Solar Irrigation for Agricultural Resilience (SoLAR)

YEAR 3 WORKPLAN

FEBRUARY 2022

IWMI International Water Management Institute

SoLAR Solar Irrigation for Agricultural Resilience

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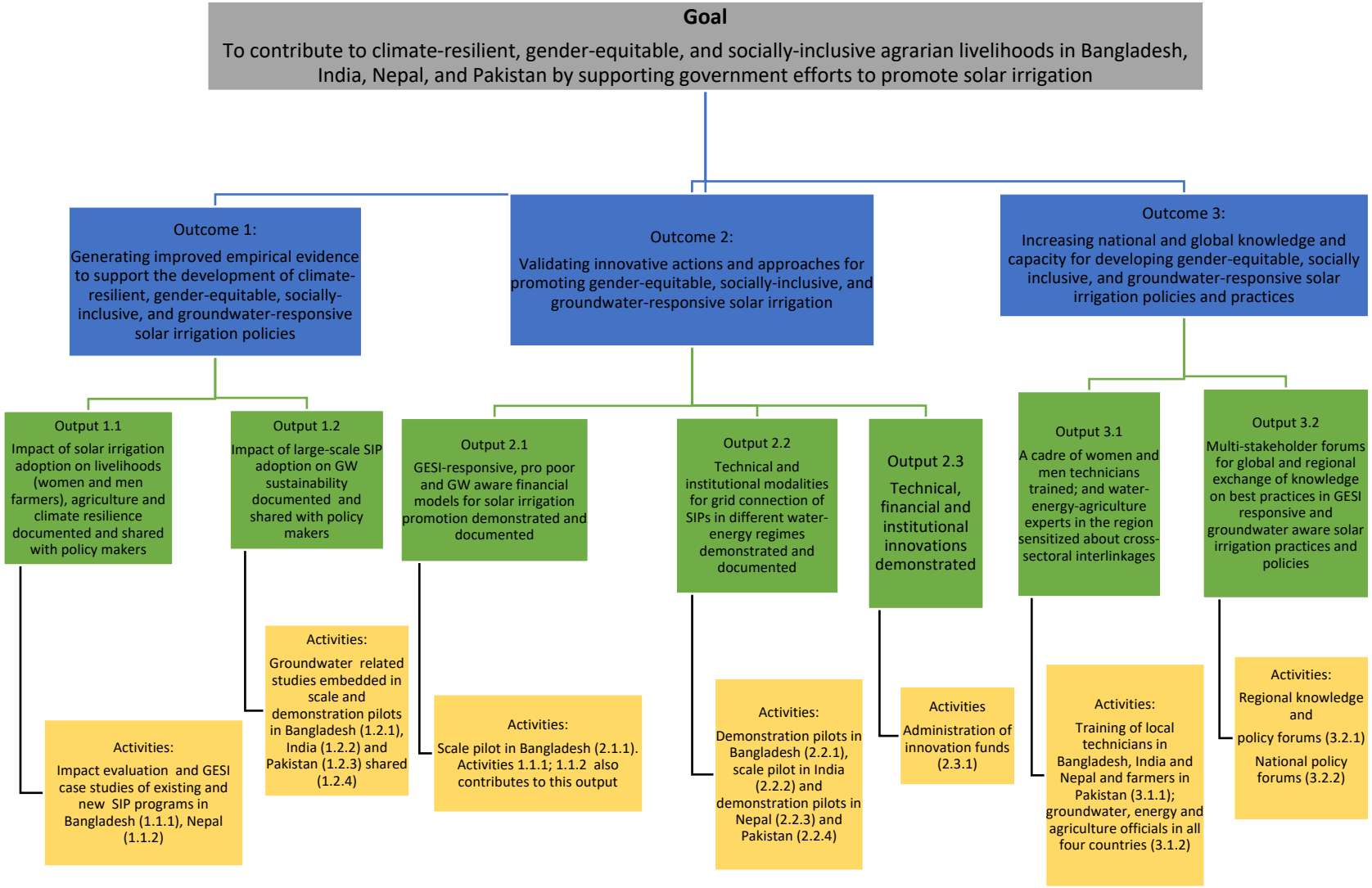
SoLAR Logical Framework



1.1.1 Impact evaluation and GESI case studies of existing and new SIP programs in Bangladesh

Brief background:

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 SIP promotion with the "fee-for-service" model, where IDCOL provides loan and grant to sponsors, who installs 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

Planned for Year 3

- Collection of 5th, 6th and 7th rounds of SIP level primary data using phone interviews
- Analysis from SIP and household-level primary data
- Communication of research findings and policy recommendations through publications, conferences, blog pieces, national and regional forums

Goals/ Objectives:

The research objective for this study is to analyse the economic and environmental impact of solar-powered irrigation in Bangladesh and look into existing programmes through a lens of gender and social inclusion. Specifically, the research would focus on the following questions

1. Impact of Solar irrigation on agricultural practices and outcomes (cropping intensity, yield, etc.), groundwater usage, and diesel use in irrigation.
2. How does grid connection affect the operation of SIP and groundwater consumption?

3. How does SIP operations evolve over time, and how do SIP characteristics (NGO/private sponsor, age, power installed, type of pump, financing) influence its operation?
4. How inclusive is the current SIP model, i.e., factors determining farmer's access to solar irrigation?

Study area/location:

Selected sites in Rangpur, Rajshahi and Khulna districts.

Methods employed:

This research component is organized into the following studies:

- SIP study from secondary data provided by IDCOL on all SIP schemes to better understand the modalities of the program, its implementation, and the evolutions over time. It will use standard descriptive statistics methods
- Policy analysis through the lens of gender and social inclusion
- SIP scheme level study that will collect and analyse scheme level data for each cropping season from aman 2020 to boro 2023. The data will be collected for a sample of 82 representative IDCOL SIPs.
- Microeconomic study at the household level using quasi-experimental methods to do quantitative impact evaluation. Two rounds of data will be collected: baseline in 2021 and follow-up at the project end (early 2023).

Timeline for each objective in Year 3:

Details of sub-activities	Start date*	End date*	Outputs/Comments	Person/s responsible
SIP Survey Rabi 2022	15/04/2022	15/05/2022	Primary data on SIP operations for 3 seasons from 83 schemes	NGO Forum, Marie-Charlotte, Archisman
SIP survey kharif 1 2022	15/08/2022	15/09/2022		
SIP survey kharif 2 2022	15/11/2022	15/12/2022		
Baseline report based 3 rounds of SIP level surveys and baseline household report	1/10/2021	15/03/2022	Baseline report submitted	Archisman, Marie-Charlotte, NGO Forum, Aditi
Journal article based on three (Kharif 2, 2020, Rabi 2021 and Kharif 1 2021) rounds of SIP surveys	1/10/2021	31/05/2022	Journal article submitted	Archisman, Marie-Charlotte, NGO Forum, Aditi
Journal article based on household survey baseline data (impact of SIP on irrigation practices and heterogeneity)	3/01/2022	30/10/2022	Journal article submitted	Marie-Charlotte, Archisman, Ahasan, Aditi

Details of sub-activities	Start date*	End date*	Outputs/Comments	Person/s responsible
Journal article, mitigatio role of solar irrigation (multi-country)**	03/01/2022	30/10/2022	Journal article submitted	Archisman, Marie-Charlotte, NGO Forum, Aditi, all cunntry leads
Policy Briefs	01/01/2022	31/12/2022	2-3 Policy Briefs based on published papers • Mitigation benefits of SIPs • Livelihoods benefits of SIPs • Equity impacts of SIPs	Archisman, Marie-Charlotte, NGO Forum, Aditi

*Notes: * The dates for the surveys are tentative dates which may be adapted to consider health and regulatory conditions and cropping calendars.*

*** This research article would be a regional research paper.*

Deliverables:

- SIP level database for 3 seasons in 2022 (i.e., Rabi, kharif2, Kharif 1) through telephone survey (30/12/2022)
- Journal article analysing the impact of SIP on farmers' irrigation practices (time, cost, yields) and the heterogeneity of the impacts (31/10/2022) Earlier
- Journal article analysing the mitigation role of solar irrigation, cross country analysis (India, Nepal, Bangladesh) (31/10/2022). Earlier
- Two to three blog posts and regular contributions to SDC-SoLAR newsletter – throughout the year
- Policy Briefs 2-3
    - Mitigation potential of SIPs in Bangladesh
    - Impacts of IDCOL SIP model on farmers incomes and livelihoods
    - Equity impacts of SIPs—who has access and who does not.

Linking activities with outputs and outcomes

This set of activities contribute to outcome #3 'Generating improved empirical evidence to support the development of climate-resilient, gender-equitable, socially-inclusive, and groundwater-responsive solar irrigation policies' and output 1.1. 'Impact of solar irrigation adoption on livelihoods (women and men farmers), agriculture and climate resilience documented and shared with policy makers.

Early results from the IE components have been presented and discussed with policy makers, implementers, private sector representatives, and NGOs at the occasion of the National and Regional Forum organized in February 2021 during the 'Solar irrigation in Bangladesh: Current situation and future prospects' session. While only the method and some early results from the SIP survey were available at the time, it allowed engaging with various stakeholders who will be

reconvened in 2022 and 2023. The CPMC meetings also contribute to this outcome in bringing empirical evidence on the impact of solar irrigation adoption on livelihoods, agriculture, and climate resilience to policy makers and main stakeholders. In May 2021, the CPMC meeting gathered participants from SREDA, BARC, BMDA, DAE, BREB, IDCOL and IWMI (minutes available here). In December 2021, the second CPMC Meeting for 2021 was held (minutes available here).
In 2022, with more results and policy-oriented recommendations becoming available, linkages between the output and the outcomes will strengthen. The engagement with various stakeholders will be pursued through the National Forum (January 2022) and the CPMC meetings. More broadly, communication of the research findings in Bangladesh, in the region or larger arenas is expected to attract policy interest.

1.1.2: 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 initial data shows 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 wave CoVID-19 impacted the activity resulting in a delay in the fieldwork and data collection.

Achieved in Year 1 (list in bullet points)

- A short note on the same size, sampling framework, and survey instruments (questionnaire) prepared
- Vendor hired for conducting impact evaluation (IE) survey
- Detailed methodology, GESI framework, and guiding questions/checklist for FGDs prepared
- Field notes and FGD transcripts prepared
- A rapid assessment of subsidy delivery mechanism in SIP was conducted, a report prepared, submitted to AEPC, and a presentation session organized for AEPC personnel
- Two Op-Eds focusing on subsidy delivery mechanism and the need for appropriate targeting of SIPs published

Achieved in Year 2 (list in bullet points)

- Phone Survey and HH survey concluded. The report from the Phone survey and Household Survey is ready.
- Situational Analysis Report for Nepal published on SoLAR website
- Journal Article based on the report submitted to AEPC in May 2020 drafted, and submitted to a journal in December 2021
- The final draft of the research report on the WEF and SIP Policy from GESI perspectives in Nepal and Bangladesh submitted for internal review
- The research report on the Qualitative study of GESI in SIP was submitted and is undergoing internal review

Planned for Year 3 (list in bullet points) focus on dissemination and dialogue

The field component of this activity was completed in Year 1 and Year 2. In Year 3, the focus will be on:

- Journal article based on Qualitative study of GESI in SIP submitted
- Journal article based on research paper on Policy review on GESI in SIP in Nepal and Bangladesh submitted
- Journal articles based on Phone Surveys and Household Surveys submitted
- Desk assessment for the development of country-specific emission factors in the Agriculture sector of Nepal in coordination with Ministry of Forests and Environment and NDC partnership Nepal

- Workshops/conference on Gender and Solar Technology during World water week /International Women's Day with stakeholders
- 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)
- 2-3 Policy briefs on results from impact evaluations of SIPs and GESI studies.

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, Srlahi, Rautahat, Parsa, Saptari and Bara) in Province 1 and 2 in Eastern Nepal for household surveys, while phone surveys in all districts in provinces other than Province 1 and 2. No new surveys will be conducted in Year 3.

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;
- Phone surveys with recipients of AEPC pump in all Provinces except Province 1 and 2, where IE field survey will be conducted.
- 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
- Analysis of secondary data on various aspects of SIPs – already collected, analysed, and reported in Year-1.

Timeline for each objective:

Details of sub-activities	Start date	End date	Outputs/Comments	Person/s responsible
Journal article based on comparisons of AEPC, IWMI-ACIAR and ICIMOD SIP models from a GESI lens based on a report developed in Y2	01-01-2022	30-06-2022	Journal article submitted	**Gitta**/ Labisha/ Manohara et al
Journal article based on research report on Policy review on GESI in SIP in Nepal and Bangladesh	01-01-2022	30-06-2022	Journal article submitted	**Manohara/Gitta**/ Labisha/ et Al
Journal article based on quantitative surveys (phone surveys and household surveys)	01-01-2022	30-06-2022	Journal article submitted	**Aditi/Shisher** and relevant consultants
IWMI Research Report summarizing entire impact evaluation of SIPs (quantitative – phone and	01-07-2022	31-12-3022	Research Report submitted	**Shisher** with all IWMI-Nepal staff

household surveys and qualitative – GESI work)				
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	01-01-2022	30-09-2022	Desk Assessment Report	**Shisher/ Aditi/**IWMI (through a Short term consultant)
National dialogues or conferences on Gender and Solar Irrigation forward during World Water Week or other forums	01-02-2022	30-04-2022	Workshop Report	**Labisha**/ Gitta/ 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)	01-07-2022	31-12-2022	Workshop Report	**Labisha**/ Gitta/ Manohara/ Shisher et al
Policy briefs	01-06-2022	31-12-2022	Policy briefs on: 1. Impact of SIPs on socio-economic and agricultural outcomes 2. Gender outcomes	**IWMI-Nepal SoLAR Team**

Deliverables:

- Journal article based on comparisons of AEPC, IWMI-ACIAR and ICIMOD SIP models from a GESI lens **(30-06-2022)**
- GESI policy journal based on the research report on Policy review on GESI in SIP in Nepal and Bangladesh **(30-06-2022)**
- Journal article based on quantitative surveys (phone surveys and household surveys) **(30-06-2022)**
- IWMI Research Report summarizing entire impact evaluation of SIPs (quantitative – phone and household surveys and qualitative – GESI work)
- Report on Desk Assessment for the development of country-specific emission factors in the Agriculture sector of Nepal on specific request from NDC and Government of Nepal**(30-09-2022)**
- Workshop Report on World Water Week **(30-04-2022)**
- Province / local level workshops Report **(31-12-2022)**
- Two to three blog posts and regular contributions to SDC-SoLAR newsletter – throughout the year
- Two to three blog posts and regular contributions to SDC-SoLAR newsletter – throughout the year

Linking activities with outputs and outcomes

This activity contributes to Outcome 1: Generating improved empirical evidence to support the development of climate-resilient, gender-equitable, socially-inclusive, and groundwater-responsive solar irrigation policies (Work Package 1) and more specifically to Output 1.1 Impact of solar irrigation adoption on livelihoods (women and men farmers), agriculture, and climate resilience documented and shared with policymakers. Evidence collected so far includes: Impact Evaluation Report and Database of the HH and Phone survey; Reports on Qualitative study of GESI in SIP; Policy review report on GESI in SIP in Nepal and Bangladesh and letter from AEPC informing IWMI about how IWMI's report is being used to revise the SIP subsidy delivery mechanism.

1.2.1 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 and Year 2

- Field visits were carried out to project locations to understand the context, and secondary data (agriculture and groundwater) was collected for the 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 for further 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.

Planned for Year 3

- Regular monitoring of irrigation water application data starting Rabi/Boro season 2021.
- Analysis of Rabi/Boro 2021 season data to compare groundwater use of solar and non-solar farmers.
- Analysis of Rabi/Boro 2021 season data to compare groundwater use between SIPs with different cropping patterns and climate.
- Setup of numerical groundwater model (building on conceptual model) for simulating impact of SIP on groundwater.

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 the 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
- Assess flow dynamics and return flows in sub-set of plots selected via instrumentation (soil moisture at different depths) and soil modelling (e.g., SWAP, HYDRUS-1D, APSIM) to estimate the difference between net and gross water application.

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, installation of field instruments	01-12-2022	01-12-2022	Structured database on irrigation water application	NGO forum
Data analysis of Rabi and Boro season (2020-21) to compare groundwater use of solar and non-solar farmers	15-03-2022	15-06-2022	Report on data analysis	Faiz
Data analysis of Rabi and Boro season (2020-21) to compare groundwater of different SIPs	15-03-2022	15-06-2022		Faiz
Set up and calibrated groundwater model of the region with SIP upscaling scenarios simulated	01-01-2022	31—12-2022	Report/publication groundwater model runs	Smaranika
Set up and calibrated vadose-zone flow model to estimate irrigation return flows	01-03-2022	31-12-2022	Report/publication vadose-zone flow modeling	Smaranika
Policy Briefs	01-01-2022	31-10-2022	Policy brief on impacts of SIPs on groundwater use (combination of groundwater observations and household surveys) based on published papers and reports	Faiz, Archisman, Marie-Charlotte Buisson, Aditi Mukherji

Deliverables:

- Initial report on groundwater use comparison of solar and non-solar farmers and different SIPs (same will be expanded in 2023 with another season data for final publication) **15-06-2022**
- Report/publication on calibrated groundwater model for the region with SIP upscaling scenarios **31-12-2022**
- Report/publication on calibrated vadose-zone flow model estimating irrigation return flows **31-12-2022**
- Blog posts and regular contributions to SDC-SoLAR newsletter – throughout the year
- Policy brief on the impact of SIPs on groundwater use in Bangladesh **31-12-2022**

Linking activities with outputs and outcomes

The activity contributes to output number **1.2** *"Impact of large-scale SIP adoption on GW sustainability documented and shared with policymakers".*

Activities will collect field data (through instrumentation and surveys) to provide a 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 and integrated with the groundwater model of the region. This will be shared with policymakers.

This output contributes to the 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. In conjunction with groundwater modelling, the data will help policymakers understand the impact of solar irrigation on groundwater and future implications on groundwater sustainability to devise any mitigation strategy.

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 ambitious programmed 'Suryashakti Kisan Yojana (SKY). However, it is important to assess how solarisation of farmers' irrigation impacts their pumping behaviour and subsequent impacts on overall groundwater levels and resources in the state. In this component of the project, we aim to monitor the groundwater abstraction under SKY and Non-SKY feeders and establish a relationship between energy consumption and groundwater abstraction. The field measurements of groundwater pumping are being carried out in partnership with INREM – a research NGO based in Anand, Gujarat.

In year 1:

- Field visits were carried out to SKY feeders to understand the context.
- Methodology and monitoring protocol for groundwater sustainability studies was developed.
- The data on district-level admin, biophysical and groundwater levels in the location of SKY feeders were collected.
- A census questionnaire to carry out the census was prepared.
- Selected and finalised groundwater measurement instruments with providers' quotations for procurement and installation after travel restrictions.
- IARI made as partners where one PhD student will work on the project. PhD plan is also prepared accordingly.

In Year 2:

- 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 2020 and is ongoing with support from INREM.
- Secondary data collection and primary fieldwork to build a conceptual model for Groundwater modeling [Indian Agriculture Research Institute (IARI), Delhi]
- Developing a decision framework to determine areas and conditions where solar irrigation succeeds with support from ATREE, Bangalore.

Planned for Year 3:

- Regular monitoring and collection of data will continue in currently selected feeders of Anand (central Gujarat) and Botad (western Gujarat).
- Instrumentation and monitoring will be expanded in North Gujarat feeders.
- Data collected (Kharif and Rabi 2020-21 season, Kharif 2021-22) will be analysed to develop groundwater abstraction-energy relationships
- Data collected (Kharif and Rabi 2020-21 season, Kharif 2021-22) will be analysed to compare groundwater use of Solar and non-solar farmers.
- Methodology development and data collection to upscale the groundwater-abstraction energy relationship to other SKY and Non-SKY feeders for estimating groundwater abstraction at larger scales.
- Preparation of district-level map of India showing areas of varying levels of groundwater abstraction estimates for demand and supply and estimation of curves for groundwater for 6 major crops in India with support from ATREE.

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 hydrogeologies of Anand district (Alluvial aquifers) and *Botad district* (Saurashtra hard rock aquifers) in Gujarat. In total 4 feeders and 40 farmers in each feeder (total 160 farmers) are being monitored.

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 the 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 and Summer 2021-22, Kharif and Rabi 2022-23 season	01-12-2021	31-12-2022	Database on farmers groundwater abstraction, cropping and irrigation	INREM Foundation
Data analysis of Kharif and Rabi 2021-22 season to develop generic groundwater abstraction-energy relationship for pumps	15-02-2022	30-05-2022	Report/publication on developed abstraction-energy relationships	Faiz
Review and comparison of methodological approaches to measure groundwater abstraction	15-02-2022	30-06-2022	Report/publication	Faiz
Data analysis of Kharif, Rabi and Summer season 2021-22 to compare groundwater use of solar and non-solar farmers	01-05-2022	30-09-2022	Report on groundwater use of solar and non-solar farmers	Faiz
Set up of numerical Groundwater model of the	01-02-2021	30-10-2022	Report on applied groundwater model	IARI student

region to simulate scenarios of solar irrigation upscaling				
Methodology notes and regional collection of data for upscaling developed groundwater abstraction-energy relationship	01-06-2022	30-11-2022	Methodological note	Faiz
Decision framework for solar irrigation suitability	01-01-2022	30-05-2022	Research Article	ATREE and Aditi Mukherji

Deliverables:

- Journal article on developed groundwater-abstraction energy relationships (30-06-2022)
- Journal article reviewing and comparing methodological approaches to measure groundwater abstraction (30-07-2022)
- Initial report on groundwater use comparison of solar and non-solar farmers (same will be expanded in 2023 with another season data for final publication) (30-10-2022)
- Methodological note for upscaling developed groundwater abstraction-energy relationship to other feeders to estimate groundwater use (30-11-2022)
- Blog posts and regular contributions to SDC-SoLAR newsletter – throughout the year

Linking activities with outputs and outcomes

The activity contributes to output number **1.2** *"Impact of large-scale SIP adoption on GW sustainability documented and shared with policymakers".* Activities will set up instrumentation to provide a 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 policymakers. The 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. In conjunction with groundwater modelling, the data will help policymakers 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, 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. Furthermore, it would help evaluate the policy direction for further promoting SIPs in Pakistan.

- Developed in 2020, the behavioural study involves selecting a sample set of farmers from various districts in Punjab province based on a set of criteria, including sample size and other details.
- An IRB application was submitted to collect data from the human respondents, which IWMI approved 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 was 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 exciting results from the phone survey and Rapid Enumeration, a draft manuscript is in the 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 will be completed in December 2021.
- Instruments for in-situ installation have been finalized and are being procured. These will be installed once the survey is complete, i.e., end of December 2021.

Planned for year 3:

- Analysis of the final behavioural study and development of the policy brief and research manuscript for possible publication in a reputed journal.
- Stakeholder consultation and Dissemination of the results of behavioural study in the form of four provincial dialogues and 1 federal workshop.
- Collection of in-situ groundwater data for the Rabi and Kharif season 2022.
- Analysis and Comparison of the survey responses with in-situ data to determine the actual impact on groundwater aquifer due to SIP pumping.

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, using SIPs simultaneously with diesel/electric pumps, or using 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:

- A total of 12 sites will be monitored with in-situ instrumentation which include 6 diesel and 6 SIPs. 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.
- The analysis and comparison will be made with the behavioural study to determine whether SIPs lead to more groundwater extraction.

Timeline for each objective:

Details of sub-activities	Start date	End date	Outputs/Comments	Person/s responsible
Analysis and finalizing reports based on phone surveys and rapid enumeration surveys	01-01-2021	01-03-2022	Report and a journal article on phone survey and rapid enumeration	Azeem/Zain
Consolidation of situation analysis of 4 provinces (Punjab, Sindh, Balochistan and KPK)	01-10-2021	01-05-2022	Consolidated report on Punjab, Sindh, Balochistan and KPK	Azeem/Zain
Analysis of behavioural study and preparation of research manuscript	01/01/2022	30/04/2022	Data Set and Research Manuscript	**Azeem**/Zain
Preparation of policy brief for the Government	01/01/2022	15/05/2022	Policy Brief	**Azeem**
Collection and analysis of in-situ groundwater data	01/01/2022	31/12/2022	Data Set	**Zain/**Azeem
4 provincial dialogues on the results of the behavioural study	01/03/2022	30/06/2022	Proceedings of the dialogues	**Azeem**
National workshop to discuss findings of the behavioural study	01/05/2022	31/05/2022	Workshop proceedings	**Azeem**

Deliverables:

- Report/journal article on
- Data set on actual groundwater usage of 12 sites in three different districts of Punjab for Rabi and Kharif seasons 2022 – Dec 2022
- A policy brief for the Government on the promotion of SIPs – May 2022
- Research Manuscript based on behavioral study submitted to journal – Apr 2022
- 4 Provincial Dialogue meetings between Mar – Jun 2022

- National workshop on the promotion of SIP – May 2022
- Blog posts and regular contributions to SDC-SoLAR newsletter – throughout the year

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 policymakers from the relevant departments (including agriculture, water and renewable energy).
- This activity directly contributes to 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 their investment plan.
- Finally, these outputs and outcomes would determine the transition from dirty diesel/electric energy to green energy from solar-based irrigation. Currently, the agriculture sector contributes 20% of the GHG emissions only through groundwater pumping. Sustainable transition to Solar will benefit the country in achieving its INDCs and contributing to the SDGs. It will also bring prosperity to the livelihood of the farmers as well.

2.1.1 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, and 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

In year 3:

- Conduct FGDs with IDCOL, BADC, and BMDA beneficiaries. FGDs will be conducted in 7 villages with IDCOL Fee for Sevice Model and 6 villages with group ownership models of BMDA and BADC, respectively. FGDs will be 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
- Qualitative descriptions from FGD and KII on different SIP promotion models
- In conjunction with household survey data collected in activity 1.1.1., the FDG information from the IDCOL site is planned to analyse to understand the impact of SIP in the local groundwater market

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 poposed 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) and Key Informant Interviews (KII), and case study method
- Collect secondary data will be collected from IDCOL
- Employ mix methods using both quantitative and qualitative methods

Timeline for each objective:

Details of sub-activities	Start date	End date	Outputs/Comments
Conduct KIIs with IDCOL, BADC, BMDA and relevant stakeholders and transcribing them	01-01-2022	15-02-2022	Data collection and transcriptions of KII
Conduct FGDs with IDCOL, BADC, BMDA farmers beneficiaries and diesel and electric pump owners in selected villages	15-02-2022	31-03-2022	Data collection and transcriptions of FGDs
Data Analysis from HH survey and FGD's from IDCOL sites	01-03-2022	30-04-2022	Results from both qualitative and quantitative data
Qualitative data framing	01-05-2022	30-06-2022	Analysis and organizing qualitative data
Final Report	01-09-2022	30-12-2022	Report on the different SIP modalities. Journal article on the effect of SIP on groundwater market

Deliverables:

- Qualitative and quantitative data from KII and FGD's
- Report on the different SIP modalities
- Journal article on the effect of SIP on groundwater market

Linking activities with outputs and outcomes

This activity contributes to Output 2.1 *"GESI-responsive, pro-poor and GW aware financial models for solar irrigation promotion demonstrated and documented*" through documentation and analysis of all the existing modalities of SIP promotion in Bangladesh through the lens of gender equity, social inclusion, and impact on groundwater market. The interviews of key informants and beneficiaries of SIP models promoted by different organizations in the country will help map the challenges and scope for scaling up each of these different models and their influence on the local groundwater market. This will inform policymakers in improving existing models towards being more GESI-responsive, pro-poor, and groundwater-aware, which are suitable for Bangladesh and contribute directly to Outcome 2 "Validating innovative actions and approaches for promoting gender-equitable, socially-inclusive, and groundwater-responsive solar irrigation".

2.2.1 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

Planned for Year 3

- Physical grid connection completed for all selected sites and detailed report on each grid integration projects with technical parameters and socio-institutional features submitted by IDCOL
- Monitoring of energy consumption and selling in Grid connection pilot sites
- FGDs and KIIs to be conducted at grid pilot sites

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 farmer's

access to irrigation and their income. Moreover, there is a growing concern for 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 between 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 3:

Details of sub-activities	Start date	End date	Outputs/Comments	Person/s responsible
Physical grid connection completed for all selected sites and detailed report on each grid integration projects with technical parameters and socio-institutional features submitted by IDCOL	15-12-2021	31-03-2022		Sponsors / IDCOL
Monitoring data on energy consumption and selling at IDCOL sites	01-01-2022	31-12-2022	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	01-03-2022	31-12-2022	SIP survey data and Field notes from the qualitative interviews	Marie-Charlotte, Archisman,

Deliverables:

- Detailed report on each of the five grid integration projects with technical parameters and socio-institutional features (IDCOL)
- SIP survey data and Field notes from the qualitative interviews (IWMI)

Linking activities with outputs and outcomes

This activity will contribute to Output 2.2 *(Technical and institutional modalities for grid connection of SIPs in different water-energy regimes demonstrated and documented)* for Outcome 2 (*Validating innovative actions and approaches for promoting gender-equitable, socially inclusive, and groundwater-responsive solar irrigation).* Besides demonstrating technical and institutional feasibility of grid connection in Bangladesh and providing inputs towards future policy design by SREDA, this pilot will also give evidence on the impact of grid integration on individual farmer's access to irrigation, groundwater usage and financial feasibility of the SIP business model. *IDCOL has already signed contracts with sponsors.* In Bangladesh, solar pumps are used primarily during four months of the year, and they remain mostly idle the rest of the year. These grid-integration pilots in Bangladesh will no doubt be a much-needed extra source of revenue for sponsors and are expected to make the solar irrigation business viable, and it will also contribute to the Bangladesh Government's target of producing 10% of energy through renewable sources. The extra revenue for sponsors is also likely to enable sponsors to reduce irrigation charges over time and lead to increased farmers' income. It can also incentivize sponsors to give more active training to farmers on improved irrigation practices that increase water use efficiency so that less water is used per hectare of irrigation.

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 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 determinants of solar generation and another on determinants of 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 (Planned Activities)

- Finalize sample selection and develop a questionnaire for the detailed household survey, including training enumerators, pre-testing and piloting of questionaires, and revisions as needed.

- Household survey with SKY and Non-SKY feeder farmers. Household surveys will be conducted in 42 feeders which have been selected through proportional random sampling method to match the utility wise distribution of feeders. Within SKY feeders, both SKY farmers and non-SKY farmers will be Another 41 control feeders have been selected. A total of 1600 farmers (600 SKY enrolled and 400 SKY non-enrolled in SKY feeders, and 600 farmers in non SKY control feeders) will be interviewed.
- Analysis of data from the household survey and writing of report and journal articles
- Completion of 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. The findings will help in suggesting mid-course policy corrections for the PM-KUSUM program.
- Finalise ongoing journal articles on solar energy generation and the effect of SKY on pumping behaviour

Goals/ Objectives:

1. To determine the impact of the SKY program on farmers' energy consumption and pumping behaviour
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 neighboring 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.

- 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 3)	Start date	End date	Outputs/Comments	Person/s responsible (Overall responsible: Yashodha)
Sample selection and questionnaire preparation, pre-testing and piloting	01/01/2022	30/03/2022	Final survey instrument	Yashodha Yashodha, Aditi Sanjay, Aditi Mukherji,
Carrying out the household survey (piloting, and monitoring survey)	15/03/2022	30/06/2022	Clean primary data for analysis	Yashodha Yashodha, Aditi Sanjay
Analysis of household survey data and writing a report based on it	10/04/2022	10/09/2022	Research paper on IE of SKY, blog pieces/articles, annual report	Yashodha Yashodha, Aditi Sanjay, Aditi Mukherji and new Researcher to be hired to replace Y. Yashodha
DISCOM official interviews	01/01/2022	31/05/2022	Data, analysis and report based on DISCOM officials interviews	
Case study on impact of SKY on informal water markets	01/04/2022	30/10/2022	Report	Aditi Mukherji and concerned consultants
Completion of three papers started in 2021. These are: a) determinants of generation b) determinants of pumping and evacuation c) Over view paper on impacts of SKY	01/01/2022	30/06/2022	Three papers submitted to journals	Y. Yashodha, Aditi Sanjay and Aditi Mukherji
Study on the progress, performance and impact of Chief Minister's Saur Krishi Vahini Program in Maharashtra	01/01/2022	30/06/2022	Research article	IRMA and Aditi Mukherji
Review of WEF policies in India and Renewable	01-01-2022	30-06-2022	Research report (India)	Manohara et al (with SaCIWaters)

Policies in major Indian states from a GESI lens				
2-3 Policy briefs	01/07/2022	31/12/2022	Policy Briefs	Aditi Mukherji
Blogs and contributions tonewsletters	01/01/2022	31/12/2022	News pieces and contributions to newsletter	All (India SoLAR Team)

Deliverables:

- Journal article on determinants of solar generation submitted to a journal 30/04/2022
- Journal article on determinants of electricity use, groundwater pumping and electricity evacuation to a journal 30/06/2022
- Overview article on SKY: Lessons Learnt, 30/06/2022
- Research report on the impact of SKY based on household surveys – 30/09/2022
- Report on case study on the impact of SKY project on informal water markets in Central Gujarat – 31/10/2022
- 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: Demonstration pilots on Grid Connection SIPs in 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 girds 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. The four parties agreed to install and operate the gridin December 2021. Year-3 will focus on the installation and 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 1

- Site prioritization report prepared based on a framework, and subsequent field study and two potential sites (with priority) are identified
- Review of various institutional models for grid-connected solar systems, their pros, limitations, and suitability conducted, and a research report prepared based on the review.
- 1 OpEd focusing on implications of grid-connected SIPs published
- Broader agreement between AEPC, working Palika, and IWMI on working together on piloting MG system (expected by the end of December 2020)

Achieved in Year 2

- Feasibility survey was conducted at two sites in Belakha Municipality and Chhipaharmai Rural Municipality, which includes the preliminary design of the MG system and cost estimation
- Four party-meeting meetings between Chhipaharmai Rural Municipality, IMWI, NEA, and AEPC to discuss the Feasibility Survey and lay foundations to sign the four-party LOI. The four-party LOI is signed.
- The baseline questionnaire was drafted.
- The monitoring framework to evaluate the success of the MG Pilot project with methodological-note drafted
- A report on Institutional Modalities for Grid-connected Solar Irrigation Project finalized. A review paper based on the report: A review of global typologies and South Asian Policies drafted and undergoing internal review before submission to a journal.

Planned for Year 3 (list in bullet points)

- Procure a vendor and install a microgrid (MG) system for connecting SIPs to the grid
- Technical report with installed MG system and its functioning
- Baseline report with results from the survey, including GESI outcomes
- Initiate and implement regular monitoring of various parameters for evaluating the effectiveness of MG system (to be continued until the end of the project) Identify and implement mechanisms for net-metering and payment processes in collaboration with NEA

- Yearly Monitoring Report and capacity building of farmers involved in the demonstration pilot.

Goals/ Objectives:

- Design and implement demonstrate pilot on grid-connected SIPs
- Establish baseline and design and implement a monitoring system to evaluate impacts of grid-connected SIPs
- Carry out continuous monitoring of parameters to evaluate the impacts in collaboration with Chhipharmain 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, Chhipharmai 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
Baseline surveys (including GESI studies) in selected grid connection and control sites	01-01-2022	30-04-2022	Draft baseline report summarizing results from qualitative and quantitative surveys, including GESI outcomes	**Shisher/** Labisha et al
Procure a consultant/vendor to install MG	01-01-2022	31-01-2022	LoI/MoU between Local Government, AEPC, NEA and IWMI Agreement with vendor/consultant	**Shisher/**IWMI
Detailed plan of micro-grid implementation, including plans for benefit sharing with local communities, along with net metering and payment guidelines	01-01-2022	30-04-2022	Report outlining benefit sharing with communities	**Shisher/**IWMI

Exchange visit of relevant officials from AEPC, NEA Municipalities to Anand, Gujarat to Dhundi scheme	01-03-2022	30-06-2022	Field visit report	**Shisher/**IWMI
Installation of grid connection in one or two SIP site	01-05-2022	30-07-2022	Grid connection completed Technical report with installed MG system & its functioning	**Shisher**/IWMI
Develop on-site monitoring mechanisms	01-02-2022	31-03-2022	A monitoring guideline/mechanism report including the mobilization of local enumerators/field staff of Chhipharmai RM	**Shisher**/IWMI
Regular monitoring of various parameters related to the micro-grid system, crop production, and change in behavior of farmers, etc.	01-05-2022	31-12-2022	An Excel database of regular monitoring	**Shisher/Labisha/** LFA (local field assistant/et al
Multi-stakeholder dialogues in the Chhipharmai RM for public awareness on MG pilot and discuss the Net metering and payment protocol	01-02-2022	30-05-2022	An agreement on Net metering and payment protocol between farmers and NEA is established in collaboration with Chhipharmai RM	**Shisher**/IWMI

Deliverables:

- Baseline report summarizing results from Baseline Survey (28-02-2022)
- Detailed plan of MG connection, including plans for benefit sharing with local communities, including new metering and payment mechanism guidelines (30-04-2022)
- Guidelines for on-site monitoring guideline (30-04-2022)
- Agreement with vendor/consultant (31-03-2022)
- Technical report with installed micro-grid system and its functioning (30-07-2022)
- Yearly Monitoring Report (31-12-2022)

Linking activities with outputs and outcomes

This activity is related to Outcome 2: Validating innovative actions and approaches for promoting gender-equitable, socially-inclusive, and groundwater-responsive solar irrigation (work package 2) and Output 2.2 Technical and institutional modalities for grid connection of SIPs in different water-energy regimes demonstrated and documented. Evidence includes Feasibility Survey Report prepared in Year 2; Commitment letter from Chhipaharmai Rural Municipality and four-party MOU signed between IWMI, AEPC, NEA and Chhipaharmai RM in December 2022.

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. After further discussions 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. Thus, 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. It can be achieved by installing pyranometer along with the ambient temperature sensor and another temperature sensor installed to the PVs. We have ordered instruments to that effect, and once we are done with the final behavioral survey in December 2021, these will be installed, and the monitoring will start. The study will be further strengthened by executing choice experiments with a more extensive set of farmers to determine their preferences for a tariff structure in 2022.

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 that since the major field research we are undertaking is limited to the province of Punjab, it would 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. They are undertaking detailed situational analysis of the SIPs, which involve collecting primary data from users, suppliers, and government agencies and augmenting their analyses with the secondary data available with different agencies. They will submit their final reports in the month of December 2021.

Achieved in year 1:

- This activity will start in the 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

Planned for year 3:

- Methodology development for the choice experiments to determine feed in tariff structure
- Pre-survey of choice experiment
- Main survey of choice experiment
- Data collection through instruments for the Rabi 2021-22 and Kharif 2022 to continue for a complete one year
- impact on groundwater aquifer due to SIP pumping.

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:

The location of the study is three districts in 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. In addition, 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.

Timeline for each objective:

Details of sub-activities	Start date	End date	Outputs/Comments	Person/s responsible
Method Statement including design of Choice Experiments	01/01/2022	31/03/2022	Methodological Note	Azeem
Pilot for testing the choice cards and making sure tariff range are relevant	01/04/2022	30/04/2022	Data Set	Zain
Choice Experiment Survey	01/04/2022	30/06/2022	Data Set	Azeem/Zain
Research Manuscript based on the results (Report and Journal article)	01/07/2022	30/09/2022 and 31/12/2022	Manuscript	Azeem
Policy brief	30/09/2022	31/12/2022	Policy brief on opportunities for connecting SIPs to the grid	Azeem

Deliverables:

- Detailed methodology for choice experiment – 31/03/2022
- Data Set for Choice Experiment – 30/06/2022
- Final report for internal review – 30/09/2022
- Journal article submitted – 31/12/2022
- Policy briefs -31/12/2022

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 organisationd 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

- Planned for year 3:
  - No further calls for proposals are planned in Year 3. However, remaining funds may given as a grant to one innovation project on the advice of SDC
  - Year 3 will focus on documenting progress of Innovation Funds Grantees and preparing case notes and materials for social media promotion.

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. Visit by IWMI Team members to various locations where Innovation Fund grantees are working and creating photo/news documentaries

Timeline for each activity:

Details of sub-activities	Start date	End date	Outputs/Comments
Identifying one additional IF Grantee in consultation with SDC	01/01/2022	01/06/2022	Contract signed with the 9th and final IF grantee
Physical field visits to all IF Grantee sites and creating photo documentaries and impact stories	01/01/2022	31/12/2022	8 field stories/photo documentaries created, minutes of meetings

Deliverables:

- Contract signed with the final IF grantee in 2022- 01/06/2022
- 8 field stories, photo documentaries and minutes of meetings with current IF grantees – 31/12/2022

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 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, an 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 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 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

Planned for Year 3:

Bangladesh:

- Third farmers' training workshop to be organized by IDCOL as a part of their larger outreach program for farmers.

India:

- Plan and implement training of 2000 plus farmers in 45 feeders in a Randomized Control Trial mode in partnership with GERMI
- Finalise and sign contract with GERMI for conducting farmers in 45 feeders in Gujarat

Nepal

- Translate the Training manual to Nepali language and handover to AEPC; Developed translated version of manuals in other regional languages in coordination with local government and partners.
- Implement Targeted training workshops for women technicians + solution-oriented targeted packages for gender-responsive information dissemination is missing from the planned activities.
- Prepare detailed Training report.

Pakistan

- Farmers and technicians trainings each in PARC and KFUEIT premises will be carried out on the design, operations and maintenance of Solar pumpng systems along with coupling these systems to the High Efficiency Irrigation Technologies.

Study area/location:

Bangladesh:

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

India

- 45 feeders 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 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.

Timeline for each activity:

Details of sub-activities	Start date	End date	Outputs/Comments	Person/s responsible
Bangladesh				
Preparation of training curricula, training modules and selection of trainers and trainees	01-06-2022	30-08-2022	Training materials finalised and trainees chosen, and all technical logistical arrangements for trainings done	IDCOL
Training workshop	01-09-2022	30-11-2022	Trainings conducted and final training report submitted	IDCOL
India				
Contract finalization with GERMI	01-01-2022	31-01-2022	Formal contract and task details with GERMI	Aditi Mukherji
Provide feedback on the training modules and other materials developed for training	1-01-2022	01-02-2022	Training module and training materials	IWMI India SoLAR Team
Piloting the training and updating the training modules	01-03-2022	01-04-2022	Training module and training materials	Yashodha Yashodha, Aditi Sanjay, GERMI
Implementing training in the form of an RCT, monitoring	01-04-2022	31-12-2022	Training conducted for selected treatment feeders and impact assessment research paper	Yashodha Yashodha, Aditi Sanjay, Aditi Mukherji, GERMI
Nepal				

Translate the final version of Training module into Nepali language	01-01-2022	28-02-2022	Final Nepali version of Training Manual	**Labisha**/ Shisher
Training / Workshop/school (2-3 days training), focus on training women technnicians	01-06-2022	31-12-2022	Training report including details of persons attended.	**Labisha**/ Shisher
Pakistan				
Preparation of training curricula, training modules and selection of trainers and trainees	1/01/2022	31/12/2022	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)	1/07/2022	31/12/2022	Training conducted	IWMI-Pakistan SoLAR Team and partners

India

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

Nepal

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

Pakistan

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

Deliverables:

Bangladesh:

- Training report, including training modules and details of the personnel trained

India:

- Training curricula, video and handouts, including training modules to be submitted by GERMI – 30/09/2022
- Training report by GERMI -30/09/2022
- Draft Research paper on impact of training on energy outcomes (IWMI) 31/12/2022

Nepal:

- Nepali version of the Training manual 30/04/2022
- Training report, including details of personnel, trained 31/12/2022

Pakistan:

- Training curricula, including training modules 30/04/2022
- Training report, including details of personnel, trained 31/12/2022

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 in a sustainable manner 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 in 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 orginially planned. Now, some 2000+ farmers would be trained. The activity involves training selected feeder farmers to improve their knowledge on 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 targetfemale 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 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 the 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

3.1.2 Training of groundwater, energy and agriculture officials in all four countries

Brief background:

The premise of this project is that water, energy and agricultural issues are deeply interlinked, but often these linkages are not well understood. As a result, work on one element by itself – say, water – can have unintended negative impacts on energy or agriculture. For example, highly subsidized SIPs in groundwater over-extracted areas pose immediate and long-term threats to groundwater sustainability. Professionals from each of these sectors are often not aware of the trade-offs and potential synergies. In view of this, we will organize regional training events where energy professionals will be trained in the basics of hydrogeology. And water and agriculture professionals will be trained in the basics of SIP technology. We will conduct two regional trainings over the course of the project.

Achieved in year 1:

- Outline of a training program, lectures and tentative speakers identified
- Preliminary discussions with ISA, SAARC Energy Centre and IISc Bangalore and IHE Delft for hosting the training,

Achieved in year 2:

- Further discussions with IHE Delft and modality of the partnership between the two organisations (IWMI and IHE-Delft) were held, but modalities, particularly, platform for hosting the online trainings could not be finalised, and the contract was not signed in 2022. This training could not be conducted in 2021.
- Outline of training and lecturers were identified and finalised.

Planned for Year 3:

- Online survey on needs assessment to understand the demand for such a training among senior-level policymakers
- Signing of contract between IWMI and IHE Delft
- Selection of participants with help from PMC members
- Implementation of online four to five-week training program between September to November 2022
- Report on training completion and participant's feedback

Study area/location:

Online training of four to five weeks duration.

Timeline for each objective:

Details of sub-activities	Start date	End Date	Outputs/Comments	Person/s responsible
Online needs assessment survey	1/01/2022	30/04/2022	Online survey designed and implemented among key government and non-governmental stakeholders	Aditi Mukherji and SoLAR PMU
Finalisation of training curricula, training	1/03/2022	30/04/2022	Training materials finalised	Aditi Mukherji and SoLAR PMU

modules and selection speakers/lecturers			and trainees are chosen, and all technical logistical arrangements for training done	
Partnership with IHE Delft to run the course issue joint certificate to the participants	1/03/2022	30/06/2022	Partnership agreement signed	Aditi Mukherji and SoLAR PMU
Selection of participants (nominated by respective country PMC member)	30/06/2022	31/08/2022	Participants nominated and selected	Aditi Mukherji and SoLAR PMU
Online training conducted and curated	1/09/2022	31/12/2022	Training conducted and training report prepared	Aditi Mukherji and SoLAR PMU

Deliverables:

- Online needs assessment survey results – 30/04/2022
- Contract signed between IWMI and IHE Delft – 30/06/2022
- Training curricula, including training modules and list of lecturers (revised version based on 2021 version)- 30/06/2022
- Training report, including details of personnel, trained- 31/12/2022

Linking activities with outputs and outcomes

This activity will contribute to output 3.2 of organising multi-stakeholder forums for global and regional exchange of knowledge on best practices in GESI responsive and groundwater aware solar irrigation practices and policies and to outcome 3 outcome 3 “Increased national /global knowledge and capacity for GESI responsive and groundwater aware solar irrigation policies and practices”.

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.

Planned for Year 3:

- Regional Forum to be held in face-to-face mode in either Gujarat, India (preferred) or Kathmandu, Nepal. This will include 2 days of research workshop and 2 days of field visits.
-

Goals/ Objectives:

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

Study area/location:

- The 3rd Regional Forum will be a face to face event and will be held between June to August 2022.

Timeline for each objective:

Details of sub-activities	Start date	End date	Outputs/Comments	Person/s responsible
Planning, call for papers, conference organisation committee and actual organisation of 2nd Regional Forum	15/03/2022	31/08/2022	Concept note for the Regional Forum, call for abstracts, finalising collaboration partners (ISA, CEEW, IRENA etc.), organisation of the workshop	Aditi Mukherji and SoLAR PMU

Detailed workshop report	31/08/2022	30/09/2022	Workshop report	Aditi Mukherji and SoLAR PMU
Quarterly newsletter	01/01/2022	31/12/2022	4 newsletters published in 2022	Comms manager
SoLAR website	01/01/2022	31/12/2022	Regular updates	Comms manager

Deliverables:

1. Regular updates to the SoLAR website – Throughout the year
2. Regular publication of SoLAR newsletter (one per quarter) – Throughout the year
3. Organisation of the 2nd Regional Forum in a face to face mode, and workshop report - 30/09/2022

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 important that are related to solar irrigation.

Achieved in year 1

- A series of 6 webinars were held in Febbruary 2021.

Achieved in Year 2:

- National Forum webinars in online mode was conducted in Nepal and Bangladesh in Febraury 2022, and in offline mode in Pakistan in December 2021 as a part of Pakistan Water Week. National Forum webinar for Year 2 is delayed in India and will be done in an online mode in April 2022.

Planned for Year 3:

- 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	01/08/2022	31/12/2022	National Forum Workshop Reports	Respective country leads

Deliverables:

- National workshop reports – 31/12/2021

Annexure 1: Activity wise progress

Table 1. Progress in planned activities in Bangladesh in 2021

Activity No.	Deliverables that were due 2021	Status of deliverables at end of 2021	Plan for 2022
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 2021	Completed: Data collected for 2nd (rabi), 3rd (kharif 1) and 4th (kharif 2) rounds and baseline household surveys with ~900 households completed	SIP level database for 3 seasons in 2022 (i.e., Rabi, Kharif 2, Kharif 1,).
		Compilation and analysis of Household-level and SIP level data in process.	Journal article analysing the impact of SIP on farmers' irrigation practices (time, cost, yields) and the heterogeneity of the impacts)
	Baseline report + Blog Post	Completed: One opinion piece published, and results presented in one international conference	Three Policy Briefs (Mitigation potential of SIPs in Bangladesh, Impacts of IDCOL SIP model on farmers' incomes and livelihoods, and Equity impacts of SIPs—who has access and who doesn't)
	Research article based on analysis of policy documents through GESI lens	In progress: Analysis of policy documents through a GESI lens completed and article in draft stages.	Part of a regional research paper, to be completed by October 2022
2.1.1 Scale pilot for testing different SIP promotion models in Bangladesh	Research article on the modified topic: Comparative case study of different SIP promotion models in Bangladesh	• KIIs with officials of different organisations conducted • Field visit and FGDs conducted to understand how different SIP modalities are working.	• Analysis of qualitative and quantitative data from KII and FGD's • Journal article on the effect of SIP on groundwater market
	Case study report on the implementation upazila		

	permit policy and its implications for SIPs	• Case study on *upazila* permit dropped as permit system is not yet implemented widely by the government due to COVID delays	• Journal article on the different SIP modalities
1.2.1 Groundwater-related studies embedded in demonstration pilot in Bangladesh	Database on farmers' pumps, wells, groundwater, and water management practices in selected SIPs and diesel plots in NW and SW Bangladesh.	• Survey of SIPs (collecting design plans, field, and farmer mapping) conducted in Northwest and Southwest Bangladesh. • Selection of 320 plots serving 235 farmers for monitoring	Initial report on groundwater use comparison of solar and non-solar farmers and different SIPs (same will be expanded in 2023 with another season data for final publication)
	Report on instrumentation installation and data collection protocol.	• Methodology and monitoring protocol for GW sustainability studies developed • Carried out instrumentation in selected SIPs • Completed training of data operators	Report/publication on calibrated groundwater model for the region with SIP upscaling scenarios
	Brief report on data analysis of kharif II season.	In progress	Report/publication on calibrated vadose-zone flow model estimating irrigation return flows
	Report on conceptual soil and groundwater model for the study area	Completed: Conceptual model for groundwater modelling in the project areas was developed.	Blog posts and regular contributions to SDC-SoLAR newsletter – throughout the year
2.2.1 Demonstration pilots for grid connection of SIPs	Detailed report on each of the five grid integration projects with technical parameters and socio-institutional features (IDCOL)	• Technical design and site selection criteria for grid-integration pilot finalized, and 3 sponsors (Gazi, Wave and KHM) were selected for the pilot grid connection • Includes 2 cluster locations (with 4 and 3 sites in each cluster) and 2 sites for net metering	• Compilation of SIP survey data and Field notes from the qualitative interviews • Detailed report on each of the five grid integration projects with technical parameters and socio-institutional features

		• Contract signed with selected sponsors for the pilot and NOC received from respective utilities	
3.1.1 Training of local technicians and farmers	Country-specific farmer training modules development, trainings and reports	Bangladesh: Two trainings completed	• Training modules to be developed and disseminated, trainings completed. • Training reports to be submitted with details of attendees
3.2.2 National forums	National Forums	Online National Forum webinars conducted in Bangladesh	

Table 2. Progress in planned activities in India in 2021

Activity No.	Deliverables that were due 2021	Status	Plan for 2022
1.2.2 GW studies in India	Preliminary report on groundwater levels and trend in SKY and non-SKY areas	Partially Completed: Ongoing monitoring and collection of data (groundwater abstraction, crops, groundwater levels)	• To be completed in 2022 in partnership with INREM • Data from another season to be collected for final publication by October 2022
	Census database on farmers' pump, well, groundwater and water management practices in selected feeders	Partially Completed: Instrumentation done to monitor groundwater abstraction with 4 feeders (2 SKY and 2 Non-SKY) in Anand and Botad, Gujrat.	• To be completed in 2022-2023 in partnership with INREM. • Journal article reviewing and comparing methodological approaches to measure groundwater abstraction (30-07-2022)
	Report on instrumentation installation and data collection protocol	Completed	No further instrumentationis planned.
	Report on conceptual groundwater model (31-08-2021)	Secondary data collection and primary fieldwork done with Indian Agriculture Research Institute (IARI), Delhi	Methodological note for upscaling developed groundwater abstraction-energy relationship to other feeders to estimate groundwater use by November 2022
	Brief report on data analysis with draft GW abstraction-energy relationship (31-12-2021)	Not completed	Journal article on developed groundwater-abstraction energy relationships by June 2022
	Blog posts and regular contributions to SDC-SoLAR newsletter – throughout the year	Completed	Blog posts and regular contributions to SDC-SoLAR newsletter to be done
2.2.2 Scale pilot on institutional aspects of grid-	Compilation of secondary data from SKY web-portal and GUVNL	MOU with GUVNL signed. Completed. Database cleaned and prepared.	Research report on impact of SKY based on household surveys by September 2022

connected SIPs in Gujarat, India	Compilation of primary and secondary data	Data is being downloaded and analysed.	Planned journal articles on: • Determinants of solar generation submitted to a journal • Determinants of electricity use, groundwater pumping and electricity evacuation to a journal
	Technical report/paper/blog piece on SKY feeder data	Data analysis for two journal articles – one on determinants of solar generation and another on determinants of electricity use and evacuation started.	• Overview article on SKY: Lessons Learnt • 2-3 policy briefs based on completed/published research reports • Case study on impact of SKY project on informal water markets in Central Gujarat
	Preliminary report on the impact of the SKY program.	Completed	
3.1.1 Training of Lead Farmers	Development of Training Curricula including training modules	Partially complete MoU signed with GUVNL to train 2000+ Farmers in 45 sky feeders Training plan in RCT mode completed and included as a part of MOU with GUVNL	• Trainings in coming months under modified MOU with GUVNL. • Signing MOU with GERMI • Training modules to be developed and disseminated with GERMI
	Training report including details of personnel trained	Not completed due delay in signing MOU with GUVNL	Training reports to be submitted with details of attendees
3.2.2 National forums	National Forums	Delayed due to COVID 19, as we were planning a F2F event in January 2022 when third wave broke out.	National Forum webinar in India will be done in April 2022.

Table 3. Progress in planned activities in Nepal in 2021

Activity No.	Deliverables that were due 2021	Status	Plan for 2022
1.1.2 [IE & GESI Studies in Nepal)	Journal article based on the Situational analysis report submitted in 2020	Completed. One journal article based on AEPC data submitted and Situation Analysis submitted to journal and. Under review	NA
	Research article/paper –Impacts of SIP from GESI lens in Nepal using field data (31/12/2021)	Partially completed – Internal draft ready, finalising it for journal submission.	Journal article based on comparisons of AEPC, IWMI-ACIAR and ICIMOD SIP models from a GESI lens
	Impact Evaluation Report (Draft and Final versions) based on phone surveys and IE survey (31-12-2021)	Completed: Detailed report based on Phone Survey and Household Survey is completed, internal review is going on.	Journal article based on quantitative surveys (phone surveys and household surveys) IWMI Research Report summarizing entire impact evaluation of SIPs (quantitative – phone and household surveys and qualitative – GESI work)
	Draft Journal article note based on analysis of policy documents through GESI lens (31/08/2021 – a combined paper with data from Bangladesh and Nepal)	Completed: The final draft is submitted for internal review	Journal article based on the research report on Policy review on GESI in SIP in Nepal and Bangladesh (30-06-2022) Report on Desk Assessment for the development of country-specific emission factors in the agriculture sector of Nepal on specific request from NDC Partnership and Government of Nepal
	Two to three blog posts and regular contributions to SDC-SoLAR newsletter – throughout the year	Not yet started. Vendor has been selected, and all questionnaires are under preparation. Surveys to be launched in March/April 2021	• Workshop Report on World Water Week (30-04-2022) • Province / local level workshops Report (31-12-2022) • Popular articles published
2.2.3 Grid connected pilot in Nepal	Technical note, methodological note and instruments for surveys	• Site feasibility survey and selection completed	• Installation of the MG grid in next six months

		• Four-party agreement signed between Chhipaharmai Rural Municipality, IMWI, NEA, and AEPC • Methodological note on impact assessment drafted	• On-site monitoring protocol tested and implemented
	Draft baseline report summarizing results from qualitative and quantitative surveys including GESI outcomes	Not yet started: Will start after installation of MG system only	Baseline report with results from surveys, including GESI outcomes
	Technical report with installed micro-grid system and its functioning	Not yet started: due to field restriction related to COVID-19	Grid connection completed
3.1.1 Training for local technicians in Nepal	Training materials (curricula/modules); Trainee chosen; All technical and logistical arrangements are done	Nepal: 7-day residential training completed with 20 farmers.	• Finish second training • Develop training manual (in Nepali and with detailed contents)
	Training report including details of persons attended	Submitted	Training report with details of training delivery, participants, feedback, etc.
3.2.2 National Forum in Nepal	National forum workshop report	Completed: Webinar organised on 5th of February 2022 and webinar report has been prepared	Organise and prepare workshop report
	At least one policy brief outlining the main findings and policy implications	In progress	Policy brief based on the theme of the national forum

Table 4. Progress in planned activities in Pakistan in 2021

Activity No.	Deliverables that were due 2021	Status	Plan for 2022
1.2.3 GW related studies embedded in demonstration pilot in Pakistan	Dataset on groundwater usage of diesel vs solar pumps in Pakistan Punjab sites – July 2021 socio-economic survey and Nov 2021 for Kharif season	• Phone surveys for rapid enumeration • Completed: Data collected through Rapid Enumeration Survey in three districts of the province of Punjab with a total of 624 respondents • Final household survey has commenced in November 2021 with the same set of respondents as in the Rapid Enumeration survey.	Finalise Data set on actual groundwater usage of 12 sites in three different districts of Punjab for Rabi and Kharif seasons in 2022 and write reports based on it
	Report/working paper on impact of SIPs on groundwater	Completed: Report combining in results from phone surveys and face to face rapid enumeration completed and is under internal review.	Journal article on the effect of SIP on groundwater market to be submitted by December 2022
	A policy brief for the Government on promotion of SIPs	Partially Completed: Methodological Note was completed and shared with Team. Suggestions incorporated and the Note revised	To be submitted by May 2022
	Collection of Data for the Kharif season – April 2021 – October 2021	Partially Completed: Instruments for in-situ monitoring to be installed by June 2022.	Full survey to be deployed in 2021
	Draft Manuscript based on analysis – Dec 2021	Partially completed: Data collection and compilation in progress	Journal article on behavioral study to be submitted by April 2022
	Blog posts and regular contributions to SDC-SoLAR newsletter – throughout the year	Completed: Video documentary screened on the World Water Week.	More popular articles to be published
2.2.4 Demonstration pilots and simulation of grid-connected pumps through heat sinks in Pakistan	Method Statement	In progress: Situational analysis study for the province of Khyber Pakhtunkhwa, Balochistan & Sindh completed. Delayed, to be done in 2022: simulation pilot through heat sink and choice experiment.	Report on detailed methodology for choice experiment to be submitted by March 2022
3.1.1 Training of local technicians in	Training curricula, including training modules	Completed: Four trainings conducted on:	Development of training curricula,

Bangladesh, India and Nepal; training for farmers in Pakistan		• In person training on "Design of Solar Pumping Unit for Precision Surface Irrigation" with 70 participants at partner university. • A hands-on training on "Operation and Maintenance of Solar Pumping Unit and Precision Surface Irrigation" was delivered to 19 farmers. • In-person training of 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	including training modules
	Training report, including details of personnel trained	Completed	Training Report
3.2.2 National Forum in Pakistan	National forum workshop report	National webinar conducted on 5th of December 2021, and report has been prepared	National Forum in 2022

Table 5. Progress in planned Regional activities in 2021

Activity No.	Deliverables that were due 2021	Status	Plan for 2022
2.3.1	Administration of innovation funds	Completed: 3 more innovation funds grants were awarded along with the 5 awardees in 2020 making it total 8 IF partners.	Regular monitoring of activities of the grantees
3.1.2	Training of groundwater, energy and agriculture officials in all four countries	Delayed, but in progress: Discussions with IHE Delft on modalities of conducting trainings could not be finalised and caused delays.	Enter into an agreement with IHE Delft to organise the training in 2022
3.2.1	Regional Knowledge and Policy Forum	• 1st Regional Forum was organised on 23rd and 24th February and report prepared. • SoLAR website was regularly updated. • A logo for the SoLAR project has been approved by the PMC. • 6 editions of newsletters shared with more than 900 stakeholders.	• Regular updates to the SoLAR website – Throughout the year • Regular publication of SoLAR newsletter (one per quarter) – Throughout the year • Organisation of the 2nd Regional Forum in a face-to-face mode, and workshop report - 30/09/2022