their development plan for solarizing electric BMDA pumps.

Planned for Year 4

- Collection of 8th and 9th rounds of SIP-level primary data using phone interviews
- Collection of endline household level data in July-August 2023
- Complete submission of 2 journal articles currently under draft.
- Draft of 2 new articles based on the panel SIP data and HH-level data.
- Communication of research findings and policy recommendations through publications, conferences, blog pieces, and national and regional forums

Timeline for each objective in Year 4:

Details of sub-activities	Start date*	End date*	Outputs/Comments	Person/s responsible
SIP Survey Rabi 2023	25/03/2023	25/04/2023	Primary data on SIP operations for 3 seasons from 83 schemes	NGO Forum, Marie-Charlotte, Archisman
SIP survey Kharif 1 2023	10/08/2023	30/08/2023		
Endline HH level data				
<ul style="list-style-type: none"> HH Questionnaire completed 	01/05/2023	20/05/2023	HH Questionnaire	Marie-Charlotte, Archisman
<ul style="list-style-type: none"> Planning and schedule (updating Group B and Group C villages that are solarized) 	01/05/2023	20/05/2023	Survey schedule	NGO- Forum/ Archisman/ Marie-Charlotte
<ul style="list-style-type: none"> ODK questionnaire 	20/05/2023	20/06/2023	ODK format questionnaire	NGO-Forum
<ul style="list-style-type: none"> Enumerator Training HH Survey Data cleaning 	20/06/2023 01/07/2023 25/07/2023	30/06/2023 25/07/2023 15/08/2023	Clean endline panel data for 900 HHs	NGO Forum, Marie-Charlotte, Archisman
Finalization of articles from 2022				
<ul style="list-style-type: none"> "State of solar irrigation in Bangladesh: learnings for solarization in off-grid areas of South Asia" 	01/01/2023	28/02/2023	Journal article submitted	Archisman, Marie-Charlotte, Aditi
<ul style="list-style-type: none"> "Adaptation co-benefits of solarizing agriculture for farmers" 	01/01/2023	30/03/2023		Marie-Charlotte, Archisman, Ahasan, Aditi
Journal article analysing the evolution of SIP business over time & determinants of its financial sustainability	15/08/2023	31/12/2023	Journal article draft	Archisman, Marie-Charlotte, NGO Forum

Details of sub-activities	Start date*	End date*	Outputs/Comments	Person/s responsible
Journal article analyzing the equity impacts and inclusivity of the current SIP model	15/08/2023	31/12/2023	Journal article draft	Marie-Charlotte, Archisman, NGO Forum
Communication and outreach	01/01/2023	31/12/2023	2 Blogs/ Issue Briefs Presentations in international conferences and to stakeholders in Bangladesh	Archisman, Marie-Charlotte, NGO Forum

Deliverables:

- SIP level database for 2 seasons in 2023 (i.e., Rabi, kharif2) through a telephone survey
- Endline Household level database in 2023
- Journal article submitted after finalizing the work from 2022
 - “State of solar irrigation in Bangladesh: learnings for solarization in off-grid areas of South Asia”
 - “Adaptation co-benefits of solarizing agriculture for farmers”
- Journal article analyzing the equity impacts and inclusivity of the current SIP model, draft
- Journal article analysing the evolution of SIP business over time & determinants of its financial sustainability, draft
- Regular contributions to the SDC-SoLAR newsletter – throughout the year
- Blogs/Policy Briefs
 - Sustainable business model for solar irrigation pumps in Bangladesh
 - Equity impacts of SIPs—who has access and who does not.
 - Communication and outreach through presentations in international conferences and to stakeholders in Bangladesh

1.1.2 (IE & GESI NP) Impact Evaluation (IE) and GESI Case Studies of SIP Program in Nepal

Brief background:

AEPC, the nodal agency for renewable energy in Nepal, has financed to install over 1,300 SIPs to date. In addition, ICIMOD has also installed nearly 60 SIPs, which have been monitored since 2016. While there are data to show that these pumps have been beneficial for the farmers, an in-depth, comprehensive, and rigorous impact evaluation (IE) of AEPC's SIP program is yet to be done. In year 1, we carried out a rapid assessment of AEPC's SIP subsidy delivery mechanism, including a detailed characterization of the SIPs supported by AEPC. We also prepared a sampling design for carrying out a detailed survey, initiated the process for selecting a vendor for data collection, and identified 1st and 2nd choice vendors. In Year 2, we implemented the impact evaluation survey, analyze the data, and prepared an impact evaluation report. The first and second waves of CoVID-19 impacted the activity resulting in a delay in the fieldwork and data collection.

Achieved in Year 3

- Phone Survey and HH survey Research Reports are ready to be published on the SoLAR website.
- Journal Article based on the report submitted to AEPC in 2020 (Are climate finance subsidies equitably distributed among farmers? Assessing socio-demographics of solar irrigation in Nepal by Kashi Kafle) published in Energy Research and Social Science Journal.
- A Journal Article based on the Quantitative IE study on diesel used by Deepal Varshney will be ready to be published by December 2023.
- Abstract of Journal article based on Qualitative study of GESI in SIP (by Gitta and Labisha) submitted; full paper accepted for review by a journal for publishing 3.
- Journal article based on research paper on Policy review on GESI in SIP in Nepal and Bangladesh to be accepted for review by a journal for publishing.
- Draft Research Report on Desk assessment for the development of country-specific emission factors in the Agriculture sector of Nepal in coordination with the Ministry of Forests and Environment and NDC partnership Nepal is received. The dissemination workshop is planned in March 2023.
- Summary Research Report on SoLAR Impact Evaluation scheduled to be completed by December 2023.
- SoLAR video documentary showcased at the Water, WASH, and Climate Virtual Symposium; 13 presentations made at different forums on GESI findings by MK, GS, and LU
- Orientation with/for local governments in the study area on best practices of how to better target and reach smallholders, the marginalized, and women farmers (on SIP information and technology dissemination) – Moved to 2023

Planned for Year 4 (focus on dissemination and dialogue)

- Publish Journal Articles developed in Y3
- Journal article based on Research Report on Desk assessment for the development of country-specific emission factors in the Agriculture sector of Nepal
- Journal Article based on the Quantitative IE study on (i) Determinants of SIP Utilization and (ii) Cost-benefit simulation on Scaling AEPC's SIP program
- Participation in national dialogues or conferences for dissemination of findings from SoLAR IE work in Nepal

Goals/ Objectives:

- Evaluate impacts of SIP program in Nepal to provide feedback to AEPC in better designing the SIP program in Nepal and disseminate the findings

Study area/location:

- 15 Palikas (i.e., local governments) in Seven districts (i.e., Morang, Sunsari, Sarlahi, Rautahat, Parsa, Saptari, and Bara) in Province 1 and 2 in Eastern Nepal.

Methods employed:

- Qualitative studies that capture the perception of farmers, including small and marginal farmers and women farmers about benefits and challenges of SIPs using a GESI-framework;
- Quantitative surveys covering farmers/plots using solar (treatment group), electric and diesel pumps (control group). Farmers/plots with similar characteristics will be matched for creating credible comparison groups for evaluation
- Desk assessment for the development of country-specific emission factors in the Agriculture sector of Nepal based on secondary data.

Timeline for each objective:

Details of sub-activities	Start date	End date	Outputs/Comments	Person/s responsible
Submit articles developed in Y3 <ul style="list-style-type: none"> - Journal article based on Qualitative study of GESI in SIP developed in Y2 (GS) - Journal article based on research report on Policy review on GESI in SIP in Nepal and Bangladesh (MK) - Journal Article based on the Quantitative IE study on diesel used by DV - Journal Article based on the Quantitative IE study on Agriculture Outcomes by DV 	01-01-2023	30-06-2023	Journal article submitted	Shisher/ Labisha/ Manohara, Aditi/ Deepak et al
Journal Article based on Research Report on Desk assessment for the development of country-specific emission factors in the Agriculture sector of Nepal	01-01-2023	30-09-2023	Journal article	Shisher/ Aditi/ IWMI Consultant / MoFE
Journal Article based on the Quantitative IE study	01-01-2023	31-12-2023	Journal article	Deepak/ Shisher /Aditi et al

<ul style="list-style-type: none"> - Determinants of SIP Utilization - Cost-benefit simulation on Scaling AEPC's SIP program 				
Participation in national dialogues or conferences for dissemination of findings from SoLAR IE work in Nepal	01-01-2023	30-09-2023	Blogpost / Workshop Report	Labisha/ Manohara/ Shisher et al
Orientation with/for local governments on best practices of how to better target and reach smallholders, the marginalized, and women farmers (on information and technology dissemination)	01-01-2023	31-12-2023	Workshop Report	Labisha/ Shisher/ et al
Policy Briefs and Research Highlights based on the Journal Article published in Y3 and Y4	01-01-2023	31-12-2023	Policy Briefs and Research Highlights	Shisher/ Labisha/ Manohara, Aditi/ Deepak/ Sunipa et al

Deliverables:

- Publish Journal Articles developed in Y3 **(30-06-2023)**
 - Qualitative study of GESI in SIP by GS and LU
 - Policy review on GESI in SIP in Nepal and Bangladesh by MK
 - Quantitative IE study on diesel used by DV
 - Journal Article based on the Quantitative IE study on Agriculture Outcomes by DV
- Journal Article based on Research Report on Desk assessment for the development of country-specific emission factors in the Agriculture sector of Nepal **(30-09-2023)**
- Journal Article based on the Quantitative IE study
 - Determinants of SIP Utilization **(31-12-2023)**
 - Cost-benefit simulation on Scaling AEPC's SIP program **(31-12-2023)**
- Province / local level workshops Report **(31-12-2023)**
- Participation in national dialogues or conferences for dissemination of findings from SoLAR IE work in Nepal **(30-09-2023)**
- Two blog posts, policy briefs, and research highlights throughout the year

1.2.1 (GW_BD)Groundwater-related studies embedded in demonstration pilot in Bangladesh

Brief background:

In Bangladesh, in partnership with the Infrastructure Development Company Limited (IDCOL), the project will assess the impact of SIP on farmers' irrigation behaviour, and subsequent impacts on overall groundwater levels and resources. The project will also analyse and compare the farmer's groundwater abstraction patterns/behaviour and volumes of water pumped by SIP (both grid-connected and off grid) and non-solar (diesel/kerosene pumps) farmers.

Achieved in Year 1, Year 2 and Year 3

- Field visits were carried out to project locations to understand the context and secondary data (agriculture and groundwater) was collected for baseline report.
- Methodology and monitoring protocol for GW sustainability studies was developed
- Survey of SIPs (collecting design plans, field, and farmer mapping) were carried out in Northwest and Southwest Bangladesh.
- Selection of 320 plots serving 235 farmers were selected for monitoring based on survey.
- Carried out instrumentation in selected SIPs, training of operator for data collection and selection of control diesel farmers and their training.
- Conceptual model for groundwater modelling in the project areas was developed.
- Regular monitoring of irrigation water application data started in Rabi/Boro season 2021-22 and is continuing.
- Analysis of Rabi/Boro 2021 season data was done to compare groundwater use of solar and non-solar farmers.
- Numerical groundwater model was setup for simulating impact of SIP on groundwater.

Planned for Year 4

- Regular monitoring of irrigation water application for the Rabi/Boro season 2022-23 season.
- Final data compilation of two-year monitoring (2021-22 season and 22-23 season)
- Final report and publication on comparing groundwater use solar and diesel farmers.
- Final calibrated and validated numerical groundwater model with future scenarios simulated.

Goals/ Objectives:

Groundwater studies in Bangladesh will focus on the following objectives:

- How does the pumping behaviour of farmer-irrigators differ between farmers who buy water from diesel pumps vs farmers who buy water from solar pumps?
- How different is the water use across SIPs with different cropping patterns and climatic regions?
- How will groundwater sustainability be affected if SIPs were to be upscaled, while also accounting for return flows and other changes, such as climate change?

Study area/location:

The SoLAR project's groundwater activities in Bangladesh will be concentrated in North and Southwest region of Bangladesh. In total, 12 SIPs (6 in each region) have been selected for data collection and monitoring.

Methods employed:

- Collection and analysis of secondary data on biophysical and groundwater characteristics in the selected project sites; installation of instruments for measurement of irrigation water application; establishing and measuring GW use patterns at a representative number of farmers within SIP command area and farmers outside SIP command area using (either owning or buying) diesel pumps.
- Groundwater model at representative scales in alluvial study sites to simulate SIPs upscaling scenarios

Timeline for each objective:

Details of sub-activities	Start date	End date	Outputs/Comments	Person/s responsible
Collection of plot level water application for SIP farmers and adjoining diesel farmers through surveys for the 2022-23 season	01-01-2023	15-05-2023	Structured data base on irrigation water application	NGO forum
Final compiled, cleaned and structured data from two-year monitoring	15-05-2023	15-06-2023	Structured data base on irrigation water application	Faiz
Data analysis to compare groundwater use of solar and non-solar farmers	15-06-2023	15-07-2023	Report on data analysis	Faiz
Final report and draft manuscript comparing solar and non-solar farmers water use	15-05-2023	30-07-2023		Faiz
Calibrated and validated groundwater model of the region with SIP upscaling scenarios simulated	15-03-2023	15-06-2023	Report/publication groundwater model runs	Smaranika

Deliverables:

- Final report and publication on groundwater use comparison of solar and non-solar farmers and different SIPs
- Report/publication on calibrated groundwater model for the region with SIP upscaling scenarios
- Blog posts and policy based on the results

1.2.2 Groundwater-related studies embedded in scale pilot in India

Brief background:

The state of Gujarat has implemented on-grid solar under the most ambitiously programmed: 'Suryashakti Kisan Yojana (SKY)'. However, it is important to assess how solarisation of farmers' irrigation has impacted on their pumping behaviour, with subsequent effects on overall groundwater resources in the state. In this component of the project, we will monitor the groundwater abstraction from SKY and Non-SKY feeder lines and, in so doing, establish a functional relationship between energy consumption and groundwater abstraction. The research monitoring activities will be carried out in partnership with the Gujarat Energy Research and Management Institute (GERMI).

Achieved in Year 1, Year 2 and Year 3:

- Field visits were carried out to SKY feeders to engage with local stakeholders and so understand the context.
- A methodological framework and monitoring protocol for evaluating groundwater sustainability was developed.
- State groundwater data was analysed and overlaid with SKY feeders.
- Instrumentation to monitor groundwater abstraction was installed on farms across 4 feeders (2 SKY and 2 Non-SKY) in Anand and Botad.
- Regular monitoring and collection of data (groundwater abstraction, crops, groundwater levels) started in August 2021 and is ongoing with support from INREM.
- Secondary data collection and primary fieldwork to build a conceptual model for Groundwater modelling [Indian Agriculture Research Institute (IARI), Delhi]
- Data collected (2021-22 season) was analysed to develop groundwater abstraction-energy relationships
- Data collected (2020-21 season) was analysed to compare groundwater use of Solar and non-solar farmers.

Planned for Year 4:

- Regular monitoring will continue for the Rabi 2022-23 season.
- Final data compilation of two-year monitoring (2021-22 season and 22-23 season)
- Final report and publication on developed groundwater abstraction-energy relationships and upscale the groundwater-abstraction energy relationship to other SKY and Non-SKY feeders for estimating groundwater abstraction at larger scale.
- Final report and publication on comparing groundwater use of solar and non-solar farmers.
- Final calibrated and validated numerical groundwater model with future scenarios simulated.

Goals/ Objectives:

- To develop groundwater abstraction-energy relationships and quantify GW use of individual tube well (TW) owners under solarized and non-solarized conditions using the developed relationship and data on energy used in pumping.
- Establish patterns in groundwater abstraction volume by accounting for confounding factors such as landholding size, crop patterns, water markets, energy exports, climate, soil type, irrigation practices etc.
- Differentiate changes in GW use between solar and non-solar farmers, accounting for the potential factors that may confound groundwater use.

Study area/location:

The feeders, both SKY and non-SKY, are distributed among contrasting hydro-geologies of Anand district (Alluvial aquifers) and *Botad district* (Saurashtra hard rock aquifers) Gujarat. In total 4 feeders and 40 farmers in each feeder (total 160 farmers) are being monitored. Work will be expanded to North Gujarat.

Methods employed:

- Collection and analysis of secondary data on biophysical and groundwater characteristics in the selected project sites.
- Baseline data collection on well, pump characteristics and water management practices used by farmers through census.
- Installation of instruments for measurement of water and energy data and monitoring of selected sample of well-owners.
- Carry out direct and indirect measurements of groundwater and energy use on a representative subset of TWs for solar and non-solar farmers
- Analysing the monitored data for developing a robust relationship between energy use and groundwater pumped.

Timeline for each objective:

Details of sub-activities	Start date	End date	Outputs/Comments	Person/s responsible
Continuous monitoring and data collection for the Rabi 2022-23 data	01-01-2023	01-03-2023	Database on farmers groundwater abstraction, cropping and irrigation	INREM Foundation
Final report on developed generic groundwater abstraction-energy relationship for pumps	01-01-2023	15-04-2023	Report/publication on developed abstraction-energy relationships	Faiz
Final report and draft manuscript comparing solar and non-solar farmers water use	01-03-2023	15-06-2023	Report on groundwater use of solar and non-solar farmers	Faiz
Calibrated and validated groundwater model of the region with SIP upscaling scenarios simulated	01-01-2023	15-07-2023	Report/publication groundwater model runs	IARI

Deliverables:

- Journal article on developed groundwater-abstraction energy relationships
- Final report on groundwater use comparison of solar and non-solar farmers
- Report/publication on calibrated groundwater model for the region with upscaling scenarios
- Blog posts and policy based on the results.

Linking activities with outputs and outcomes

Activity contributes to output number **1.2** *“Impact of large-scale SIP adoption on GW sustainability documented and shared with policy makers”*.

Activities will set up instrumentation to provide quantitative measure of groundwater abstraction of solar and non-solar farmers. This will be analysed with data collection on other factors (hydrogeology, cropping pattern) to answer if there is any difference in irrigation pumping behaviour of solar and non-solar farmers. This will be shared with policy makers.

Output will contribute to project outcome on *“Generating improved empirical evidence to support the development of climate-resilient, gender-equitable, socially-inclusive, and groundwater-responsive solar irrigation policies.”*

Field data collected on groundwater abstraction of solar and non-solar farmers will provide the field evidence on whether solar farmers pump more water and if yes, under what conditions. This data in conjunction with groundwater modelling will help policy makers understand the impact of solar irrigation on groundwater and future implications on groundwater sustainability to devise any mitigation strategy.

1.2.3: Groundwater-related studies embedded in demonstration pilot in Pakistan

Brief background:

- Given the overall state of groundwater over-exploitation in Pakistan; there is an active debate on whether SIPs will further aggravate the problem of groundwater over-exploitation.
- So far, studies conducted by PARC, FAO and others have had somewhat contradictory results, and hence the need for a study with the experimental method
- With this study, we want to objectively assess the situation on the ground using rigorous science on the impact on groundwater by collecting data from SIP and diesel pump farmers. This would help us to evaluate the policy direction for further promotion of SIPs in Pakistan

Achieved in year 1:

- The methodology that involves a selection of the sample for the behavioral study was developed in the year 2020. It involves the criteria for the selection of respondents from various districts in Punjab province, sample size and details regarding the sample sizes in different districts.
- An IRB application was submitted to collect data from the human respondents which was approved by IWMI before the start of the data collection.
- A pre-survey questionnaire was developed for the diesel and SIP farmers and a phone-based pre-survey was conducted with the SIP farmers.
- The data for the pre-survey was digitized and preliminary analysis has been conducted

Achieved in year 2:

- Report on the phone survey results was finalized and submitted.
- Methodology of the Rapid Enumeration Survey was finalized, and the survey was conducted in three districts of the province of Punjab with a total of 624 respondents
- Report on the Rapid Enumeration Survey results was finalized and submitted.
- Based on the very interesting results of phone survey and Rapid Enumeration, it was decided to prepare a draft manuscript to be submitted to a journal for publication. The draft manuscript is in final stages and will be submitted to a journal in December 2021.
- Final behavioural survey has commenced in November 2021 with the same set of respondents as in the Rapid Enumeration and it will be completed in December 2021.
- Instruments for in-situ installation have been finalized and the procurement of the instruments is underway. These will be installed once the survey is complete i.e. end of December 2021.

Achieved in year 3:

- Analysis of the final behavioural study completed and policy brief developed.
- Stakeholder consultation and Dissemination of the results of behavioural study in the form of three dialogue meetings.
- Collection of in-situ groundwater data for the Rabi and Kharif season 2022.
- On-going Analysis and Comparison of the survey responses with in-situ data to determine the actual impact on groundwater aquifer due to SIP pumping.

Planned for year 4

- Finalization of the research manuscript for the behavioral study
- Preparation of policy brief for the Government
- Collection and analysis of in-situ groundwater data
- Analysis and preparation of research manuscript for a year long in-situ data

Goals/ Objectives:

The objective of the study is to provide empirical evidence for the Government of Pakistan for the policy regarding the promotion of SIPs in the country. The Government of Pakistan wants to reduce the oil import bill by reducing the amount of fossil fuel used in the agriculture sector. The study aims to provide evidence on the behaviour of farmers when they have the option of switching to SIPs from the existing diesel/electric pumps, use SIPs simultaneously with diesel/electric pumps, or use SIPs and diesel/electric pumps under different modes of irrigation.

Study area/location:

- The location of the study is in three different zones of Punjab, in selected tehsils of representative districts to incorporate variations in groundwater quality and demographic variability. These districts that are chosen in the northern, southern and central zones include Chakwal, Rahim Yar Khan and Jhang. These districts are included in the Rapid Enumeration survey as well as the final behavioural study.

Methods employed:

- Monitoring of 12 sites with in-situ instrumentation which include 6 diesel and 6 SIPs will continue during the year 2023. Four sites will be monitored in each district chosen for the behavioural study. The instruments will record the actual discharge flowing through the tube wells as well as the duration of their operation along with the field characteristics of soil moisture and actual energy generated through the PVs vs actual consumption by the SIP during the course of operation.
- The analysis and comparison will be made with the behavioural study to determine whether SIPs lead to more groundwater extraction.

Linking activities with outputs and outcomes

- Activity 1.2.3 contributes to the output 1.2 Impact of large-scale SIP adoption on GW sustainability documented and shared with policy makers from relevant department (including agriculture, water and renewable energy).
- This activity directly contributes to the Outcome 1: Generating improved empirical evidence to support the development of climate-resilient, gender-equitable, socially-inclusive, and groundwater-responsive solar irrigation policies
- Federal Water Management Cell (FWMC) of the Ministry of National Food Security and Research of Pakistan has put on hold their national project of providing 30000 SIPs on subsidy to the farmers until they receive concrete evidence from IWMI that this investment would not further exacerbate the depletion of groundwater in cultivated areas in Pakistan.
- The outputs of this activity will result in a policy brief and consultative discussions to help them finalise on their investment plan.
- Finally, these outputs and outcomes would determine the transition from dirty diesel/electric energy to green energy from the solar based irrigation. Currently 20% of the

GHG emissions are contributed by the agriculture sector only through groundwater pumping. Sustainable transition to Solar will benefit the country in achieving its INDCs as well contributing to the SDGs. It will also bring prosperity in the livelihood of the farmers as well.

Timeline for each objective:

Details of sub-activities	Start date	End date	Outputs/Comments	Person/s responsible
Finalization of the research manuscript for the behavioral study	01/01/2023	30/06/2023	Research Manuscript	Solar Pak team
Preparation of policy brief for the Government	01/01/2023	15/04/2023	Policy Brief	Solar Pak team
Collection and analysis of in-situ groundwater data	01/01/2023	31/12/2023	Data Set	Solar Pak team
Analysis and preparation of research manuscript for a year long in-situ data	01/01/2023	31/12/2023	Research Manuscript	Solar Pak team

Deliverables:

- Data set on actual groundwater usage of 12 sites in three different districts of Punjab for Rabi 2022 and Kharif 2023 seasons 2022 – Dec 2023
- A policy brief for the Government on promotion of SIPs – April 2023
- Research Manuscript based on behavioral study submitted to journal – June 2023
- Research Manuscript based on in-situ GW data submitted to journal – Dec 2023
- Blog posts and regular contributions to SDC-SoLAR newsletter – throughout the year

2.1.1 (Scale Pilot_BD) Scale pilot for testing different SIP promotion models in Bangladesh

Brief background:

IDCOL is the largest sponsor of SIP in Bangladesh, covering about 80% of the SIP in the country. In the first year of the project, it was planned to evaluate the farmer's preference for the “fee-for-service” and “ownership” model supported by IDCOL. However, IDCOL has decided to hold back the ownership model to be rolled out in Bangladesh. The remaining 20% of the SIP in the country are supported by BADC, BMDA, BREB, DAE, RDA etc., which follow different institutional and financial modalities and target different groups of farmers. For example, BADC targets SIPs for a group of small and marginal farmers mostly through grants, while BREB targets individual farmers with a mix of grants, loans and equity.

Since IDCOL and other organizations differ in their modalities with respect to the loan, grants, equity, and other supports like training, etc., it is important to generate evidence on how different SIP promotion models are working, their effects on farmer's dependency on diesel, agricultural production, and livelihood outcomes. Accordingly, this activity aims to conduct a case study to evaluate the performance of different SIP promotion models and their implications on farmers' livelihoods and the local groundwater market.

In Year 1 and 2:

- Collected secondary data from the SREDA website on the number of SIPs promoted by different organizations
- Contributed to situation analysis report
- Established contacts with BREB, BMDA, and BADC for conducting KII and FGDs and obtained beneficiary list from BADC and BMDA
- Planned number of KII's and FGD's to be conducted in IDCOL, BADC, and BMDA SIP sites.
- Prepared KII guiding protocol
- Field visit to the northwest region to understand how the different modalities are working and conduct FGD pilots.
- Conducted KII's with officials of different organisations

Achieved in year 3:

- 18 FGDs and 28 KIIs completed covering 2 IDCOL villages and 10 villages with group ownership models of BMDA and BADC solar pumps respectively. FGDs were conducted with water buyers who receive/buy water from SIP, water buyers who buy water from diesel/electric pumps, and owners of diesel/electric pumps.
- Transcription of recorded FGDs and KIIs interviews and translation completed
- Started a qualitative study in collaboration with Bangladesh Agricultural University to analyze
 - implication of the tubewell permit system on energy transition in the irrigation sector &
 - the impact of this transition from diesel to solar & electric on the informal groundwater market of BD

7 FGDs with farmers and field-level government officials, along with (qual+quant) data from 105 farmers collected.

Planned for Year 4

- Analysis of qualitative data (in conjunction with quantitative HH survey data) for characterizing alternative SIP promotion models in Bangladesh and understanding the impact of SIP in the local groundwater market
- Research report/issue brief characterizing different SIP promotion models in BD
- Journal Article characterizing institutional modalities of Solar irrigation and its impact on the local groundwater market in Bangladesh
- Research report on the implication of the tubewell permit system on energy transition in the irrigation sector
- Research report on the impact of energy transition from diesel to solar & electric in the irrigation sector on the informal groundwater market of BD

Goals/ Objectives:

Comparative case study of different SIP promotion models in Bangladesh in order to compare advantages and disadvantages of each of the models as proposed by ADB's solar irrigation roadmap; document and qualitatively understand the impact of SIPs on local groundwater services markets.

Study area/location:

Selected sites in northwest Bangladesh and Khulna region

Methods employed:

- Use focus group discussion (FGD) Key Informant Interviews (KII), and case study method
- Collect secondary data will be collected from IDCOL
- Employ mixed-methods using both quantitative and qualitative methods

Timeline for each objective:

Details of sub-activities	Start date	End date	Outputs/Comments	Person Responsible
Prepare Qual data for analysis The first iteration of the coding tree and thematic mental maps with simultaneous manual coding initiated	10-01-2023	31-01-2023	Analysis and organization qualitative data	Manikanta, Shreya, Zahid, Archisman
Complete manual coding and second iteration of the coding tree and thematic mapping	01-02-2023	15-02-2023		
Complete transcript coding	15-02-2023	20-02-2023		
Review literature, and policy documents, and get expert field insights to develop the analytical	20-02-2023	06-03-2023		

context for transcript data analysis				
Research report/issue brief characterizing different SIP promotion models	07-03-2023	30-03-2023	Research report/Issue Brief	Manikanta, Shreya, Zahid, Archisman
Journal article (<i>in conjunction with quantitative HH data</i>) characterizing institutional modalities and impact on the local groundwater market	01-04-2023	30-06-2023	Journal article submitted	Manikanta, Shreya, Zahid, Archisman, Marie
KII with high-level Government officials	01-02-2023	28-02-2023		Saidur Rahman (BAU)
Research report on the implication of the tubewell permit system on energy transition in the irrigation sector	01-01-2023	28-02-2023	Research report	Saidur Rahman (BAU)
Research report on the impact of energy transition from diesel to solar & electric in the irrigation sector on the informal groundwater market of BD	01-03-2023	30-04-2023	Research report	Saidur Rahman (BAU)

Deliverables:

- Research report/Issue Brief on the different SIP modalities in Bangladesh
- Journal Article characterizing institutional modalities of Solar irrigation and its impact on the local groundwater market in Bangladesh
- Research report on the implication of the tubewell permit system on energy transition in the irrigation sector
- Research report on the impact of energy transition from diesel to solar & electric in the irrigation sector on the informal groundwater market of BD

2.2.1 (MicroGrid_BD) Demonstration pilots for grid connection of SIPs Bangladesh

Brief background:

In Bangladesh, solar pumps are used primarily in the initial four months of a year, and they remain mostly idle the rest of the year. Consequently, capacity utilization for these solar pumps is very low, and it becomes important to find ways to increase the capacity utilization of these solar pumps. Grid connection of SIPs is a viable alternative use of solar power, and 9 SIPs will be grid-connected under this project. Results from the study will be shared with SREDA and will provide future policy design.

SREDA has finalized the “Grid Integration Guideline for Solar Irrigation Pumps-2020” on 30th June 2020, in the first half of 2020. Six sponsors, with 70% of then installed projects among the 1,515 installations done by IDCOL, were nominated to collect and submit the design in 2020. Out of the 6 sponsors, IDCOL selected 3 sponsors in 2021 based on their cost and completed BOQ. These included 2 cluster locations (with 4 and 3 sites in each cluster) and 2 sites for net metering. Selected sponsors then applied for NOC from the respective utilities and completed the physical grid integration by the end of 2021 with approval from the CPMC of Bangladesh. The impact of Grid connection on energy and water uses, profitability for sponsors and impact on farmers would be analysed through the SIP survey and HH level surveys as described in activity 1.1.1.

Achieved in Year 1

- 5 cluster locations have been selected in Kushtia, Chuadanga, Bogura, Rangpur and Dinajpur districts
- Sponsors have been nominated to collect and submit the design.

Achieved in Year 2

- Technical design (Clustered SIP sites via HT line) and site selection criteria for grid-integration pilot were finalized by IDCOL
- Out of the 6 sponsors nominated in 2020 for submitting the proposal, 3 sponsors (Gazi, Wave and KHM, quoting lowest cost per site with complete BOQ), were selected for the pilot grid connection in 2021, which includes 2 cluster locations (with 4 and 3 sites in each cluster) and 2 sites for net metering
- Contract signed with selected sponsors for the pilot and NOC received from respective utilities

Achieved in Year 3

- Physical grid connection completed for 2 WAVE sites (individually) and 4 GAZI sites (in a clustered mode)
- Detailed report with technical parameters and socio-institutional features submitted by IDCOL for the 2 WAVE sites
- Logbook data on pump operation and energy export is being collected at grid-integrated sites

Planned for Year 4

- Physical grid connection to be done for 1 WAVE site and 2 additional SHEL sites using the remaining budget for grid integration
- Installation of additional monitoring instruments for grid integration using the remaining budget for grid integration
- Detailed report to be submitted by IDCOL for the 4 Gazi sites and additional sites after grid integration
- Continue monitoring of energy consumption and selling in Grid connection pilot sites
- FGDs and KIIs to be conducted at grid pilot sites
- Research report on the impact of grid integration sites on the irrigation service business of sponsors

Goals/ Objectives:

This demonstration pilot will help us understand the technical and institutional feasibility of grid connection. It will also give evidence on how grid integration of SIPs might affect individual farmers' access to irrigation and their income. Moreover, there is a growing concern about groundwater usage for irrigation purposes in Bangladesh. In such a scenario, connecting solar pumps to the grid to sell electricity can result in the sponsors pumping less and selling more to the grid.

This demonstration pilot in Bangladesh will specifically answer the following policy questions:

- How does the grid connection of solar pumps affect the irrigation service business of sponsors/IDCOL partners in terms of capacity utilization of Solar PV, price of water, changes in water schedule, etc.?

Study area/location:

Project locations have now been finalised and include: 1 cluster location (with 4 SIPs) in Dinajpur district; 1 cluster location (with 2 SIPs) in Kushtia district, and 2 SIPs for net-metering in Kushtia district

Methods employed:

This pilot research component is organized into the following studies

- SIP scheme level study that will collect and analyse scheme level data between grid-connected and off-grid IDCOL SIPs
- Microeconomic study at the household level by comparing grid-connected and off-grid IDCOL SIPs. Two rounds of data will be collected in early 2021 and follow-up at the end of 2022/early 2023.
- GW study on how SIP pumping, operations, and groundwater level dynamics change after grid connection of SIP relative to a BAU scenario (non-grid connected SIPs)?

Timeline for each objective in Year 4:

Details of sub-activities	Start date	End date	Outputs/Comments	Person/s responsible
Detailed report with technical parameters and socio-institutional features for 4 Gazi sites under grid integration	01-02-2023	28-02-2023	Detailed report for 4 Gazi sites	Sponsor /IDCOL
Installation of additional monitoring instruments for grid integration	01-01-2023	28-02-2023		Sponsor /IDCOL
Physical grid connection to be done for 1 WAVE site and 2 additional SHEL sites using the remaining budget for grid integration	01-01-2023	30-04-2023		Sponsor /IDCOL
Detailed report for new sites under grid integration	01-05-2023	30-05-2023	Detailed report for new grid pilot sites	Sponsor /IDCOL
Monitoring data on energy consumption and selling at IDCOL sites	01-01-2023	31-12-2023	Monitoring data on energy consumption and selling at IDCOL sites	IDCOL
SIP level survey at selected sites (also see 1.1.1) and qualitative interviews at grid connection sites	01-06-2023	31-08-2023	SIP survey data and Field notes from the qualitative interviews	Archisman, Marie-Charlottle
Report on the impact of grid integration sites on the irrigation service business of sponsors	01-09-2023	31-12-2023	Research Report/Issue brief	Archisman, Marie-Charlottle

Deliverables:

- Detailed report on grid integration projects with technical parameters and socio-institutional features (IDCOL)
- Report on the impact of grid integration sites on the irrigation service business of sponsors/IDCOL partners in terms of capacity utilization of Solar PV, price of water, and changes in water schedule.
- Monitoring data on energy consumption and selling at IDCOL sites for 2023

2.2.2 Scale pilot on institutional aspects of grid-connected SIPs in Gujarat, India

Brief background:

Under Suryashakti Kisan Yojana (SKY) scheme, the government of Gujarat and GUVNL (Gujarat Urja Vikas Nigam Limited) have solarized nearly 92 agricultural feeders in the state. Under the SKY programme, farmers connected to the SKY feeders can generate solar energy, which can be used for pumping purposes, and excess energy can be sold back to the grid at the pre-specified feed-in-tariff (FIT) mentioned by GUVNL. It is presumed that FIT will give incentive to farmers to save more energy and thus efficiently use groundwater to increase the additional earnings from selling energy back to the grid. In this component, IWMI aims to assess the impact of the SKY program on farmers' energy consumption, livelihoods, and informal groundwater markets.

Year 1 activities completed:

- Preliminary field visits to understand the context and characteristics of SKY feeders.
- Evaluation protocol and methodological note
- Download SKY web-portal data for the year 2019- 2020
- Coordinate with Gujarat Urja Vikas Nigam Ltd. (GUVNL), a state energy company, to collect secondary data related to the SKY program

Year 2 activities completed:

- Situation analysis report prepared and uploaded on the website
- Detailed methodological note prepared
- Monthly feeder and farmer level energy data indicators from the SKY web portal for 2018-2021 were downloaded and compiled
- Analysis of SKY web portal data and presentation of early findings done in CPMC and National Forum 2021
- Two field visits by IWMI Team to SKY and Non SKY feeders and utilities in all four feeders in Gujarat and field notes were prepared.
- Primary survey instrument for quick enumeration prepared.
- Completed quick enumeration of 2447 farmers from 40 feeders, which included SKY feeder enrolled, SKY feeder non-enrolled and Non SKY feeder farmers on agricultural practices, perceived benefits of SKY, operation and maintenance, billing, pumping behaviour, pump and well details and socio-economic characteristics, completed analysis of the data and prepared a report.
- Signed LoA with Gujarat Urja Vikas Nigam Ltd. (GUVNL), a state energy company to access and use SKY web portal data for analysis and research outputs.
- Data analysis for two journal articles – one on solar generation determinants and another on electricity use and evacuation started. Database cleaned and prepared.
- Ongoing assessment study on the progress, performance and impact of Chief Minister's Saur Krishi Vahini Program in Maharashtra from the perspectives of DISCOMs, farmers, and state and central government with support from IRMA, Anand.

Year 3 activities completed:

- Finalized the report on assessing the progress, performance, and impact of Chief Minister's Saur Krishi Vahini Program in Maharashtra from the perspectives of DISCOMs, farmers, and state and central government with support from IRMA, Anand. The findings will help in

suggesting mid-course policy corrections for the PM-KUSUM program. It is in the pipeline for publication.

- Finalized sample selection and developed a questionnaire for the detailed household survey to assess the effect of the SKY scheme. The contract for conducting the survey is already done. The survey will start in the last week of February 2023.
- Data extraction, cleaning, and processing of the SKY portal data on a range of indicators for 2019-20, 2020-21, and 2021-22.
- Finalized the report on Farmer responses to solar irrigation: Agent-based modeling to understand sustainable transitions with support from Ashoka Trust for Ecology and Environment (ATREE). It is in the pipeline for publication.
- Finalized 2 research briefs on Institutional modalities for solarizing groundwater irrigation in India and the Solarization of grid-connected agricultural pumps. It is in the pipeline for publication.
- Finalised the analysis for a paper on an overview of the SKY scheme. The writing is in progress.
- Finalised the paper on the drivers of solar generation in a distributive policy framework.
- A new paper on the cost-benefit analysis of the SKY scheme is initiated. The analysis related to the assessment of the financial model is already completed. The cost-benefit analysis of the overall scheme is in progress.
- A new paper on the impact of the SKY scheme on the pumping behavior is initiated. The descriptive analysis is already completed. The data collection for pre-SKY pumping data is in progress to conduct the causal analysis of the impact.
- Conducted a survey of Discom officials to understand the governance issues. The analysis is completed and added to the solar generation paper.
- A report has been done on assessing the informal water market in Gujarat with support from a concerned consultant. The report is under review.

Year 4 activities planned:

- Publication of a report on assessing the progress, performance, and impact of Chief Minister's Saur Krishi Vahini Program in Maharashtra from the perspectives of DISCOMs, farmers, and state and central government with support from IRMA, Anand. The findings will help in suggesting mid-course policy corrections for the PM-KUSUM program.
- Completion of a household survey to assess the effect of the SKY scheme.
- Data extraction, cleaning, and processing of the SKY portal data on a range of indicators for 2022-23.
- Publication of a report on Farmer responses to solar irrigation: Agent-based modeling to understand sustainable transitions with support from Ashoka Trust for Ecology and Environment (ATREE).
- Publication of 2 research briefs on Institutional modalities for solarizing groundwater irrigation in India and the Solarization of grid-connected agricultural pumps.
- Publish research briefs/opinion articles/blogs.
- Submit an article for a peer-reviewed publication on the overview of the SKY scheme. We have planned to publish this paper in the Economic and Political Weekly.
- Publication of a paper on the drivers of solar generation in a distributive policy framework.
- Complete and submit the paper on the impact of the SKY scheme on the pumping behavior.
- Publication of report on assessing the informal water market in Gujarat with concerned consultant

Goals/ Objectives:

1. To determine the impact of the SKY program on a range of indicators including farmers' energy generation and consumption, pumping behavior, and agricultural outcomes.
2. To assess the impact of solar irrigation on farmers' livelihood and informal groundwater markets.

Study area/location:

The 93 feeders for the study are located across the entire state of Gujarat, within the administrative boundaries of each of the four regional electricity utilities/distribution companies (DISCOMs). All 93 feeders are being covered based on SKY portal data. Another 41 feeders have been

Methods employed:

The impact of the SKY program will be assessed using regression analysis and econometric matching methods. This implies that we would compare the program's heterogeneous effects between SKY enrolled, SKY non-enrolled, and farmers with Non-SKY feeders and farmers before and after solarisation. Since the solarisation under the SKY program is not randomized, the selection of Non-SKY control feeders is crucial to have the right counterfactual to evaluate the effect of the SKY program. Therefore, for the quick enumeration and household survey:

- We select all the Non-SKY feeders within the taluk admin of SKY feeders. We assume that this ensures the bio-physical characteristics of Non-SKY are similar to that of SKY feeders, and, therefore, comparable for analysis.
- The propensity of matching technique is employed to match Non-SKY feeders with SKY feeders' characteristics which ensures that the selected Non-SKY feeders have similar characteristics as that of SKY feeders. For this, we have collected feeder level characteristics such as total consumers, the number of non-agri connections, total load (Kw), average load (Kw), and farmers list from both SKY and Non-SKY feeders.
- From the SKY feeders that are proportionally sampled at the feeder level and selected neighbouring Non-SKY feeders, we collect primary data on cropping patterns, pumping behavior, billing, perceived benefits, SKY app usage, socio-economic characteristics from all farmers within that feeder.
- For the detailed household survey on water consumption, cropping patterns, and groundwater markets linking the same to pumping behavior, we select a sub-sample of farmers following a random sampling strategy to compare the differences in energy and water usage, agricultural practices, and water selling between SKY and Non-SKY farmers.
- A case study using mixed methods on the impacts of SKY on informal groundwater markets in Central Gujarat

Timeline for each objective:

Details of sub-activities (Year 4)	Start date	End date	Outputs/Comments	Person/s responsible (Overall responsible: Deepak Varshney)
Carrying out the household survey (piloting and monitoring survey)	01/01/2023	30/04/2023	Clean primary data for analysis	Deepak Varshney, Aditi Mukherji
Analysis of household survey data and writing a report based on it	01/05/2023	30/08/2023	Research paper on IE of SKY, blog pieces/articles, annual report	Deepak Varshney, Aditi Mukherji
A research paper on the drivers of solar generation paper.	01/01/2023	31/03/2023	Article submitted	Deepak Varshney, Aditi Mukherji
A research paper on the overview of the SKY scheme	01/01/2023	30/04/2023	Article submitted	Deepak Varshney, Aditi Mukherji
A research paper on the impact of SKY on pumping behavior	01/03/2023	30/8/2023	Article submitted	Deepak Varshney, Aditi Mukherji
A research paper on the impact of SKY on agricultural outcomes	01/06/2023	30/10/2023	Article submitted	Deepak Varshney, Aditi Mukherji
Study on the progress, performance, and impact of Chief Minister's Saur Krishi Vahini Program in Maharashtra	01/01/2023	30/04/2023	Publish a report	IRMA and Deepak Varshney
Study on the Farmer responses to solar irrigation: Agent-based modeling to understand sustainable transitions	01/01/2023	30/04/2023	Publish a report	ATREE and Deepak Varshney
Study on the informal groundwater market.	01/01/2023	30/04/2023	Publish a report	Concerned consultant, Deepak Varshney, Aditi Mukherji
Review of WEF policies in India and Renewable Policies in major Indian states from a GESI lens				

2-3 Policy briefs	01/01/2023	31/07/2023	Policy Briefs	Deepak Varshney and Aditi Mukherji
Blogs and contributions to newsletters	01/01/2023	31/12/2023	News pieces and contributions to the newsletter	All (India SoLAR Team)

Deliverables:

- Journal article on determinants of solar generation submitted to a journal (31/03/2023)
- Journal article on overview of the SKY scheme (30/4/2023)
- A research paper on the cost-benefit analysis of the SKY scheme (31/7/2023)
- A research paper on the impact of SKY on pumping behavior (31/7/2023)
- A research paper on the impact of SKY on agricultural outcomes (30/10/2023)
- Report on case study on the impact of SKY project on informal water markets in Central Gujarat (31/03/2023)
- 2-3 policy briefs based on completed/published research reports
- Regular contributions to SoLAR newsletter (blogs/articles) – year-round

Linking activities with outputs and outcomes

This activity contributes to Output 2.2 “Technical and institutional modalities for grid connection of SIPs in different water-energy regimes demonstrated and documented” – It will analyze the technical and human factors driving differences in the impacts of grid-connected solar pumps on energy generation and consumption and groundwater pumping behavior in the context of the SKY scheme in Gujarat. This will involve examining the trade-off that farmers face between exporting excess solar power to the grid and other alternative uses of energy and water (cultivating crops and groundwater selling), which is dependent on the financial design of the scheme, maintenance of solar PV system, existing agricultural practices, etc. An LoA has been signed with GUVNL, the Gujarat state electricity regulation board, in order to implement research activities under this component. The activities from this output will contribute to Outcome 2: “Validating innovative actions and approaches for promoting gender-equitable, socially-inclusive, and groundwater-responsive solar irrigation” – This activity assesses the determinants of participation in the SKY scheme to determine the extent of socio-economic inclusion, which has implications for other solar irrigation programs.

2.2.3 Grid Connection Pilot, Nepal

Brief background:

All SIPs in Nepal are currently off-grid and stand-alone pumps. Nepal is also investing in hydropower and will achieve electricity self-sufficiency in the near future. National electricity grids are also being extended to every corner of the country. The grid connection of solar pumps will ensure that the stand-alone SIPs do not become obsolete once the grid connection reaches those sites. In Year-1, we developed a set of criteria for prioritizing potential sites for piloting grid-connected SIPs, identified a set of potential sites, and prioritized them as per the criteria. Based on that, a report titled “Targeting pilot site to install microgrid system for SIPs in Nepal” was prepared. Year-2 focused on the feasibility study and getting the local government on board for the design and implementation of the demonstration pilot in Chhipaharmai Rural Municipality, and the four parties agreed to install and operate is expected to be done in December 2021. Year-3 was focused on the implementation of the MG pilot in coordination with Project partners and stakeholders, and developing Monitoring Framework. Y4 will focus on the operation of the MG-connected SIPs in the study site, monitoring and capacity building of local government officials and technical staff on the demonstration processes and results.

Achieved in Year 3 (list in bullet points)

- A review paper based on the research report: A review of global typologies and South Asian Policies drafted. Expected to be submitted in 2023.
- Presenting the SoLAR MG Pilot project as a Solution in World Water Challenge 2022 at Korea Water Forum and Awarded Outstanding Solution.
- Contract signed with an EPC contractor to install a microgrid (MG) system for connecting SIPs to the grid.
- Baseline survey (Qualitative and Quantitative) conducted at the MG pilot site. The Baseline survey report is finalized for the Quantitative part. The Qualitative part report is expected to be finalized by Q1 2023.
- Baseline survey (Qualitative and Quantitative) conducted at the MG pilot site. The Baseline survey report is finalized for the Quantitative part. The Qualitative part report is expected to be finalized in Q1 2023.
- Monitoring framework highlighting the monitoring guideline/mechanism, including the mobilization of local enumerators/field staff of Chhipaharmai RM developed. The framework also includes a logbook and excel based database.
- Multi-stakeholder dialogues in the Chhipaharmai RM with the Farmer User group, Local Government, and local NEA Office;
 - Formation of Farmer User Group; Sensitization of Farmers about the SoLAR MG pilot project.
 - Opening of Bank account for the User Group
 - Krishi-meter application for bi-directional TOD meter at local NEA Office.

Planned for Year 4 (list in bullet points)

- Research Report/Paper/Issue Brief - Documenting the opportunities and challenges in implementing the Grid-connected Pilot project in Nepal through the SoLAR project's lessons from the MG Pilot in Nepal
- Finalize the Journal article based on a review of global typologies and South Asian policies.
- Initiate and implement regular monitoring of various parameters for evaluating the effectiveness of the MG system (to be continued until the end of the project)
- Identify and implement mechanisms for net-metering and payment processes and sign an agreement with NEA
- Capacity Building Workshop for the User Community
- Yearly Monitoring Report
- OpEds on Grid-connected SIP in Nepal

Goals/ Objectives:

- Design and implement demonstrate pilot on grid-connected SIPs
- Establish a baseline and design and implement a monitoring system to evaluate the impacts of grid-connected SIPs
- Carry out continuous monitoring of parameters to evaluate the impacts in collaboration with Chhipaharmai Rural Municipality
- Design and implement procedures for payment mechanisms of saved energy to farmers involved in the MG pilot

Study area/location:

- Sambhawata village, Chhipaharmai Rural Municipality-2, Parsa district, Province-2;

Methods employed:

- Design the grid-connected SIP program, identification of treatment and control sites, and design impact evaluation framework, including GESI impacts, etc.
- Carry out a baseline survey in the treatment and control sites.
- Procure and install the micro-grid system, including connecting to the SIPs in at least one location
- Held on-site multi-stakeholder dialogues among farmers, NEA, Chhipaharmai RM, technicians, private sector, social mobilizers to sensitize on the MG pilot and define mechanisms for payment to farmers for the saved energy.

Timeline for each objective:

Details of sub-activities	Start date	End date	Outputs/Comments	Person/s responsible
Documentation of the opportunities and challenges in implementing the Grid-connected Pilot project in Nepal; SoLAR project's lessons from the MG Pilot in Nepal	01-01-2023	30-06-2023	Research Report / Paper / Issue Brief on Grid-connected SIP in Nepal	Shisher/IWMI

Submit the Journal article based on a review of global typologies and South Asian policies (SS and BG)	01-01-2023	30-06-2023	Journal Article prepared and submitted for review	Shisher/Aditi/Labisha
Regular monitoring of various parameters related to the micro-grid system, crop production, and change in the behavior of farmers, etc.	01-01-2023	31-12-2023	An Excel database of regular monitoring and Yearly monitoring report	Shisher/Labisha/ LFA et al
Identify and implement mechanisms for net-metering and payment processes in collaboration with NEA	01-01-2023	30-06-2023	An agreement on Net metering and payment protocol between farmers and NEA*	Shisher/IWMI
Design an Endline Survey to assess the success of the MG pilot project	01-09-2023	31-12-2023	Endline Survey Questionnaire	Shisher/IWMI
Engagement with community and Capacity-building Workshops	01-03-2023	31-12-2023	Workshop Report	Shisher/IWMI
One OpEd or Blogpost on Grid-connected SIP highlighting the experiences from SoLAR project initiatives	01-01-2023	31-12-2023	OpEd and Blogpost	Shisher/IWMI

Deliverables:

- Research Report / Paper / Issue Brief on Grid-connected SIP in Nepal **(30-06-2023)**
- Journal Article on a review of global typologies and South Asian policies **(30-06-2023)**
- Yearly Monitoring Report **(31-12-2023)**
- Net Metering agreement with NEA* **(30-06-2023)**
- Endline Survey Questionnaire **(31-12-2023)**
- Community Capacity Building Workshop report **(31-12-2023)**
- One OpEds or Blogposts on Grid-connected SIP highlighting the experiences from SoLAR project initiatives **(31-12-2023)**

2.2.4: Demonstration pilots and simulation of grid-connected pumps through heat sinks in Pakistan

Brief background:

This activity builds on the sample of farmers using SIPs in Activity 1.2.3. Originally as mentioned in the proposal we thought it would be technically too-time consuming and expensive to connect pumps to the grid and negotiate with electricity suppliers, hence we propose to simulate feed-in-tariffs by having a heat/energy sink. Further discussions during the year 2022 with the suppliers of the equipment, it was realized that we can calculate the exact amount of energy generated and consumed through an installed SIP system and we would know exactly how much energy was generated and how much energy was available that can be put to some alternative use or fed to the grid. This would show us the potential benefits that the farmers may accrue from their installed SIP system. The instrumentation to measure this was installed at 06 locations in three different districts of Punjab and data is being monitored on regular basis. Moreover, choice experiments with more than 200 farmers in three different districts were completed in the year 2022 and the analysis of the data is in final stages.

Additional work included in the Activity 2.2.4 in Year 2021:

Since the methodology for our behavioral study dictated us to conduct three surveys instead of two as originally planned, we knew this would have a knock-on effect on the activity 2.2.4. As a result, the project team consulted and we thought since the major field research we are undertaking is limited to the province of Punjab, it will be useful to undertake additional studies in the remaining three provinces of Pakistan to determine the overall country outlook of where we stand with regards to the adoption and promotion of SIPs. We commissioned three experts from the respective provinces and they completed their situational analysis studies for the provinces of Khyber Pakhtunkhwa, Balochistan and Sindh.

Achieved in year 1:

- This activity will start in year 2021 as per the original work plan submitted in the proposal.

Achieved in year 2:

- Situational analysis study for the province of Khyber Pakhtunkhwa
- Situational analysis study for the province of Balochistan
- Situational analysis study for the province of Sindh
- Procurement and installation of hardware to measure excess energy – Dec 2021

Achieved in year 3:

- Methodology developed for the choice experiments to determine feed in tariff structure
- Pre-survey of choice experiment completed
- Main survey of choice experiment completed
- Data collection through instruments year 2022 continued and this will also continue for year 2023

Planned for year 4

- Finalization of the choice experiment results and research manuscript to be submitted to a journal – June 2023
- Development of Policy Brief – July 2023

- Dissemination of the Choice experiment results and potential of feed in tariff in Pakistan – Sep 2023
- Collection of in-situ data – complete year 2023

Goals/ Objectives:

This activity offers considerable potential for groundwater pumping to be managed through feed-in-tariffs rather than through licensing and/or pumping exclusion zones. It also provides opportunities to the farmers with saline groundwater and minimal access to canal water to earn a decent livelihood by utilizing their land and selling electricity to the grid

Study area/location:

- Location of the study is three districts in the province of Punjab i.e. Chakwal, Jhang and Rahim Yar Khan to incorporate variations in groundwater quality and demographic variability.

Methods employed:

- To test this hypothesis, we will use the group of farmers (identified in activity 1.2.3) who are currently using SIPs. We are instrumenting 06 SIP farmers to monitor their actual usage of groundwater and the excess energy they generate, which is available to be sold during the course of the day. A larger sample of SIP farmers from the behavioral survey respondents will be selected to run choice experiments to identify their preferences for the feed-in-tariff structure for the excess energy available with them. Choice experiments represent an alternative to analysis of revealed preference or contingent valuation exercises and avoid the weaknesses or pitfalls associated with both. We hypothesize that farmer behavior will respond to feed-in-tariffs, but in a non-linear fashion: at low feed-in-tariffs, the behavior will be invariant but at higher feed-in-tariffs, farmers would switch to 'selling' electricity and perhaps only undertake minimal farm activities for self-consumption purposes. This activity is completed in year 2022 and the final analysis of the results will be published in year 2023

Linking activities with outputs and outcomes

- Activity 2.2.3 contributes to the output 2.2 Technical and institutional modalities for grid connection of SIPs in different water-energy regimes demonstrated and documented.
- This activity directly contributes to the Outcome 2: Validating innovative actions and approaches for promoting gender-equitable, socially inclusive, and groundwater-responsive solar irrigation.
- Once completed, this activity will generate evidence for the Ministry of Energy which is represented in the project CPMC membership and is eager to know how we can bring the agriculture sector using SIPs in the national grid. There is no policy by the Pakistan Government on the feed-in-tariff structure and our primary investigations and policy recommendations will help the Ministry to craft a policy for the Agriculture sector of Pakistan. We will facilitate the Ministry to carry out consultative discussions to help them finalise their policy roadmap.

Timeline for each objective:

Details of sub-activities	Start date	End date	Outputs/Comments	Person/s responsible
Final Analysis to be completed and published in a journal	01/01/2023	30/06/2022	Research Manuscript	Solar Pak Team
Policy Brief based on choice experiment results	01/05/2022	30/07/2023	Policy Brief	Solar Pak Team
dissemination of results to policy makers through workshop	01/09/2023	30/09/2023	workhop	Solar Pak Team

Deliverables:

- Research Manuscript – June 2023
- Policy Brief – July 2023
- Workshop – Sep 2023

2.3.1 Administration of innovation funds

Brief background:

The Innovation Fund (IF) will support the development and field-testing of technical, financial and institutional innovations to address the constraints and challenges of upscaling solar irrigation, with a special focus on the constraints faced by small, marginal, and women farmers. The IF will especially support innovations and practices that can influence policy or be expanded and integrated into regular programs and practices with the support of additional funding sources.

IWMI will administer a SoLAR-SA innovation fund worth USD 400,000. Through this fund, the project seeks to support 6-8 innovations total at an approximate level of USD 50,000 per innovation for a maximum duration of 24 months. Three broad groups of innovations will be supported by the IF: technological, financial and institutional.

Achieved in year 1:

- Five innovation funds were granted to 5 organisations. These 5 organisations were chosen from among 87 applicants through a transparent process. Of these, two were from India and one each from Bangladesh, Nepal and Pakistan. The five organisations which were granted IF in 2020 were: KHM Power, Bangladesh, KARMA and SwitchOn, India, Gham Power, Nepal and PARC, Pakistan.

Achieved in year 2:

- Three innovation funds were granted. These 3 grantees were selected from a total of 50 eligible applicants, and by following an open, rigorous selection process. The idea was to grant 4 awards, but only three could be granted as the technical selection panel did not approve the other proposals. Of these grantees, two were from India and 1 from Nepal. From India, Urmul Seemant Samiti and Collectives for Integrated Livelihoods Initiatives (CINI) and MinErgy from Nepal got the 2021 Innovations Funds Grants

• Achieved year 3:

- No further calls for proposals are planned in Year 3. However, remaining funds may be given as a grant to one innovation project on the advice of SDC
- Y3 focused on site verification as IWMI team visited all the SoLAR IF grantee in Bangladesh, India, Nepal and Pakistan

• Planned for year 4:

- Y4 will focus on documenting the impact of the SoLAR IF project across the four countries.

Goals/ Objectives:

IF funds are used to:

- To support innovations to bridge any identified gap that hampers adoption, use, and upscaling of SIPs in South Asia;
- To support innovations targeted at reducing barriers for adoption by small, marginal, and women farmers; and
- To support innovations that are cost-effective and have the potential for scaling up. Any location in the four project countries of Bangladesh, India, Nepal and Pakistan

Study area/location:

Any location in the four project countries of Bangladesh, India, Nepal and Pakistan

Methods employed:

1. Evaluate the impact of SoLAR IF project by comparing the target and achievement of the IF Grantee

Timeline for each activity:

Details of sub-activities	Start date	End date	Outputs/Comments
Documentation of impact of SoLAR IF project	01/01/2023	31/12/2023	Project Completion Report

Deliverables:

- Project completion report with impact assessment (31/12/2023)

3.1.1 Training of farmers and local technicians in Bangladesh, India and Nepal and Pakistan

Brief background:

In our preliminary research, our partner organizations expressed the need for a cadre of local technicians or trained farmers who can repair and maintain SIPs. Currently, all the projects funded by national governments and donors include a 2-3 year of a maintenance contract with the SIP vendor. However, these initial contracts are nearing expiration in all the partner countries, and thus, there is an urgent need to train local technicians, including young electrical engineering diploma holders. The project will pay extra attention to ensure that at least 33% of the technicians trained are women. We will also work closely with the national implementing agencies to ensure these trained mechanics are closely allied with the private sector players and existing SIP programs so they can find gainful employment.

Achieved in year 1

- Bangladesh 2 trainings completed
- In India, due to CoVID-19, the training couldn't be conducted.
- In Nepal, training could not be conducted as per plan in 2020. The training s scheduled in February 2021. This will be a residential training where 15 engineers (nominated by AEPC) will be trained by a partner agency.
- In Pakistan, online training for setting up precision agriculture with surface water was undertaken.

Achieved in year 2

Bangladesh:

- In Bangladesh, two trainings (both with farmers) were conducted in October 2021. Training reports prepared.

India

- In India, the entire training plan had to be changed (and budgets amended) because GUVNL—our main partner in India wanted IWMI to train 2000+ farmers in 45 SKY feeders.
- MOU with GYVNL was signed in December 2022, and the trainings will happen in 2022.
- Detailed plan for conducting Randomized Control Trials has been prepared.

Nepal

- A 7-day residential training was conducted from Feb 28 2021 to March 06 2021 on designing and maintaining Solar Irrigation Systems in Itahari with 20 participants.
- Training modules developed, which has been further refined for Solar technician. The final version is expected to be finalized by December 2021.
- The second training is scheduled in November/December at two sites in Saptari and Rautahat. The training report is expected to be completed by December 2021.

Pakistan:

- Completed successful trials of the wheat crop at partner university through solar-based precision surface irrigation – results have been analysed, and the manuscript will be submitted to journal by Dec 2021.
- A second trial for Kharif season was carried out using SIP configured through precision surface irrigation to irrigate Maize. IWMI, through its own resources. instrumented the field to check water infiltration and regularly monitored soil salinity. An analysis is underway to

see whether a small amount of surface water applied will impact the salinity. Based on our previous trials of wheat the technology has already been adopted by local farmers, and if we provide robust evidence of SIP using precision surface irrigation without any negative impacts on soil salinity, it has the potential to impact millions of farmers.

- A training on “Design of Solar Pumping Unit for Precision Surface Irrigation” was delivered in a face-to-face format to 70 participants at a partner university
- A hands-on training on “Operation and Maintenance of Solar Pumping Unit and Precision Surface Irrigation” was delivered to 19 farmers at the field site where IWMI has installed a SIP through SDC funding.
- A training in face-to-face format was provided to 04 staff members of PARC in Islamabad on laser grading to prepare the field for precision surface irrigation using SIP.
- A virtual training to 06 KFUEIT researchers and staff was delivered on laser grading to prepare the field for precision surface irrigation using SIP

Achieved in Year 3:

Bangladesh:

- Third farmers’ training was delayed and completed on 24th January 2023, instead of 2022. Currently, the report is being prepared by IDCOL, to be submitted by mid-February.

India:

- Implemented and completed training of farmers in 35 feeders (out of 45) covering 1500 plus farmers in a Randomized Control Trial mode in partnership with GERMI.
- Conducted a pre-training survey of all the farmers who participated in the training to raise awareness among farmers about the scheme. The survey is already completed in 35 feeders covering 1500 plus farmers.
- Conducted a workshop to present the findings based on the pilot training of farmers to GUVNL officials.

Nepal

- Training manual translated into Nepali language; dual language manual created
- The third training conducted in December at Chitwan with 20 participants (technicians) and 2 (AEPC representatives). The training report is completed developed.

Pakistan

- Training to 20 water professionals from the Agriculture Department of Punjab and academics from various universities
- Field training of around 15 farmers using SIPS in Punjab

Planned for Year 4 :

Bangladesh

- Fourth farmers’ training to be completed by IDCOL in 2023

India:

- Implemented and completed training of farmers in the remaining 10 feeders in a Randomized Control Trial mode in partnership with GERMI.
- Analysis of the pre-training survey of farmers and prepare a short report based on it.
- A research paper to examine the impact of training on energy outcomes.
- A research paper to examine the impact of training on pumping behavior.

Nepal :

- Finalize dual language manual and handover to AEPC.
- Implement Targeted training workshops for technicians/farmers.

Pakistan :

- Training of technicians and water professionals through partner organization PARC

Study area/location:

Bangladesh:

- At a location of choice by IDCOL and the country lead

India

- 45 feeders were randomly selected from 4 utilities in Gujarat where the training will be implemented.

Nepal

- The training will be implemented in the Tarai districts

Pakistan

- At a location of choice by PARC/KFUEIT and the country lead

Methods employed:

Each country's training activity for the year and training proposal will be approved at one of the C-PMC meetings.

Bangladesh:

The training plans will be shared with the PMU, who will keep the PSC informed. In Bangladesh, the training for each year will be decided based on needs identified by IDCOL and IWMI through discussion.

India

Randomised Control Trial (RCT) approach will be adopted to evaluate the impact of training on energy outcomes for farmers

Nepal

Training plans will be finalised in consultation with Nepal C-PMC, and all partners (AEPC and NEA).

Pakistan

In Pakistan, the focus of the training is on better on-farm water management and use of precision surface irrigation using WinSRFR software.

Timeline for each activity:

Details of sub-activities	Start date	End date	Outputs/Comments	Person/s responsible
Bangladesh				
Training workshop for farmers	01-05-2023	30-06-2023	Trainings conducted and final training report submitted	IDCOL
India				
Completion of training in 45 feeders covering 2000 plus farmers	01-01-2023	30-05-2023	A comprehensive report on the training	GERMI and IWMI team
A report based on the pre-training survey of farmers	1/04/2023	31/07/2023	Publish a report	Deepak Varshney and Aditi Mukherji
A research paper to study the impact of training on energy outcomes	1/05/2023	30/10/2023	Article submitted	Deepak Varshney and Aditi Mukherji
A research paper to study the impact of training on irrigation behavior	1/06/2023	30/11/2023	Article submitted	Deepak Varshney and Aditi Mukherji
Nepal				
Finalize the dual language version of Training module and handover to AEPC	01-01-2023	30-03-2023	Dual Language Manual	Labisha/Shisher
Training / Workshop/school (2-3 days training)	01-07-2023	31-12-2023	Training report including details of persons attended	Labisha/Shisher
Pakistan				
Preparation of training curricula, training modules and selection of trainers and trainees	1/01/2023	30/06/2023	Training materials finalised and trainees are chosen, and all technical logistical arrangements for training done	IWMI-Pakistan SoLAR Team and partners
Training workshop/school (3-5 days training)	1/07/2023	31/12/2023	Training conducted	IWMI-Pakistan SoLAR Team and partners

Deliverables:

Bangladesh:

1. Training report and details of personnel trained

India:

- Training report by GERMI (30/05/2023)
- Research paper on the impact of training on energy outcomes (30/10/2023)
- Research paper on the impact of training on pumping behavior (30/11/2023)
- A report based on the pre-training survey of farmers (31/7/2023)

Nepal:

- Dual Language (English and Nepali) version of the Training Manual
- Training report, including details of personnel, trained

Pakistan:

- Training curricula, including training modules
- Training report, including details of personnel, trained

Linking activities with outputs and outcomes

This activity contributes to output number 3.1 “A cadre of women and men technicians trained, and water-energy-agriculture experts in the region sensitized about cross-sectoral interlinkage” and outcome 3 “Increased national /global knowledge and capacity for GESI responsive and groundwater aware solar irrigation policies and practices”.

In Bangladesh, based on the need identified by IDCOL (our partner and the primary organization for SIP promotion in Bangladesh), this activity will involve training SIP water buyers to educate the farmers about solar pumps and their operational processes, and enhance capacity in improved agricultural and water management practices. The objective is to intensify agriculture sustainably through efficient water uses and sustain the SIP business model by increasing command area, and revenue with optimum water uses from solar irrigation pumps. This will contribute on the ground to facilitating groundwater-aware solar irrigation policies and practices in Bangladesh.

In India, this activity has been revised based on feedback received by GUVNL – our main partner and has widened in scope than was originally planned. Now, some 2000+ farmers would be trained. The activity involves training selected feeder farmers to improve their knowledge of efficient solar generation and understand the financial modalities of the scheme through the increasing frequency of energy monitoring of their PV panels. The training has been designed in a way to allow rigorous impact evaluation.

In Nepal, the training needs have been identified in consultation with AEPC, NEA and the private sector, which target female farmers and technicians and are planned in Y3. The idea here is to support capacity development for women farmers/technicians in Solar. The training manuals developed and refined in Y2 will be translated into the Nepali language and handed over to AEPC. In coordination with the local government, the manuals can be translated into other regional languages (as needed) to increase their reach.

In Pakistan, the training has been designed and is being implemented by partners. In addition to contributing to output 3.1 and outcome 3, this Activity in Pakistan also contributes to output 2.3: Technical, financial and institutional innovations demonstrated

3.2.2 National forums

Brief background:

The project countries will regularly organize national policy forums to solicit feedback from national, provincial, and local policymakers and disseminate information to these groups. The frequency of these national policy forums will be need-based, but no fewer than three policy consultation forums will be held in each country during the 4-year span of the project. In years 1 and 2, due to COVID-19, we could not organise national workshops in a face to face mode. Instead, online workshops have been held.

Goals/ Objectives:

- To disseminate project findings by the country teams to country partners
- To seek feedback and policy partnerships with national nodal agencies
- To initiate discussions on issues of national importance that are related to solar irrigation.

Achieved in year 1,2 and 3

Bangladesh

- National workshop could not be organized due to COVID in the first year. 1st Webinar held in February 2021.
- 2nd Webinar held in January 2022
- 3rd National Forum (physical) organized in Dec 2022

India :

- Delayed due to COVID 19, as we were planning a F2F event in January 2022 when the third wave broke out.
- Presentation of early findings done in CPMC and National Forum 2021
- National Forum webinar in India will be done in April 2022.

Nepal :

- In Year-1 such a forum could not be held due to the 1st Wave of Covid. As part of a Webinar, National forum organized in Feb 2021 on Appropriate Institutional Modalities for Grid-Connected Solar Irrigation Pumps in Nepal.
- In Year-2, The virtual national forum was organized on Making Solar Irrigation Pumps (SIPs) programs equitable and inclusive in Nepal on Making Solar Irrigation Pumps (SIPs) programs equitable and inclusive in Nepal in Feb 2022.
- In Year-3, National Forum organized as Technical Session on Water technologies and innovation: Solar irrigation as tool for responding to food and water insecurities, and inclusive development. This was part of Knowledge forum on Accelerating Change in a

Federal Nepal through Transformative Actions for Inclusive Water Management in Kathmandu held on March 2023

- Implement a National Forum in Q4 of Y4, and Prepare a report based on the deliberation in the forum
- At least one policy brief around which national forum discussions are held

Pakistan :

- . In year 1, due to COVID-19, we could not organise national workshops as planned. Instead, we conducted a series of 6 webinars in the week of 1st to 5th February, 2021.
- A session on the “The Real Potential of Solar-Based Irrigation in Pakistan” is planned in the Pakistan Water Week 2022 to be held in Islamabad from 6 – 9 Dec. 2021. The session will have eminent speakers and panelists who will discuss the real potential of Solar Irrigation in Pakistan. The forum will take place on Dec. 6th, 2021. More than 30 participants will attend the session in person and other will join virtually.
- A session on the “Sustainable Solar Irrigation - What Do We Know?” was conducted in the Pakistan Water Week 2022 held in Islamabad from 24 – 28 Oct. 2022. The session included eminent speakers and panelists who discussed the the current status of solar irrigation in Pakistan and the proposals to make it sustainable in the long turn. More than 40 participants attended the session in person and virtually.

Planned for year 4 :

- 4 national forums, hopefully in off-line mode by the end of 2022.

Study area/location:

- Online or offline, at a location deemed appropriate by country leads

Methods employed:

- Either online meetings, or face to face meetings

Timeline for each objective:

Details of sub-activities	Start date	End date	Outputs/Comments	Person/s responsible
National forum (20-30 participants – mostly policymakers) in face-to-face mode, if not possible, then online	01/10/2023	31/12/2023	National Forum Workshop Reports	Respective country leads

Deliverables:

- National workshop reports – 31/12/2023

3.2.1 Regional knowledge and policy forums

Brief background:

All SoLAR-SA partners and innovation fund grant recipients will meet each year to share information on progress. The SoLAR Project Steering Committee will also attend this meeting to approve the work plan, review progress and provide feedback. The annual meetings will be a platform for the project partners to come together and exchange information and knowledge on various aspects of their work. Whenever feasible, field visits to SIP sites will be organized. The first regional forum was held in Sri Lanka in January 2020, and it was also the Inception Workshop for the SoLAR project. The second regional forum was organized in an online format on 23rd and 24th February 2021.

Achieved in year 1:

- Inception workshop in Colombo in January 2020. Inception workshop report is [here](#).
- SoLAR website created.
- Newsletter series launched.

Achieved in year 2:

- 1st Regional Forum was organised on 23rd and 24th February. Workshop report is [here](#).
- SoLAR website was regularly updated.
- A logo for the SoLAR project has been approved by the PMC.
- Newsletters continued. So far, 6 editions of newsletters have been shared with more than 800 stakeholders.

Achieved in Year 3:

- Regional Forum was planned in face-to-face mode from 6th-8th February in IIT Gandhinagar, Gujarat, India. It includes 2 days of research workshop and 1 day of field visits.

Plan for Year 4

- Regional Forum is already done from 6th-8th February 2023 in IIT Gandhinagar, Gujarat, India. It includes 2 days of research workshop and 1 day of field visits.
- Preparation for the next regional forum.

Goals/ Objectives:

- Share updates and findings from work conducted
- Discuss with relevant partners and stakeholders about policy uptake and future collaborations

Study area/location:

- Nepal, Bangladesh, India, Pakistan

Deliverables:

1. Regular updates to the SoLAR website – Throughout the year
2. Regular publication of SoLAR newsletter (one per quarter) – Throughout the year

Annexure 1: Activity-wise progress

Table 1. Progress in planned activities in Bangladesh in 2022

Activity No.	Deliverables that were due 2022	Status of deliverables at end of 2022	Plan for 2023
1.1.1 Impact evaluation and GESI case studies of existing and new SIP programs in Bangladesh	SIP level survey data for three seasons in 2022	Completed. Data was collected for the 5th (rabi), 6th (kharif 1), and 7th (kharif 2) rounds.	SIP level database for the final 2 seasons in 2023 (i.e., Rabi, Kharif 1).
			Endline HH Survey data to be collected.
			2 new Journal articles based on endline data and the full SIP survey data
	Baseline report based 3 rounds of SIP level surveys and baseline household report	Completed. Results were presented at multiple international conferences.	NA
	Journal article on the state of Solar irrigation in BD, based on SIP surveys and secondary data	The first draft is done, being revised for submission	To be submitted in 2023
	Journal article based on household survey baseline data (impact of SIP on irrigation practices and heterogeneity)	In progress	To be submitted in 2023
	Research article based on analysis of policy documents through GESI lens	Submitted to a journal. Under Review	NA

	Policy Briefs	Completed publication of 3 Policy Issue briefs + 1 Research Brief	2 blogs/issues briefs on the sustainable business model for SIPs and Equity impacts of SIPs are to be published
	Journal article, mitigation role of solar irrigation	Delayed	A research note to be prepared in 2023
2.1.1 Scale pilot for testing different SIP promotion models in Bangladesh	<ul style="list-style-type: none"> • Conduct KIIs with IDCOL, BADC, BMDA, and relevant stakeholders and transcribe them • Conduct FGDs with IDCOL, BADC, BMDA farmers beneficiaries, and diesel and electric pump owners in selected villages 	<p>Completed 18 FGDs and 28 KIIs covering 2 IDCOL villages and 10 villages of BMDA and BADC solar pumps. FGDs were conducted with SIP, diesel and electric water buyers, and owners of diesel/electric pumps.</p> <p>Transcription + translation completed.</p>	

	<ul style="list-style-type: none"> • Data analysis from the HH survey and FGDs from IDCOL sites • Qualitative data framing • Final Report 	In progress.	<p>To be completed in 2023 –</p> <ul style="list-style-type: none"> • Research report/issue brief characterizing different SIP models in BD • Research report on the implication of the tubewell permit system on energy transition in the irrigation sector • Report and Journal Article characterizing SIP impact on the local informal groundwater market
1.2.1 Groundwater-related studies embedded in demonstration pilot in Bangladesh	Collection of plot-level water application for SIP farmers and adjoining diesel farmers through surveys, installation of field instruments	Structured database on irrigation water application for 2022 completed.	Data collection for 2 nd round is to be continued in 2023
	Data analysis to compare groundwater use of solar and non-solar farmers & compare groundwater of different SIPs	Report based on 2022 data completed	Final report and draft manuscript comparing solar and diesel farmers' water use to be submitted in 2023

	Set up and calibrated groundwater model of the region with SIP upscaling scenarios and calibrated vadose-zone flow model to estimate irrigation return flows	The numerical groundwater model has been set up for simulating the impact of SIPs on groundwater under different scenarios	Final Report/publication in 2023
	Policy brief on impacts of SIPs on groundwater use	Delayed, to be done in 2023	Based on 2 years of data analysis, the policy brief to be published
2.2.1 Demonstration pilots for grid connection of SIPs	Physical grid connection completed for all selected sites and detailed report on each grid integration project with technical parameters and socio-institutional features submitted by IDCOL	Grid integration completed in 6 sites – 2 sites individually and 4 sites on a cluster basis.	<ul style="list-style-type: none"> • Final Detailed Report for all the grid sites to be published in 2023, currently ongoing • Physical grid connection to be done for 1 WAVE site and 2 additional SHEL sites using the remaining budget for grid integration
	Monitoring data on energy consumption and selling at IDCOL sites	Currently ongoing, monitoring started in 2022 after grid integration	<ul style="list-style-type: none"> • Monitoring data on energy consumption and selling to continue • Installation of additional monitoring instruments for grid integration

	SIP level survey at selected sites (also see 1.1.1) and qualitative interviews at grid connection sites	Delayed, to be done in 2023	· Final Report on the impact of grid integration sites on the irrigation service business in 2023
3.1.1 Training of local technicians and farmers	Country-specific farmer training modules development, trainings and reports	Bangladesh: Third farmers' training completed	Fourth training to be completed in 2023
3.2.2 National forums	National Forums	3rd National Forum (physical) organized in Dec 2022	4 th National Forum to be organized in 2023

Table 2. Progress in planned activities in India in 2022

Activity No.	Deliverables that were due 2022	Status	Plan for 2023
1.2.2 GW studies in India	Preliminary report on groundwater levels and trend in SKY and non-SKY areas	Completed Report on Gujarat hydrogeology along with analysis of secondary groundwater dataset was done.	NA
	Census database on farmers' pump, well, groundwater and water management practices in selected feeders	<ul style="list-style-type: none"> Monitoring ongoing from Aug 2021 and data was regularly collected for the year 2022 (Rabi and summer 2021-22 season and Kharif 2022-23 season) Journal article reviewing and comparing methodological approaches delayed as Household survey couldn't be completed. 	<ul style="list-style-type: none"> Regular monitoring will continue for the Rabi 2022-23 season. Final report/publication on groundwater use comparison of solar and non-solar farmers
	Report on instrumentation installation and data collection protocol	Already completed	No further instrumentation is planned.
	Report on conceptual groundwater model (31-08-2021)	Secondary data collection was completed and conceptual model was setup for the alluvial aquifer of the Anand region	Report/publication on calibrated groundwater model for the region with upscaling scenarios
	Brief report on data analysis with draft GW abstraction-energy relationship (31-12-2021)	<ul style="list-style-type: none"> Data was analysed for developing groundwater-abstraction energy relationship and draft presented and shared for finalisation. 	Final report and publication on developed groundwater abstraction-energy relationships and upscaling the groundwater-abstraction energy relationship to other SKY and Non-SKY feeders for estimating groundwater abstraction at larger scale.

	Blog posts and regular contributions to SDC-SoLAR newsletter – throughout the year	Published one blog on SoLAR project work: https://solar.iwmi.org/2022/02/15/solar-irrigation-a-boom-or-bane-for-groundwater/	Blog posts and policy based on the results.
2.2.2 Scale pilot on institutional aspects of grid-connected SIPs in Gujarat, India	Research report on the impact of SKY based on household surveys	Household survey is ongoing.	A report/paper based on the household survey on the impact of SKY on agricultural outcomes. Finalized the Analysis.
	Planned journal articles on: <ul style="list-style-type: none"> • Determinants of solar generation submitted to a journal • Impact of SKY on groundwater pumping 	The analysis is completed.	<ul style="list-style-type: none"> • Writing needs to be completed. • Article submitted for publication.
	<ul style="list-style-type: none"> • Overview article on SKY: Lessons Learnt • 2-3 policy briefs based on completed/published research reports • Case study on the impact of the SKY project on informal water markets in Central Gujarat 	<p>The analysis for the 'Overview article on the SKY: Lessons learned' is completed.</p> <p>Two policy briefs are completed and are under publication.</p> <p>A case Study on the impact of the SKY project on the informal water market is being finalized.</p>	<p>Writing of the article 'Overview article on the SKY: Lessons needs to be completed. Article submitted for publication.</p> <p>A report on the case Study on the impact of the SKY project on submitted for publication.</p>
	A report on 'Farmer responses to solar irrigation: Agent-based modeling'	Completed.	Report submitted for publication.
	A report on assessing the progress, performance, and	Completed.	Report submitted for publication.

	impact of Chief Minister's Saur Krishi Vahini Program in Maharashtra		
3.1.1 Training of Lead Farmers	<ul style="list-style-type: none"> • Trainings in coming months under modified MOU with GUVNL. • Signing MOU with GERMI <p>Training modules to be developed and disseminated with GERMI</p>	Training of more than 1120 farmers covering 35 feeders is completed.	<p>The training in remaining feeders needs to be completed.</p> <p>One paper is planned to study the impact of training on energy outcomes. Data collection is ongoing. Finalized the analysis.</p>
	Training reports are to be submitted with details of attendees	Training is ongoing.	Report submitted.
3.2.2 National forums	National Forum		Organise by the end of the year.

Table 3. Progress in planned activities in Nepal in 2022

Activity No.	Deliverables that were due 2022	Status of deliverables at end of 2022	Plan for 2023
1.1.2: Impact Evaluation (IE) and GESI Case Studies of SIP Program in Nepal	Journal article based on a Qualitative study of GESI in SIP developed in Y2 Journal article submitted	COMPLETED Abstract of Journal article based on Qualitative study of GESI in SIP (by Gitta and Labisha) submitted; full paper accepted for review by a journal for publishing.	Publish Journal Article
	Journal article based on research report on Policy review on GESI in SIP in Nepal and Bangladesh Journal article submitted	COMPLETED Journal article based on research paper on Policy review on GESI in SIP in Nepal and Bangladesh to be accepted for review by a journal for publishing.	Publish Journal Article
	Journal article based on quantitative surveys (phone surveys and household surveys)	DELAYED Two Journal articles developed by Deepak Varshney	Submit Journal Article
	IWMI Research Report summarizing the entire impact evaluation of SIPs (quantitative – phone and household surveys and qualitative – GESI work) Research Report	DELAYED Moved to 2023	Planned as 2023 Activity

	<p>Desk assessment for the development of country-specific emission factors in the Agriculture sector of Nepal in coordination with Ministry of Forest and Environment and NDC partnership Nepal</p> <p>Research Report</p>	<p>COMPLETED</p> <p>Research Report developed</p> <p>Dissemination Workshop</p>	<p>Develop into a paper</p>
	<p>National dialogues or conferences on Gender and Solar Irrigation forward during World Water Week or other forums</p> <p>Workshop Report</p>	<p>COMPLETED</p> <p>SoLAR video documentary showcased at the Water, WASH, and Climate Virtual Symposium; 13 presentations made at different forums on GESI findings by MK, GS, and LU</p> <p>No event was organized on World Water Week in 2022, hence SoLAR GESI findings were disseminated at various forums.</p>	<p>-</p>
	<p>Orientation with/for local governments on best practices of how to better target and reach smallholders, the marginalized, and women farmers (on information and technology dissemination)</p> <p>Workshop Report</p>	<p>DELAYED</p> <p>Moved to 2023</p>	<p>Planned as 2023 Activity</p>

	Policy Briefs	COMPLETED One Issue brief on AEPC Subsidy Delivery Mechanism published in SoLAR Website. Another Issue Brief on Diesel consumption drafted	Publish Diesel Consumption Issue brief in SoLAR website
	Commission WEF policy review in Pakistan and India from the GESI lens Research report	COMPLETED Research Report received from respective Pak and Ind consultants	-
Activity 2.2.3: Grid Connection Pilot, Nepal	Baseline surveys (including GESI studies) in selected grid connection and control sites Baseline Report summarizing results from qualitative and quantitative surveys, including GESI outcomes	COMPLETED Reports drafted	-
	Procure a consultant/vendor to install MG Shisher/IWMI	COMPLETED Four Party Lol EPC Contract	-

	<p>Installation of grid connection in one or two SIP site</p> <p>LoI/MoU between Local Government, AEPC, NEA and IWMI Agreement with vendor/consultant</p>	<p>COMPLETED</p> <p>Installation completed in December 2022</p> <p>Technical Report drafted</p>	<p>Commissioning Verification</p> <p>Finalized Technical Report</p>
	<p>Regular monitoring of various parameters related to the micro-grid system, crop production, and change in behavior of farmers, etc.</p> <p>An Excel database of regular monitoring</p>	<p>DELAYED</p> <p>The system was installed in December 2022</p>	<p>Monitoring to start in 2023</p>
	<p>Multi-stakeholder dialogues in the Chhipaharmai RM for public awareness on MG pilot and discuss the Net metering and payment protocol</p> <p>An agreement on Net metering and payment protocol between farmers and NEA is established in collaboration with Chhipaharmai RM</p>	<p>PARTIALLY COMPLETED</p> <p>Multi-stakeholder meetings in Chhipaharmai Rural Municipality, Farmer User group, and local NEA Office</p> <p>Bi-directional TOD Meter from NEA installed</p>	<p>Net-metering agreement to be done in 2023</p>
Activity 3.1.1 [Training for Local Technicians in Nepal]	<p>Translate the final version of Training module into Nepali language</p> <p>Final Nepali version of Training Manual</p>	<p>COMPLETED</p> <p>Nepali translation completed</p> <p>Dual Language manual prepared</p>	<p>Finalize Dual language manual</p>

	<p>Training / Workshop/school (2-3 days training)</p> <p>Training report including details of persons attended</p>	<p>COMPLETED</p> <p>Training completed in December 2023</p>	-
<p>Activity 3.2.2: National Forum in Nepal</p>	<p>Training / Workshop/school (2-3 days training)</p> <p>Training report including details of persons attended</p>	DELAYED	<p>National Forum in March 2023</p>

Table 4. Progress in planned activities in Pakistan in 2022

Activity No.	Deliverables that were due 2022	Status	Plan for 2023
1.2.3 GW related studies embedded in demonstration pilot in Pakistan	Analysis of the final behavioural study and development of the policy brief	Partially Completed: Analysis of the final behavioural study completed, and policy brief developed and shared with the team	Research Manuscript based on behavioral study submitted to journal – June 2023
	A policy brief for the Government on promotion of SIPs	Partially Completed: Policy brief based on behavioral survey study developed and shared with the team	A policy brief for the Government on promotion of SIPs – April 2023
	Collection of in-situ groundwater data for the Rabi and Kharif season 2022.	Completed: Installation of In-situ instrumentation at 12 sites completed. Data collected for Rabi season 2022.	Data set on actual groundwater usage of 12 sites in three different districts of Punjab for Rabi 2022 and Kharif 2023 seasons 2022 – Dec 2023
	Analysis and Comparison of the survey responses with in-situ data to determine the actual impact on groundwater aquifer due to SIP pumping	In progress: Collection of data from in-situ instrumentation is on-going. Subsequent, analysis and comparison of the survey responses with in-situ data to determine the actual impact on groundwater aquifer continues.	Research Manuscript based on in-situ GW data submitted to journal – Dec 2023
	Stakeholder consultation and Dissemination of the results of behavioural study in the form of four provincial dialogues and 1 federal workshop	Completed: Stakeholder consultation and Dissemination of the results of behavioural study in the form of three dialogue meetings	
2.2.4 Demonstration pilots and simulation of grid-connected pumps through heat sinks in Pakistan	Method Statement including design of Choice Experiments Pre-survey and Main survey of choice experiment	Completed: Methodology developed for the choice experiments to determine feed in tariff structure Completed: Data collection completed and data set compiled Completed: Choice experiment results and research manuscript to be submitted to a journal for review	All completed – journal article submitted Dissemination of the Choice experiment results and potential of feed in tariff in Pakistan – Sep 2023
	A policy brief based on choice experiment results	In progress: Policy brief will be developed	Development of Policy Brief – July 2023

	Data collection through instruments for the Rabi 2021-22 and Kharif 2022 to continue for a complete one year	Data collection through instruments year 2022 continued and this will also continue for year 2023	Collection of in-situ data will continue for complete year 2023
3.1.1 Training of local technicians in Bangladesh, India and Nepal; training for farmers in Pakistan	Training curricula, including training modules	Completed: Trainings conducted on on-farm water management and use of use precision surface irrigation using WinSRFR software: Training to 20 water professionals from the Agriculture Department of Punjab and academics from various universities Field training of around 15 farmers using SIPs in Punjab	Training of technicians and water professionals through partner organization PARC
	Training report, including details of personnel trained	Completed	Training Report
3.2.2 National Forum in Pakistan	National forum workshop report	A session on the “Sustainable Solar Irrigation - What Do We Know?” was conducted in the Pakistan Water Week 2022 held in Islamabad from 24 – 28 Oct. 2022. National Forum report prepared and submitted	A National Forum to be conducted in Pakistan Water Week 2023