IWMI
International Water Management Institute

SoLAR
Solar Irrigation for Agricultural Resilience

Schweizerische Eidgenossenschaft
Confédération suisse
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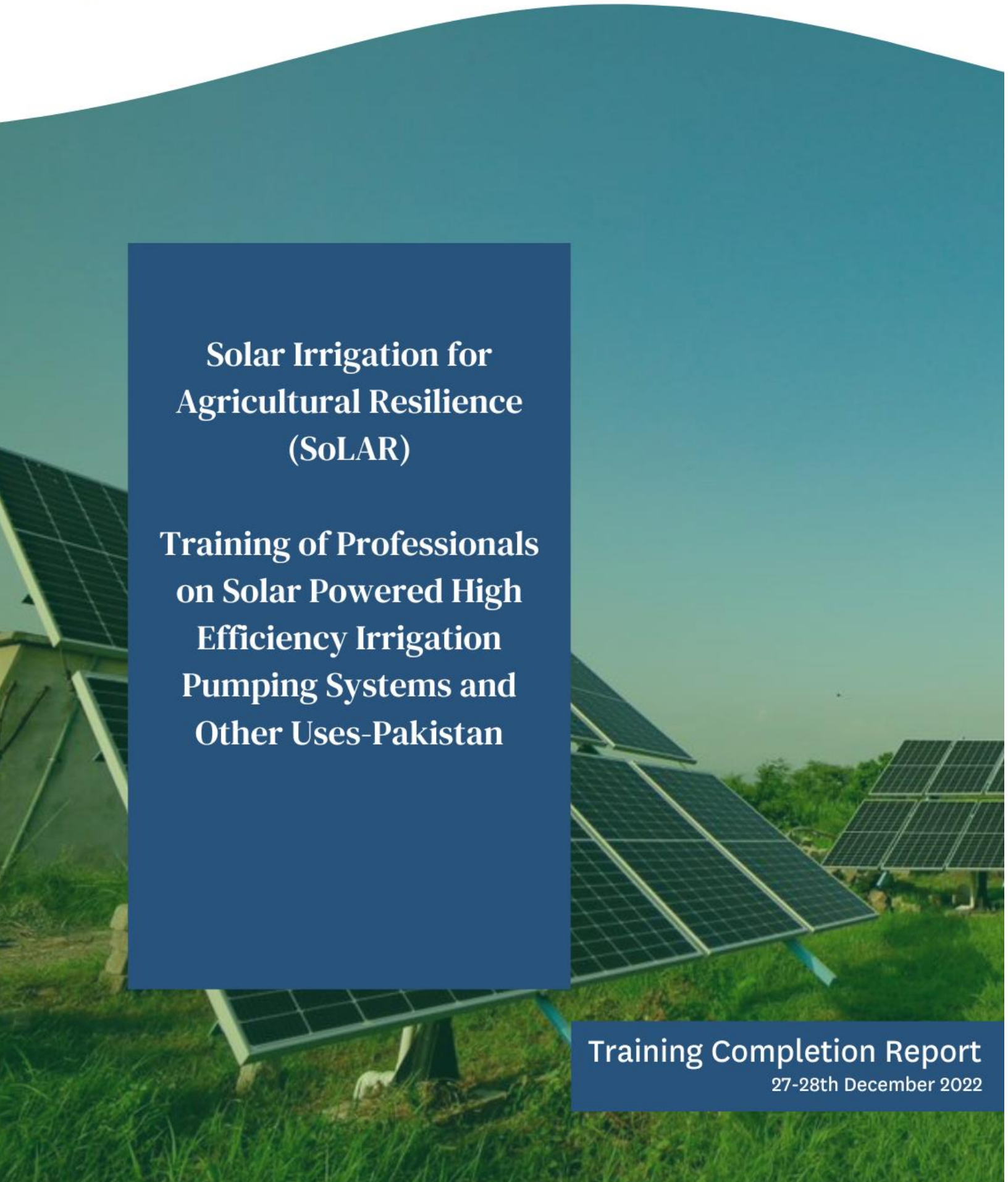


Solar Irrigation for Agricultural Resilience (SoLAR)

Training of Professionals on Solar Powered High Efficiency Irrigation Pumping Systems and Other Uses-Pakistan

Training Completion Report

27-28th December 2022

Contents

Background

With the assistance of the International Water Management Institute (IWMI) - Pakistan, the Climate Energy Water Research Institute (CEWRI) organized the training of technicians/Professionals on solar water pumping systems in order to enhance the technical knowledge and capacity of local technicians and engineers on those systems. The training was conducted as part of the SoLAR (Solar Irrigation for Agricultural Resilience) project, which supports government initiatives in Pakistan, India, Bangladesh, and Nepal while generating knowledge and research to manage water-energy and climate interlinkages by promoting solar irrigation pumps.

Objective of the training

This program's primary goal was to educate qualified professionals on solar pumping systems so that they could later offer technical services like solar pumping system installation, oversee the continued operation of the systems, and assist maintenance and promotion as needed.

Specific objectives of the training were as follows:

- To teach participants how to handle and operate necessary tools and equipment related to solar PV and solar water pumping systems.
- To familiarize participants with the fundamentals of solar PV and solar water pumping technology.
- To capacitate participants on PV system sizing, including pump sizing, panel sizing, battery sizing, controller sizing, cable sizing, and inverter sizing.
- To capacitate participants to be able to install, assemble, and test solar PV and solar water pumping systems.
- To educate the government officials regarding performance analysis of solar panels by using IV Curve Tracer.

Date and Venue of the training

The training was conducted on 27th and 28th December, 2022. Thetraining was held at

National Agriculture Research Council (NARC) at Islamabad in Pakistan.

Participants

There was twenty-five participants who attended the training sessions and hailed from different professional backgrounds of Govt. organizations. Most of them had an engineering background, while one of them was from the agriculture background and another hailed from the environmental sciences background.

Description of the training

The training method was diverse with lectures, presentations, group discussions, demonstrations at CEWRI field station, and practical exercises of solar system performance evaluation. The participants were provided with a basic background of the significant components of solar PV systems and were introduced to its design aspects which involved detailed system sizing calculations. Other essential elements of the Solar PV systems, such as site survey, system commissioning, O&M, and performance evaluation were discussed at length. CEWRI also provided several useful reference materials and the final training manual to the participants. The two-day training had a 6-hour session each day.

Day 1st (27th Dec,2022)

Dr Bashor, Director CEWRI NARC **inaugurated session with a** Welcome note & training objective. Afterwards Dr delivered lecture on "Integration of solar pumps and irrigation system- PARC Experience in the potohar and Thall region of Pakistan".

Dr Abdul Wahab, presented the over view of solar power, Components of a Typical Solar-Powered Pumping System and On Grid/off Grid/Hybrid solar system.

Eng. Muhammad Asif, Scientific Officer, CEWRI, NARC, delivered three lectures on "Design, layout, and installation of Solar powered irrigation system"

The **1st** lecture was delivered on the "**Solar Water Pump: Design Concepts & Procedures**." Under this presentation complete design of solar pump was discussed, stepwise procedure was adopted for the design of solar water pump. There are 10 steps discussed with proposer case study, the

participants were completely involved in the design steps and tried to engage each participant in the design process. You can say, I have given them hands on training. Basic solar terminologies were also discussed before design of solar pump; further Pakistan solar potential was also highlighted.

2nd presentation was carried out on the "**Design of solar Powered Drip Irrigation**"; Formulas involved in the design of drip irrigation were presented. Afterwards a case study of ber orchards on 5 acres was designed. Basic information required for the design of drip irrigation highlighted, crop water requirement per plant, kc factor of ber orchards, flow rate determination and design of laterals, submain and mainlines. Head loss calculation was determined by Darcy law. And in the last, TDH and flow rate was used to determine pump power requirement. Pump selection charts was also used for an appropriate pump selection. Pipe selection was carried out by using Total Dynamic Head for different bearing heads. In the last, bill of quantity was determined along with its unit cost incurred on the design of Ber orchards for five acres. An excel sheet was also used with the participants having complete design of drip irrigation i.e. from start to complete in all respect.

3rd presentation was on the "**Design of solar powered Sprinkler Irrigation and Materials Requirements"**. The same methodology was adopted as did for the Design of drip irrigation system. Overlapping and sprinkler selection was discussed in detail in case of sprinkler design. There was some recommendation has been discussed for overlapping under windy conditions. Similarly for sprinkler selection, application rate of different soil type was also discussed. Number of sprinkler per laterals was determined after an appropriate overlapping keeping in view the wind condition as 4km/hr (selected in the case study). The case study was carried out on 5 acres for groundnut cultivation in the Attock region of Punjab. Complete stepwise procedure was followed for the design of sprinkler system of irrigation. For that an excel sheet was used with formulas and presented. At the end of the session, all the relevant materials related to design of Solar, Drip and sprinkler was handed over to the organizers for the participants of professional training workshop. Some pictorials of the training workshop are attached as Appendix A;

Day 2nd (28th Dec, 2022)

1st Lecture (09:00-10:15):

This method was used to introduce theoretical concepts of the Solar PV system and its main components to the trainees by Dr. Abdul Wahab. Lecture included theoretical introductions of off-grid solar PV systems, solar pump types, installation and maintenance of solar panels, portable solar pumping, and solar systems utilization for lighting, fodder chopping and grain grinding. This session also focused on the system design and sizing. Various components of solar pumps used in Indus Basin Irrigation System (IBIS), systems utilization in different agriculture sector were introduced to the participants. Dr. Abdul Wahab gave brief lecture on fixed solar pumping and furthermore described about the economics and components of portable solar water pumping. Frequent classroom discussions and problem-solving exercises supported the lectures. At the end of lecture there was question and answer session by the attendees of the workshop.

2nd Lecture (10:15-11:30):

Second lecture was given by Engr. Akhtar Abbas on various components along with various measurement instruments of solar systems testing and performance analysis as explained below.

1. Assessment of the pumping requirements includes determining the desired flow rate, total dynamic head (TDH), and discharge pressure.
2. Selection of the appropriate inverter: Choosing the right inverter for the application requires considering factors such as power requirement for pumping, the required output voltage and current and remote access, and the intelligent control.
3. Sizing of the solar panels: The size required to power the pump system is determined based on the pump's power consumption, the local solar insolation, and the desired run time.
4. Battery bank sizing: If the pumping system is designed to operate during periods of low or no sunlight, a battery bank is needed to store excess energy generated by the solar panels during the day and provide energy to the pump during periods of low light.
5. Controller and wire selection: A controller is required to manage the energy flow from the solar panels to the battery bank and the pump. Proper wiring is required for efficient and safe power extraction from the power generation system.

6. Installation and commissioning: The second last point of the session was about the installing the components of the solar pump system, connecting the various components, and commissioning the system to ensure it is operating as expected.
7. Performance analysis: Power analysis by using multimeter and troubleshooting of system in case of lower power generation by the system. Testing of PV solar panel by using IV Curve Tracer.
8. Safety measurements and international standards for inverter, panel, and charge controllers were taught regarding safety at workplace.

The exposure visits were organized to give a hands-on experience to trainees in terms of real-life contexts and challenges of the solar PV pumping sector. During such events, participants observed scenarios, asked questions, and re-validated their learning. Trainees interacted with enterprise owners, technical persons, and other community members.

CEWRI Field Station Demonstration Site (11:30-13:15):

A 20kWp solar irrigation pump was installed at CEWRI field station.. The site had eight 300 Wp solar panels, a controller, and a submersible pump. The pump was operational during the visit, and the pumped water was diverted to the adjacent farm as irrigation was not required at that moment.

The participants were demonstrated by hands on training of multimeter usage for solar panel power generation. Participants were also given field experience of usage of IV curve analyzer for determination of efficiency of solar system based on the training classes. Participants were taught how to check efficiency deterioration through IV curve tracer. The participants verified the status of the pump and inverter regarding its O&M details.

Final Session (14:00-15:00):

This session's primary goal was to compile the lessons learned over the full two-day program. Participants solved and presented answers to a variety of theoretical and application-based challenges during the training's final presentation sessions. Theoretical presentations included the design of solar PV household systems and solar water pump systems as well as feasibility studies. Various concepts and computations relating to load analysis, panel sizing, battery sizing, inverter sizing, charge controller sizing, etc. were also presented by the participants. The participants also demonstrated their knowledge of system selection (among the ones that are offered on the market) from the PV system's theoretical design. It was also shown how to choose

cables from among the commercially available cable sizes on the market and how to size cables appropriately.

Conclusion:

Even though participant qualification levels varied greatly, the majority expressed great interest in the training. The training's efficacy has been demonstrated. Participants could thoroughly identify problems with the installed system and effectively complete the O&M checklist even if they had very little prior understanding of solar systems. Some of the participants shared knowledge-sharing events with their fellow participants and had considerable industry expertise. Reflections from participants that were shared with the group showed that most of them had learned from and appreciated the training and were looking forward to other opportunities for similar learning. The locations chosen for NARC were suitable for giving participants a hands-on presentation that would sum up the theoretical lessons. However, with more thorough organization, the field trip may have been organized more successfully. A demo setup at the training venue could have provided more opportunities for the participants to learn about the solar PV system.

Day-1	
1	Introduction and Overview of Solar energy
2	Components of a Typical Solar-Powered Pumping System
3	Multimeters and understanding PV Power
4	Integration of solar pumps and irrigation system
5	Field Trip to view solar Pumping Systems for High Efficiency Irrigation Installations
Day 2	
1	Solar pump design concept and procedure with case study.
2	Irrigation Demand and total dynamic head for solar pump sizing
3	Design of Small-Scale Solar lighting system at farm level
4	Use of Multimeters for Assessment of Solar Panel
5	General safety guidelines for installation and commissioning of photovoltaic system
6	Hands-On training ▪ Using a Multimeter ▪ Testing a PV solar Panel ▪ IV curve tracing using IV curve tracer
	Type of panels, solar pump types, installation of modules, installation of pumps, troubleshoots, fixed pumping system, portable pumping system, multiple use of solar power including lighting, household, fodder chopping and grain grinding etc.

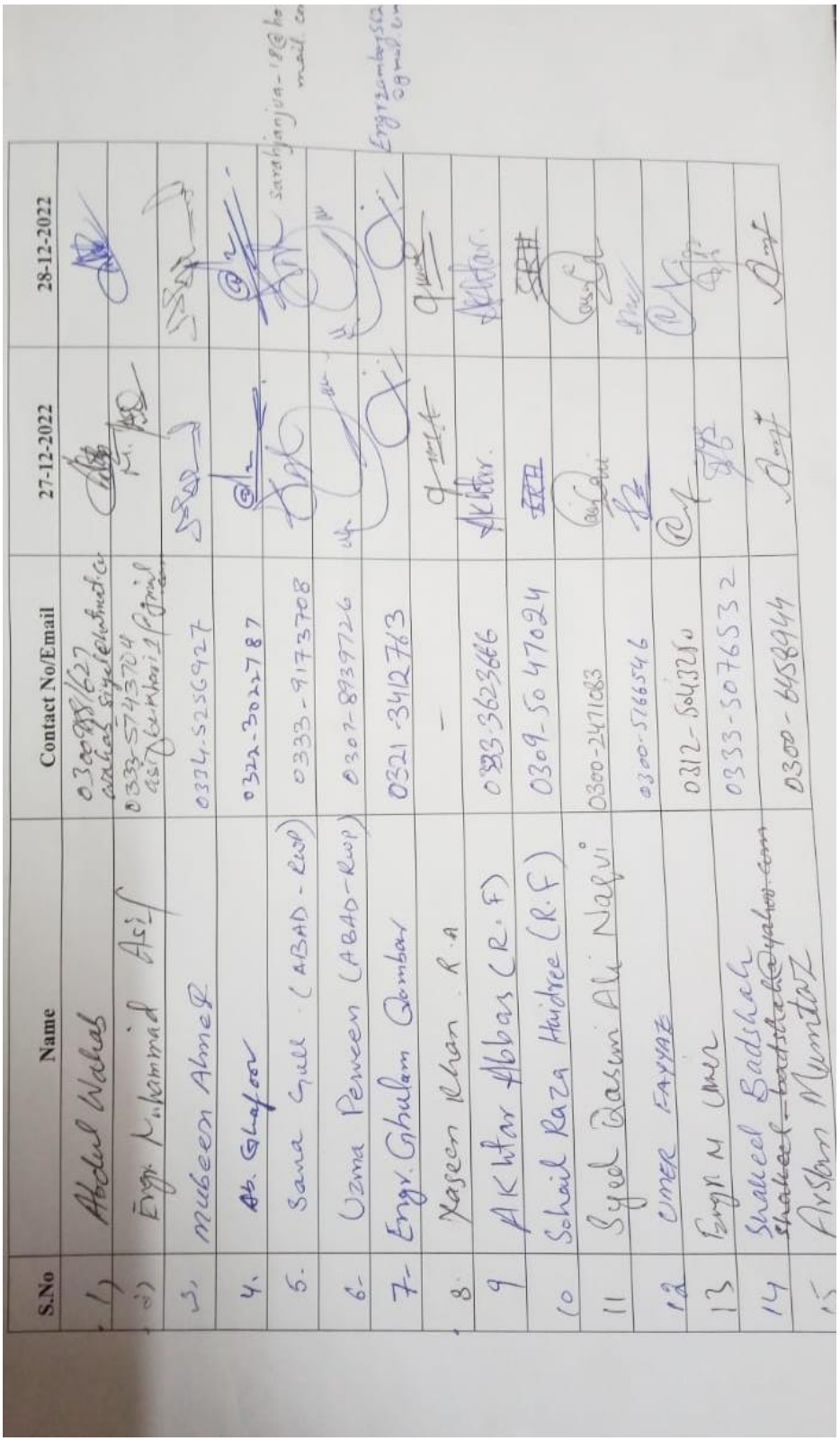
Table 1: Day-wise activities

Appendix A: Program Schedule

Monday December 26, 2022 **Venue: NARC Community Centre**		
Day-1		
Time	**Activity**	**Resource Person**
9:00-9:30	Registration	Mr. Yaseen Khan
09:30-09:35	Recitation from the holy Quran	
09:35-09:40	Welcome note & training objective	Dr Bashir Ahmad, Director CEWRI-NARC
09:40 09:45	Welcome note & training objective	Dr Shakil, Country Manager IWMI
09:45 10:30	Introduction: – Introduce yourself – Describe your technical background – Describe your experience with solar power – Do you have any project that you are currently working on in this area? – Describe what you hope to get out of this training workshop	
10:30-11:00	**Tea Break**	
11:30 12:30	– Over view of solar power – Components of a Typical Solar-Powered Pumping System – On Grid/off Grid/Hybrid solar system	Dr Abdul Wahab, SSO CEWRI NARC
12:30-13:00	– Integration of solar pumps and irrigation system- PARC Experience in the potohar and Thall region of Pakistan	Dr Bashir Ahmad, Director CEWRI-NARC
13:00-14:00	**Lunch/prayer**	
14:00-15:30	– Solar pump design concept and procedure with case study. – Irrigation Demand and total dynamic head for solar pump sizing – Hands on excersie for designing solar pumping unit for irrigation	Engr Muhammad Asif, SO, CEWRI-NARC
Tuesday December 27, 2022 **Venue: NARC Community Centre**		

Day -2		
09:00-09:10	Video on portable solar water pumping and future prospects	Dr Bashir Ahmad, Director CEWRI-NARC
9:15-10:15	Type of panels, solar pump types, installation of modules, installation of pumps, troubleshoots, fixed pumping system, portable pumping system, multiple use of solar power including lighting, household, fodder chopping and grain grinding etc.	Dr Abdul Wahab, SSO CEWRI NARC
10:15 10:45 10:45 11:30	– General safety guidelines for installation and commissioning of photovoltaic system – Design of Small-Scale Solar lighting system at farm level	Engr Muhammad Asif, SO, CEWRI-NARC
11:30 13:00	Use of Multimeters for Assessment of Solar Panel Hands-On training ▪ Using a Multimeter ▪ Testing a PV solar Panel ▪ IV curve tracing using IV curve tracer	Dr Abdul Wahab, SSO CEWRI NARC Engr Muhammad Asif, SO CEWRI NARC Engr Akhat Abbass, Research Fellow
13:00-14:00	Prayer, Lunch and end of program	
14:00 14:15	Chief Guest Remarks	
14:15 14:30	Participants Experience about training workshop	
14:30 14:45	Certificate Distribution	
14:45	Vote of thanks by DG NARC	
15:00	End of Workshop	

Appendix B: List of participants



S.No	Name	Contact No/Email	27-12-2022	28-12-2022
1.	Abdul Wahab	0300-5766546		
2.	Engr. Muhammad Asif	0333-5743704		
3.	Mubeen Ahmed	0314-5256927		
4.	Mr. Ghafoor	0322-3022787		
5.	Sana Gull (ABAD - Rwp)	0333-9173708		
6.	Uzma Perveen (ABAD-Rwp)	0307-8939726		
7.	Engr. Ghulam Qambar	0321-3412763		
8.	Yaseen Khan R.A	-		
9	AKhtar Abbas (R.F)	0333-3623666		
10	Sohail Raza Haidree (R.F)	0309-5047024		
11	Syed Qasim Ali Naqvi	0300-2471083		
12	Umer Fayyaz	0300-5766546		
13	Engr N Umer	0312-5643250		
14	Shakeel Badshah	0333-5076532		
15	Arslan Mumtaz	0300-8458944		

Attendance Sheet for Training Workshop on " Solar Powered High Efficiency Irrigation Pumping Systems and Other Uses " on 27-28 December, 2022

S.No	Name	Contact No/Email	27-12-2022	28-12-2022
16	ARSLAN JAVED	0334-5399285		
17	Badar Munir Niazi	0321-6609656		
18	Mahmood Ali	0321-6650659		
19	ABID Hussain	0342-2500222		
20	AMBREEN FATIMA	0336-5416287		
21	Dr. Fiaz Hussain	0306-5508264		
22	Dr. Arslan Afzal	0332-6975287		
23	Amjad Jamal	0332-8500989 amjad.jamal@cgiar.org		
24	Raja Ahmad	0316 8532612		
25	REHAN AHMAD	0334-7145153		
26	Ahsan Mukhtar	0335-9971185		

Appendix C: Photos

Fig:1 Lecture by Engr Asif on Solar pump design concept and procedure with case study.

Figure 2: Lecture conducted by Dr. Abdul Wahab on various solar pumping system

Figure 3: Participants interacting with Engr. Akhtar Abbas regarding solar sizing and troubleshooting

Figure 4: Engr. Akhtar Abbas explaining various solar technologies and their component

Figure 5: A site visit to Solar Irrigation Pump installation site in NARC at CEWRI Field Station.

Figure 6: Curve Analyzer utilization of performance evaluation of solar system.

Fig 7: Distribution of certificates among the participants, Dr. Abdul Wahab awarding certificate to the participant

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The International Water Management Institute (IWMI) is an international, research-for-development organization that works with governments, civil society and the private sector to solve water problems in developing countries and scale up solutions. Through partnership, IWMI combines research on the sustainable use of water and land resources, knowledge services and products with capacity strengthening, dialogue and policy analysis to support implementation of water management solutions for agriculture, ecosystems, climate change and inclusive economic growth. Headquartered in Colombo, Sri Lanka, IWMI is a CGIAR Research Center with offices in 14 countries and a global network of scientists operating in more than 30 countries.

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