IWMI
International Water Management Institute

CGIAR
Transforming Agrifood Systems in South Asia

SoLAR
Solar Irrigation for Agricultural Resilience

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Agency for Development and Cooperation SDC

CONFERENCE REPORT

Energizing Agriculture and Enabling Just Energy Transitions in South Asia

A Regional Knowledge Forum

06th to 8th February 2023
Venue: Indian Institute of Technology Gandhinagar, Gujarat

WRI INDIA

Global Green Growth Institute

IRENA
International Renewable Energy Agency

Ahmedabad University | Global Centre for Environment and Energy

ISA International Solar Alliance

german cooperation
DEUTSCHE ZUSAMMENARBEIT

Implemented by giz

About the Organizations

International Water Management Institute (IWMI)

IWMI is a research-for-development (R4D) organization, with offices in 14 countries and a global network of scientists operating in more than 30 countries. For over three decades, our research results have led to changes in water management that have contributed to social and economic development. IWMI's Vision, reflected in its Strategy 2019-2023, is 'a water-secure world'. IWMI targets water and land management challenges faced by poor communities in developing countries, and through this, works towards the achievement of the Sustainable Development Goals (SDGs) of reducing poverty and hunger and maintaining a sustainable environment.

Solar Irrigation for Agricultural Resilience

The Solar Irrigation for Agricultural Resilience in South Asia (SoLAR-SA) project aims to sustainably manage the water-energy and climate interlinkages in South Asia through the promotion of SIPs. The main goal of the project is to contribute to climate-resilient, gender-equitable, and socially inclusive agrarian livelihoods in Bangladesh, India, Nepal and Pakistan by supporting government efforts to promote solar irrigation. This project responds to government commitments to transition to clean energy pathways in agriculture. All countries in this project have NDC commitments to reduce GHG emissions and SIPs can play a significant role in reducing emissions in agriculture.

Swiss Agency for Development and Cooperation

The SoLAR -SA project is supported by the Swiss Agency for Development and Cooperation (SDC). SDC is the agency for international cooperation of the Federal Department of Foreign Affairs (FDFA). Swiss Agency for Development and Cooperation, which is an integral part of the Federal Council's foreign policy, aims to contribute to a world without poverty and in peace, for sustainable development. SDC, through its Global Programme Climate Change and Environment (GPCCE), helps find solutions to global challenges linked to climate change. It engages in global political dialogue and manages specific projects in the fields of energy, climate change adaptation, sustainable development of mountainous regions and prevention of natural hazards that are likely to influence regional and international policy.

Dr Kiran C Patel Centre for Sustainable Development

The Dr Kiran C Patel Centre for Sustainable Development (KPCSD) at IIT Gandhinagar undertakes cutting-edge research on sustainability and related challenges of high societal importance. It promotes cost-effective and sustainable solutions through its strong outreach and technology-transfer programmes. KPCSD strengthens and complements sustainability research and development activities underway at IITGN across diverse Engineering, Science, and Humanities and Social Science disciplines. The Centre strives to identify, prioritize and lead sustainability-related thrust areas and promote research on sustainability. The Centre enables our faculty and students to develop practical solutions through the integration of advanced research, traditional knowledge and field understanding. It addresses major sustainability challenges and translates them into prototypes, patents, and publications through supporting various research activities of the faculty and students of IITGN.

World Resources Institute

WRI is a trusted partner for change. Using research-based approaches, we work globally and in focus countries to meet people's essential needs; to protect and restore nature; and to stabilize the climate and build resilient communities. We aim to fundamentally transform the way the world produces and uses food and energy and designs its cities to create a better future for all. Founded in 1982, WRI has nearly 1,800 staff around the world, with country offices in Brazil, China, Colombia, India, Indonesia, Mexico and the United States and regional offices in Africa and Europe.

The Global Green Growth Institute

GGGI is a treaty-based international, inter-governmental organization dedicated to supporting and promoting strong, inclusive and sustainable economic growth in developing countries and emerging economies.

The International Renewable Energy Agency

IRENA is a lead global intergovernmental agency for energy transformation that serves as the principal platform for international cooperation, supports countries in their energy transitions, and provides state of the art data and analyses on technology, innovation, policy, finance and investment. IRENA drives the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy in the pursuit of sustainable development, energy access, and energy security, for economic and social resilience and prosperity and a climate-proof future.

Ahmedabad University - Global Centre for Environment and Energy

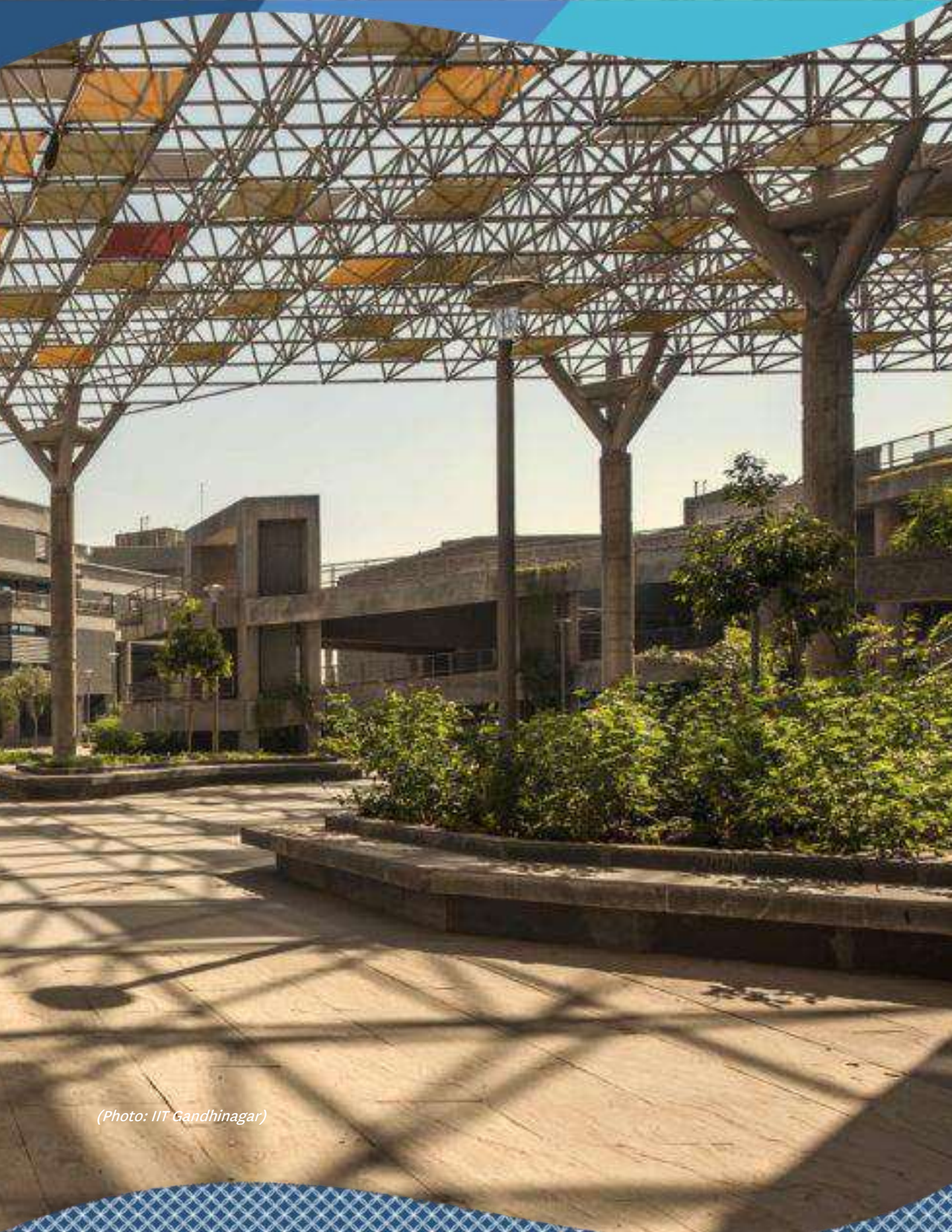
Global Centre for Environment and Energy is a one-of-its-kind Centre of Excellence at Ahmedabad University. The Centre fosters and pursues interdisciplinary research, and designs technological and social experimentation related to climate change, energy and natural resources. Areas of expertise include but are not limited to assessing global climate change and its impacts, development pathways and long-term scenarios for India, climate and energy policy, urban mitigation and adaptation strategies, low carbon technologies, aerosol modelling and environmental impact of aerosols.

The International Solar Alliance

ISA is an action-oriented, member-driven, collaborative platform for increased deployment of solar energy technologies as a means for bringing energy access, ensuring energy security, and driving energy transition in its member countries. The ISA strives to develop and deploy cost-effective and transformational energy solutions powered by the sun to help member countries develop low-carbon growth trajectories, with particular focus on delivering impact in countries categorized as Least Developed Countries (LDCs) and the Small Island Developing States (SIDS). Being a global platform, ISA's partnerships with multilateral development banks (MDBs), development financial institutions (DFIs), private and public sector organizations, civil society and other international institutions is key to delivering the change its seeks to see in the world going ahead.

German Society for International Cooperation

GIZ, or the Deutsche Gesellschaft für Internationale Zusammenarbeit (German Society for International Cooperation), is a federal enterprise of the Federal Republic of Germany that provides services to promote sustainable development worldwide. GIZ works in over 130 countries. A leading provider of international development services and has a long history of working in developing countries. It is committed to working in a sustainable and responsible way and to making a positive difference in the lives of people around the world.



(Photo: IIT Gandhinagar)

CONCEPT

Science is unequivocal that emissions of Greenhouse Gases (GHG) by humans have caused global warming. We live in a warmer world where global surface temperatures are ~1.2 degrees Celsius higher than in pre-industrial times and the impact of climate change, including extreme events, are being felt by a large section of people everywhere and disproportionately so, by the poor and vulnerable population, in the Global South. Hence, it is imperative to keep global temperatures within the Paris Agreement goals of 1.5°C - 2C, which requires sharp reductions in GHG emissions in this decade.

Just Energy Transition for South Asia

Energy transition involves moving away from fossil fuels to renewable energy sources to reduce GHG emissions. In this context, just energy transitions are strategies that allow these systemic changes to happen in fair and equitable ways to ensure that the costs and benefits of climate action are distributed equitably. More than 60% of South Asia's population is engaged in agriculture; this sector is highly exposed to climate hazards such as heat waves, droughts, floods, and the rainfall variability. Current impact and future risks are compounded as those involved in the sector are highly vulnerable. Thus, Just Energy Transition, particularly in agriculture, is critical for South Asia.

Solarizing South Asian Agriculture

South Asia is home to 25-30 million agricultural pumps, the largest worldwide. These pumps, powered by either dirty diesel or electricity, cause substantial carbon emissions from groundwater irrigation. Replacing these fossil fuel-based pumps with solar irrigation pumps (SIPs) is an effective mitigation strategy. Unlike agricultural emissions, mitigation strategies (such as improved water management in paddy or fertilizer management protocols which can have short-term negative productivity impact), replacing fossil fuel-based pumps with SIPs has no negative productivity impact. Deployment of solar technologies for rural enterprises and agricultural processing and value chain improvements are happening across South Asia and policies underpinning their implementation and institutional models that support them are crucial for their success.

The SoLAR Regional Forum

The forum was proposed as a two and half-days conference of regional researchers, policymakers, and practitioners in the renewable energy sector. It was co-organized by the International Water Management Institute (IWMI), Swiss Agency for Development and Cooperation (SDC), Indian Institute of Technology, Gandhinagar (IIT-Gandhinagar), Ahmedabad University, Global Centre for Environment and Energy, International Renewable Energy Agency (IRENA), World Resources Institute (WRI), India, International Solar Alliance (ISA), India, and the Global Green Growth Institute (GGGI).

THEMES OF THE CONFERENCE

Theme 1: Solarizing Smallholder Irrigation

(Policy landscape and empirical evidence of the impact of solar irrigation pumps (SIPs) on farmers' incomes and livelihoods)

The adoption of solar irrigation pumps (SIPs) has rapidly increased in South Asia in the last decade. The region now has nearly 300,000 SIPs. Various technical, financial, and institutional models have also been tried. In this session, we welcome presentations and panel discussions on the policy landscape of solar irrigation in South Asia, issues related to the governance of utilities that affect solar irrigation, and impact of solar pumps on diesel use and farmers' livelihoods and incomes.

Theme 2: Conserving Groundwater through Solar Irrigation

(Empirical evidence and future projections)

Given the zero marginal energy costs of solar pumping, there are apprehensions that the rapid spread of SIPs will lead to excessive groundwater use for irrigation, causing depletion in regions that are already water scarce. In this session, we look forward to presentations and panel discussions providing empirical evidence of the impact of SIPs on groundwater use or model the same, given future climate change scenarios.

Theme 3: Connecting off-grid to the Grid

(Pilots and lessons from grid-connected solar irrigation projects)

SIPs started as an off-grid enterprise in South Asia but most countries felt the need to shift to on-grid solar irrigation over the years. This is because on-grid solar pumps help electricity utilities meet their renewable energy mix targets. At the same time, feed-in tariffs are attractive for consumers (farmers) and investors, if set right. Incomes derived from selling electricity to the grid can incentivize farmers to pump less groundwater without losing income. In this session, we solicit presentations and panel discussions on grid-connected solar pumps' technical, policy and institutional aspects.

Theme 4: Renewable Energy in Agricultural Value Chains

(Institutional models, policies, and case studies on livelihoods and impacts)

Renewable energy (RE) is used in many agricultural processes, including irrigation, harvesting, drying, post-harvest processing or cooling and preserving agricultural products. In this session, we solicit papers and posters that examine policies, institutions, and financial models that support the use of RE in agriculture and empirical case studies that look at the impact of RE in agriculture and its effect on farmers' livelihoods and incomes. Presentations and panel discussions on the use of RE in agricultural processes other than irrigation are also welcome.

Theme 5: Making Energy Transitions Inclusive and Equitable

(Is renewable energy transition Gender, Equity, and Social Inclusiveness (GESI) compatible?)

The requirement that RE policies and institutions are GESI transformative is at the heart of just energy transition. In this session, we look forward to presentations and panel discussions on RE policies, technologies, and institutions from a GESI perspective, and examine if they are gender transformative or not, and the ways in which these can be made so.

FORMAT OF THE CONFERENCE

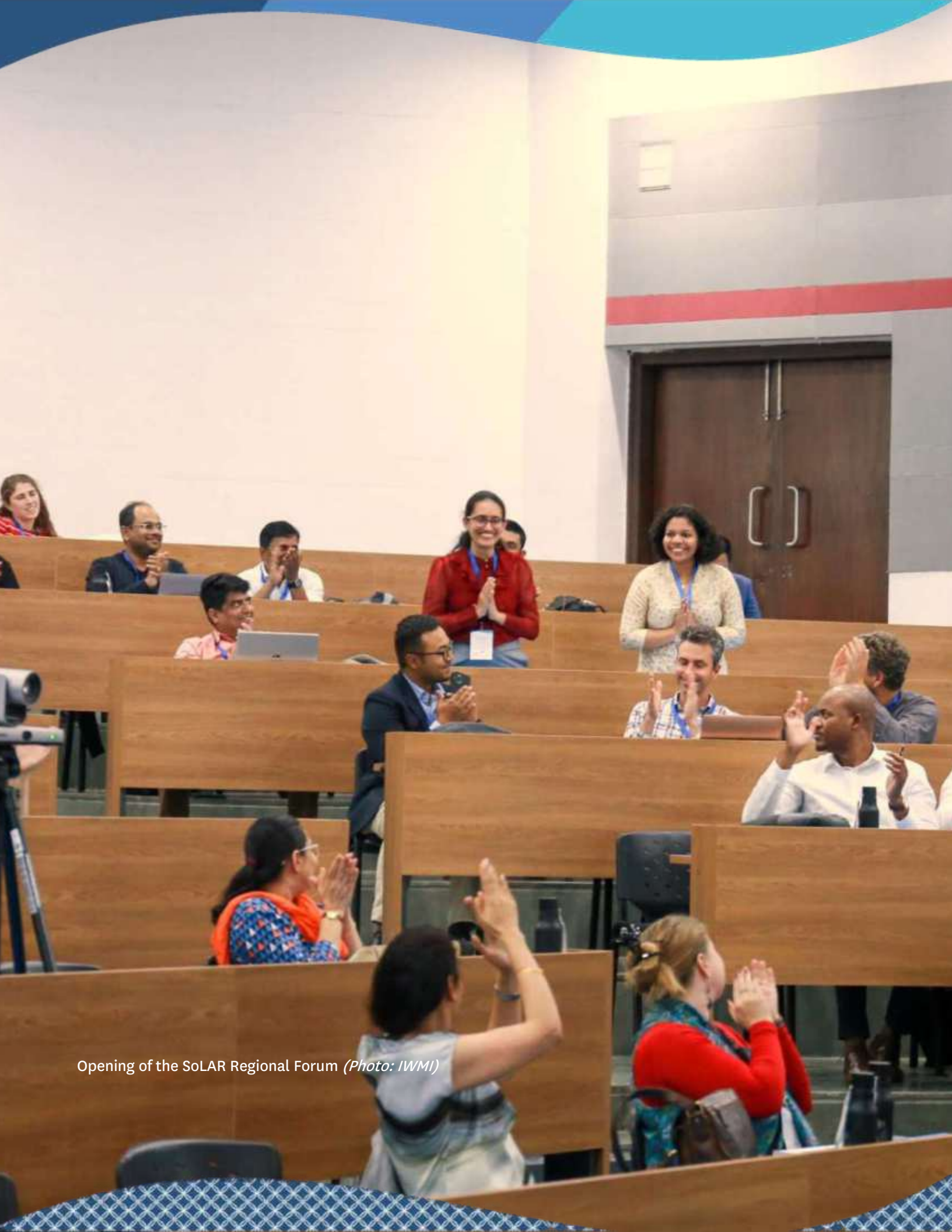
The conference was organized in a hybrid format, with most of the participants (invited as speakers and panelists) participating on-site and others joining online. The conference sessions were divided into three distinct categories:
1.1 **Keynote Sessions**: Keynote speakers were invited to deliver their talk on broader key issues in the sector spread over **2 days** and **4 plenary sessions**.
1.2 **Technical Sessions**: Participants were selected internally by the conference partners, based on prior or ongoing work and experience and to present their work under the five themes of the conference across a total of **14 Technical** sessions. These sessions were designed by the conference organizers and were conducted in person.
1.3 **Partner Sessions**: All conference co-organizers organized at least one session on one of the above-mentioned themes. Partners were given complete flexibility to design their sessions, invite suitable panelists and speakers, and prepare the dissemination material.
2 **Field Visits**: All in-person attendees were given the option to join a half-day-long field work to solar irrigation pumps (in operation) sites and had the opportunity to interact with farmers and utility officials and visit a training facility of Gujarat Energy Research Institute (GERMI), Gandhinagar.

PARTICIPATION

The conference was attended by a total of **189 participants** (including **131 in-person** and **58 virtual participants**) from across **16 countries**, representing over **70 institutions** globally, with a key focus on participants from Africa, Central Asia, and South Asia.

SESSIONS AND PRESENTATIONS

The conference was planned for **2 days**, divided into **4 plenary** and **14 technical sessions** (including partner sessions). These sessions brought together **8 keynote presentations**, **57 technical presentations** and **8 panel discussions**.



Opening of the SoLAR Regional Forum *(Photo: IWMI)*

Day 1: February 6, 2023

Plenary Session 1 - Setting the scene: Agriculture and Energy Transition in South Asia

Inaugural Session - Welcome Address: *Alok Sikka (IWMI)*

Dr. Alok Sikka (IWMI, Country Representative India) welcomed all country partners and conference partners (WRI, SDC, ISA, GIZ, GGGI, IRENA), emphasizing on the representation from 16 countries. He introduced the importance of this assembly in the context of clean energy adoption, addressing ground water depletion in the water-energy intensive region of Southeast Asia. In this context, he also emphasized that the adaptation and mitigation to Climate Change (CC) must be derived from the notion of Just Transition pathway. In his conclusive remarks, Sikka provided an overview of the overall nature and work of IWMI focusing on the thematic areas that the organization has worked on over the recent years.

Opening Remarks: *Janine Kuriger (SDC)*

Janine Kuriger, Head of Division of the Global Programme, Climate Change and Environment (GPCCE), SDC, emphasized on the reality of CC and especially, focused on decarbonization. As other sectors of energy start to decarbonize, the agriculture sector also comes into focus. However, the Agri sector must focus on a pathway that is equitable in nature, while considering the aspect of small holder farmers. Emphasizing on the principles of equity, she laid down the importance of equitable distribution of cost and benefits. With this premise, it was important to promote discussion and ideation on sustainable and fair transition of the agriculture sector; sensing the bigger intersection across multiple stakeholders and how it was important to have a bigger stakeholder discussion is how Kuriger ended her session.

Opening Remarks: *Rajat Moona (IIT Gandhinagar)*

Rajat Moona appreciated the institutional collaboration for the conference emphasizing the need for a reversal specially in the context of addressing the issues of CC and its effect on agriculture in the South Asia region. In order to address this, a systemic reversal is necessary, which can happen only through grass roots connection and a **solar based system** would be **pivotal** in this process. He also discussed the sustainability initiatives undertaken by the campus, for example, on how IIT Gandhinagar was the first campus to have a GRIHA 5-star large area development rating (equivalent to the LEAD platinum rating), net-zero discharge, rainwater harvesting system known as *Jal mandap* tanks, and solid waste management.

Opening Remarks: *Frank Rijsberman (GGGI)*

Frank Rijsberman, GGGI, highlighted the need for transformation of agri-food system as the need of the hour; however, the overarching principle must be decarbonization (sequester), ecosystem conservation, and rehabilitating degraded ecosystem with the aim to decrease emission effectively, conserve biodiversity, thereby, building resilience. In order to achieve this, there are many pathways and focus areas, such as agro-forestry, bio economy, forest economy, circular economy, climate smart agriculture and regenerative agriculture. Focusing on GGGI's work on Agrifood system, (forest conservation/forest economy, reforestation, solar irrigation, etc.), Rijsberman presented case studies from different locations such as Peru (promoting the inclusion of small holder producers in forest economy); Indonesia forestry (forest conservation, mangrove restoration REDD+ result based project, jurisdictional forest management program); Uzbekistan (green rehab investment project, small farmers to rehabilitate the area); Ethiopia (land stewardship program, reforestation, nature-based solutions); Nepal

(climate smart agriculture, reintegrating the displaced through Climate smart project); African nations such as Burkina Faso, Ethiopia, Uganda (working on solar powered systems micro and mini grids); Korea (reduction on methane focusing on livestock sector), etc.

Insights from the SoLAR Project: *Aditi Mukherji (IWMI)*

Aditi Mukherji set the context and tone for solar and agriculture in South Asia region. Her presentation explored questions of whether SIPs contribute to adaptation & reduce vulnerability to climate risks. It was evident from the case study of Nepal and Bangladesh that SIPs provide assured irrigation in case of rainfall variability and, also provide supplementary irrigation during the monsoon, when there is a gap between two rainfall events. In Bangladesh, farmers receiving irrigation from SIP and electric pumps tend to grow more summer Paddy while high-cost diesel farmers diversify their crops to low water consuming crops. Similarly, in the case of Nepal, those who adopted SIP were more likely to grow new crops in Nepal. Lastly, SIP adoption leads to enhanced incomes and contributes to overall savings from reduced diesel use. In Nepal, it is evident that SIP adoption has led to an increase in transition towards high value crops. Similarly in the case of Gujarat (SKY scheme), agriculture households had an increase in earning opportunity by selling extra electricity generated.

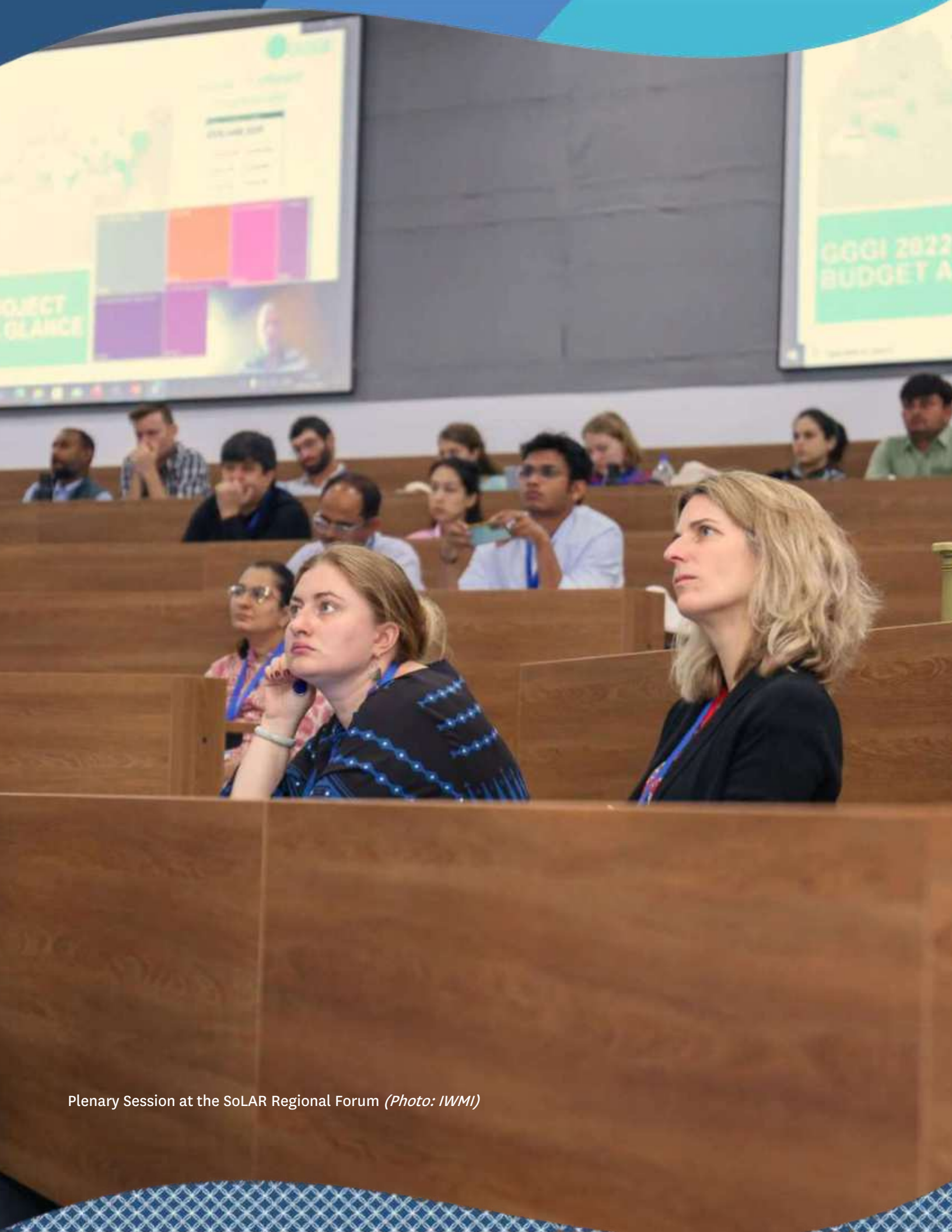
However, there are several fundamental issues with SIP adoption – SIPs and equity outcomes are mixed and not very well understood. Small, marginal farmers and sharecroppers get access to SIPs though the elite capture remains a significant threat. In the context of ground water pumping in India, preliminary data showed no significant difference in volume of groundwater pumped by the grid connected SIP and electric pump owners. Similarly, evidence from Bangladesh suggests no substantial difference in groundwater application for summer paddy between solar and diesel pumps. However, there is a need to maximize the command area to optimize SIP water use. Finally, Mukherji discussed the potential benefits of grid connection of SIPs to replace millions of diesel and coal-based electric pumps, and provide income for farmers even during climatic stress, hence, reducing energy loss.

Energy Transition in Agriculture: *Ulka Kelkar (WRI)*

In the opening plenary, Ulka Kelkar, emphasized the need for transition and discussed that the energy demand in the agriculture sector is projected to increase two times in the next three decades. However, energy-related CO2 emissions in Indian agriculture can be reduced ~80% by 2050 through renewable energy, energy efficiency, water-use efficiency, carbon tax on electricity, etc. Highlighting the premise for up-scaling of solar based systems in the agriculture sector, she presented two case studies – Assam (Solar based off grid cold storage 5 tons, FPO based (run by women) and Jharkhand (LEADS Ragi Processing unit).

Apart from talking about the benefits, she presented the challenges posed by solar based systems, through the case study of Pavagada solar park. The land cultivation declined by 88% compared to 24% in the neighboring villages. The impact of such a project was that women landless worker lost access to the land and it was clear that to promote just transition, focus should be given to social safety nets and skilling of women.

[For full presentations and zoom recordings. Click here]



Plenary Session at the SoLAR Regional Forum *(Photo: IWMI)*

DAY 1: FEBRUARY 6, 2023

TECHNICAL SESSION 1: SOLARIZING SMALLHOLDER IRRIGATION- EVIDENCE FROM SOLAR

Theme 1: Solarizing Smallholder Irrigation

Session Description: *South Asia has seen a major upsurge in the adoption of solar irrigation pumps in the last decade, and yet, very little is known about the impact of those pumps on farmers and their livelihoods. This session will present the findings from the SoLAR project on the impact of solar irrigation pumps on agricultural outcomes.*

Co-benefits of Solarizing Irrigation for Farmers: The Case of Bangladesh - *Marie Charlotte Buisson (IWMI), Ahasan Habib (NGO Forum)*

In the context of the water-food-energy-climate nexus, the study aimed to understand the impact of access to SIP on the farm level and the pathways that explain the outcomes, adaptation, and co-benefits of using SIP in Bangladesh. The current irrigation narrative is diesel dominated, (over 3 million hectares being irrigated by diesel pumps). This leads to carbon emissions, estimated to be around 27 million CO2 equivalent. This burdens the forex reserves with over 2.6 USD billion spent on the import of diesel. Around 2464 SIP (50 MW capacity) has been installed by various agencies such as IDCOL, BREB, BMDA and BADC RDA. The findings from the study are as follows:

- Access to solar irrigation positively impacts yield, value of outputs and added value for dry season irrigated Boro paddy.
- These effects, particularly that of higher yields of boro paddy are explained by a combination of three pathways:
    1. The first and strongest pathway is the release of constraints related to water uses for SIP users with SIP irrigated plots receiving more water (especially) before transplanting and in the late vegetative stage of the crop growth.
    2. Second pathway is that the SIP users benefit from lower costs of irrigation without any associated increase in other input costs.
    3. The third pathway is a change in time allocation with SIP users spending less time on irrigation.
- In Bangladesh's context, where the development of solar irrigation remains costly and relatively slow while benefits from omitted emissions are under-valued, these results argue for a more accurate and comprehensive measurement of the benefits associated with solar irrigation.
- It also positions solar irrigation as one of the only mitigation strategies without trade-off and with co-benefits for farmers' adaptation to CC and shocks.

Impact of SIPs on Agricultural Outcomes and Farmers' Diesel Use: Evidence from Nepal - *Shisher Shreshtha (IWMI)*

Around 20% of the 9,100 farmers who had applied for SIPs, received subsidized SIPs from AEPC. Among those who applied for SIPs, AEPC chose smaller and DAGs farmers. SIP farmers from the Disadvantaged group reported higher benefits (farmers received almost 100% subsidy - 60% from AEPC and the rest from private companies and local governments). SIP reduces diesel use but does not necessarily replace it (SIPs are used for ~750 hours and SIP owners use diesel pumps for ~275 hours in a year). Through linear models, it was estimated that SIP farmers reduced diesel pump use by 64 and 33 percent for monsoon paddy and wheat, respectively. Farmers who received SIPs are less likely to use diesel pumps by 17 p.p. and 20 p.p for monsoon paddy and wheat, respectively. SIP farmers are also shifting their cropping pattern from cereals to vegetables.

It was found that 21% of SIP farmers introduced new crops, mostly vegetables, after using SIPs. A 1% increase in SIP use is associated with a 7% increase in the likelihood of introducing new crops. The cumulative impact is that SIP farmers earn more revenue compared to non-SIP farmers. Even though there are many co-benefits, O&M, and breakdowns remain a major issue. Therefore, there is a need to allocate funds for the capacity building of technicians to address this to improve adoption.

Understanding the SKY Scheme in Gujarat: How do Technical and Financial Models Work on the Ground? - *Deepak Varshney (IWMI)*

The study aimed to understand the factors that determine the enrolment into SKY, ground-level operationality of the technical and financial model, and the performance of energy generation, earnings as well as evacuation status. The major outcomes of the study were as follows:

- Strategies to improve participation rates for marginal and small farmers by addressing both demand and supply-side constraints.
- The technical model of SKY seems to work well on the ground. The loan-repayment period of 7 years largely explains that despite the evacuation of energy by 90% of farmers, only 58% are earning a positive income.
- Our simulation result suggests that increasing the loan-repayment period may help increase the percentage of farmers who earn positive income and their current income.
- Evacuation-based incentive fares better for well-performing farmers (in terms of solar generation) compared with a one-time 30% subsidy at the time of installation but not for the poor-performing farmers.
- Back-of-envelope cost-effective calculations suggest that the returns to the financial investment in SKY are very high. In fact, one-fourth of the financial cost was recovered in the first two years of the implementation itself.

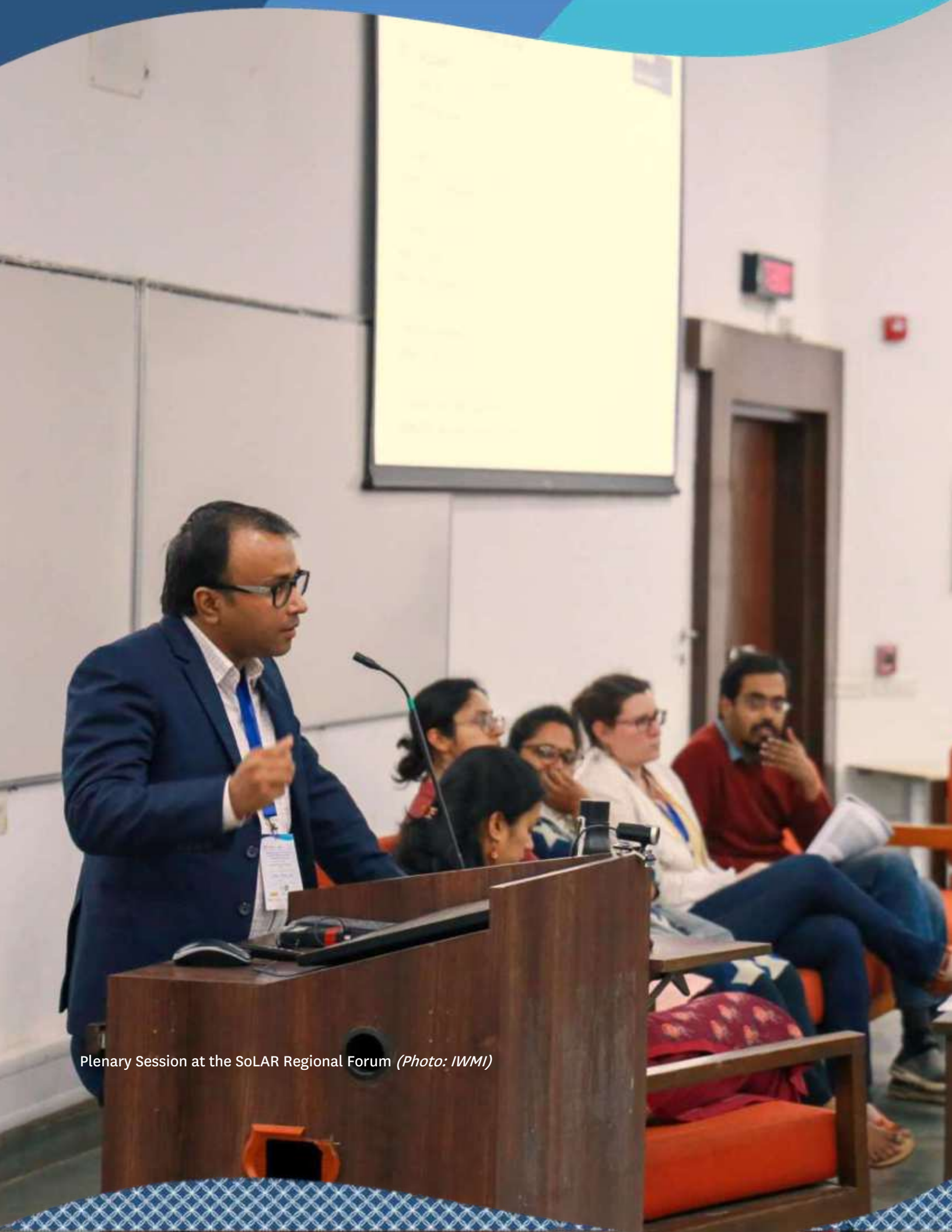
Perception Vs Reality: In-situ Instrumentation Analysis for Solar & Non-Solar Farmers - *Azeem Shah, Zain Akbar (IWMI)*

As part of the SoLAR program, installations have been done for GW Monitoring, soil moisture and Simulation of grid-connected pumps. A total of 12 sites were monitored with in-situ instrumentation, including 6 SIPs and 6 non-SIPs. Four sites were being monitored in each of the following districts chosen for the behavioral study.

- Chakwal (Northern Punjab)
- Jhang (Central Punjab)
- Rahim Yar Khan (Southern Punjab)

Though the results from the instrumentation data and behavioral analysis are inconclusive, some interesting outcomes have been observed. Results from in-situ instrumentation data tend to contradict results from pumping behavior results of the Behavioral survey. It was observed that SIPs lead to more pumping of Groundwater. Pumping and soil moisture data indicate that SIP farmers growing sugarcane in Canal fed areas of Punjab are pumping more.

[For full presentations and zoom recordings. Click here]



Plenary Session at the SoLAR Regional Forum *(Photo: IWMI)*

DAY 1: FEBRUARY 6, 2023

TECHNICAL SESSION 2: GROUNDWATER ISSUES IN THE CONTEXT OF IRRIGATION INTENSIFICATION AND CLIMATE CHANGE

Theme 2: Conserving Groundwater Through Solar Irrigation

Session Description: Groundwater has always been the mainstay of irrigation in South Asia and issues of groundwater over-extraction have emerged as an important management challenge, especially in the context of climate change. This session will discuss the major challenges of groundwater management and how solar irrigation can likely affect groundwater use in the near future.

Groundwater Security of India: Interplay of Science and Policy - *Abhijit Mukherjee (IIT Kharagpur)*

The presentation highlighted the usage and status of groundwater in modern India. According to the water commission, irrigation consumes 85% of the groundwater. On one hand, India is facing water scarcity, while a few regions in India face an excess of water, such as floods, which lead to drinking water crises for humans and livestock and in turn, causes diseases.

In the Indus-Ganges-Brahmaputra-Meghna (IGBM) river basins, 70% of the groundwater use contributes to 21% of the land mass. From 2003-2014, it got depleted heavily while in South India it was replenished. Assam has the maximum depletion in IGBM due to the significant role played by agriculture. Apart from this, restricted subsidized electricity hours for groundwater use caused groundwater to replenish in Gujarat. 3 km3/year gets replenished, while 10 km3/year gets lost.

Excessive Pumping Limits the Benefits of Strengthening Summer Monsoon for Groundwater Recovery in India - *Vimal Mishra (IIT Gandhinagar)*

The increase in rainfall alone does not guarantee the recovery of lost groundwater, primarily due to the concurrent increase in pumping. While higher rainfall contributes to replenishing groundwater reserves, excessive pumping can offset or even surpass the replenishment rate, leading to a net loss of groundwater. The dominance of non-renewable groundwater abstraction further exacerbates the issue of groundwater storage. When the rate of groundwater extraction exceeds the rate of natural recharge, the available groundwater reserves become depleted over time. This unsustainable extraction practice puts immense pressure on the groundwater storage, leading to long-term consequences for water availability.

Implementing measures to limit the depth of groundwater extraction and tube well depth can result in significant water and cost savings. By restricting the depth of groundwater abstraction, the water source can be preserved, ensuring its long-term sustainability. Additionally, reducing the depth of tube wells can minimize the energy and operational costs associated with pumping groundwater. Addressing the larger issue of climate change can also play a crucial role in preserving groundwater storage, particularly in regions like North India. Limiting the global mean temperature rise within 2℃, as outlined in the international climate agreements, can have a positive impact on the groundwater storage. A controlled temperature rise can help mitigate the adverse effects of climate change, such as changes in precipitation patterns and increased evaporation rates, which directly affect groundwater availability.

Ensuring the recovery and sustainability of groundwater storage requires a comprehensive approach. Simply relying on increased rainfall may not be sufficient, especially in the face of excessive pumping hence, addressing non-renewable groundwater extraction, implementing measures to limit extraction depths, and taking global climate action steps are essential towards safeguarding groundwater resources for future generations.

The Bengal Water Machine—Understanding Recharge Dynamics in Bangladesh - *Anwar Zahid (BWDB)*

The issue of groundwater depletion is particularly alarming in Dhaka city and the Barind area of Bangladesh. Despite the operation of the Barind Water Management (BWM) project since 2000, around two-thirds of the wells in the region do not exhibit the desired impact of the project in curbing groundwater depletion. Compounding the problem, there has been a decline in monsoon water availability from 2001 to 2018, even with the BWM project in operation. This suggests that additional measures are needed to address the declining water levels in the region.

Bangladesh possesses a multi-layered aquifer system, with the shallow aquifer being replenished by rainfall and long-distance water recharge happening from other areas. To ensure the sustainability of groundwater resources, it is crucial to maintain pumping rates below the replenishment rate (R) to prevent overexploitation. Developing a water budget and water management plan can help regulate groundwater pumping and allocate water resources effectively. To address water stress in the region, Managed Aquifer Recharge (MAR) techniques should be adopted. MAR involves deliberately recharging aquifers with surface water or excess rainfall to replenish depleted groundwater levels. By implementing MAR, water-stressed areas can effectively recharge their aquifers and ensure the long-term sustainability of groundwater resources.

In Summary, the alarming rate of groundwater depletion in Dhaka city and the Barind area necessitates immediate action. Despite the implementation of the BWM project, the desired impact has not been achieved in a significant portion of the wells. Sustainable water management practices, such as regulating pumping rates, preparing water budgets and plans and adopting MAR techniques, are crucial for mitigating groundwater depletion and ensuring the availability of water resources in the affected areas.

The Trajectory of Groundwater Development in Bangladesh - *Anindita Sarkar (University of Delhi)*

One of the main challenges faced in Bangladesh is the declining land-to-area ratio. As the population continues to grow, the available land for various purposes, including agriculture and infrastructure, becomes limited. This puts additional pressure on resources, including the groundwater. In Bangladesh, major policy decisions have significantly influenced the use of groundwater while surface water usage has remained relatively low. Policies and regulations related to groundwater abstraction and management have played a crucial role in shaping the patterns of water use in the country.

The development of groundwater resources in Bangladesh relies on three important pillars. Firstly, investment and cost play a critical role in the development and utilization of groundwater. Adequate financial resources are required for drilling wells, installing pumping infrastructure and maintaining the equipment. Without sufficient investment, groundwater development becomes challenging. Secondly, technology and accessibility are vital for effective groundwater use. Access to appropriate technologies for groundwater extraction and management is essential for sustainable utilization. The availability of equipment, tools and techniques that suit the local conditions and hydrogeology is crucial. Additionally, ensuring accessibility to groundwater resources for all stakeholders, including farmers and communities is important to promote equitable use and management.

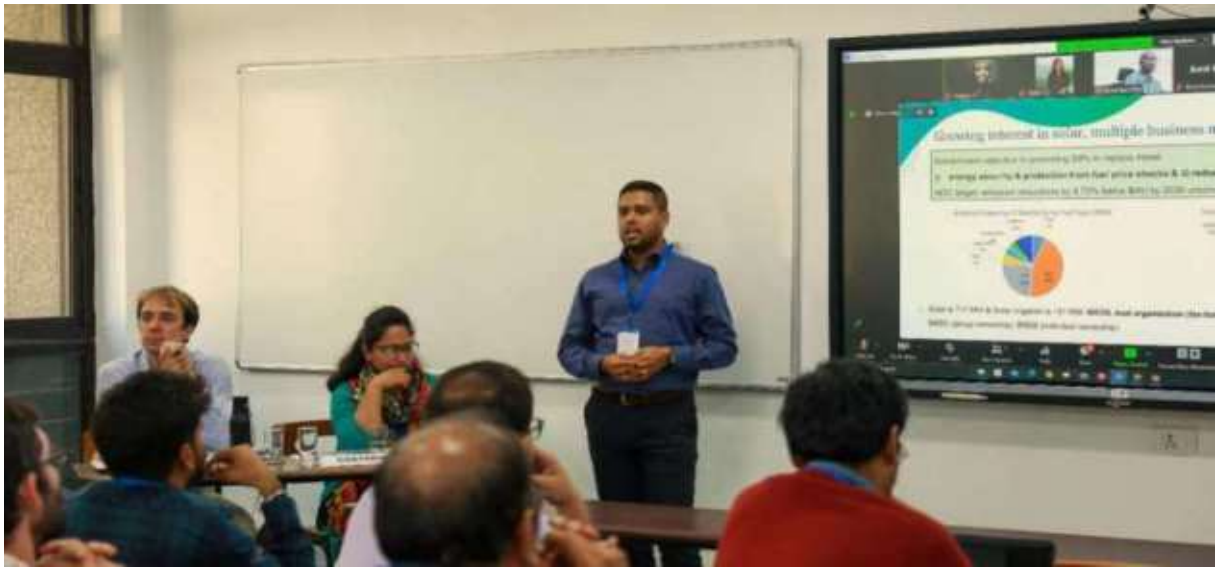
The third pillar is the government's priority and intention in managing groundwater resources. The commitment and support of the government through policies, regulations and initiatives are crucial in ensuring sustainable groundwater development. The government's intention to prioritize groundwater management and address issues related to over-extraction, quality deterioration and equitable distribution is essential for long-term sustainability. Addressing the challenges associated with the declining land-to-area ratio in Bangladesh requires a holistic approach that encompasses effective policies, sustainable investment, appropriate technology, and the commitment of the government to prioritize groundwater management. By addressing these pillars, sustainable groundwater development can be achieved, ensuring the availability of water resources for the growing population and various sectors of the economy.

Understanding the Impact of Upscaling Solar Irrigation on the Sustainability of Groundwater in Bangladesh -

Mohammad Faiz Alam (IWMI) and Md. Abdul Haque (NGO Forum)

Based on field studies and data collected over a one-year period, it has been observed that there is a significant amount of variability within a specific location. This indicates that there are variations in factors such as groundwater levels, water availability and pumping patterns even within a relatively small area. When comparing the performance of solar and non-solar pumping systems, the difference observed is not significant, with a variation of around +-10%. This suggests that the choice between solar and non-solar pumping systems does not have a substantial impact on pumping for the Boro crop specifically. However, it is important to note that this conclusion should be confirmed with data collected over an additional year to ensure the validity and consistency of the findings.

Similarly, household surveys conducted in the area have shown some variations, although not significant enough to draw conclusive results. The numbers obtained from the surveys may differ slightly but the overall differences are not considered highly significant. To gain a clearer understanding of the relationship between different pumping systems and their impact on crop irrigation and water availability, it would be beneficial to continue collecting data over an extended period and conduct further analyses. Long-term data collection can help identify trends, patterns, and potential correlations between different factors that contribute to more accurate and reliable conclusions.



Zahid Osmani (NGO Forum) presenting in a technical session at the SoLAR Regional Forum *(Photo: IWMI)*

DAY 1: FEBRUARY 6, 2023

TECHNICAL SESSION 3: SOLAR ENERGY FOR AGRICULTURAL INCOME AND LIVELIHOOD

Theme 1: Solarizing Small Holder Irrigation

Session Description: *South Asia has seen a major upsurge in the adoption of solar irrigation pumps in the last decade, and yet, very little is known about the impact of those pumps on farmers and their livelihoods. This session will present the findings from partners and other IWMI-led projects on the impact of solar irrigation on rural livelihoods.*

Solar Energy for Rural Livelihood - *Shilp Verma (IWMI)*

The presentation provided the roadmap of the pilot projects to be initiated by IWMI-India along with its partners. The project aims to mainstream smallholder farmers by enabling friendly and sustainable value chains. Systematic field pilots, complementary field studies and policy engagements are phased out to create a rural livelihood, agriculture value-chain, lucrative and sustainable model of irrigation practices and value-chains of produce. Two regions are chosen for the study – (A) Indo-Gangetic Floodplains (Bihar, Nepal Terai) characterized by high population, largely rural and agrarian poverty, where land holdings are small and highly fragmented. These regions have high well density with abundant groundwater yet energy infrastructure to access the groundwater has yet to be supported through public or private funds. – (B) Central Indian Tribal Heartlands (Jharkhand) mainly consist of tribal populations residing in undulating geography. The land holding is relatively higher in the tribal population deprived of irrigation services, and which also suffers from a poor grid connection, market access and connectivity.

In Bihar, IWMI partners with Aga Khan Rural Support Programme AKRSP (India) and Jeevika-BRLPS for creating a solar saturation cluster of 25-30 villages. The cluster would encompass a production cluster run by women's Self-Help Groups (SHGs). The project aims to be an advisory entity on solar irrigation expansion in the Nepal Terai region and generate south-south knowledge expansion. Field pilots in Jharkhand are planned out as three models: individual distributed micro-SIPs, solar energy enterprise model and community models. These models are designed to be water buffer-friendly environments in terms of cost and access to groundwater. All three initiatives are phased out in the consultation, dissemination, and policy design stages.

The presentation brought up discussions on solar life cycle management during the Q&A sessions. Given the individual spread of the Micro SIPs, the best cost-effective life cycle management that the discussion provided was to repurpose old solar panels for other domestic uses.

Role of Solar Irrigation for Agricultural Development in Bangladesh - *Sarwar Hossain (BADC)*

In Bangladesh, irrigation is categorized by extensive diesel pump irrigation spread. Increasing diesel prices have a huge impact on the cost income of farmers. Around 13 lac diesel pumps emit 9100k-ton carbon dioxide. The diesel pumps used are carbon-emitting sources. Despite being relatively low, when aggregated, the emissions are large that can be mitigated. Solar Irrigation pumps offer the right solution for being a cost-effective and cleaner energy source. Given the high average solar radiation and bright sun days, Bangladesh has a huge potential for SIP. At present, just 3,414 SIPs are generating 56.695 MWp. To upscale the use of renewable energy and expand SIPs, the

government of Bangladesh has been framing different national-level policies. These policies are targeted at the production and expansion of SIPs and grid integration of solar irrigation pumps. The challenges that lie ahead are high upfront costs, achieving efficiency in water usage and collecting water chargers from farmers.

Scenarios for the Deployment of Solar for Groundwater Irrigation in India - *Nitin Bassi (CEEW)*

India is the largest abstractor of groundwater in the world, with 87% of the groundwater being used for irrigation. With PM-KUSUM, agriculture is an important sector for transition towards clean energy. In order to help policymakers, implement the proper procedures to assure the adoption of solar-based irrigation while considering the various regional constraints, CEEW has created a decision support tool. District-wise aggregated data of parameters concerning environmental sustainability, economic viability, and social equity. Weights are assigned to parameters using the Delphi approach. Based on the parameters and weights assigned, districts are assigned into three categories (A) suitable for feeder-level solarization, (B) suitable for individually owned off-grid solar pumps (C) suitable for solarization of individual grid-connected pumps. The tool provides more field-based evidence for scaling up PM-KUSUM.

Solar Irrigation; Cost Reducing Technology in Agriculture Case Study in Nepal - *Sanjib Bimali (DoA)*

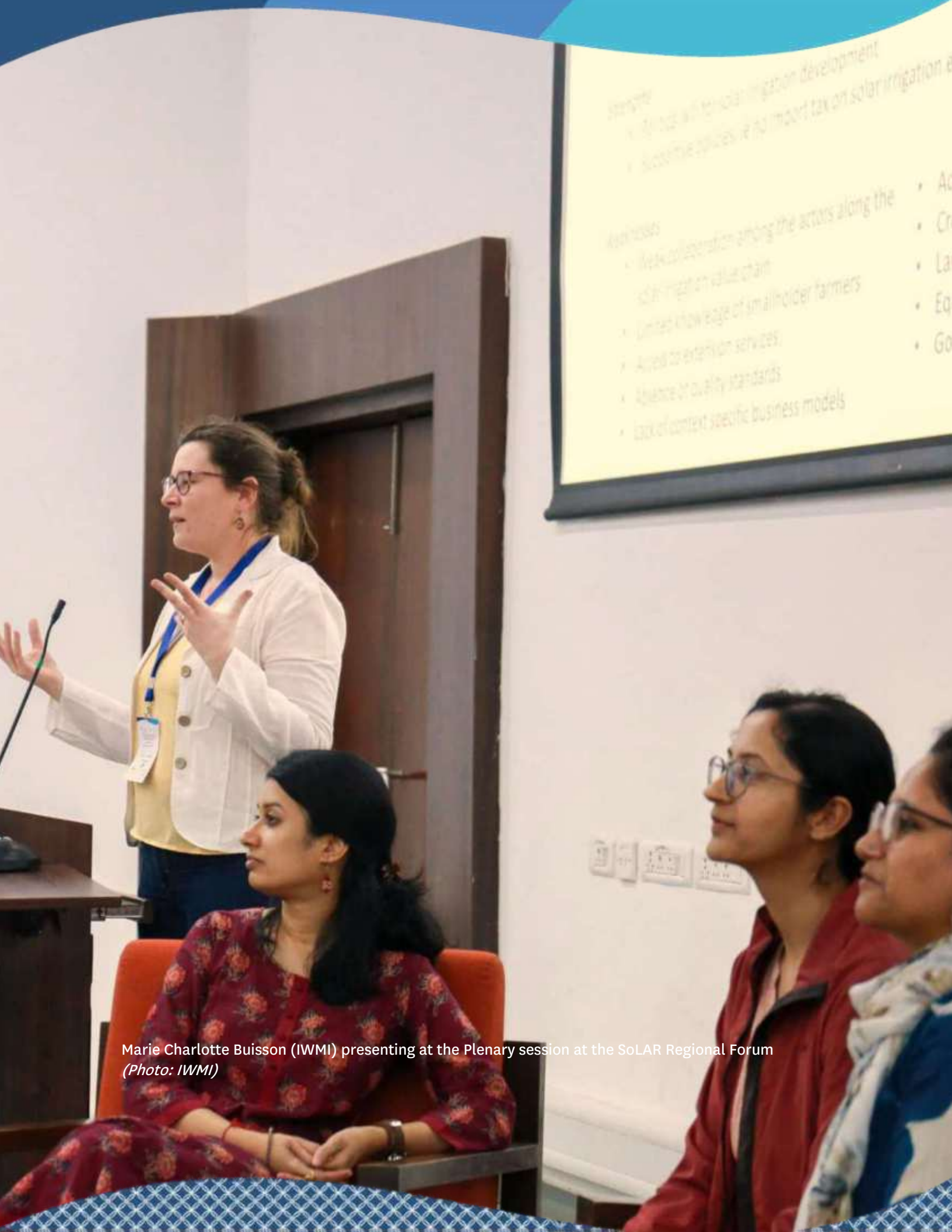
Nepal's government, through the Ministry of Agriculture and Livestock Development, provides an 85% subsidy on providing SIP in regions (that are dry areas) where no previous scheme of surface irrigation is available. Several other programs and schemes have been implemented under the subsidy model: Alternative Energy Promotion Center (AEPC) and the Prime Minister Agricultural Project (PMAMP). The study aims to study the cost and benefit of SIPs pre-and-post-intervention through case studies in Nepal's selected districts (Kaski and Sarlahi). The study captures farmers' perspectives and quantitative cost and income data at individual farm levels of two sites as case studies. While there is cost saving due to the rising diesel cost and shift to subsidized SIP, farmers also feel a sense of ownership and have better yields due to timely water availability. At the individual farm level, SIP is operated only at 20% of its potential and thus, has vast scope when operated in a community that needs to be explored.

Upazilla Permits in Bangladesh: Effective Regulation or a Constraint for Small Holder Farmers wanting to Invest in Solar Irrigation? - *Saidur Rahman (BAU)*

Bangladesh has Upazilla permits (license for water extraction from rivers, aquifers, and new machines) for land irrigation. This is targeted at better management of groundwater. The study highlighted three questions: (a) Why was the Upazilla groundwater permit re-introduced? (b) What was the policy discourse before the re-introduction, and how did it contribute? (c) How are the permits implemented at the ground level?

The study looked at six villages: diesel-operated machines, two villages with electric-operated machines and two with SIP. Responses were collected through FDGs, and structured questionnaires from owners and users. 52% and 54% of owners and other users reported no issue with the permit system. Most of the respondents reported government irregularities and bribery as significant hindrances.

[For full presentations and zoom recordings. Click here]



Marie Charlotte Buisson (IWMI) presenting at the Plenary session at the SoLAR Regional Forum
(Photo: IWMI)

DAY 1: FEBRUARY 6, 2023

TECHNICAL SESSION 4: SCALING UP OFF-GRID SIPS IN SMALLHOLDER AGRICULTURE

Theme 1: Solarizing Smallholder Irrigation

Session Description: *Installation of solar pumps in off-grid areas which are currently rainfed or dependent on diesel irrigation gives farmers access to a clean energy alternative for irrigation, often with multiple adaptation co-benefits. These regions are more often cultivated by poorer smallholder farmers. Scaling up solar irrigation in off-grid areas requires financially and institutionally sustainable models that are also equitable. This session will discuss the challenges and potential solutions for scaling up off-grid solar irrigation.*

State of Solar Irrigation in Bangladesh: Learnings for Solarization in off-grid Areas of South Asia - *Archisman Mitra (IWMI), Zahid Osmani (NGO Forum)*

The presentation highlighted the importance of diesel-based irrigation for food security, as it sustains a significant portion of Boro cultivation. However, the increased use of diesel-based irrigation has negative impact, such as increased carbon dioxide emissions and a subsidy conundrum. The study analyzes the impact of transitioning to SIPs, with findings indicating a significant reduction in diesel use and labor costs. However, challenges such as high CAPEX, liquidity constraints, risk aversion, and lower CUF exist. The study suggests increasing capacity utilization, promoting grid integration and net-metering, and considering a higher buyback rate to address these challenges.

Solar Pumping Looking Beyond the Obvious - *Prodyut Mukherjee (EnGenuity)*

The study highlights innovative decentralized solar pumping interventions, which were classified as centralized generation - decentralized pumps and decentralized generation - decentralized pumps. Over a 20-year period, SIPs were found to be a profitable option despite their high upfront costs and zero marginal usage costs. The study emphasizes that a one-size-fits-all approach would not be effective in scaling up SIPs, and it is crucial to consider context-specific, SHG-based designs. Additionally, it is necessary to decouple solar generation from pump usage and explore multiple pumps connected to centralized generation to improve overall capacity utilization. The limitations of government programs, such as being straight-jacketed by design, low-capacity utilization due to individual focus and non-inclusion of women, need to be addressed through a holistic and context-specific approach. It is important to recognize that access to irrigation is dependent on reliable and cheaper power that needs to be considered to reduce dependence on other sources of irrigation such as diesel.

Do small farmers make optimal use of solar irrigation pumps: Evidence from Nepal - *Dan Oziel (Tel Aviv University)*

The study focuses on utilization as a key factor in addressing the gap between optimal pricing and utilization when scaling up SIPs. The study finds that a SIP can only be cheaper than a diesel pump if it is used to its fullest extent, and over a 20-year lifecycle. The net value is positive compared to diesel, even after taking into account, replacement and O&M costs. However, the condition is that the capacity utilization factor (CUF) needs to be high. Currently, farmers do not tend to use solar to its full extent, with utilization being only at 80-87%. The study explores the hypothesis that the low utilization of diesel pumps is due to various reasons, such as winter foggy days, enough rain to meet irrigation requirements, insufficient sun hours per day, expensive and hard-to-find labor, and insufficient water for irrigation. The study leaves an open-ended question to understand the limitations of SIP usage, as it has a significant impact on their profitability.

Panel Discussion: How Sustainable is the Off-Grid Model of Solar Pumps?

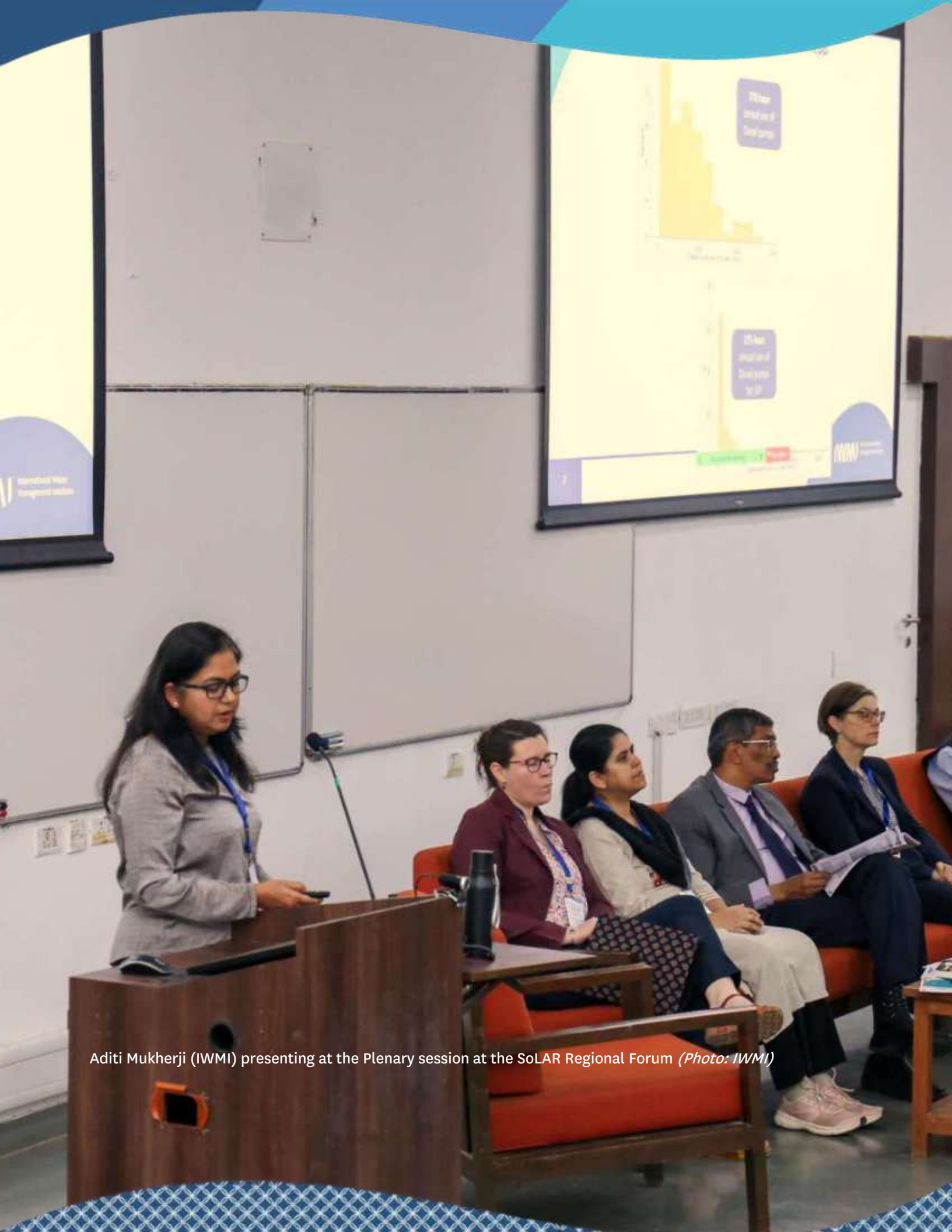
Moderator: *Archisman Mitra*

Panelists: Kalpana Kumari Katwal (Barahatwa Municipality, Nepal); Omar Diouf (GGGI); Shilp Verma (IWMI); Ashok Biswas (DEA, Bangladesh), Adebayo Oke (IWMI Ghana)

The panel discussion brought out a multitude of insights from different locales. The major highlights from the discussion are as follows:

- Transition to SIP forms of locus of energy use transition narrative across all geographies. However, some of the major challenges were attributed to access to credit, proper irrigation facilities and large CAPEX upfront. In this regard, Bangladesh has come up with three unique models to promote SIPs in rural areas that are generally beyond the scope of grid connections.
- Another interesting highlight that came from Nepal was that it was evident that Diesel pumps are difficult to maintain and ergonomically unsuitable for female farmers. The Govt. of Nepal provides significant levels of subsidies that covers up to 85 percent of the cost of setup. However, there are significant gaps in terms of know-how at the institutional levels that requires training functionaries and capacity building to promote SIPs.
- SIPs In India face a similar issue in terms of the scale up part, however an interesting conundrum arises in the case of India, where the eastern regions, known for being the best suited areas of SIP have significantly low CUF as compared to the Western belt. Therefore, the aspect of reducing the diesel and electricity dependence is achieved through price-market mechanism by scaling up SIP's.
- Deployment of SIPs in the West African region like Ghana faces similar challenges of financial viability. In terms of scaling up off-grid systems the farmers' cooperative and farmer group have been explored as an important pathway.
- All the panelists unequivocally agreed upon the aspect of elite capture in terms of SIP scale-up that exists due to installation requirements that need high upfront capital.

[For full presentations and zoom recordings. Click here]



Aditi Mukherji (IWMI) presenting at the Plenary session at the SoLAR Regional Forum *(Photo: IWMI)*

DAY 1: FEBRUARY 6, 2023

TECHNICAL SESSION 5: MAKING ENERGY TRANSITIONS INCLUSIVE AND EQUITABLE

Theme 5: Making Energy Transitions Inclusive and Equitable

Session Description*: A just and equitable energy transition is a critical part of climate action yet pathways for such transitions are not always clear. In South Asia, discussions on just transitions are still at an early stage and this session will deliberate on the pathways for the same.*

Elements of a Just Transition - *Jim Skea (Imperial College, London)*

The presentation is based on practical, realistic, and affordable recommendations that could support the Scottish Ministry for a just transition towards a 2045 Net-zero Economy. These recommendations include - Develop a Comprehensive Water Management Plan that addresses the challenges faced by farmers, especially with regards to irrigation to ensure that they are not left behind during the transition. Create a training and education program for coal miners, oil and gas engineers, and other workers in high-carbon industries, providing them with necessary skills and knowledge to transition to the renewable energy sector. Establish a community-driven approach that empowers local economies, especially those in regions heavily reliant on high-carbon industries, to be a part of the transition process and benefit from the opportunities it presents. Ensure that the benefits of climate change action are shared widely while ensuring that the costs are distributed fairly and based on the ability to pay. This includes supporting low-income households to access clean and affordable energy as well as promoting fair work and land tenure practices.

It also talked about setting up a Just Transition Commission that focuses not only on the supply side but also on the demand side and recognizes the importance of "place" in the transition process. The Commission should monitor and evaluate the transition plan and engage meaningfully with other sources of expertise with annual reports being published. Establish a Citizen Climate Assembly that represents the demographic diversity of Scotland to ensure that climate emergence is dealt with in an effective and fair way. By following these recommendations, Scotland can maximize the economic and social opportunities presented by the transition to a net-zero economy while ensuring that the process is just and equitable for all.

Reconciling Justice with Coal Phase-out: District Level Analysis from India - *Minal Pathak, Kopal Agrawal (Ahmedabad University)*

The study focuses on addressing the issue of distributive justice in the coal transition process in India, using a social, economic, and environmental framework. India's dependency on coal is not just energy dependency but also social and economic dependency and the energy systems need to adapt quickly to reach net-zero goals. The shift that was supposed to take place over generations must now be completed in the ensuing decades, resulting in an early phase-out of coal. The research aims to answer two main questions: how the burden and benefits of the transition are distributed through coal-dependent districts and how vulnerable these districts are to the transition. The study area includes 9 states and 119 districts. The research methodology focuses on distributional justice and uses a vulnerability index on three issues: dependency of the district, intensity of the dependency, and adaptive capacity of the district.

Gender and Inclusion in Energy Transitions - *Joyashree Roy (AIT)*

The study focuses on gender, equity and just transitions that include both decarbonization and portfolio management. Food production, crops, and water are important aspects, and inefficiencies at different levels can be improved. The methodology focuses on the rising uncertainty, food production, distribution, and delivery mechanisms from a nutritional point of view. Addressing inefficiencies in the food subsystem can reduce CO2 emissions. Developing skills to move away from fossil fuels is a supply-side effort. Women are often pushed into manual and low-paying jobs and gender aspects need to be considered carefully in climate transitions. The study looks at nine diverse countries in the global South, with a focus on gender aspects and equitable distribution in just transitions.

Gender Considerations in Renewable Energy Policies: Evidence from South Asia - *Manohara Khadka (IWMI)*

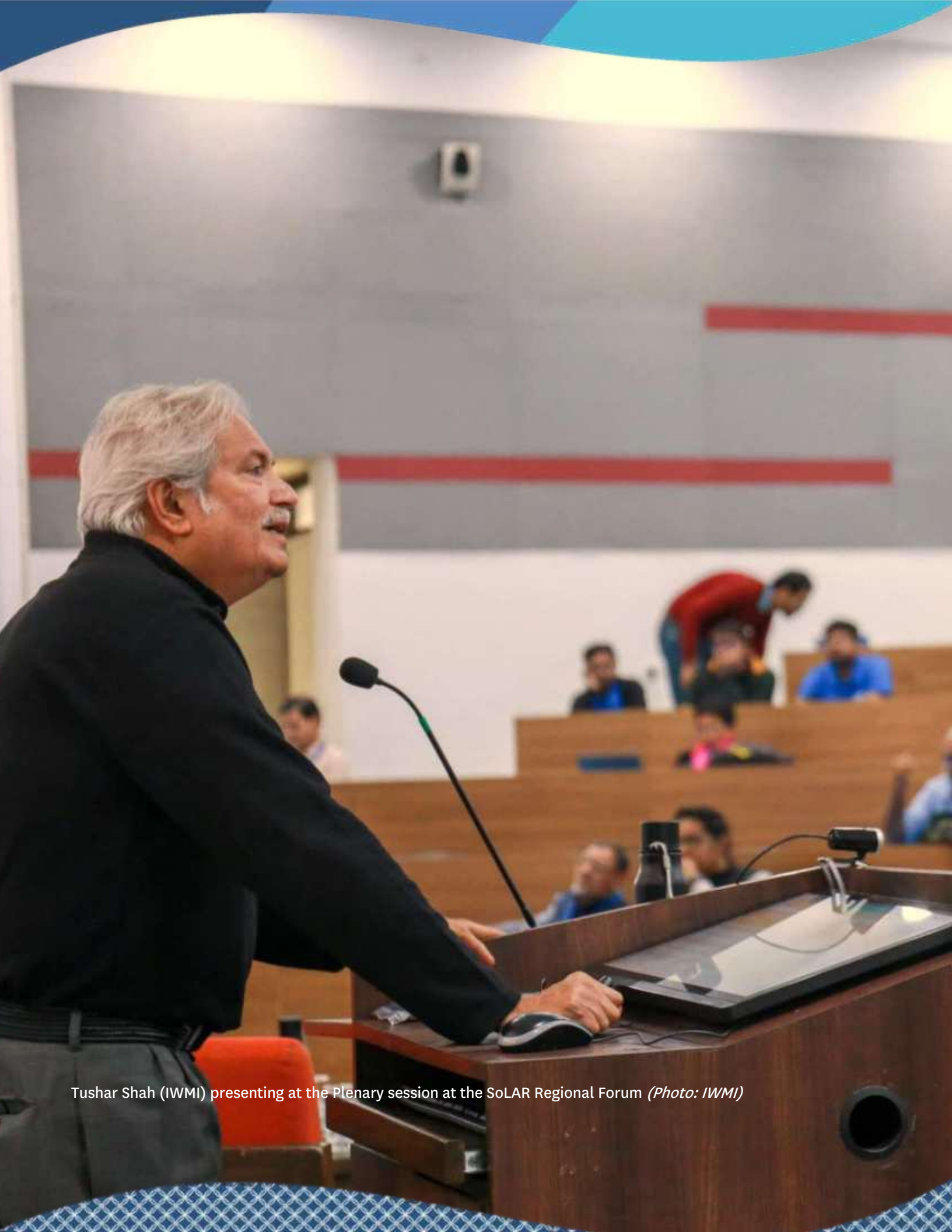
The study focuses on deep-rooted gender and social inequalities and discrimination in South Asia's socio-cultural and decision-making systems, specifically regarding access to water, energy, food systems technologies and information. The research objective is to investigate if the current energy policies and related water and agricultural policies that support solar irrigation, promote gender inequality or transformative change, in South Asia. The research questions are about how gender equality and social inclusion have been integrated and conceptualized in policies related to the water, energy, and food/agriculture sectors and how policies related to solar irrigation subsidies and financing mechanisms have incorporated and put into practice GESI principles. The methodology is policy analysis using the Gender Transformative Approach (GTA), which considers agency, relations, and structure. The results show that there are currently no subsidy policies or financing mechanisms designed specifically to ensure access to SIPs for women and tenant farmers, thus, creating a gap in gender, equity, and social inclusion. However, some agencies promoting solar irrigation have made efforts to address GESI concerns, with around 22% of SIP recipients being women in Nepal and approximately 30% of SIP farmers being smallholders in Bangladesh.

Panel Discussion: Mainstreaming Just Energy Transitions in the South Asian Context

Moderator: *Aditi Mukherji, IWMI*

Panelists: Jim Skea (Imperial College, London) – virtual, Minal Pathak (Ahmedabad University), Joyashree Roy (AIT) – virtual, Shwetal Shah (State Climate Change Department, Government of Gujarat), Manohara Khadka (IWMI)

The discussion on South Asian countries revolves around sector-specific issues, particularly the informal sector, and how employees can be protected. When it comes to food security, the focus should not only be on mitigation but also on development. There is a need to improve productivity while reducing emissions and working across sectors. Intersectionality is a crucial aspect of the discussion, particularly the intersection of women, policy change and development. Mitigation and adaptation are essential and energy access should be prioritized in adaptation. India should speak on energy access before aiming for carbon neutrality, and cost-effective transitions should empower people. The mainstreaming of regional policies and state knowledge is critical and the solar rooftops are a possible solution. Agriculture should also be included in just transition and diesel to solar conversion in farms should be explored. A detailed understanding of the energy basket is necessary for decarbonization and policy making should be analyzed beyond the structural barriers of gender.



Tushar Shah (IWMI) presenting at the Plenary session at the SoLAR Regional Forum *(Photo: IWMI)*

DAY 1: FEBRUARY 6, 2023

TECHNICAL SESSION 6: INNOVATIONS IN SOLAR TECHNOLOGY FOR SMALLHOLDERS' LIVELIHOODS

Theme 1: Solarizing Smallholder Irrigation

Session Description: *The SDC-supported and IWMI-led SoLAR project has provided small grants to support various innovations in the space of solar irrigation applications. In this session, the Innovation Fund Grantees will provide an update on their innovations and their readiness for upscaling.*

Solar Irrigation for Agricultural Value Chains: Creating Livelihoods for Small and Marginal Women Farmers - *Aakriti Srivastava (Urmul Seemant Samity)*

The Thar region despite being one of the most arid areas is home to several plantations that contribute to the ecosystem. However, the region faces a 40% shortage of green fodder that adversely affects 70 million farmers, 70% of whom are women. This shortage leads to fluctuation in milk production, as a single cow produces 70-120 kg of methane. To address this, the Bahula dairy model has been developed, which involves a fodder solution and biogas to achieve net-zero dairy. Solar-powered microclimate-controlled vertical farming systems are used at the ground level to produce carbon-negative, high protein fodder at a low cost. This innovation has the capacity to produce 100-170 tons of fodder and provides several benefits, including self-sustaining systems that are run by two women farmers, a registered increase in milk production and fat content and 7,500 units of electricity produced in one year. Bahulaverse is the first to pilot this technology and caters to agro-pastoralists. Community mobilization and sensitization have been conducted, ensuring better quality feed and seed, and instant milk chillers have been disseminated. Bahula, a social enterprise promoted by Urmul, links farmers to markets, impacting 1,000 markets and ensuring $31,000 per month income enhancement in the last quarter. The enterprise also develops wheatgrass powder, with the surplus being sold back to farmers, making it a sustainable solution.

Excess Energy Accumulation and Redistributed Network (EARN) - *Ayan K. Deb, Karsan Reddy (CINI)*

The organization works across the pre and postproduction value chain and focuses on enabling solar irrigation with precision farming and access to credit and cold storage. They work mostly in Jharkhand with tribal households with a landholding of 3.2 acres governed by Gram Sabhas (given rights by the government). Even if 35% of a 5 HP pump is yet to be utilized, 1,000 hours of irrigation is employed for 5 to 10 metric tons of production. The organization aims to create a decentralized microgrid through the aggregation of existing solar pumps, utilizing excess energy available for 3-4 hours a day. They plan to set up three productive loads (oil expeller, rice huller, and flour mill) at the Khunti site and have a tripartite agreement with government agencies (Gramsabha, CInI, and PRADAN) for this purpose. Challenges include onboarding the Gram Sabha, convincing all three stakeholders to approve changes in design, finding a tech consultant for remote areas, marketing the livelihood center near the village, and identifying and building the capacity of an entrepreneur from the village. The organization aims to pull in 100 households for each productive load, with an estimated annual profit of Rs 43,000 per year.

Livelihood Improvement of Dug well Dependent Vulnerable Communities through Energy and Water Efficient Responsive Drip Irrigation Systems - *Bashir Ahmed (PARC)*

The water and climate crisis in Pakistan has led to government schemes benefiting only big farmers, while 90% of farmers are smallholders. An innovation has been proposed to provide a viable irrigation and agricultural

production system for dug and open wells, as well as access to solar energy for marginal farmers and financing for irrigation efficiency. The innovation involves customizing the operation of the Responsive Drop Irrigation Line (RDI) with solar power, which feeds water to plants from small pores and only stops after receiving a hormonal signal from the plant. The RDI system has successfully experimented with different vegetables and fruits at various sites, resulting in low water and energy consumption, low system cost, and no significant difference in yield. The next steps involve promoting regenerative agriculture for small farmers, training farmers, developing tech demonstration centers and continuous research for optimization of the solution.

Helping Smallholder Farmers Access Finance - *Indranil Dasgupta (SwitchON)*

The innovation is a mini solar pump for women farmers, which aims to create an ecosystem of technology and finance to promote the adoption of micro solar pumps and establish a revolving guaranteed fund. The fund is set up with a bank to ease financing by giving collateral-free loans to women and guarantees to banks on behalf of "unbankable" customers, especially women who do not have land. The goal is to install 20 SIPs (0.3 to 2 HP) for women farmers, and so far, 356 women have been sensitized, 11 exposure visits have been conducted, water user groups have been formed, and livelihood diversification has been achieved. The innovation aims to enhance income, additional savings, and cost-effective agriculture. Previously, farmers were skeptical of the solar pump, but now they have adopted it as the water output is satisfactory, and they are interested in adding micro-irrigation with SIPs. Water user groups are acting as platforms of change for women. Initially, banks were not optimistic about giving loans to landless women, but after one and a half years, the bank saw good returns, Punjab National Bank also became interested in the scheme.

Mobile URJA-Scalable Solar Power with Innovations beyond Silicon Technology - *Suraj Kumar (KARM5)*

Mobile URJA is an innovative solution that aims to provide affordable and sustainable energy for irrigation through mobile solar power units. The initial idea of a pump on wheels had transport issues due to uneven land, but the current idea is to use larger pumps with one supercharger and transport the panels where tractors can go. This mobile solution can be rented out to multiple users and serves as a “fuel” without any recurring costs, providing opportunities for new entrepreneurs. Beyond irrigation, the system can also provide power to processing units, homes, and more. The flexible and lightweight panels make it easily transferable.

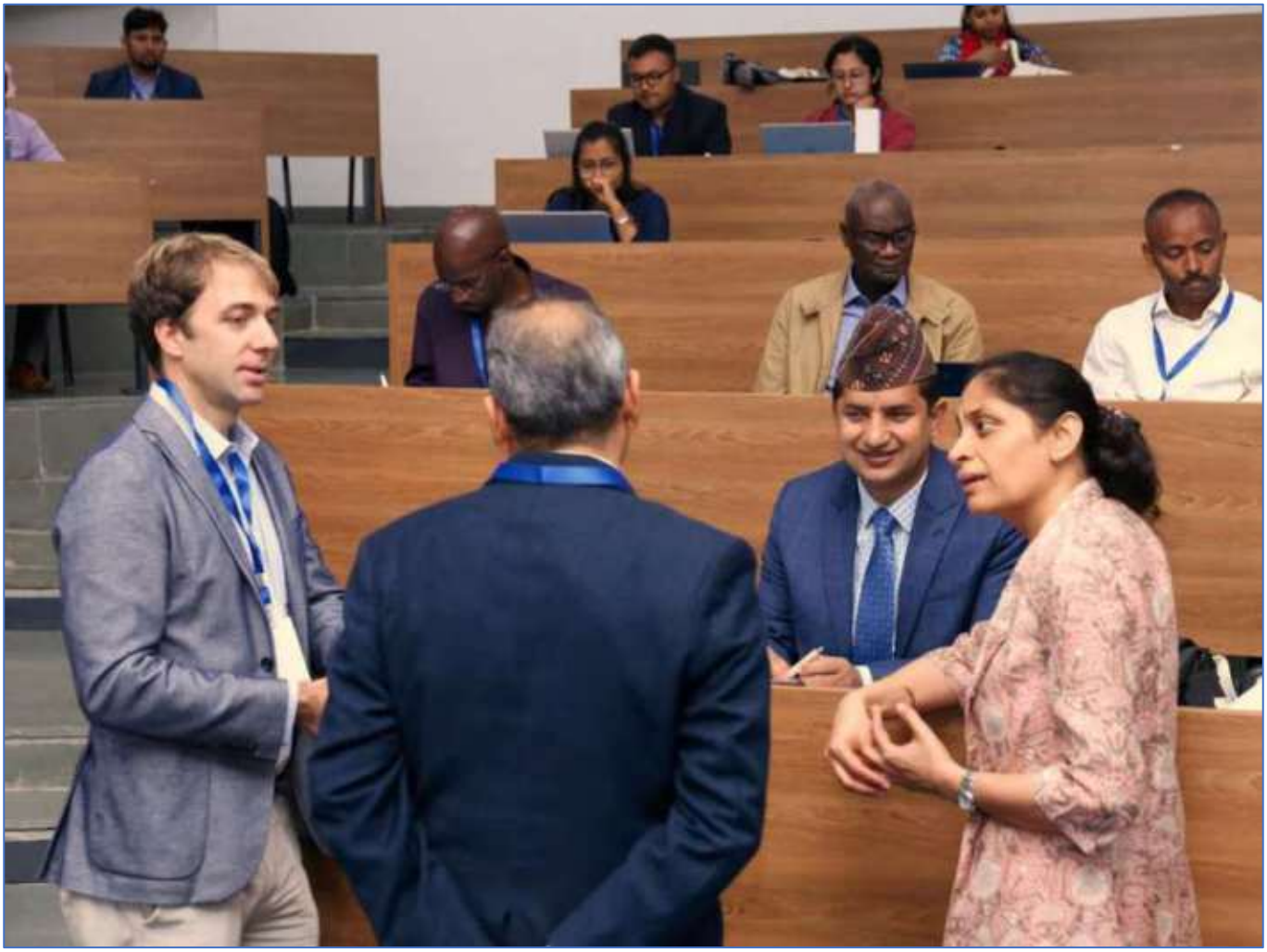
Off Grid Bazaar – Scaling the Deployment of Solar Irrigation Systems Using a Digital Platform and Personalized Agri-advisory for the Farmers - *Kiran Timalsina (Gham Power)*

The paper focused on “Off grid bazaar” which aims to improve farmer yield and income by 80% in 3 years or less by using a combination of solar water pumps, financing, and data-driven crop planning. The project consists of four work packages, including stakeholder training and onboarding, enhancement of personal agri-advisory, impact measurement and validation, and market activation and development. The development of SOPs and applications such as OGB app and Super Krishak app is also included in the project. The project faced challenges due to COVID, supply chain disruptions, and partnership development with government institutions. The project team has identified the need for immediate help for farmers, possibly through partnerships with other institutions and businesses.

Solar Water Mini Grid with Smart Meter for Optimization of SIPs and its Widespread Adoption Among Smallholder Farmers of Nepal - *Ritavrat Joshi (MinEnergy)*

The aim of this intervention is to improve access to SIPs for small and marginal farmers in a registered cooperative in Nawalpur, Nepal, and promote efficient groundwater extraction. The area previously relied on canal irrigation,

then moved to pipe irrigation without proper design or calculation. The cooperative installed three SIPs over a four-year period, but many members still faced delays in irrigation. The proposed model is a community-owned single large SIP based on a subscription fee and meter-based usage, reducing the investment required per household due to economies of scale. The current tariff structure has a per-hour rate for water supply through the solar pump, which is separate for members and non-members. The way forward includes installing flow meters, testing after installation, conducting additional research, training users on the billing system, generating static and dynamic QR codes, and conducting comparative analyses between different models. A secondary assessment of groundwater levels will also be conducted.



Left to right - Joanathan Demenge (SDC), Laxman Prasad Ghimire (AEPC) and Divya Kashyap (SDC) at the SoLAR Regional Forum *(Photo: IWMI)*

[For full presentations and zoom recordings. Click here]

Day 1: February 6, 2023
Plenary 2: Wrapping up Day 1

Energizing Agriculture and Enabling Just Energy Transitions in South Asia - *Dilip Singh, Shweta Koshy (UNDP)*
The United Nations Development Program (UNDP) and the International Solar Alliance (ISA) have collaborated to develop a concept note for scaling solar applications in agricultural use. This initiative, known as the Scaling Solar Applications for Agricultural Use (SSAAU) program, aims to address the growing demand for solar water pumps in Africa. The project focuses on 10 African countries selected from a pool of 22, based on their high demand for solar water pumps. The pilot phase of the program, supported by IBSA Facility at UNOSSC, will span over two years and involve the deployment of approximately 200 solar water pumps across these ten countries, with an estimated cost of $2 million.

The overarching goals of the project are to strengthen South-South Cooperation, enhance inclusive institutions and conducive markets, mitigate vulnerabilities in agricultural communities and ensure long-term sustainability and resilience. To achieve these objectives, the initiative emphasizes good energy governance, social action for energy and gender equality. The project comprises four key components: feasibility studies, demonstrations, capacity building and knowledge management. Multiple stakeholders are involved in the implementation process, focusing on fostering partnerships and collaboration.

The pilot countries have a range of opportunities stemming from this initiative, including access to clean energy for sustainable irrigation and increased income generation. The program also seeks to leverage international experiences to develop innovative and localized solutions while fostering local ecosystems for the replication and scaling of solar applications. Furthermore, the project aims to establish linkages with international vendors, provide training to develop skilled manpower and institutional capacity, offer policy recommendations, and support governments in devising and implementing national plans on clean energy and climate change. Overall, the Solar Water Pumps for Agriculture project aligns with several Sustainable Development Goals (SDGs), including SDG 1 (No Poverty), SDG 2 (Zero Hunger), SDG 7 (Affordable and Clean Energy), SDG 8 (Decent Work and Economic Growth), SDG 12 (Responsible Consumption and Production) and SDG 13 (Climate Action).

Closing Panel Discussion: The Main Takeaways from Day 1 and Thinking Ahead on Phase 2
Moderator: *Shilp Verma (IWMI)*
Panelists: Tushaar Shah (IWMI), Divya Sharma (SDC) A K M. Fazlul Hoque (SREDA, Bangladesh), Nazmun Nahar Karim (BARC), Pratignya Neupane Mishra (NARMIN, Nepal)

The panel highlighted the need for managing aquifer recharge, implementing water-saving technologies in conjunction with solar irrigation pumps, and conducting feasibility studies to understand financial and farmer behavior. The sustainability of these interventions and equity in their distribution are becoming increasingly important second-generation questions that require dialogue between researchers and policymakers. Additionally, the potential for solar energy is more economically sustainable in western India than in eastern India, where operating/utilization ranges are more varied across villages and regions. To ensure a fair and planned transition to renewable energy, policymakers need to design policies that consider gendered aspects of agriculture and water policies, which are overlooked in technology-focused energy policies.

The discussion focused on several key questions related to the future of solar energy and its sustainable scaling. One question was how to rationalize subsidies to ensure that scaling is sustained over a longer period. Another important consideration was how to address the nexus question around groundwater and food production in order to think about rationalizing subsidies. Participants emphasized the importance of taking research to policymakers and funders and governments helping to take rich knowledge from South Asia to other parts of the world by learning from others' experiences. Overall, the discussion highlighted the need for continued dialogue and collaboration to ensure that solar energy is adopted in a sustainable and equitable way.

Day 2: February 7, 2023

Plenary 3: Setting the scene: Agriculture and Energy Transition in South Asia

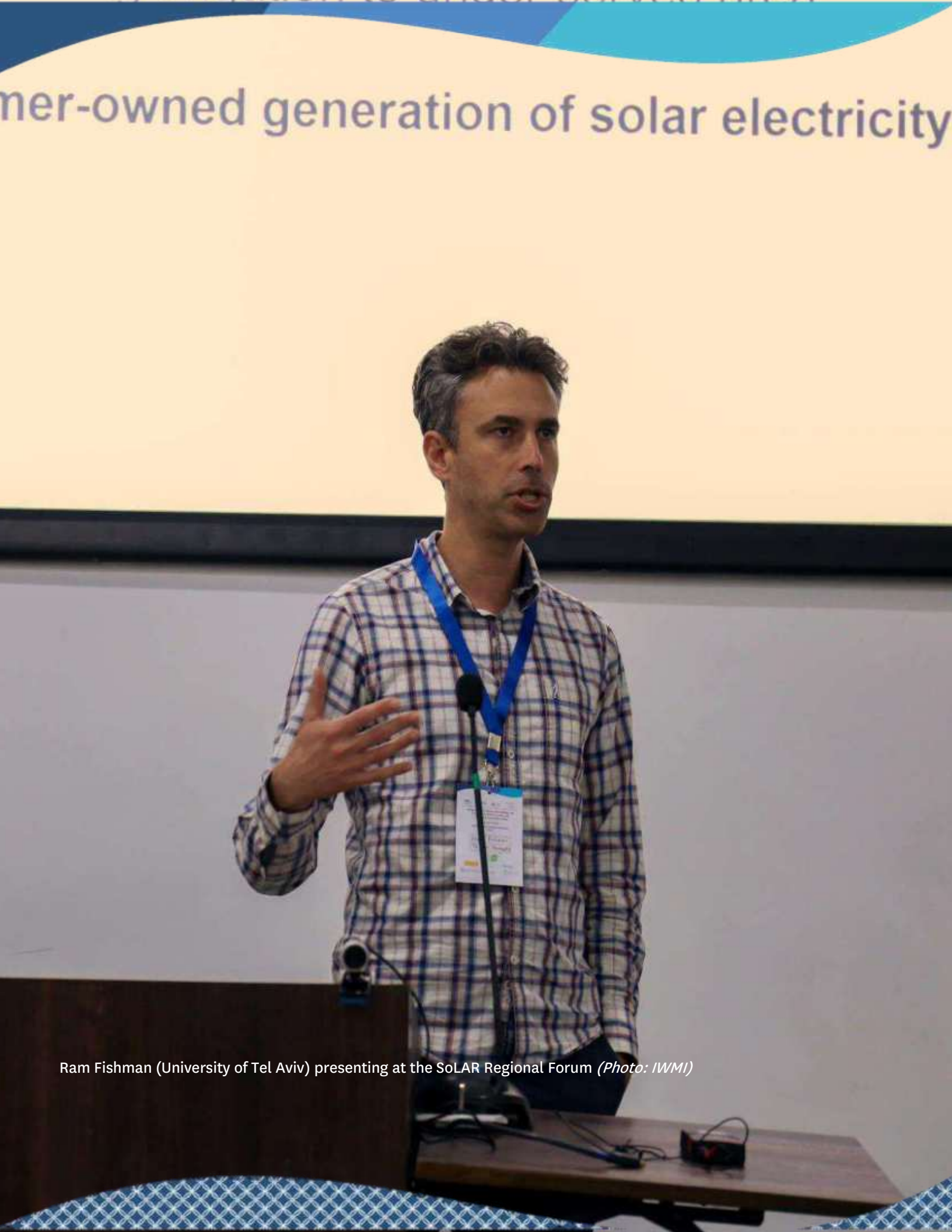
IRENA and the renewable energy-agriculture nexus - *Ute Collier (IRENA)*

Since 2011 and across 126 member states, IRENA has focused on renewable energy and its interlinkages with other sectors. She focused on the importance of the connection of energy with the agrifood system presenting 33% share of energy-related activities in food system emissions and high number of people still using traditional fuels for cooking. The nexus of energy and agriculture has emerged in research and development in recent years. There was a focus on the central and important role of biomass in energy transitions and is likely to increase in decarbonizing many sectors. There needs to be a shift from traditional biomass as cooking fuels to a more sustainable production and use of bioenergy by 2050; this is where agriculture will play an important role to reduce the deforestation for bioenergy. There is a close correlation of agricultural development with energy growth, and this is the highest in Asia. In Africa, however, there has hardly been any increase in energy consumption and that poses a challenge for agriculture and food security. Energy inputs are essential throughout the agrifood system at different levels from production to consumption (FAO-IRENA Report: renewable energy in agriculture - irrigation, cold storage, agro-processing, bioenergy). Scaling up renewable energy requires a focus not only on finance but the entire system including data and information, cross-sector linkages, innovation, awareness and capacity, and inclusion.

The presentation then discussed an example of a study carried out by IRENA on the viability assessment of decentralized renewable energy solutions in agrifood value chains in the Hindukush region for buckwheat, Yak, potatoes, and vegetables. The recommendations of the study included the need for improvement of local skills and capacities for scaling, enhancing commercial viability of local food products, promotion of solar PV solution and development of a project pipeline.

The SKY Experience of Gujarat - *R J Vala (PGVCL)*

The presentation described the journey of the state of Gujarat in scaling solar schemes. Under the policy initiatives of Gujarat, it was presented that Gujarat was the first state to notify Solar Policy in 2009. Since then, Gujarat has notified various renewable energy policies such as - Gujarat Solar Power Policy 2015, Gujarat Wind Power Policy 2016, Gujarat Wind – Solar Hybrid Policy 2018, Policy for SSDSP – 2019, Policy for allotment of Govt. Wasteland for development of Wind / Solar / Wind-Solar Hybrid Parks – 2019, and Gujarat Solar Policy 2021. The solar tariffs have come down significantly over this journey. Best practices in the renewable sector presented included – rooftop solar, microgrids in government offices, canal top solar, large solar park, and the SKY solar irrigation scheme. Of the total installed capacity, Gujarat's renewable energy capacity solar constitutes 43%, of which 45% is the share of solar and wind constitutes 54%. A scheme for installation of Solar Rooftops by Residential



Ram Fishman (University of Tel Aviv) presenting at the SoLAR Regional Forum *(Photo: IWMI)*

Consumers - “SURYA-Gujarat” notified in Aug-2019 – was presented. Over 600 agencies are empaneled to carry out the installation work through public-private partnership and mass outreach activities program through print, electronic and social media were initiated for consumer awareness. Through this program, Gujarat contributes over 25% of India’s total Solar Rooftop installations with 2000+ MW and enables users to earn incomes from evacuating surplus power.

The PM-KUSUM program and its three components were described – Component A (Solar Plants to Solarize Grids), Component B (Off-grid Solar Pumps) and Component C (Farm Level Grid-connected Solar Pumps). Under Component C in Gujarat, the SKY scheme has been piloted for over 4,500 farmers with a financial modality of 5% upfront payment, 65% loan from NABARD, and 30% capital investment from the state government. Evacuation-based Incentives are provided to support repayment of loans. The income generation potential from electricity evacuation in the grid-connected systems has reduced groundwater extraction by farmers as they are incentivized to evacuate generated electricity.

There has been a mixed experience of this scheme, where the scheme is particularly successful in north Gujarat. It has been more successful in the PGVCL area, though in some other areas, challenges such as pollution, dust, shadow effects, farmers’ behaviour, timing of energy supply sometimes leading to higher water consumption and lesser evacuation due to sugarcane farming and other such challenges are being faced. The presentation also appreciated the positive impact of IWMI’s capacity building of farmers in the scheme to reduce groundwater extraction and better evacuation incentives. Demand for the SKY scheme has now increased from farmers due to the financing mechanism which requires only 5% upfront payment from farmers as against 40% in PM-KUSUM. In the non-crop season too, farmers are able to earn from evacuation. However, the importance of maintenance is crucial for higher levels of generation such as cleaning panels.

Next Generation Questions in Solar Irrigation - *Ram Fishman (University of Tel Aviv)*

The presentation aimed at posing important broader conceptual questions about SIP. The agenda and goals of SIPs were reducing emissions from electrical/diesel pumps, removing the electricity subsidies, expanding irrigation to under-served area and farmer-owned generation of solar electricity. Beyond this, the presentation proposed a larger guiding goal of rural solar electricity generation for income generation and supply of low carbon energy for growing energy demand in all sectors. And in line with this larger goal, the presentation compared distributed small-scale generation and large-scale fields in terms of cost-effectiveness, land requirement, financing, equity, and income generation capacity. Challenges of generating utilizable and scaled cost-effective small scale were flagged off. These included high cost of subsidies, wide variations in technical reductions in generation, and low utilization (in quantity or in value generated) due to constraints to cultivation or weak water markets to create additional uses of the SIP. Potential solutions for these challenges included – smarter financial models using a mix of public and private models, risk sharing mechanisms instead of subsidies, possibilities for non-pumping usage, and a mix of off and on grid. Another issue flagged included the potential impact of on-grid SIP on small farmer water buyers. A proposed direction is to enable the non-well owning water buyers to setup a solar panel to sell electricity to the grid to supplement or replace the lost income from reduced irrigation access from the water market. Future research areas were presented. One core area would be research on all the aspects of SIP expansion, constrained by the common model pursued by governments. Therefore, there is scope for research on non-governmental models of SIPs, in terms of determinants of adoption, factors inhibiting utilization and distributional impacts.

[For full presentations and zoom recordings. Click here]

Day 2: February 7, 2023

Technical session 7: Grid-connected solar irrigation in India

Theme 3: Connecting Off-Grid to the Grid

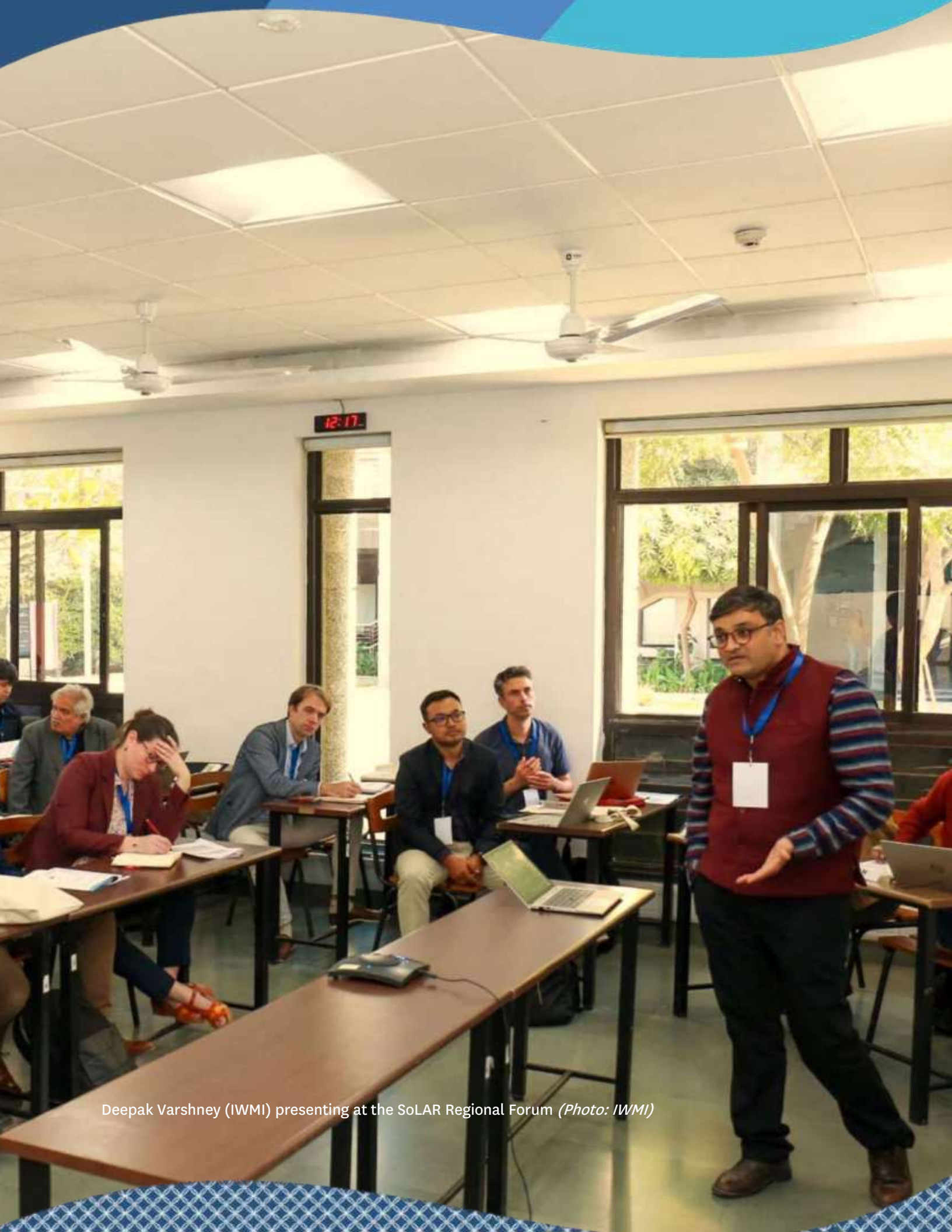
Session description: *While solar irrigation programs started as off-grid programs, many states in India have moved away from the off-grid model and invested in grid-connected solar irrigation. This session will present evidence from Gujarat and Maharashtra. These two states have experimented with different modalities of grid-connected solar, which in turn, inspired the architecture of the ongoing KUSUM scheme.*

SKY Scheme and Farmers Pumping Behaviour in Gujarat - *Deepak Varshney (IWMI)*

The SKY scheme, introduced in 2018, aimed to provide clean energy for pumping groundwater in agriculture while allowing farmers to sell excess solar energy to the grid. The study analysed whether incentivizing farmers influenced their pumping behaviour. The growth in pumping time was compared between SKY and non-SKY consumers to understand the impact of the scheme. Econometric analysis was used to analyse the differential growth in pumping hours and energy consumption for SKY versus non-SKY consumers over two years. The study found that SKY farmers had higher growth in pumping time compared to non-SKY farmers. There was no significant increase in groundwater extraction for SKY farmers, indicating that the scheme did not negatively impact the environment. Grid-connected solar pumps and incentives were key to achieving these results. The study highlights the importance of corrective measures and grid-connected solar pumps in promoting groundwater sustainability, which could serve as a pathway for future policy decisions.

SKY and its Influence on Informal Water Markets in Central Gujarat - *Sonal Bhatt (Sardar Patel University, Anand)*

The implementation of the SKY scheme has led to some interesting questions about its impact on groundwater withdrawal and water markets. One potential consequence of the scheme is the possibility of increased withdrawal for farmers' own use or sale, which raises the question of whether this will lead to a lowering or increase in the price of water for irrigation. However, the SKY design incentivizes farmers to reduce their water withdrawal and consume less power than what they produce through the solar panels to generate income. The study found that non-economic factors, such as social ties and financial incentives, play a significant role in irrigation patterns and water markets. Although SKY has had some positive impacts, it has caused a significant increase in water rates. However, the scheme's impact on groundwater tables could not be determined, as water tables in the area have been steadily declining over time.



Deepak Varshney (IWMI) presenting at the SoLAR Regional Forum *(Photo: IWMI)*

Grid-connected Solar in Maharashtra - *Hippu Salk Kristle Natha (IRMA)*

The study aimed to assess the progress and impact of the solar feeder program in Maharashtra and identify policy issues. The findings revealed that while the average cost of supply was Rs 6.83 per unit, the average revenue from agriculture was only Rs 0.63 per unit, which could be addressed through subsidies. However, there were constraints, such as the increased cost of solar panels and materials, higher GST rates, increased installation costs, and land acquisition issues. On the positive side, the program has led to improved voltage quality and reduced T&D losses, resulting in lower load shedding. Despite these achievements, awareness of the program at the grassroots level remains low.

Agent-based Models for Solar Irrigation in India - *Anjali Neelajantan (ATREE)*

The implementation of solar irrigation in agriculture presents a complex challenge of finding the right balance between groundwater depletion and farmers' financial sustainability. While too much irrigation can cause depletion of groundwater, too little irrigation can lead to insufficient earnings for farmers. The issue becomes even more complex as the study found that farmers' decisions are not solely based on maximizing profits but also minimizing risks. Both biophysical and socioeconomic factors play a crucial role in the outcomes of solar irrigation, and the implications of solar irrigation vary depending on the region's constraints around land and water. Neither rationing nor the pricing regime can ensure groundwater sustainability as rationing does not consider biophysical limitations, and fixing the number of hours of power supply does not necessarily translate into a demand for water. Thus, policymakers need to adopt a holistic approach, which considers various factors and constraints to promote sustainable solar irrigation in agriculture.

Capacity Building of Grid-connected Solar Farmers: Some Insights and Field Experiences - *Nikunj Usadadia (GERMI)*

There is a lack of understanding about the SKY scheme at the ground level. Farmers are misunderstanding the subsidy aspect of the scheme, with 60% not understanding the 60% subsidy angle, and there is a communication gap regarding the direct subsidy and evacuation aspects. Additionally, more than 60% of feeders are not maintaining the 18% capacity utilization factor (CUF) as required by the scheme. There is also a lack of understanding about the operational requirements of the system. However, the program has helped farmers to understand the loan component, tariffs, technical aspects, and operational requirements. The capacity-building program will have a positive impact on the generation, CUF, and farmers' income. The presentation highlighted that it is important to address the communication gaps and misunderstandings surrounding the SKY scheme for farmers to fully realize its potential benefits. Providing clear and accessible information about the subsidy and evacuation aspects of the program and the operational requirements could help address these issues. The capacity-building program is also a positive step towards helping farmers to understand and utilize the scheme effectively.

For full presentations and zoom recordings. Click here

DAY 2: FEBRUARY 7, 2023

TECHNICAL SESSION 8: LEVERAGING SOLAR IRRIGATION POTENTIAL IN AFRICA (CONVENED BY GGGI)

Theme 1: Solarizing Smallholder Irrigation

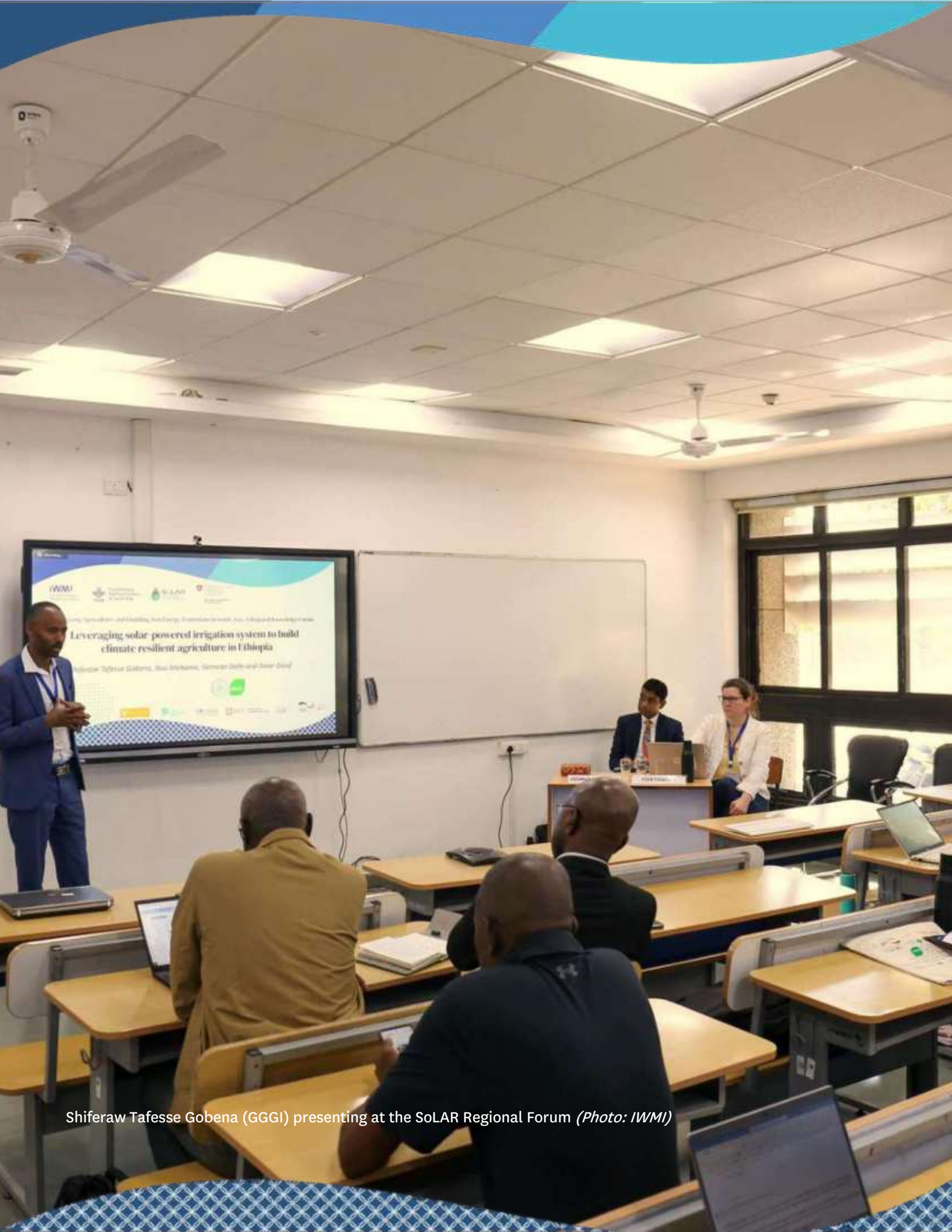
Session Description*: Several countries in Africa have started ambitious solar irrigation programs with support from organizations such as the ISA and GGGI. In this session, GGGI will present their implementation experience from the field.*

Leveraging Solar-powered Irrigation Systems to Build Climate-resilient Agriculture in Ethiopia - *Shiferaw Gobena/Omar Diouf (GGGI)*

Agriculture is the backbone of Ethiopia's economy, with 95% of farming done by smallholders who rely heavily on rainfall. However, frequent droughts and global crises have severely affected the country's agriculture sector and overall economy. To address these challenges, the Government of Ethiopia has renewed its emphasis on developing the agriculture sector, ensuring food security, and achieving import substitution. One promising solution is the promotion of solar irrigation technologies, which has huge potential in the country. To support this effort, GGGI designed and implemented a project funded by the Danish Government, focusing on promoting Solar Powered Irrigation Systems (SPIS) for Climate Smart Agriculture (CSA) in Ethiopia. The project aims to train farmers on the practical operation and maintenance of SPIS and CSA practices and motivate them to acquire SPIS equipment for sustainable development. The project also introduces SPIS best practices to mitigate climate change, promote climate-smart agriculture practices and raise awareness of the socio-economic and environmental benefits of climate-smart agriculture. Innovative and large-scale SPIS, spearheaded by GGGI, will help contribute to the national initiative to transition from diesel to solar-powered irrigation, ensuring a climate-smart agriculture sector in Ethiopia. This will not only improve agricultural productivity and food security but also contribute to the country's overall economic development and resilience to climate change. The project has the potential to transform the agriculture sector in Ethiopia and serve as a model for other countries in the region facing similar challenges.

Improving Institutional and Business Environments to Foster the Adoption of Solar-powered Irrigation Systems among Farmers in Ethiopia - *Shiferaw Gobena/ Omar Diouf (GGGI)*

In Ethiopia, majority of smallholder farmers lack irrigation skills and have limited access to irrigation equipment, which hinders their productivity and ability to sustain their livelihoods. Additionally, weak collaboration among the actors along the solar irrigation value chain, limited knowledge of smallholder farmers and absence of quality standards are some of the challenges facing the sector. There is also a lack of comprehensive strategies and clear business models to promote solar irrigation. To overcome these challenges, the business environment needs to be improved. This includes increasing farmers' interest in the technology, providing suitable credit modalities, and improving the ability of solar companies to provide the technology. Financial institutions and institutions willing to provide financing is also crucial. However, the limited availability of foreign currency and a limited number of suppliers pose challenges in the development of the sector. The Ethiopian government recognizes the importance of enhancing agricultural production and productivity, and has made it as one of the major strategic pillars in its development plan. To create an enabling environment for the development of solar irrigation, the government has put in place a tax-free import of solar irrigation technologies, increased awareness and demand for SPIS, and



Shiferaw Tafesse Gobena (GGGI) presenting at the SoLAR Regional Forum *(Photo: IWMI)*

designed an appropriate strategy to promote a green economic growth model. A National Technical Guideline for procurement of SPIS has also been developed. With these measures, the government aims to promote sustainable agriculture, increase food security, and achieve import substitution.

Challenges and Determinants of Solar-powered Systems Adoption in the Irrigation Schemes in the Senegal River Valley - *Mamadou/Omar Diouf (GGGI)*

The Senegal River Valley has a large agricultural potential, with 240,000 hectares of land available for farming, but only 75,000 hectares are being utilized at present. The area has about 200,000 producers operating through various production operators, village sections, MSEs, and women's groups. Despite the significant potential, solar energy represents only about 2% of the production activity in this area. Four types of irrigation schemes are used in the valley: large-scale, medium-scale, village, and private irrigation schemes. However, the adoption of solar systems in Senegal is challenged by a lack of access to affordable solar equipment, a climate finance landscape, and technical knowledge. Farmers also lack an understanding of the benefits of solar power, which makes it difficult for them to make informed decisions about investing in solar systems. To address these challenges, a methodology has been developed for technology sizing in the Senegal River Valley. This methodology involves identifying crop types and seasons for enhancement, conducting a maximum power analysis, assessing power consumption and Cos Phi, selecting solarizing pumps based on operating time, and performing technical-economic sizing of solar investment. All in all, increasing the adoption of solar irrigation systems in the Senegal River Valley could significantly enhance agricultural production and productivity but overcoming the barriers to adoption requires collaboration among various stakeholders, including farmers, technical experts, and financial institutions.

Challenges to Implementation of Solar Irrigation in Public Irrigation Schemes in South Africa - *Mary Jean Gabriel (Department of Agriculture, Land Reform and Rural Development, South Africa)*

South Africa has immense potential for the adoption of solar-powered irrigation systems (SPIS) due to its high solar irradiance levels and the rising cost of grid power, among other factors. Despite the country having 1.6 million hectares under irrigation, only 2,000 hectares of land is currently being irrigated using solar power, with large commercial farmers being the primary implementers of SPIS. Agriculture accounts for 12% of PV solar systems installed in South Africa. However, the use of SPIS comes with challenges, including their limited operational time of 8 hours a day, which becomes even lesser on overcast days. Additionally, transitioning to SPIS may not be cost-effective, and there are issues of theft and vandalism to consider. Access to quality products and services, especially for smallholder farmers, is also a concern. Nonetheless, the adoption of SPIS in South Africa is expected to continue to grow due to the benefits it provides, such as reducing dependence on the grid, increasing energy security, and promoting sustainable agriculture. With further investment in research and development, as well as in policy and financing mechanisms, SPIS adoption can be scaled up to improve the livelihoods of farmers while also contributing to the country's energy and food security goals.

DAY 2: FEBRUARY 7, 2023

TECHNICAL SESSION 9: SOLAR IRRIGATION AND IMPLICATIONS FOR GROUNDWATER USE

Theme 2: Conserving Groundwater Through Solar Irrigation

Session description: *As solar irrigation becomes widespread, there are emerging concerns that zero marginal costs of solar irrigation may incentivize farmers to extract more groundwater. In regions that are already over-exploited in terms of groundwater, further expansion of solar irrigation may be a threat. This session will provide evidence of the impact of solar pumps on groundwater use from Africa and South Asia.*

Smallholder Farmer Solar Irrigation Pumping Opportunities and Constraints in Southern Africa: A Regional Perspective - *Manuel Magombeyi (IWMI – South Africa)*

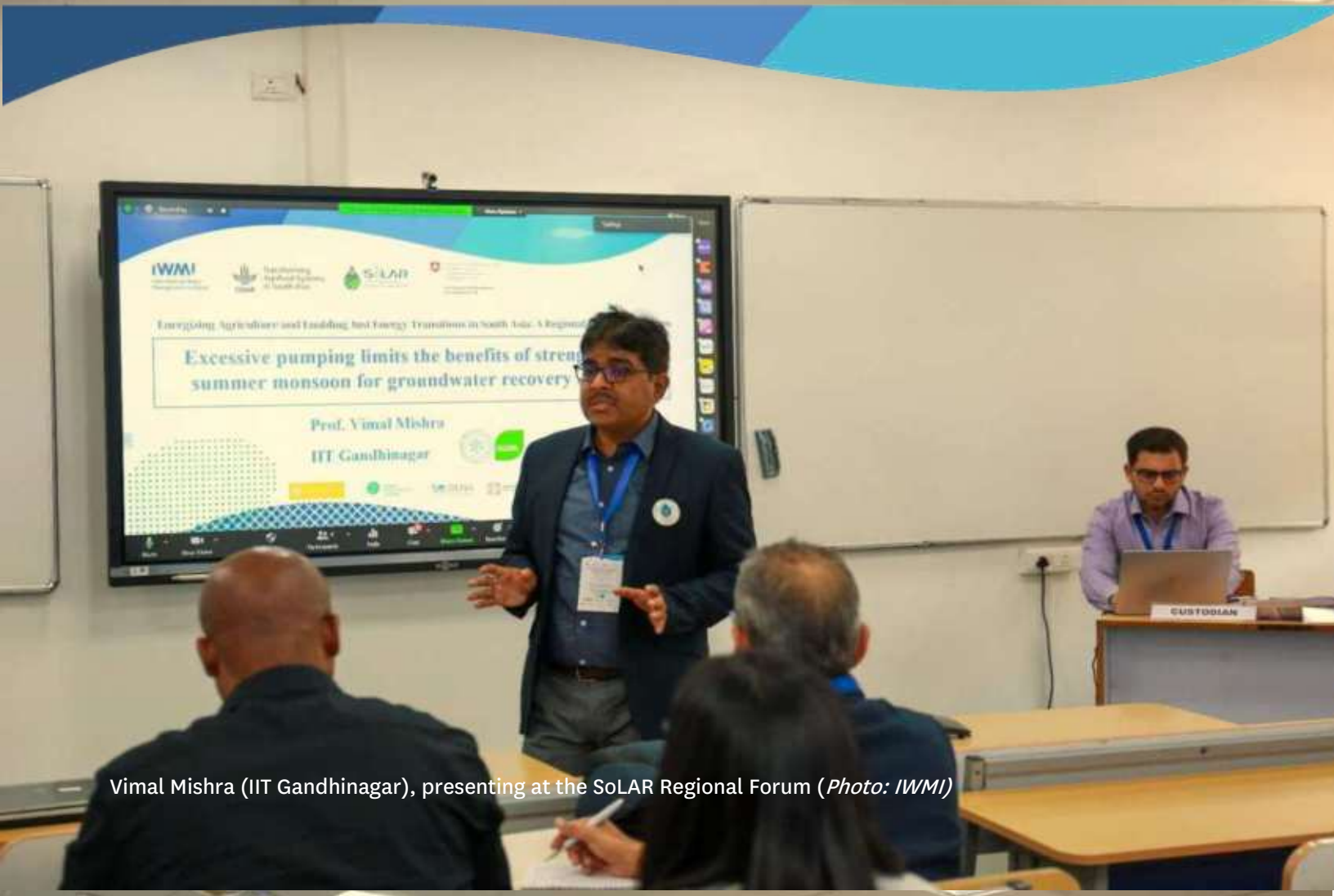
The study discusses the potential of solar irrigation to mitigate global emissions, and the possibility of bundling it with Bhungroo Irrigation Technology (BIT) to improve water availability, food security and livelihoods. The project involves capacity building of farmers, installation of BIT, and monitoring the recharge process. The study was conducted in the Inkomati-Usuthu Catchment Management Agency (IUCMA) in South Africa and Swaziland, and data sets were collected to assess the impact of the technology. Multi Criteria Decision Making (MCDM) along with Geographic Information Systems (GIS) were used to evaluate the impact of the BIT-Solar bundle technology. The results show high suitability for solar pumping and BIT, with water recovery efficiency of 6% and 18% through BIT, respectively. There was also a significant reduction in CO2 emissions. The study concludes that the conjunctive use of water has promising potential to scale up to other African nations, such as Tanzania, Zambia, and Zimbabwe, where the accelerating impact of CGIAR climate research is taking place.

Solar Irrigation and Pumping Behavior of Farmers in Gujarat - *Mohammad Faiz Alam (IWMI)*

This study focuses on the impact of large-scale adoption of solar irrigation pumps (SIPs) on groundwater resources in India. The research question is to investigate the possible impacts of SIPs on groundwater resources. The study area is the SKY scheme, analyzed in two regions: Anand and Botad. Anand has alluvial aquifers and Botad has weathered hard rock aquifers with low cropping intensity. The methodology involves examining the relationship between groundwater and energy use. The data was collected from census and sample farmers tube wells with meters installed, along with gathering cropping patterns. The results show no statistically significant difference between SIP and non-SIP farmers. Although the study's limitation is the small subset of farmers, it provides a methodology for understanding the groundwater abstraction using energy. The study indicates that there is no change in water use between SIP and non-SIP farmers. However, the research provides insight into the impact of SIP on groundwater resources in the SKY scheme.

Modelling Groundwater Scenarios - *Smaranika Mahapatra (IWMI)*

Bangladesh heavily relies on groundwater for irrigation, with 86 percent of the country's groundwater used for this purpose. Unfortunately, 53.5 percent of the irrigated area still depends on diesel pumps, leading to high carbon emissions. To mitigate these emissions, solar irrigation pumps are being introduced. However, little research has been done on the sustainability of groundwater using solar irrigation pumps, and their potential impact on groundwater due to climate change. The study aims to assess the sustainability of groundwater in the Barind area of Bangladesh, a region heavily dependent on groundwater for agriculture. The study uses a regional groundwater



Vimal Mishra (IIT Gandhinagar), presenting at the SoLAR Regional Forum (*Photo: IWMI)*

(Photo: IWMI)

model to analyze the depletion of groundwater under various scenarios. The model used is MODFLOW, a location-specific model that has been extensively used to simulate groundwater flow and transport. The results of the study indicate that groundwater depletion in the Barind area is a result of both solar irrigation pump (SIP) pumping and future climate scenarios. The study also found that in regions where the aquifers are not linked to rivers, the groundwater depletion occurs at higher pumping rates. However, high pumping rates also create high river inflows to the aquifer during the wet season, which is known as the Bengal Water Machine (BWM) effect. It is worth noting that the BWM effect is not occurring in every part of Bangladesh. In conclusion, the study highlights the potential impact of SIP pumping and future climate scenarios on the sustainability of groundwater resources in the Barind area of Bangladesh. The study shows that further research is needed to understand the impact of solar irrigation pumps on groundwater resources in Bangladesh.

Panel Discussion: How can Groundwater Models help Understand Farmers' Behaviour?

Moderator: *Alok Sikka (IWMI)*

Panelists: Anwar Zahid (BWDB), Vimal Mishra (IIT Gandhinagar), Abhijit Mukherjee (IIT Kharagpur), Alka Subedi (DWRI, Nepal), Ram Fishman (Tel Aviv University), Sunderrajan Krishnan (INREM Foundation)

Understanding the behavior of farmers is essential for effective water management and sustainable groundwater extraction. However, it is challenging to model farmers' behavior, as it depends on multiple factors, including social, cultural, economic, and political contexts. Despite the challenges, modelling can provide useful insights into farmers' behavior and help inform policy decisions. To develop better models, it is crucial to frame the right questions and expectations from the modelling process. For instance, defining what we mean by sustainability is critical in framing the modelling questions. Moreover, modelling can be framed in simple terms, using the least parametric model that can provide reasonable uncertainty. While modelling can provide useful insights, it is essential to remember that no model is perfect. Therefore, a combination of parsimonious parameters and rigorous models can provide a way forward. In data-scarce regions, where big data analysis may not be feasible, a simple way of metering data and extracting data can be helpful. Furthermore, while modelling provides insights into physical and chemical aspects, it is vital to consider the various hydrogeological factors and other variables that affect pumping and extraction behavior. Ground-truthing, i.e., verifying the modelling results with real-world data, is pivotal in the analysis. In summary, modelling farmers' behavior and its impact on groundwater resources is a challenging task but it provides useful insights for sustainable water management. Effective modelling requires framing the right questions, using parsimonious parameters and rigorous models, and ground-truthing the results.

For full presentations and zoom recordings. Click here

Day 2: February 7, 2023

Technical session 10: Leveraging solar irrigation potential in the Middle East, Africa, and Central Asia and what can the region learn from South Asia?

Theme 1: Solarizing Smallholder Irrigation

Session description*: Central Asia and parts of the Middle East are seeing the introduction of solar irrigation. What kinds of innovations and business models are being implemented and what can the region learn from the South Asian experience?*

Solar Irrigation Innovations in the Middle East - *Vinay Nangia (ICARDA)*

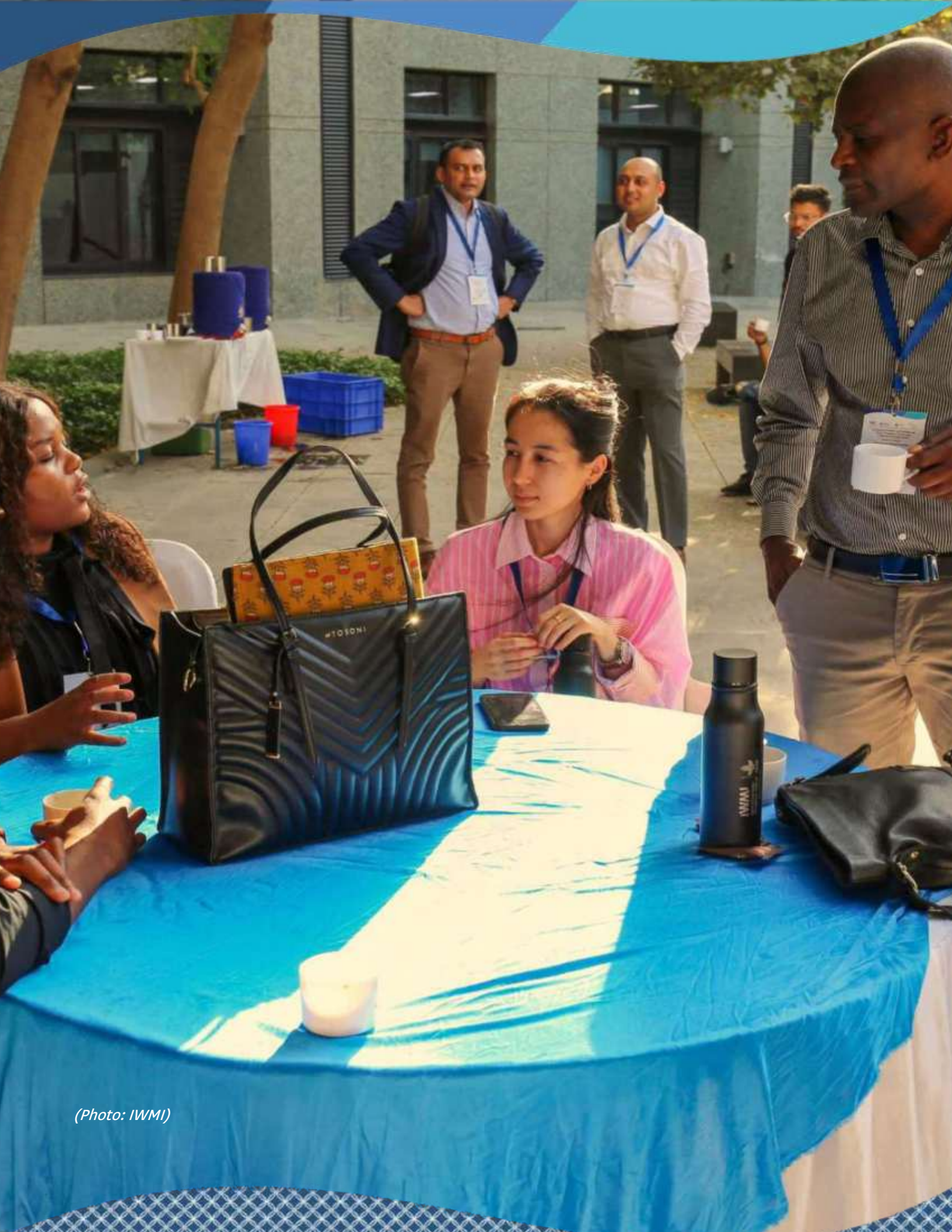
Pressure compensating drippers are designed to activate at a certain pressure, and anything below that threshold will result in no water delivery. Even if the pressure is increased beyond the activation threshold, the flow rate will not increase. Studies have shown that using pressure compensating drippers can lead to significant energy savings of 20-24% compared to non-pressure compensating drippers, particularly when the activation pressure is set at 0.25 bar. This reduction in energy consumption can have a significant impact on the cost of irrigation systems, as pump costs can make up 40% of the overall cost. By using pressure compensation, the pump size can be reduced, leading to a lower overall cost for the irrigation system. This is particularly important in areas where the cost of energy is high, as reducing energy consumption can have a major impact on the affordability of irrigation. The use of pressure compensation is also important for maintaining the uniformity of water application across an irrigation system. By ensuring that each dripper delivers the same amount of water regardless of pressure fluctuations, pressure compensating drippers can help prevent over-or-under-watering of crops. Overall, the use of pressure compensating drippers lead to significant energy and cost savings while improving the uniformity and efficiency of water application in irrigation systems.

Solar Energy Potential in Uzbekistan and Prospects in Irrigated Agriculture - *Zafar Gafurov (IWMI, Tashkent)*

In recent years, there has been a push towards replacing diesel pumps with solar pumps for irrigation in both surface and groundwater sites in rural areas. However, there is a low demand for solar pumps due to a lack of knowledge among farmers on the benefits of using them. To address this issue, the government has arranged a 50% subsidy for solar pumps, which is expected to increase their uptake. It is also essential to showcase best practices in the region to increase awareness of the benefits of solar irrigation. One key challenge that needs to be addressed is linking low-pressure compensating drip systems with solar pumping to overcome the 8-hour period when solar energy is available. This will ensure continuous and efficient irrigation for farmers. While the transition to solar pumping may require an initial investment, the long-term benefits in terms of cost savings on diesel and reduced carbon emissions make it a sustainable option for irrigation in rural areas.

Promoting Solar Irrigation with Shallow Groundwater Sources among Smallholder Farmers in West Africa - *Adebayo Oke, Abena Ofosu (IWMI, Ghana)*

One approach to reducing water use under irrigation is to use wetting front detectors in combination with solar pumps. These detectors can help schedule irrigation and determine the appropriate amount of water to apply, which can be especially useful in regions where water is scarce. Additionally, providing relevant and appropriate bundles to farmers, such as solar panels, seeds, drip and sprinkler systems, access to markets, and water, can



(Photo: IWMI)

coordination among projects in the region is required to assist farmers. Furthermore, these bundles can be applied across the entire value chain, from production to drilling of boreholes, to storage, marketing, and financing. This approach involves partners supporting each stage of the value chain, which can help ensure that farmers have access to the resources they need to improve their productivity and sustainability while reducing their water use under irrigation.

Panel Discussion: Lessons from South Asia

Moderator: *Shilp Verma (IWMI)*

Panelists: Vinay Nangia (ICARDA), Ram Fishman (Tel Aviv University), Omar Diouf (GGGI) Joshua Wycliffe (ISA), Marie-Charlotte Buisson (IWMI)

Solar pumps have been widely adopted in various regions globally. The largest number of solar pumps were deployed in Afghanistan, which they started on their own without any support from funders in or outside the country. In Africa, unlike Asia, there are no subsidies for irrigation, which poses a challenge to the adoption of solar pumps. The adoption enablers for solar pumps include the price of solar pumps and access to finance and diesel. For example, Sunculture provided a pay-as-you-grow model in Ghana (West Africa). In Africa, the focus is on small pumps, which is market-driven, as there are no subsidies. On the other hand, in Asia, big pumps are used, with Bangladesh having an average pump size of more than 20HP. This is because they grow crops that need more water, such as rice. In Africa, groundwater levels are still high, and only 4% of groundwater is used, thus presenting significant potential for groundwater use. However, the main challenge is access to finance and risk management. Creating community assets, such as sharing a 5HP pump among 20 farmers, can help overcome these challenges.

Bundling is another approach that enables an integrated approach to using solar energy, not only for irrigation but also for other uses when farmers are not irrigating their fields. To promote the adoption of solar pumps, it is crucial to provide relevant and appropriate bundles to farmers, such as solar panels, seeds, drip systems, sprinklers, market access, and water. However, lack of access to land remains a significant challenge. Coordination of projects in the region is required to assist farmers, and showcasing best practices in the region is also essential. In conclusion, solar pumps have shown enormous potential for agricultural irrigation in various regions, but the adoption of this technology is influenced by factors such as subsidies, access to finance and diesel, and access to land. Creating community assets and bundling can help overcome some of these challenges. Therefore, it is essential to consider an integrated approach to promoting the adoption of solar pumps, which goes beyond irrigation to other areas, such as energy access and market access, to maximize the benefits of this technology for farmers.

Day 2: February 7, 2023

Technical session 11: Are energy policies in South Asia gender transformative?

Theme 5: Making energy transitions inclusive and equitable

Session description: Just and equitable energy transitions require gender transformative approaches and yet, there is very little evidence that renewable energy policies incorporate gender transformative approaches. This session will compare renewable policies from a gender lens.

Technology for Whom? Solar Irrigation Pumps, Women, and Smallholders in Eastern Tarai, Nepal. - *Gitta Shrestha (Independent GESI Expert)*

The three-dimensional theory of change was applied to examine the impact of SIP technology on women and smallholders. A comparison was made among three models: AEPC, IWMI-IDE, and ICIMOD, focusing on irrigation and financial aspects. The IWMI-IDE study aimed to investigate a sample with a significant representation of landless and near-landless women, particularly Dalits. The findings revealed that SIP technology enhances access to water, improves crop productivity, and increases income. SIP is also considered women-friendly in terms of ergonomics. However, the power dynamics related to access to land still play a crucial role. Notably, wealthy landlords have started leasing land to Dalits, thereby implying improved livelihood security. While there have been visible changes in gender roles with women participating in irrigation activities, gender stereotypes remain prevalent. Moreover, there has been no significant change in the gender/power relationship, as men primarily make decisions about SIP adoption and implementation.

A major limitation in the SIP-gender thematic area is the inability to break down the generalized “female group” based on factors such as family type, age, and education. Therefore, further exploration of the socio-economic dimensions and power relations is necessary to understand the potential for expanding SIP. Additionally, the shallow targeting approach in project planning and implementation is identified as a significant gap that requires attention and consideration.

Do Water, Energy, and Food Policies in Support of Solar Irrigation Enable Gender Transformative Changes in South Asia? Evidence from Policy Analysis in Bangladesh and Nepal - *Labisha Uprety, Manohara Khadka (IWMI)*

The study assesses whether policies related to Water, Energy, and Food (WEF) supporting solar irrigation enable gender transformative changes. Using the Gender Equality and Social Inclusion (GESI) domain of the chain framework, the study examines agency, relations, and structure to promote equitable access, enhance women's representation, and foster GESI and justice across various WEF sectors. Based on GESI-based scores, the study found that overall scores were higher than the average. For example, the agriculture development strategy 2016 scored well in providing equitable access. However, the energy policy scored low due to its gender-neutral structure and incomplete representation of gender, reinforcing stereotypes about women’s cooking roles.

Comparing Bangladesh and Nepal, the study revealed that the Nepal food policy scored higher than the Bangladesh policy. Both countries had low scores in water policies, but Nepal's water policy appeared more gender-inclusive than Bangladesh's. The energy policies in both countries had low scores, indicating their gender-

(Photo: IWMI)

neutral nature. Furthermore, the study found that GESI provisions in national constitutions and development frameworks must be fully translated into sectoral WEF policies. The integration of GESI is crucial in solar irrigation financing and subsidy mechanisms to benefit women and smallholder farmers. In conclusion, the study highlights the need for gender-responsive policies and the inclusion of GESI considerations in the WEF sector to bring about gender transformative changes and promote equitable access and representation.

Are Water, Energy, and Food Policies in India Gender Transformative? - *Shreya Chakraborty (IWMI)*

The study focuses on understanding the Gender Equality and Social Inclusion (GESI) opportunities and gaps in India's Water, Energy, and Food (WEF) policies and programs. It explores whether the nexus policies related to water, energy, and food enable gender transformative changes in the country. Despite a significant proportion of women in the agricultural labour force, questions remain regarding their access to resources, markets, and institutions. The study employs the GESI lens to examine the representation of gender, particularly women, in major national policies. It reveals that while national policies exhibit some gender representation, the focus on "women" is excessive, and archaic gender representation is observed in sectors such as nutrition, health, and reproductive and child health. Like neighbouring countries, the energy policy scores poorly while agriculture and food policies stand out for their gender representation. However, a concerning trend of deteriorating GESI from 2007 to 2017 is observed, especially in farmer policies, such as doubling farmers' income and shifting towards renewables.

The way forward involves mobilizing the progressive and transformative components of national frameworks, learning from gaps in those frameworks, focusing on unequal access to resources, skills, and services, recognizing and addressing systemic barriers, addressing gender-blind energy sector policies, broadening the conceptualization of inequality and inclusion, recognizing the continuum between reproductive and productive domains for gender inclusion, and utilizing the nexus approach to identify co-benefits and trade-offs. In conclusion, the study highlights the need to enhance gender equality and social inclusion in WEF policies and programs in India, addressing the gaps and challenges identified to enable gender transformative changes and achieve greater equality and justice.

GESI and Energy in Nepal: Insights from a Literature Review - *Marlene Buchy (IWMI)*

The evidence does not show clear signs of women's empowerment from Solar Irrigation Pump (SIP) technology. While there may be reduced drudgery and increased free time, women still need more economic opportunities and assets like finance and education, preventing them from fully benefiting. There is no evidence of changes in gender relations resulting from SIP adoption. Power relations play a crucial role in accessing SIP. The impact of access to electrical appliances depends on who controls them. Energy innovations often focus on practical needs such as reducing drudgery or providing cheaper energy. However, the focus should shift towards addressing strategic needs and co-developing energy solutions that challenge gender imbalances and social exclusion. Energy solutions should not be solely technical but should consider the underlying causes of inequality from the design stage. In conclusion, studies need to examine intra-household dynamics and the impact of energy innovations. Action research is required to test how energy solutions can be developed in collaboration with women and marginalized groups. Furthermore, considering both practical, conceptual, and political factors, understanding the institutional processes that create bottlenecks in implementing GESI-aware policies, is essential.

DAY 2: FEBRUARY 7, 2023

TECHNICAL SESSION 12: CONNECTING THE OFF-GRID TO THE GRID

Theme 3: Connecting Off-Grid to the Grid

Session description: Nepal and Bangladesh started their solar irrigation journey with off-grid pumps, but are now piloting grid-connected solar pumps to increase the financial viability and sustainability of these off-grid pumps. In this session, we present the emerging evidence on challenges for grid connection in terms of both technology and policies.

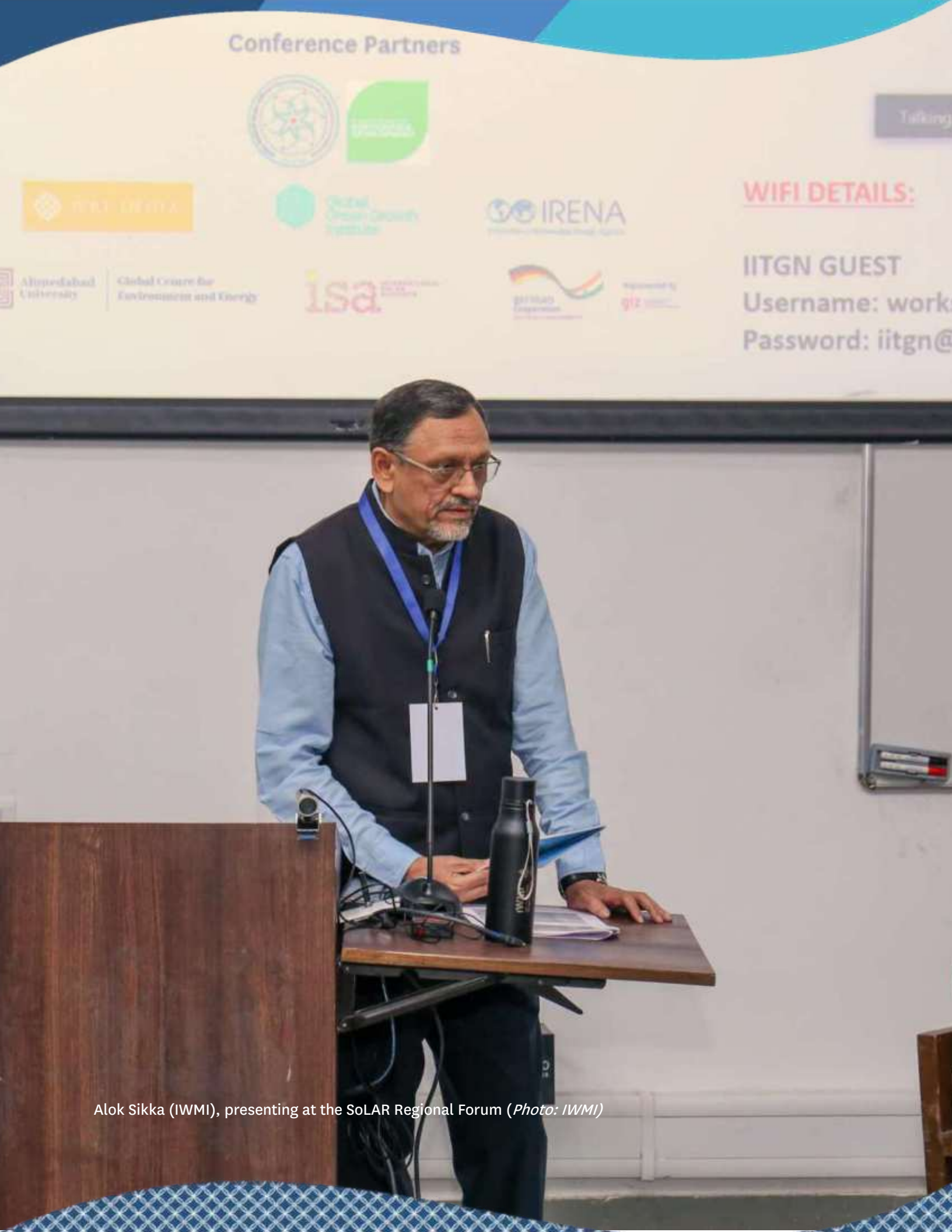
SIP Grid Integration in Bangladesh: Setting the Incentives Right - *Md. Abdullah Al Matin (IDCOL)*

Infrastructure Development Company Limited (IDCOL) has achieved over 80% of installations with the maximum capacity, indicating a high level of utilization and efficiency in implementing solar irrigation pump (SIP) systems. The utilization of SIP for irrigation is more intensive in Water, Agriculture, and Village Environment (WAVE) sites compared to Gazi sites. This difference can be attributed to varying factors such as weather conditions, groundwater levels, cropping patterns, and seasonal variations, which impact the availability of surplus electricity for SIP operation. Comparing tariffs, the cost of diesel for irrigation is higher than that of SIP systems, with a 25% cost reduction, and both options are more cost-effective than using grid electricity, which has a 60% higher tariff. Among different scenarios, SIP systems and grid dispatch at a tariff rate of 8.5 Tk/kWh are deemed viable options. This suggests that utilizing SIP technology and accessing electricity from the grid at the specified tariff rate offer economically feasible solutions compared to other alternatives.

In conclusion, IDCOL has achieved a high installation rate with maximum capacity in SIP systems. The intensity of SIP utilization for irrigation varies between WAVE and Gazi sites, influenced by factors such as weather, groundwater levels, cropping patterns, and seasonal variations. Tariffs indicate that SIP and grid dispatch at a specific tariff rate is more cost-effective options compared to diesel and grid electricity, offering viable solutions for sustainable irrigation practices.

Opportunities and Challenges in Implementing the Grid-connected Pilot Project in Nepal - *Shisher Shrestha (IWMI)*

The impact on SIP farmers have been predominantly positive. These farmers have experienced significant reduction in the use of diesel pumps, which implies reduced dependency on fossil fuels and a more sustainable approach to agriculture. Additionally, due to the implementation of SIP techniques, farmers have allocated more land for cultivating vegetables. This diversification has likely contributed to increased revenue, with reports suggesting a 10% rise in earnings. However, one of the challenges faced by the SIP program is that the budget allocated for subsidizing SIP practices is insufficient to meet the demand. The program's popularity and effectiveness may have resulted in a higher number of farmers wanting to adopt SIP techniques, creating a strain on the available funds. This limitation could impede the program's scalability and hinder its potential impact. In order to address the limitations posed by the budget constraints and ensure the scalability of the SIP program, an innovative business model with a focus on finance is required. This model could involve exploring alternative funding sources, such as partnerships with private entities or financial institutions, attracting investments from sustainable agriculture initiatives, or seeking government support to increase the budget allocation for SIP subsidies. By developing a sustainable financial framework, the SIP program can expand its reach and benefit a



Alok Sikka (IWMI), presenting at the SoLAR Regional Forum (*Photo: IWMI)*

larger number of farmers. Grid integration is another factor that can play a pivotal role in scaling the SIP program. By integrating the agricultural activities of SIP farmers with the existing power grid infrastructure, surplus electricity generated through renewable energy sources, such as solar panels or wind turbines, can be efficiently utilized. This integration allows farmers to become energy producers, reducing their dependence on the grid and potentially providing them with an additional source of income by selling excess electricity back to the grid. Grid integration can enhance the sustainability and economic viability of the SIP program while contributing to the overall energy transition and reduction of greenhouse gas emissions.

Drivers of Solar Energy Generation in a Distributive Policy Framework - *Deepak Varshney (IWMI) and Shisher Shrestha (IWMI)*

The study focused on identifying the determinants of solar energy generation within a distributive policy framework, with a specific emphasis on the SKY scheme. Utility officials involved in the implementation of the SKY scheme were surveyed to examine governance-related issues and improve energy outcomes. Here are the key findings:

- The overall estimates of the annual Capacity Utilization Factor (CUF) and Performance Ratio (PR) for the SKY scheme were found to be relatively low compared to the benchmark CUF and PR estimates in India. This indicates that there is room for improvement in terms of maximizing the solar energy generation potential of the scheme.
- Regular communication of information on energy outcomes to farmers has proven to be beneficial. By providing farmers with regular updates on their solar energy generation, they can identify issues and areas for improvement. Additionally, from a policy perspective, issuing energy bills at frequent intervals (such as quarterly or monthly) can also contribute to improving solar energy generation.
- The uptake of the SKY app among farmers has been low, primarily due to a lack of knowledge and awareness. Implementing capacity-building programs that focus on creating awareness about the SKY app and educating farmers on how to access information from it can help address this issue and increase farmer engagement with the app.
- Swift identification of technical, network, and maintenance-related issues is crucial for rectifying them in a timely manner. Issues such as solar panel/cell damage, meter burnout, SIM card burnout, network and connectivity issues, and inverter malfunction due to mechanical or electric faults need to be promptly identified. This ensures that necessary repairs or replacements are carried out efficiently, minimizing downtime and optimizing solar energy generation.

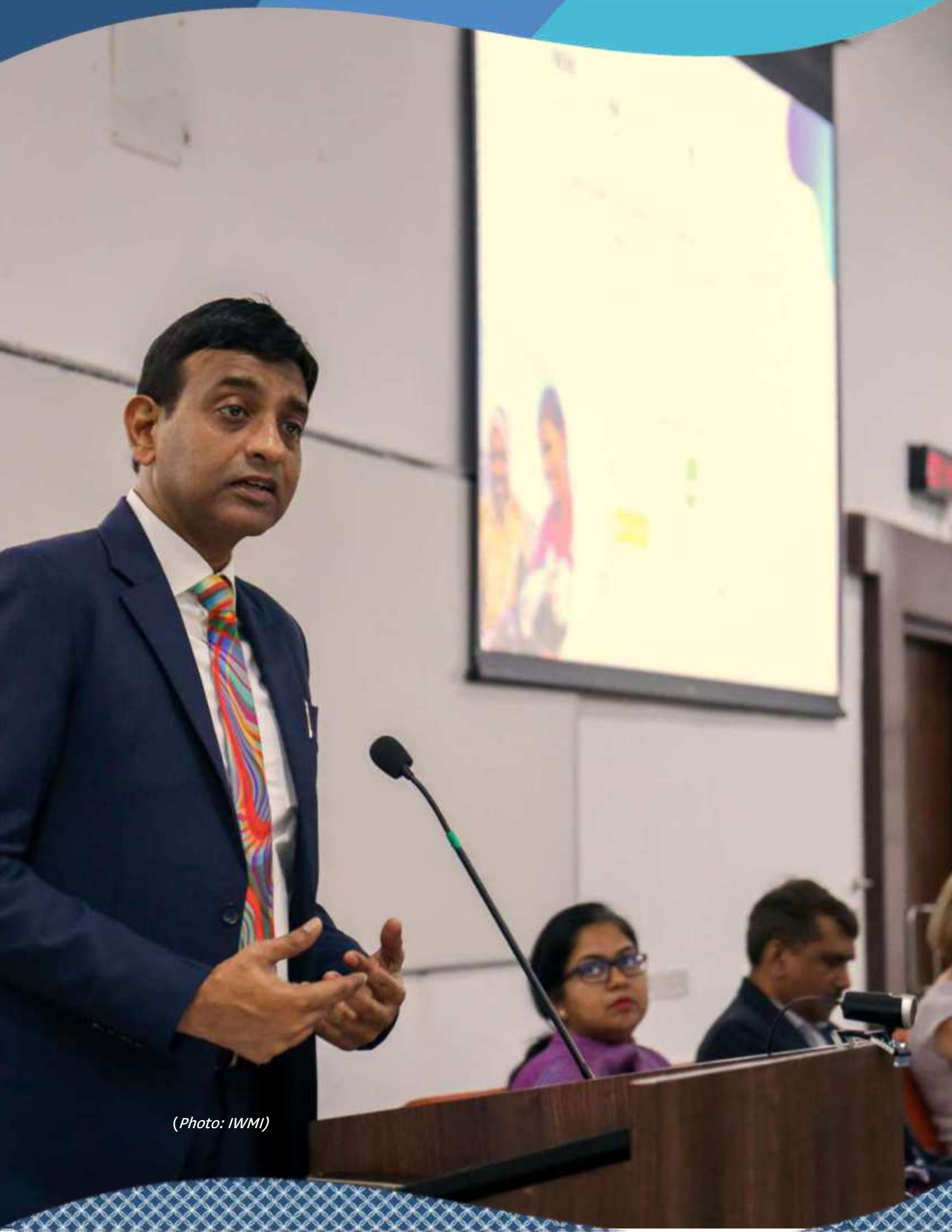
In summary, the study highlights the importance of all three stakeholders (utilities, solar agencies, and farmers) in improving energy outcomes within a distributive policy framework. By addressing issues related to communication, awareness, and technical problem-solving, the SKY scheme can enhance its performance and maximize solar energy generation.

Panel discussion: What are the Challenges for Grid Connection and What Lessons can Gujarat's SKY Scheme Offer?

Moderator: *Archisman Mitra (IWMI)*

Panelists: RJ Vala (PGVCL), Laxman Ghimire (AEPC), Sakil Ibn Sayeed (BREB), Md. Abdullah Matin (IDCOL), Birat Sharma (NEA)

In two countries – Nepal and Bangladesh – grid connection is just starting out, while in India grid connection of SIPs is already well established. The aim of the panel was to discuss the challenges and future potential for grid connection in these countries based on lessons from the case of India. In Nepal, a pilot project has been done for grid connected SIPs from where lessons are yet to be learned for further pilots in other regions. AEPC has mandates for off-grid pumps only, which is an institutional challenge. There are also technical constraints in replacing existing off-grid systems into grid connected systems. Nepal also does not have separate grids for agriculture.



(*Photo: IWMI)*

DAY 2: FEBRUARY 7, 2023

TECHNICAL SESSION 13: INTEGRATING RENEWABLE ENERGY IN AGRICULTURAL VALUE CHAINS: EXPERIENCE FROM DEVELOPING COUNTRY (CONVENED BY WRI AND IRENA)

Theme 4: Renewable Energy in Agricultural Value Chains: Institutional models, policies, and case studies on livelihoods and impacts

Session description: Decentralised Renewable Energy (DRE) solutions in agriculture value chains is on the rise in developing countries in order to reduce fossil fuel use, provide energy access, raise productivity and incomes, and reduce food loss and waste. DRE solutions can also enhance resilience to climate impacts in the agriculture sector and associated livelihoods. This session will discuss diverse experiences of integrating DRE solutions in agricultural value chains and the need for supportive policy frameworks, financing, capacity building and technology solutions.

Powering Smallholder Agriculture in East Africa for an Inclusive and Equitable Development - *Beryl Ajwang (WRI Africa)*

The presentation highlighted project learnings from solar projects implemented in multiple countries. Here are some examples:

- In Tanzania, a project focused on the mango value chain. It involved the installation of a 12-kilowatt solar power pumping system combined with a 40-acre drip irrigation system. This initiative aimed to improve water access and irrigation efficiency for mango farmers.

- In Uganda, a project focused on supporting smallholder farmers in the fresh fruits sector. The project facilitated the development of a business model to finance the procurement of 10 solar irrigation kits. This initiative aimed to enhance irrigation capabilities and promote sustainable agriculture practices among small-scale farmers.

- In Amahara, Ethiopia, the project focused on the energy-water-food nexus. It aimed to address the interconnected challenges of energy, water, and food security in the region. Specific details about the project's interventions were not provided, but it likely involved implementing solar energy solutions to support agricultural activities and promote sustainable resource management.

The key lesson derived from these projects is the importance of providing more granular data on available opportunities for improving Power Usage Efficiency (PUE). While solar energy solutions are beneficial, the focus should extend beyond energy alone. Access to end-user finance is also a significant issue that needs to be addressed. By providing detailed information on PUE opportunities and ensuring access to financial resources, the effectiveness and impact of solar projects can be enhanced. Overall, these project examples demonstrate the diverse applications of solar energy in agriculture and emphasize the need for holistic approaches that consider multiple factors such as water access, irrigation, and finance to achieve sustainable outcomes.

Application of Solar Technologies in Aquaculture in Cambodia and Tanzania – Technology Transfer and Training - *Luca Regazzoni, Severin Spring (ZHAW Zurich University of Applied Sciences)*

In recent years, the pursuit of sustainable and efficient farming practices has gained significant attention worldwide. In Cambodia, a study was conducted to explore the potential benefits of integrating energy-efficient fishpond aeration systems with off-grid energy sources, with the aim of enhancing small-scale aquaculture farming. The results of this study showcased promising outcomes, demonstrating the positive impact of such systems on the productivity and profitability of aquaculture operations.

However, the success of this endeavor was not solely attributed to technological advancements. Capacity building through education and training played a crucial role in empowering local farmers and equipping them with the necessary knowledge and skills to utilize these innovative approaches effectively. By enhancing their understanding of energy-efficient practices, farmers were able to optimize their fishpond aeration systems, leading to increased productivity and improved profitability in the aquaculture sector.

Meanwhile, in rural Tanzania, a different approach was taken to promote sustainable aquaculture. An off-grid fish farm was established, fully powered by solar energy, including a hatchery, with the goal of fostering the development of sustainable aquaculture practices in the region. This pioneering initiative showcased the technical feasibility and success of a solar direct drive (SDD) system, which utilized alternative storage technologies for water supply, feed milling, and hatchery operations. By eliminating the need for batteries, this system offered a cost-effective and environment-friendly solution for powering aquaculture facilities in remote areas.

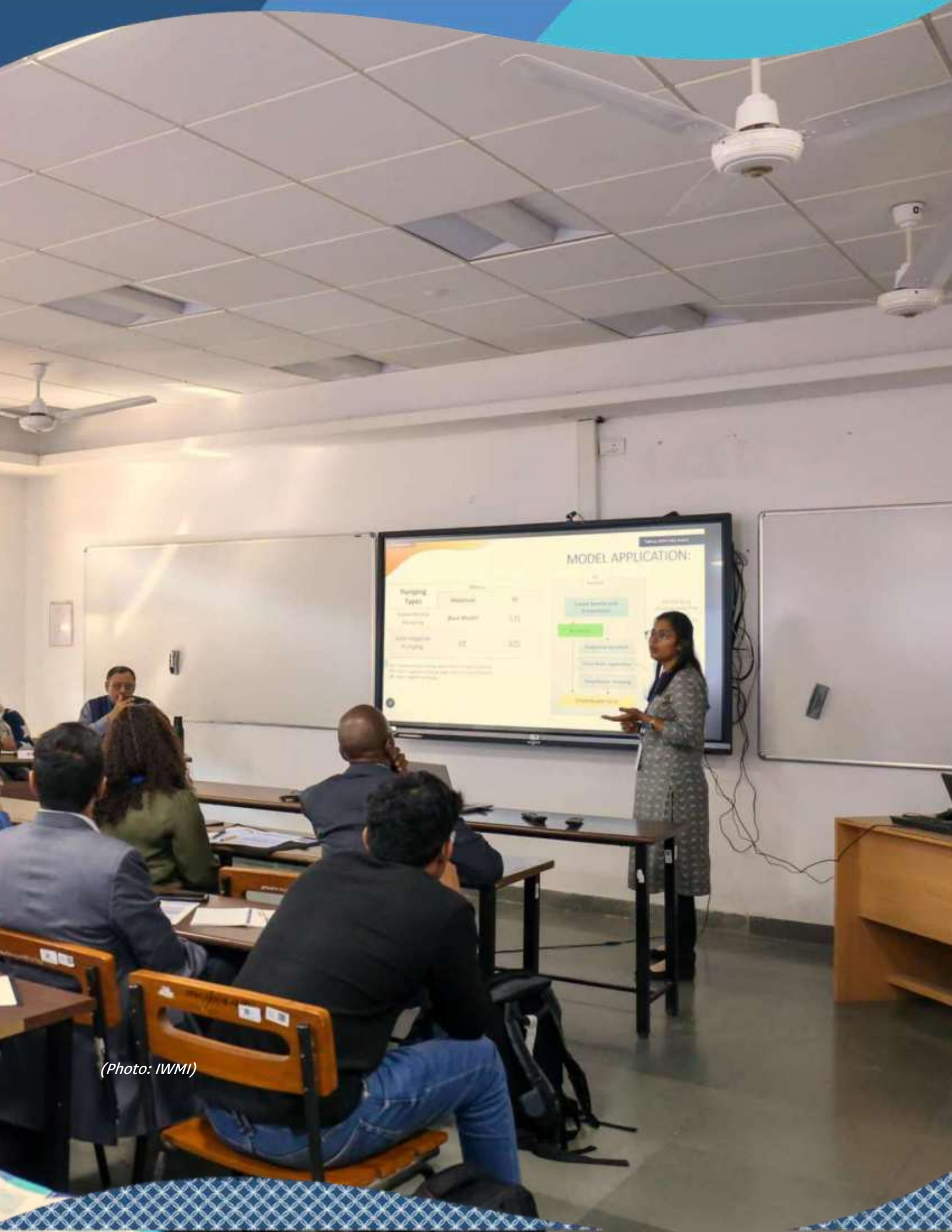
These two stories demonstrate the transformative potential of integrating renewable energy sources and innovative technologies into aquaculture practices. Through capacity building and the adoption of sustainable energy solutions, small-scale farmers in Cambodia and rural Tanzania were able to enhance their productivity, profitability, and long-term viability. These initiatives serve as inspiring examples for the global aquaculture community, highlighting the importance of embracing environmentally friendly practices and empowering local farmers for a sustainable future.

Energy Auditing and Capacity Building on Energy Management for Five Rice Mills in the Senegal River Valley - *Mamadou (GGGI)*

To address the challenges faced by rice mills in terms of energy consumption and production efficiency, a project was undertaken to increase energy efficiency and access to the international climate for rice mills. The objective was to boost local rice production and improve overall efficiency in the rice milling process.

The project adopted a comprehensive approach to achieve its goals. Initially, a combination of analysis of electricity bills and energy audits was conducted to assess the current energy usage and identify areas for improvement. This provided valuable insights into the energy consumption patterns and inefficiencies within the rice mills.

Based on the findings from the analysis and energy audits, an energy efficiency action plan was developed. This plan outlined specific strategies and measures to optimize energy usage, reduce wastage, and enhance overall efficiency. By implementing these measures, the project aimed to maximize the utilization of available energy resources and minimize energy losses during the rice milling process.



(Photo: IWMI)

The results of the study were highly encouraging. It was found that there was a significant energy-saving potential of up to 79% by implementing the recommended energy efficiency measures. This substantial reduction in energy consumption not only contributed to environmental sustainability but also resulted in tangible economic benefits. The electricity bills of the rice mills were reduced by an impressive 10-12%, leading to substantial cost savings. Additionally, the overall cost price of rice production decreased by 10%, making it more competitive in the market.

By focusing on energy efficiency and access to the international climate, this project showcased the importance of sustainable practices in the rice milling sector. The combination of detailed analysis, energy audits, and the implementation of an action plan proved to be a successful approach in enhancing local rice production. This project serves as a valuable model for other rice mills and agricultural industries, highlighting the potential for substantial energy savings, cost reduction, and improved environmental performance through targeted energy efficiency measures.

Panel Discussion

Moderator: *Namrata Ginoya (WRI)*

Panelists: Divyam Nagpal (IRENA), Amit Saraogi (Oorja Solutions), Rehana Riyawala (SEWA), Surabhi Rajagopal (SELCO Foundation), Ashok Kumar (Transform Rural India), Gaurav Gupta (Private Financing Advisory Network) – virtual

To ensure sustainable and effective decentralized energy solutions for livelihoods, it is crucial to analyze and consider the entire value chain from input to output. While standardization can be applied in the health sector, customization is often required for the agriculture and livelihood sectors due to their unique needs. The Hariyali village program, initiated by Self-Employed Women's Association (SEWA), follows a systematic approach to implementing innovative solar energy solutions. The program begins with piloting solutions in specific villages, allowing for adaptation and refinement based on the local context and requirements. Once the solutions have been successfully tested and adapted, they are scaled up by integrating them into existing infrastructure rather than deploying standalone systems. This approach ensures optimal utilization of resources and facilitates the widespread adoption of solar energy solutions.

Another notable approach is the establishment of Farming as a Service company. These companies focus on interventions across the entire value chain, taking a bottom-up approach to understanding the demand for energy solutions and selecting appropriate project locations. To overcome the barrier of capital cost, these companies often employ a pay-as-you-use business model, enabling users to access energy solutions without significant upfront investments. By considering the value chain approach and addressing specific demands, these companies contribute to the overall growth and sustainability of the agriculture sector.

Community-managed decentralized energy systems, such as mini-grids, have also emerged as a viable solution. However, careful location selection is vital due to the high investment involved. Building trust within the community is crucial for the successful adoption of mini grids. Over time, users transition from consumptive use (utilizing only a small portion of the generated energy) to productive use by investing in enterprises that leverage the available energy. This shift towards productive use is key to ensuring sustainable economic benefits. When scaling up decentralized energy solutions, it is essential to adopt a bottom-up approach and prioritize the value chain perspective. By understanding the unique requirements of each segment of the value chain, sustainable income generation opportunities can be identified and harnessed. This comprehensive approach ensures that energy solutions are effectively integrated into livelihoods, leading to tangible improvements in productivity and income generation.

Day 2: February 7, 2023

Technical session 14: Monitoring the PM - KUSUM Scheme (Convened by GIZ, India)

Theme 3: Connecting the off-grid to the grid

Session description: India is implementing the PM KUSUM scheme to replace agriculture diesel pumps with solar water pumps and solarise grid connected agriculture pumps. A new innovative component called USPC is introduced in the scheme to maximise the utilization of solar pumps. This session will cover the key aspects of KUSUM portal and the potential USPC adoption roadmap in India.

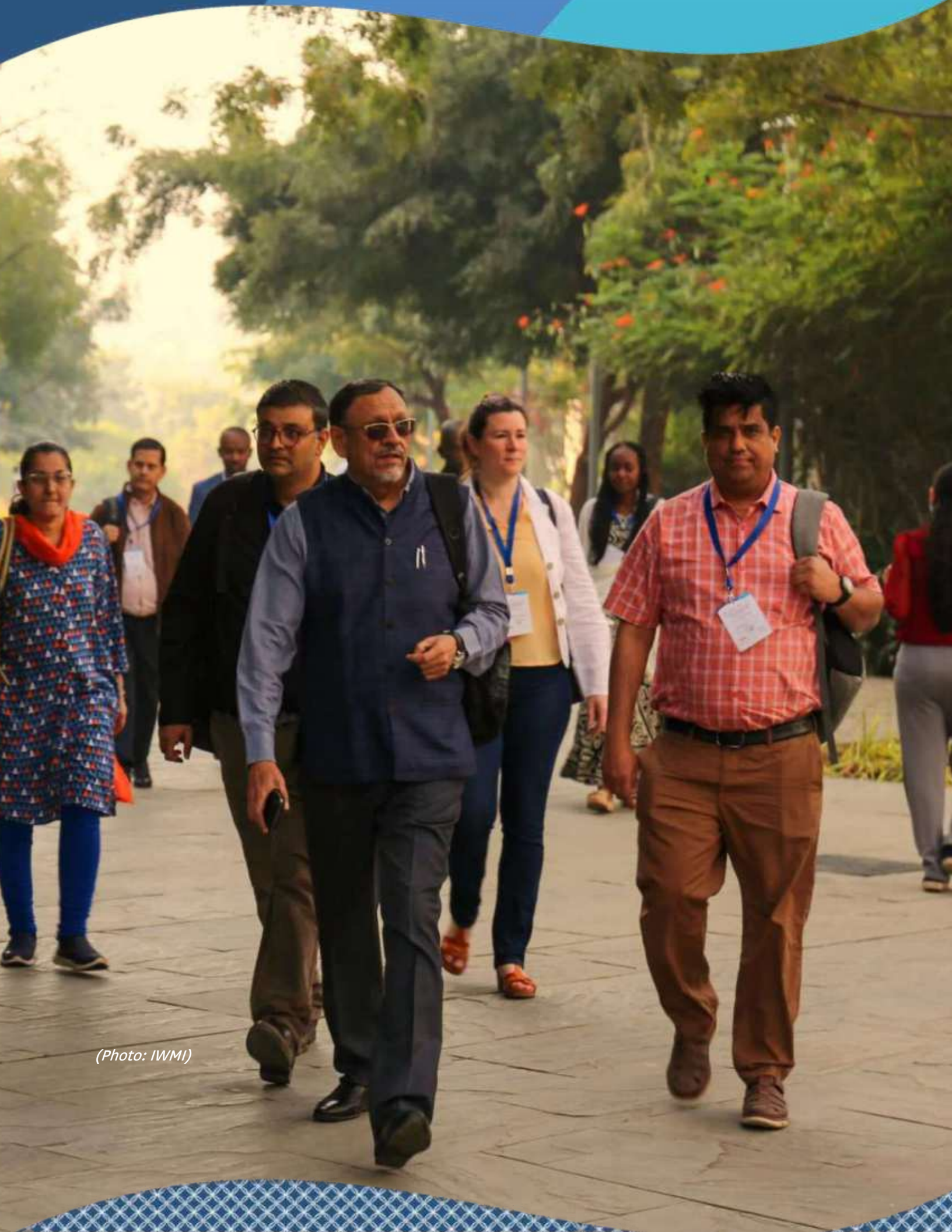
Digitisation of PM KUSUM Scheme - *Sachin Munot (Hari Krupa Automation Pvt. Ltd.)*

The objective of the project is to provide clean energy to 35 lakh farmers, focusing on various aspects to ensure its successful implementation. To effectively manage the project and engage multiple stakeholders, a common platform is being developed. This platform serves as a centralized hub to integrate data from various sources, including the PM KUSUM initiative. By consolidating data and stakeholders on a single platform, efficient management and coordination of the project can be achieved. Monitoring the utilization and quality of energy supply is crucial to evaluate the performance of the project. Regular monitoring enables the identification of any issues or areas that require improvement, ensuring that the clean energy provided meets the required standards.

Integration with National State Energy Departments and Ministries (SEDM), third-party apps, and the KUSUM mobile app further enhances the project's reach and accessibility. By integrating with these platforms, the project can leverage its existing user base and resources, expanding its impact and making it more user-friendly. A pilot study conducted by Jaipur Vidyut Vitran Nigam Limited (JVNL) demonstrated the positive impact of the project. Before the implementation of PM KUSUM, the bill for 2,144 units was high, but after the project's implementation, the consumption was reduced to 1,265 units. This reduction in energy consumption not only contributes to cost savings but also generates income for the farmers. The project has also resulted in significant reductions in time and management efforts. By streamlining processes and utilizing technology, the project has achieved efficient operations and minimized administrative burdens.

A common Remote Monitoring System (RMS) is employed to capture data from field devices and sensors. This centralized system facilitates data collection, analysis, and decision-making, enabling effective monitoring and control of the clean energy supply. Open protocols are being utilized, ensuring compatibility and interoperability between different devices and systems. This approach promotes flexibility, scalability, and ease of integration, allowing for the seamless operation of the clean energy infrastructure. Motivating farmers to save water and electricity is an important aspect of the project. Through awareness campaigns and incentives, farmers are encouraged to adopt sustainable practices and utilize resources efficiently, contributing to environmental conservation and cost savings.

Overall, this project aims to provide clean energy to large number of farmers while ensuring efficient management, integration with existing platforms, monitoring of performance, and motivation for resource conservation. By addressing these aspects, the project strives to create a sustainable and impactful solution for the agricultural sector.



(Photo: IWMI)

Improving the Utilization of SIPs via Universal Solar Pump Controller (USPC) - *Prasun Das (GIZ)*

USPC is introduced as a replacement for normal controllers and is a component of the PM KUSUM scheme. Three specific cases highlight the benefits of utilizing the USPC. In Case 1, a solar pump powers a 3 HP Ata *Chakki* machine, showcasing the potential for clean energy to drive agricultural machinery. Case 2 demonstrates the savings achieved by using a shredder powered by a 5 HP SPIS (Solar Pumping Irrigation System) with the USPC and a 6.5 kW solar panel setup. Case 3 focuses on the savings obtained by utilizing a cow dung machine with the USPC.

Several key issues have been identified. From a product perspective, there is a need for rationalization of the USPC, along with a complex certification process. In terms of features, there are limitations in operating single-phase equipment with the USPC, and there is limited awareness about its capabilities. Additionally, the lack of suitable business models to promote and accelerate the adoption of the USPC poses a challenge. The takeaways from this analysis suggest specific actions to address these issues. Simplification of certification and testing procedures can help streamline the process, making it easier for manufacturers and users to adopt the USPC. Awareness campaigns are necessary to educate stakeholders about the benefits and functionalities of the USPC, fostering greater understanding and interest. Finally, a unified approach is required to drive the adoption of the USPC, involving stakeholders such as government agencies, manufacturers, and industry associations.

Overall, the USPC presents a promising solution for enhancing the efficiency and utilization of solar-powered agricultural machinery. By addressing the key issues and implementing the suggested takeaways, the widespread adoption of the USPC can be facilitated, contributing to the success of the PM KUSUM initiative and the promotion of clean energy in the agricultural sector.

Sharing Insights from the Implementation of the PM-KUSUM Scheme - *Shobhit Srivastava (MNRE)*

The PM KUSUM scheme is designed to benefit young entrepreneurs and farmers with a specific focus on agricultural use. The scheme consists of three components, each addressing different aspects of solar power generation and utilization.

Component A provides support to farmers for utilizing barren land and enables them to sell the power generated to distribution companies. For example, in the Rajasthan area, farmers have earned Rs 4.8 million through this component, with 90 MW of installed capacity. Component B focuses on standalone solar pumps, which provide reliable and sustainable water supply for agricultural activities. These pumps operate using solar power, reducing the dependence on traditional energy sources. and minimizing costs for the farmers. Component C aims to solarize individual pumps on a national level. Under this component, financial support is provided to farmers to convert their existing pumps into solar-powered systems. The scheme was initiated with the solarization of 1000 pumps. By leveraging solar energy for pump operation, farmers can meet their own energy needs and potentially sell any excess power generated, without having to invest additional funds to make the switch.The scheme has allocated 2 million feeders for solarization under Component C. This demonstrates the scale and ambition of the initiative, aiming to solarize a significant number of pumps across the country. Overall, the PM KUSUM scheme offers multiple avenues for young entrepreneurs and farmers to benefit from solar power in the agricultural sector. It provides financial support, encourages the utilization of barren land, promotes standalone solar pumps, and facilitates the conversion of individual pumps to solar power. By embracing solar energy, farmers can reduce their operational costs, enhance their agricultural productivity, and contribute to sustainable development in the agricultural sector.

Day 2: February 7, 2023

Plenary: Wrapping up Day 2

What is Next in our SoLAR Journey? - A decade of Solar Irrigation in South Asia - *Tushaar Shah (IWMI)*

The presentation highlights the key learnings from the IWMI-TATA water policy program over the past decades, specifically focusing on installing solar pumps in India. The number of solar pumps installed in the country has significantly increased from 11,600 in 1992 to 339,607 in 2022. During the design phase since 2010, three hypotheses guided the policy decisions. Firstly, it was believed that SIPs and SIP-led water markets would alleviate the burden of high diesel prices for small-scale farmers in the Ganga basin. Secondly, it was assumed that SIPs, with their zero marginal cost and daytime power generation, would exacerbate the groundwater crisis in semi-arid and arid regions with alluvial and hard-rock geologies. Lastly, it was believed that providing SIPs instead of grid power connections would save future subsidy burdens for power distribution companies (DISCOMs).

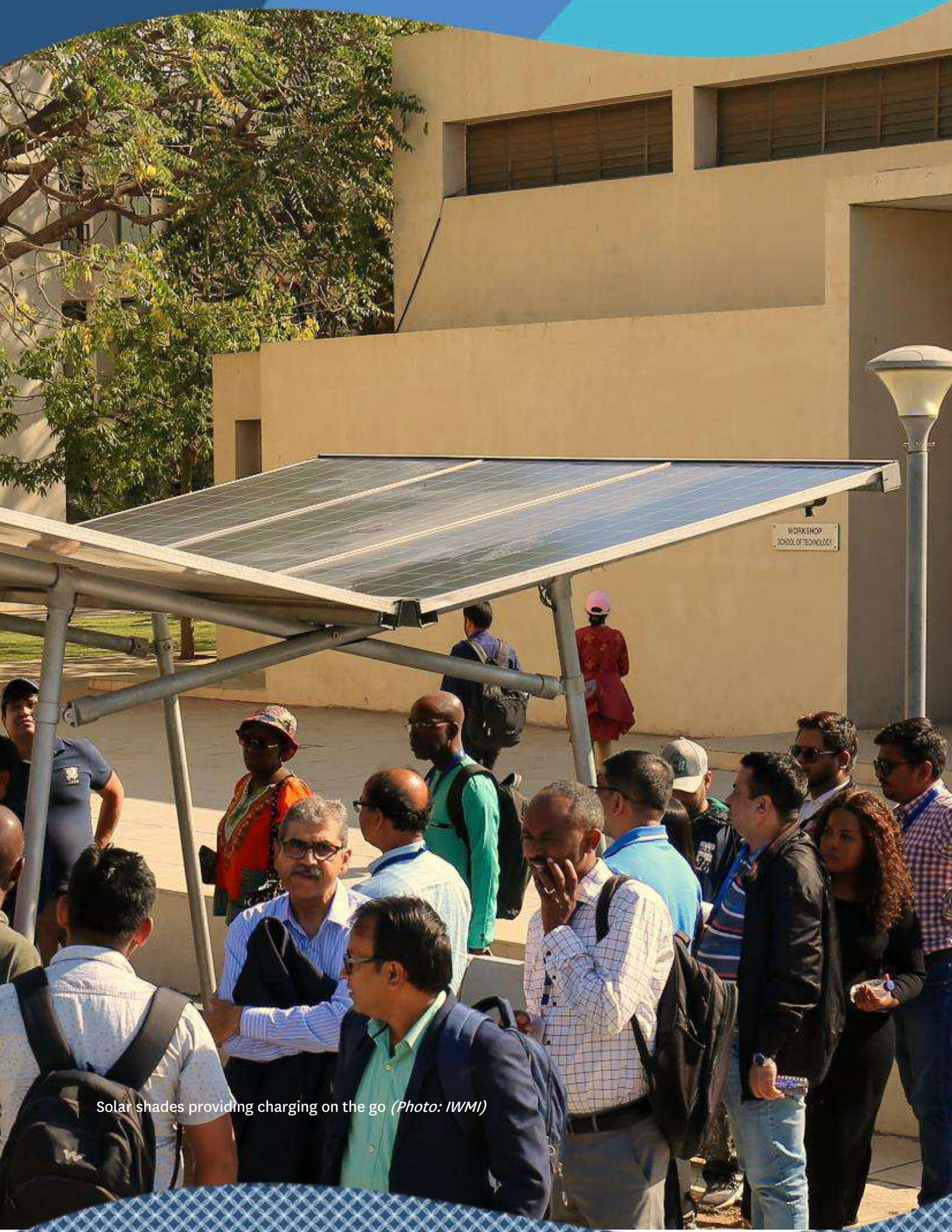
However, the evidence gathered raises questions and challenges these beliefs. It questions whether diesel vouchers would be a better alternative and whether investing Rs 500,000 in SIPs is the most effective way to improve livelihoods. Currently, SIPs do not pose a threat to groundwater. In Gujarat, for example, the Rs 500,000 SIP subsidy amounts to Rs 50,000/year energy subsidy, and one-third of SIP owners also have grid power connections. In India, there are now four SIP promotion models. Gujarat's SKY SIPs and Maharashtra Solar Feeders have achieved 100% utilization of the generated electricity. Tata Power-Smart Power Microgrids have achieved 70% utilization, while KUSUM B off-grid SIPs have lower utilization, at 30% of the generated energy.

The presentation suggests reconceptualizing the PM-KUSUM program with several recommendations. First, off-grid SIPs should only be subsidized in off-grid villages, of which there are none in India. Second, the policy should acknowledge that SIPs play an important but minor role in irrigation. Third, all SIPs should be grid-connected and net-metered. The objectives of the new KUSUM program should include metering 19 million unmetered grid-connected tube wells, creating a farmer-participatory rural power grid, and enabling farmers to earn income by selling 60-70% of their solar generation. The feed-in tariff (FiT) should be determined to maximize farmer capital contribution and local water prices, with lower FiTs in water-abundant regions and graduated rises in FiT in water-stressed areas to discourage excessive groundwater extraction.

Closing Panel Discussion: The Main Takeaways from Day 1 and Thinking Ahead on Phase 2

Moderated: *Aditi Mukherji (IWMI)* **Panelists**: P. C. Sharma (ISA), Md. Enamul Karim Pavel (IDCOL), Shiferaw Gobena (GGGI), Mary Jean Gabriel (DALRRD, South Africa), William Ponela (Zonful Energy, Zimbabwe),

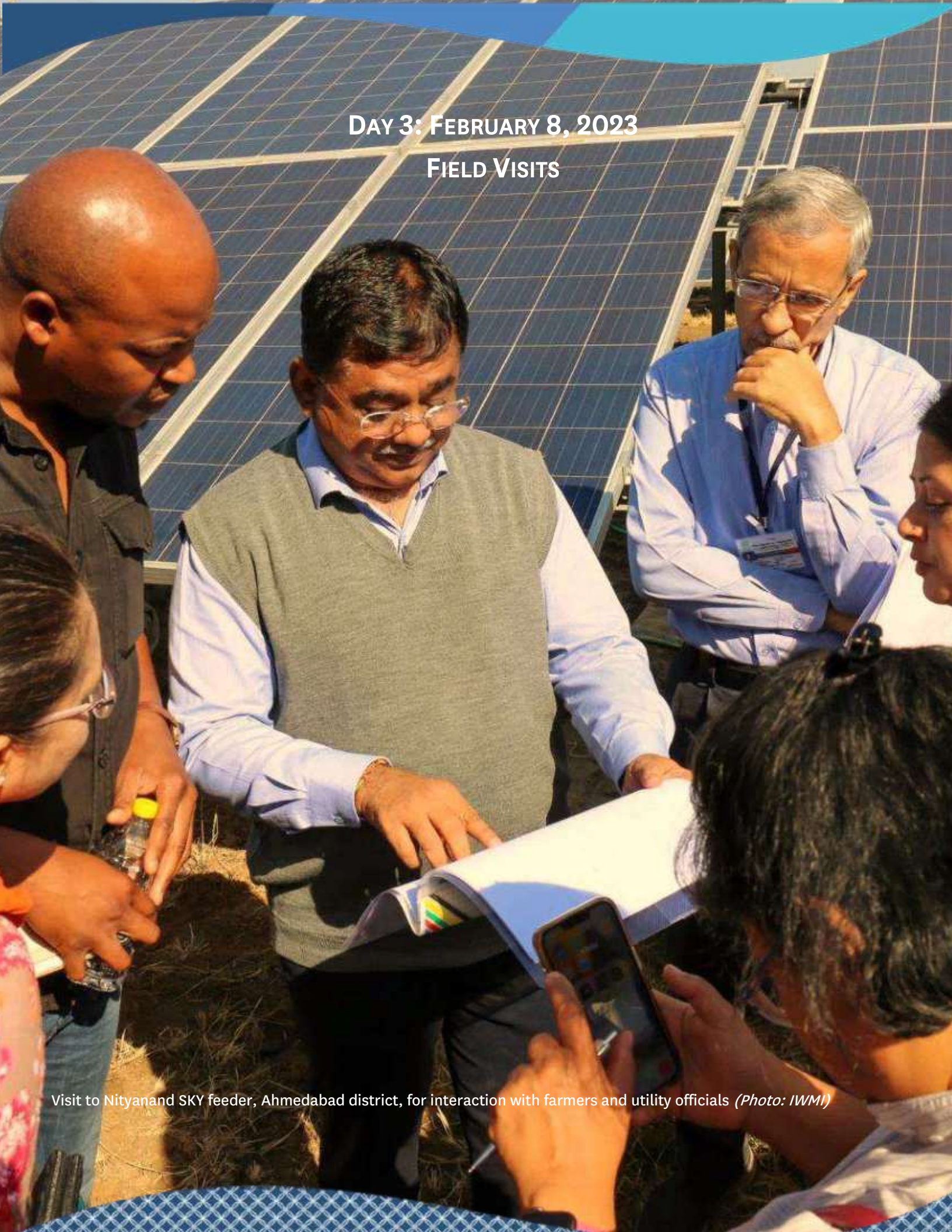
The panel discussion on SIPs and promoting solar irrigation in agriculture highlighted several key takeaways. These included the importance of conducting hydrological surveys to assess feasibility, addressing issues related to farmers' purchasing power and land ownership, and integrating gender perspectives into the policy design. The panel also emphasized the benefits of local production of pumps, subsidies, and market linkages to incentivize adoption. Credit access, value chain strengthening, and technical challenges such as installation and maintenance were identified as crucial factors. Financial considerations, including innovative models and private sector involvement, were highlighted, along with the need for proactive policy formulation and capacity building at all levels. Maximizing capacity utilization, grid integration, and promoting technology and innovation were also emphasized as essential for the benefit of smallholder farmers. The focus was on addressing technical, financial, and policy-related aspects while prioritizing capacity building, market linkages, and gender-inclusive approaches. Considering these key takeaways, the promotion and scaling of solar irrigation in agriculture can be supported, contributing to sustainable and resilient agricultural practices.



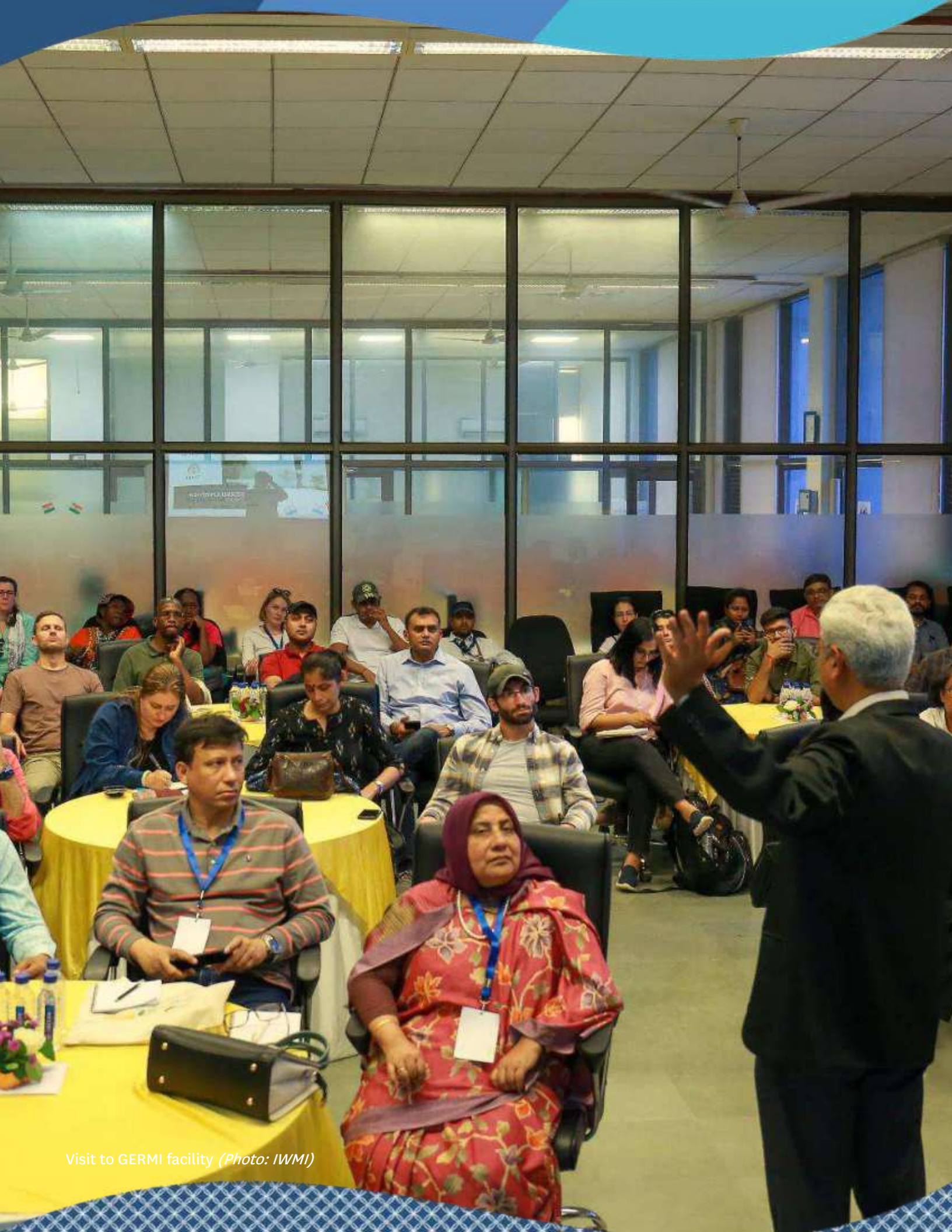
Solar shades providing charging on the go *(Photo: IWMI)*

Day 3: February 8, 2023

Field Visits



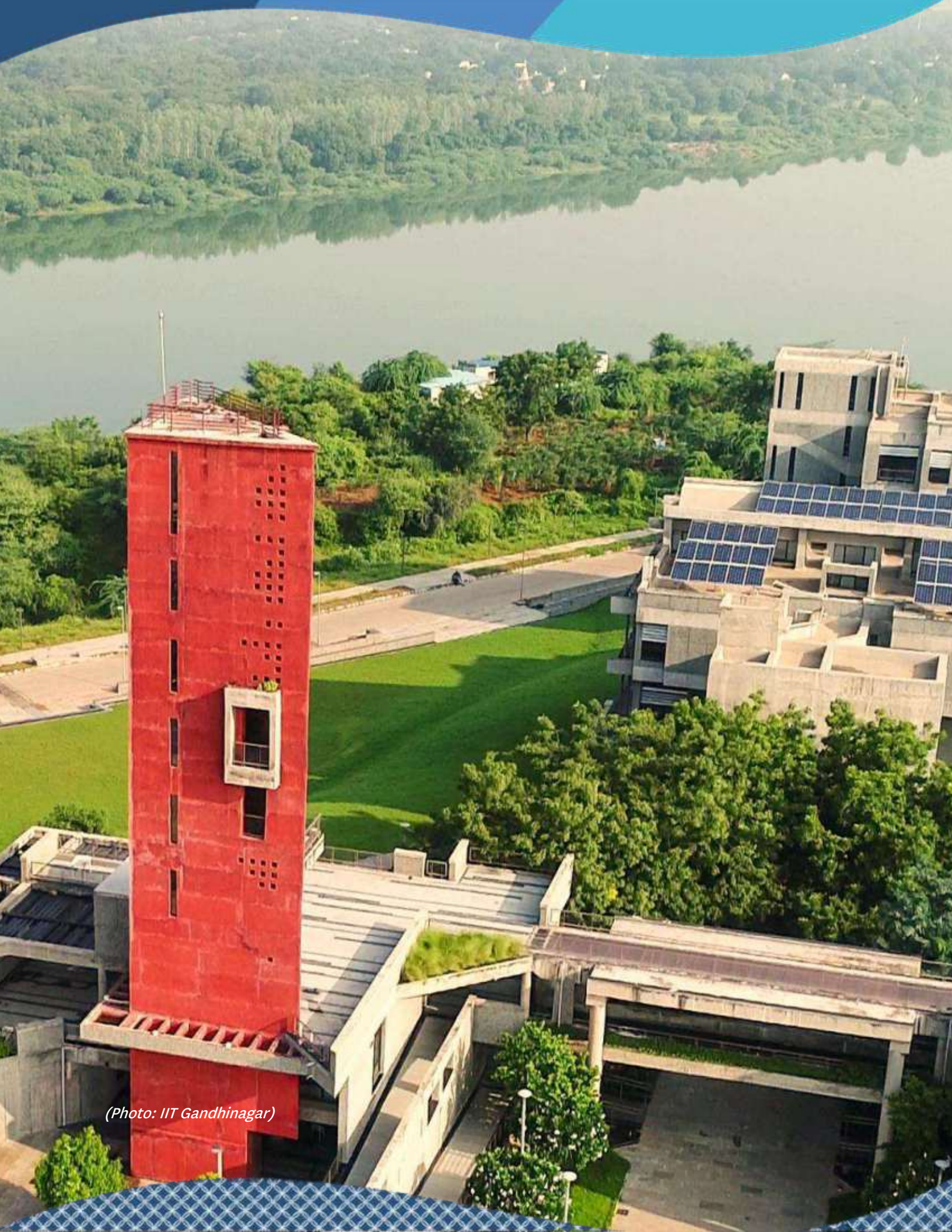
Visit to Nityanand SKY feeder, Ahmedabad district, for interaction with farmers and utility officials *(Photo: IWMI)*



Visit to GERMI facility *(Photo: IWMI)*

ACRONYMS

AEPC	Alternative Energy Promotion Centre
AIT	Asian Institute of Technology, Thailand
ATTREE	Ashoka Trust for Research in Ecology and the Environment
BADC	Bangladesh Agricultural Development Corporation
BARC	Bangladesh Agricultural Research Council
BWDB	Bangladesh Water Development Board
CEEW	Council on Energy, Environment and Water
CINI	Collectives for Integrated Livelihood Initiatives
DAE	Directorate of Agricultural Extension
DWRI	Department of Water Resources and Irrigation
EARN	Excess Energy Accumulation and Redistributed Network
GGGI	Global Green Growth Institute
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GUVNL	Gujarat Urja Vikas Nigam Limited
ICARDA	International Center for Agricultural Research in the Dry Areas
IDCOL	Infrastructure Development Company Limited
IIT-GN	Indian Institute of Technology Gandhinagar
IRENA	International Renewable Energy Agency
IRMA	Institute of Rural Management
ISA	International Solar Alliance
IWMI	International Water Management Institute
KARMA	Kalinga Renewable Energy Manufacturers Private Limited
MNRE	Ministry of New and Renewable Energy
NARMIN	National Association of Rural Municipalities in Nepal
PARC	Pakistan Agricultural Research Council
PGCVL	Paschim Gujarat Vij Company Limited
SDC	Swiss Agency for Development and Cooperation
SREDA	Sustainable And Renewable Energy Development Authority
UNDP	United Nations Development Programme
WRI	World Resources Institute



(Photo: IIT Gandhinagar)

IWMI
International Water Management Institute

CGIAR
IWMI is a CGIAR Research Center

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.

International Water Management Institute (IWMI)
Headquarters
127 Sunil Mawatha, Pelawatta
Battaramulla, Sri Lanka

Mailing address:
P. O. Box 2075
Colombo, Sri Lanka
Tel: +94 11 2880000
Fax: +94 11 2786854
Email: iwmi@cgiar.org
www.iwmi.org