SDC-SoLAR Phase II Proposal

Submitted by: International Water Management Institute

Contents

Acronyms

ADB	Asian Development Bank
AEPC	Alternative Energy Promotion Centre
AfDB	African Development Bank
Agroecology TPP	Transformative Partnership Platform on Agroecological Approaches
ATI	Agricultural Transformation Institute
AWD	Alternate Wetting and Drying
BADC	Bangladesh Agricultural Development Corporation
BMDA	Barind Multipurpose Development Authority
BREB	Bangladesh Rural Electrification Board
BRRI	Bangladesh Rice Research Institute
CEE	Council on Energy, Environment, and Water
CEEW	Council on Energy, Environment, and Water
CGIAR	Consultative Group on International Agricultural Research
CIMMYT	International Maize and Wheat Improvement Center
CInI	Collectives for Integrated Livelihood Initiatives
CSP	Concentrated Solar Power
DAE	Department of Agricultural Extension
DGVCL	Dakshin Gujarat Vij Company Limited
DISCOM	Power Distribution Companies
DIWASA	Digital Water Solutions for Africa
DSIR	Department of Scientific and Industrial Research (India)
FAO	Food and Agriculture Organization
FSRP	Food Systems Resilience Programme
GCF	Green Climate Fund
GERMI	Gujarat Energy Research and Management Institute
GESI MDII	GESI Multidimensional Inclusivity Index
GESI	Gender Equity and Social Inclusion
GGA	Global Goal on Adaptation
GHG	Greenhouse Gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GOB	Government of Bangladesh
GOB	Government of Bangladesh
GSPCL	Gujarat State Petroleum Corporation Limited
GUVNL	Gujarat Urja Vikas Nigam Limited
ICAR	Indian Council of Agricultural Research
IDCOL	Infrastructure Development Company Limited
IFAD	International Fund for Agricultural Development

IF Grantee	Innovation Fund Grantee
IFRCRCS	International Federation of Red Cross and Red Crescent Societies
ILSSI	Innovation Lab for Small-Scale Irrigation
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
IRENA	International Renewable Energy Agency
ISA	International Solar Alliance
IWMI	International Water Management Institute
KfW	Kreditanstalt für Wiederaufbau (German Development Bank)
KOSAP	Kenya Off-Grid Solar Access Project
KVK	Krishi Vigyan Kendra
LGED	Local Government Engineering Department
LMIC	Low and Middle-Income Countries
MGVCL	Madhya Gujarat Vij Company Limited
MNRE	Ministry of New and Renewable Energy
MoA	Ministry of Agriculture (Ethiopia)
MoEF&CC	Ministry of Environment, Forest and Climate Change
MoRD	Ministry of Rural Development
MOSPI	Ministry of Statistics and Programme Implementation
MSW	Ministry of Social Welfare
NABARD	National Bank for Agriculture and Rural Development
NAP	National Adaptation Plan
NAPCC	National Action Plan on Climate Change
NDC	Nationally Determined Contributions
NEA	Nepal Electricity Authority
NREGA	National Rural Employment Guarantee Act
OC1	Outcome 1 (Evidence-based Policy Design)
OC2	Outcome 2 (Accelerating Finance)
OC3	Outcome 3 (Knowledge and Capacity Building)
OC4	Outcome 4 (Piloting and Validating)
PACT	Productive Assets for Communities and Transformation
PAYGO	Pay-as-you-go
PAY-OWN	Pay-Own pump sales model
PFC	Power Finance Corporation
PGVCL	Paschim Gujarat Vij Company Limited
PM-KUSUM	Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan
PMU	Project Management Unit
PRIAT	Punjab Resilient and Inclusive Agriculture Transformation
PSC	Project Steering Committee
REC	Rural Electrification Corporation

SDC	Swiss Agency for Development and Cooperation
SDG	Sustainable Development Goals
SE4RL	Solar Energy for Rural Livelihoods
SESA	Solar Energy Systems for Agriculture
SENDAI	Sendai Framework for Disaster Risk Reduction
SIP	Solar Irrigation Pump
SKY	Surya Shakti Kisan Yojana
SME	Small and Medium Enterprises
SoLAR	Solar Irrigation for Agricultural Resilience in South Asia
SPIS	Solar-powered Irrigation Systems
SREDA	Sustainable and Renewable Energy Development Authority
TAFSSA	Transforming Agrifood Systems in South Asia
ToC	Theory of Change
UGVCL	Uttar Gujarat Vij Company Limited
UPNEDA	Uttar Pradesh New and Renewable Energy Development Agency
USAID	United States Agency for International Development
WaPOR	Water Productivity through Open Access of Remotely Sensed Data Initiative
WASCA	Water Security and Climate Adaptation
WEF	Water, Energy, and Food
WEFE	Water-Energy-Food-Environment (Nexus)
WEF-SS	Water-Energy-Food-Solar Suitability

Glossary

Beneficiaries: The individuals, groups, or organizations, whether targeted or not, that benefit, directly or indirectly, from the chain of events that project research has contributed to.

CGIAR Portfolio: CGIAR Science Programs, Accelerators, and bilateral projects

GESI Multi-Dimensional Inclusivity Index (MDII): The GESI Multidimensional Digital Inclusiveness Index (MDII) provides a holistic guideline and metrics for promoting digital inclusivity, that indicates all aspects of 6 enabling a socially inclusive digital transformation process. It emerges from a series of strategic efforts from the CGIAR Digital Innovation Initiative work led by the International Water Management Institute (IWMI), Alliance Bioversity- CIAT and International Rice Research Institute (IRRI)

Impact: An effect that a project is expected to have upon the condition of people, organizations and their environment brought about by a chain of events to which research, innovations, and related activities have contributed.

Impact assessment: Studies that estimate the causal effects of research outputs and related activities on one or more development parameters of project interest. Impact evaluation helps people answer key questions for evidence-based policy making: what works, what doesn't, where, why and for how much?

Innovation bundle: It is a set of technological, social, institutional, financial, business or process innovations complementing each other's to adapt and scale to new contexts they are being introduced. Innovation bundles in solar reflect a combination of product/service innovations or solutions: e.g., solar powered irrigation pumps are bundled with complementary innovations (like drip + sprinkler, pay-as-you-go financing and pre- and after-sales services) that improve the enabling environment for adoption.

Innovation system: The interlinked set of people, processes, assets, and social institutions that enable the introduction and scaling of new ideas, products, services, and solutions capable of facilitating impact.

Logframe: Logical Framework is a planning tool/methodology consisting of a matrix which provides an overview of a project's goal, activities and anticipated results used for designing, monitoring, and evaluating projects. It also identifies measures (indicators) by which the project's anticipated results will be monitored.

Micro-SIP: These are small and portable solar irrigation pumps which helps the small and marginal farmers to meet their irrigation needs

Living Labs: in the context of this proposal refer to programs/initiatives that are being continually honed and implemented in real-life contexts using iterative feedback processes. Examples include PM-KUSUM, Krishi Vigyan Kendra (KVK) platform [IN], IDCOL's business models [BG], platforms for implementing micro-SIPs by the DAE and BRRI [BG], PACT [ET], SHIDEP [ET], NSSID [ET]; IFAD [KE].

Marginalized groups: It is a group of under-represented people such as women, marginal farmers, Women, migrated, Indigenous and displaced people/community.

Outcome: A change in knowledge, skills, attitudes and/or relationships, which manifests as a change in behavior/policy, to which project research outputs and related activities have contributed.

Output: Knowledge, technical or institutional advancement produced by project research/activities, examples of outputs include new research methods, policy analysis, capacity development, partnership building, maps/tools, institutional innovations or other products of research work.

Responsible scaling: Responsible scaling requires ethics of co-responsibility for ensuring that the project impacts are well captured by the intended beneficiaries and minimizing negative societal or ecological consequences

Results: The output, outcome or impact of an intervention/project.

SoLAR 1: Solar Energy Systems for Agriculture phase 1 refers to the first phase of the SDC-funded solar energy for agricultural resilience program that was implemented between 2019-2024 in four countries of South Asia (India, Pakistan, Nepal and Bangladesh)

Scaling: Scaling of innovations is a deliberate and planned effort to enable the use of innovations to have positive impact for many people across broad geographies.

Scaling pathways refer to the strategies, processes, and actions taken to scale the adoption of innovations, practices, or technologies beyond their initial scope.

Scaling Readiness: Scaling readiness is a process that helps organizations, projects, and programs scale innovations and achieve impact. It encourages critical reflection on how ready an innovation is for scaling, and what actions can be taken to accelerate or enhance scaling

Theory of change: An explicit, testable model of how and why change is expected to happen along an impact pathway, drawing on a causal analysis based on available evidence.

Water-Energy-Food Nexus: The water-energy-food nexus (WEF nexus) is the study of the complex relationships between water, energy, and food, and how they impact ecosystems.

Executive Summary

Solar Energy for Agricultural Resilience (SoLAR) Phase 2 builds upon learnings and experiences from Phase 1 of SoLAR (2019-2024) in South Asia while expanding its scope to East Africa through meaningful south-south collaborations. The program aims to **strengthen the enabling environment and unlock investments for sustainable scaling of socially inclusive and climate-resilient solar agri-tech solutions in South Asia (India, Bangladesh) and East Africa (Ethiopia, Kenya).** It will deliver across four main outcomes (OCs) that relate to Evidence-based policy design (OC1), Accelerating Finance (OC2), Capacity Building (OC3) and Scaling Solar through Living Labs (OC4). Through this, the project will support improvement of energy and water security for vulnerable populations, help mitigate emissions from agriculture, increase adaptive capacity and resilience to climate change and ultimately support poverty reduction and development.

Solar Phase 2 will be implemented in four countries - Bangladesh, India, Ethiopia and Kenya in partnership with government and implementing agencies who have the mandate to implement policies and programs on solar energy for agriculture. The duration of this phase will be three years and seven months, from June 2025 till December 2028.

Background and context

In South Asia, agriculture is primarily irrigation-dependent and relies on grid-connected (electricity) or fossil fuel-based pumps, both heavily subsidized by governments. Conversely, agriculture is mainly rainfed in semi-arid East Africa, and food and livelihood security concerns have mandated improving irrigation infrastructure through small-scale decentralized schemes. Across the regions, high fossil fuel prices, global energy disruptions, unreliable grid electricity, and high subsidy costs are pushing farmers and governments to seek alternative energy sources like solar to power their irrigation and agriculture needs, as visible through explicit national commitments and schemes. Improved photovoltaic technologies have allowed solar-based irrigation pumps (SIPs) [and wider solar technologies, such as used for agrivoltaics, cold-storage, water heating, drying crops and grains], to be a cost-effective alternative to grid-connected-electric and off-grid-diesel pumps in South Asia and East Africa. Solar provides decentralized and reliable energy for agriculture and promotes climate resilience, carbon mitigation, and sustainable groundwater management in regions facing increasing climate risks, e.g. unseasonal floods and droughts. Solar energy systems can have multiple co-benefits for farmers in terms of reduced cost and labor for irrigation without any yield/profitability penalty, thereby supporting farmers in their livelihood and income security. Innovative solar models have demonstrated the potential to overcome Gender and Social Inclusion (GESI)-related barriers to energy access, empowering women farmers and smallholders in the agriculture sector.

However, significant constraints remain on the large-scale adoption of solar for agriculture across South Asia and East Africa, including prohibitively high upfront costs, restricted access to finance (bank loans and insurance), and lack of awareness of its benefits due to inadequate outreach, especially among smallholders and women farmers. In South Asia, high subsidies (grid electricity and fossil fuel) disincentivize farmers to switch to solar even when long-term benefits are visible.

SoLAR Phase 1

SoLAR Phase 1 (2019-2024) was set up to provide improved empirical evidence, understand, validate and test actions and approaches to solar irrigation to support government policies in South Asia. It is

a successful multi-country program supported by SDC, that explored the potential of Solar Irrigation Pumps (SIPs) in developing climate-resilient, gender-equitable, and socially inclusive agrarian livelihoods in South Asia (Bangladesh, India, Nepal and Pakistan). The project created robust evidence-based knowledge for SIP policy development, targeted subsidy design and innovative adoption tools under an integrated water-energy-food (WEF) nexus framework. SIPs were piloted, validated, and promoted as multi-purpose vehicles for achieving food and livelihood security, sustainable groundwater management, climate adaptation, and carbon mitigation, with a strong GESI focus on women entrepreneurs and smallholders. Using effective science communication, the project built the technical and social capacity of policymakers, local governments, technicians, and farmers.

The project demonstrated the importance of south-south knowledge exchange for documenting interlinkages between SIPs, emission reduction, agricultural productivity, livelihoods and food security within differing contexts. The program learnings have shown that transitioning to solar-based irrigation provides various livelihood benefits to farmers, besides mitigating diesel-driven carbon emissions in agriculture and holds considerable value for countries updating their national climate and development plans. The fundamental need for this program has thus only strengthened since SDC's initial support was provided.

Following a successful phase 1, the program proposes to expand its reach to include countries in East Africa, and build upon lessons learnt in South Asia. Ethiopia and Kenya will be included in the study alongside phase one countries - Bangladesh and India. To aid setting up of the most effective partnerships and stakeholders, a 6-month inception phase will be planned in Kenya and Ethiopia. In all four countries, there is burgeoning political and market interest to scale solar energy applications in agriculture. India, Bangladesh, and Ethiopia explicitly mention solar in general and SIPs in particular in their NDC submissions. Ethiopia and Bangladesh have submitted National Adaptation Plans (NAPs), which reference SIPs for water security. In India, PM-KUSUM (A, B and C schemes) promotes SIP adoption through various incentives, and the draft NAP has incorporated water as a key sector. Furthermore, given evidence of livelihood co-benefits in India, consultations with policymakers have indicated an interest to better integrate solar schemes into national and state rural livelihood missions. In Kenya, under vision 2030, the government aims to promote development of renewable energy as an alternative source of energy, which includes generation of energy from solar and promotion of low-cost irrigation technologies.

SoLAR Phase 2: Outcomes

The program outcomes will strengthen existing governance structures and systems and enable policies in the agriculture and energy sectors to ensure sustainable scaling and financing of solar energy for agriculture and food systems in South Asia and East Africa. The Project will deliver across four main outcomes in selected countries - South Asia (India, Bangladesh) and East Africa (Ethiopia, Kenya). The four outcomes together cover key elements needed to unpack barriers to scale solar energy for agriculture (SESA) - policy, finance, capacity and scaling (Figure 1). The resulting outputs and activities will work together synergistically in a logical and effective way, ensuring that the program goals and impact are achieved. Outcome 1 will develop decision-support tools and principles for effective scaling for policymakers, Outcome 2 will enhance these tools by introducing innovative financing options. However, without adequate capacity and buy-in from end-users, the challenges for scaling solar will persist - Outcomes 3 and 4 will leverage findings from Outcomes 1 and 2 to ensure that stakeholders are informed and equipped to utilize these innovations. Outcome

4 will focus on scaling and optimizing through existing platforms and living labs, such that sustainability of the innovations is well embedded beyond the timeframe of this program.

Tools, methodologies, and products from this phase will be co-designed and developed alongside partners who play leading roles in solar energy upscaling and policy development and eventually will be embedded and hosted by stakeholders including government (e.g. Ministries such as Ministry of New and Renewable Energy of India, Ministry of Agriculture, Ethiopia) and implementing agencies (e.g. National Solar Help Desk of Bangladesh).

Outcome 1 - Policymakers embed water energy food interlinkages in a socially inclusive manner, to enhance effectiveness of solar agri-tech programs [Evidence-based **Policy** design**]**: Under this outcome, the project assesses the impact of solar irrigation on Water-Energy-Food (WEF) and climate systems to propose a WEF-sensitive solar irrigation framework. A WEF composite index and first-of-its-kind Water-Energy-Food-Solar Suitability (WEF-SS) maps for India, Bangladesh, Ethiopia, and Kenya will support policymakers in evaluating solar applications in agriculture. To enhance the effectiveness of solar schemes, decision-support tools will be developed and refined, including the development of tailored solar sizing models for Bangladesh, Kenya, and Ethiopia. Key deliverables include a functional online solar sizing tool and user manual, a live digital database of critical indicators for PM-KUSUM in India, and country-specific training sessions with implementing agencies to facilitate the practical use of these tools for implementing solar policy schemes but also to be used alongside rural livelihood schemes.

Outcome 2 - Climate-smart and socially inclusive financing solutions for scaling solar agri-tech are co-developed and launched [Accelerating **Finance**]: Under this outcome, the project focuses on advancing financial mechanisms to improve equitable and inclusive access to solar technology, finance, and markets, specifically in India and Bangladesh, through the identification and validation of effective financial instruments and incentives. This includes assessing both market and non-market-based instruments and co-designing climate-smart financial models in collaboration with private sector partners and government stakeholders. In Ethiopia and Kenya, working alongside ImpactSF (a CGIAR initiative) and responsAbility (an impact asset manager), the project will explore the feasibility of a Solar4Africa Irrigation Investment Fund by conducting an investment and financing landscape assessment and identifying promising investment solutions, culminating into a comprehensive feasibility report of the most viable investment options.

Outcome 3 - Strengthened knowledge, capacities and south-south collaboration leads to greater uptake of solar agri-tech applications [**Capacity** Building]: Under this outcome, the project aims to boost the adoption of solar energy practices through training, capacity building, South-South collaboration, and knowledge dissemination via national and global forums. Key activities include tailored training programs and knowledge exchange for farmers, technicians, and implementing officials, focusing on tools and methodologies developed under OC1 and OC2, with particular emphasis on empowering women. In India, for instance, a partnership with Indian Council of Agriculture Research (ICAR, Government of India) will conceptualize and implement the role of extension agents to promote uptake of solar and assist farmers, along with a roadmap to institutionalize this model within agricultural extension services. In Ethiopia and Kenya, targeted training programs (Training of Trainers) from both government and private sectors will be developed, complemented by a roadmap to embed these capacity-building initiatives within local frameworks. To ensure that benefits of solar towards income security, growth, food security, nutritional diversity and community resilience are well-captured in capacity building efforts, the program will aim to work alongside alliances such as *'SufoSec'* that are present in our project countries.

Outcome 4 - Existing platforms and living labs are assessed and optimized for scaling solar agri-tech bundles [Solar **Scaling** through Living Labs]: Under this outcome, the project focuses on assessing the scalability of solar energy innovations, particularly for women and marginal farmers, and through a "living labs" approach linked to OC1 and OC2. By working alongside existing initiatives and centering on farmers, these pilots and assessments aim to identify optimal bundling solutions that maximize benefits and facilitate scaling and optimizing solutions. The findings will aid governments and agencies in understanding real-world applicability and necessary adjustments for effective scaling of solar energy systems.

Through these outcomes, SoLAR - Phase 2 will significantly contribute to water, energy, food, and climate security for people, ecosystems, and businesses and support countries in meeting national commitments and goals set by global frameworks such as the Paris Agreement and multiple Sustainable Development Goals.

In addition to a 4.6 million CHF contribution by the Swiss Development Corporation (SDC), Phase 2 will seek enhanced convergence with IWMI and CGIAR programs. Under the new CGIAR 2025-2030 portfolio, the program will likely be homed under the 'Scaling for Impact' Science Program (SP). SoLAR – 2 and its objectives align well with the key areas of work under this SP. The work will also leverage existing and upcoming solar-supporting programs by international donors, including GIZ, ISA, World Bank, IRENA, IFAD among others in the respective regions.

Context

Climate change affects crop yields, livestock and soil and water resources which combined, impacts on sustainable development as a whole through its effects on livelihoods, food security, nutrition and nutritional quality. As crops become less resilient to climate stressors, the variety and quality of food may decline with potentially wide-reaching impacts. Simultaneously, agriculture is a major source of Greenhouse Gas (GHG) emissions both directly (through on-farm emissions linked to production e.g. diesel irrigation) and indirectly (through land use change as a result of agricultural expansion).

Renewable energy presents a viable means of ensuring energy security and supporting improved climate and livelihood resilience for rural livelihoods across the Global South. Among the diverse array of renewable energy projects now in operation, solar energy offers a promising solution to build climate resilience by providing access to irrigation and associated services particularly for populations living in remote areas. This is especially beneficial in regions where access to electricity is unreliable, expensive or where farmers lack electricity connections. In most regions in the 'Global South', solar photovoltaics can offer 1,400 – 2,200 peak-hours of reliable and affordable green energy. With unit costs declining, and significant promotion by government and the private sector in many parts of the global south, it is not surprising that solar energy is becoming a popular alternative in the agricultural settings of South Asia and East Africa.

Solar Energy for Agricultural Resilience (SoLAR) – 1 was set up in 2019 specifically with the intention to provide improved empirical evidence to understand, validate and test actions and approaches to support government policies on solar irrigation in South Asia. SoLAR 1 implementation experience has underscored the fundamental need and justification for the program across wider regions of the Global South where there remain barriers to scaling the technology in different agricultural settings.

Over the last decade, solar energy systems for agriculture (SESA) have gained significant traction, with rising uptake of solar powered technologies, particularly irrigation. In South Asia alone, more than 500,000 small standalone pumps have been installed, while in Sub-Saharan Africa, solar pumps are becoming a crucial technology for expanding irrigated agriculture. Emerging evidence from Solar Phase 1 highlights the transformational potential of solar energy in enhancing livelihoods, agri-food systems, poverty reduction, and recognizing the agency of women and marginalized groups in climate-resilient irrigation. With consistent water supply and marginal running costs, solar-adopting communities can grow multiple crops annually and thus ensure nutritional security, report higher yields, diversify into new crops, and achieve significant improvements in farm income, food security, nutrition, and overall economic and social well-being. Importantly, harnessing solar unlocks a cascade of benefits - socially, economically, and developmentally, improving overall community resilience to climate shocks. Solar power places power 'back into the hands of individuals and communities', breaking down barriers that have long excluded them from the energy economy. This shift empowers people, particularly women, making them direct participants in the economy and catalysts for change, rather than just beneficiaries.

Despite these opportunities, there remain questions around the impacts of solar, and particularly solar irrigation, across Water, Energy, and Food (WEF) systems. For instance, impacts on groundwater needs to be managed carefully as there is a risk that the rising number of solar irrigation pumps (SIPs) may increase groundwater abstraction. Evidence has however shown that

highly subsidized electricity has facilitated unsustainable rates of abstraction, that in turn, have led to groundwater overexploitation, diminishing well yields and falling water tables[1]. There are concerns that this can be exacerbated by solar irrigation, due to lower running costs of SIPs. Additionally, the adoption of solar pumps could incentivize farmers to make changes to land use and input choices that increase carbon-intensive practices, such as cultivating water-intensive crops, which may lead to a net increase in emissions, and have negative impacts on nutritional diversity. Issues of equity and inclusion in access to and control over Solar Systems for Agriculture remain a systemic challenge to tackle, given the high cost and capacity needed to install and operate.

Through Phase 1 of SDC-SoLAR, we have delivered evidence that confirms that the scaling of solar energy in a Water-Energy-Food (WEF) nexus-responsive way can maximize synergies and minimize some of the above trade-offs from solar expansion, generating multiple benefits spanning water, energy, food and nutrition, environment, development and climate sectors. However, policy, implementation and capacity barriers have stunted scalability. Policies aimed at quick adoption and expansion of solar pumps should clearly outline the goals for using solar energy in agriculture while also making strategies to address its limitations and risks (e.g. groundwater sustainability, exclusion of small and marginal farmers). For instance, the PM-KUSUM scheme in India lacks specific criteria for allocating highly subsidized SIPs to small and marginal farmers.

Climate finance and investments, key to scaling, represent a critical opportunity, but are not well understood, particularly in the Global South. The value chains of small-scale agriculture and the financial institutions that support them receive only 0.2% of the approximately $600 billion in global climate-related funding. Recent research[2] however has shown that investments in programs like SoLAR can yield high returns. For instance, investing just over $200 million to provide solar irrigation pumps to 1.3 million farmers in Kenya would avert emissions of 6.7 million tons of CO2 annually. Similarly, investing $10 million in solar conduction dryers in India would reduce CO2 emissions by 1.6 million tons per year. Replacing just one-quarter of the 8.8 million diesel irrigation pumps in India with solar pumps—requiring an investment of about $3.3 billion—would reduce CO2 emissions by 11.5 million tons per year.

Finally, there remains a gap in understanding how current policies and regulations can be leveraged for upscaling but also expanding the use of solar in agriculture beyond irrigation (SIPs) and to include uses such as cold storage, solar drying, solar lighting, water heating among others. These additional uses can help improve Return on Investment (RoI), and ensure excess energy is suitably accounted for.

Solar Energy for Agricultural Resilience (SoLAR) – 2, will aim to unlock the barriers to scaling and investment, build on existing platforms and programs, to support governments, practitioners and farmers around effective, inclusive and sustainable use of solar energy systems in agriculture.

In this phase, solar energy will be viewed through a wider lens of Solar Energy Systems for Agriculture (SESA), looking beyond Solar Irrigation Pumps (SIPs) and into broader applications of solar technology to support agricultural practices. The program will be implemented across four countries – India, Bangladesh, Ethiopia and Kenya, offering valuable insights for south-south knowledge exchange. The new program phase will build on the extensive impact work done through

[1] Balasubramanya, S., Garrick, D., Brozović, N., Ringler, C., Zaveri, E., Rodella, A. S., ... & Hope, L. (2024). Risks from solar-powered groundwater irrigation. *Science*, *383*(6680), 256-258.

[2] https://shellfoundation.org/wp-content/uploads/2022/02/Climate_finance_Report-1.pdf

Solar Phase 1 of the program and will continue to leverage resources from ongoing and planned IWMI and CGIAR projects and programs on Food and Water systems, Climate Change and Resilience.

Program outputs will ultimately provide countries with resources to better design and implement solar energy for agriculture policies. This ensures alignment with global, regional and national climate change strategies, including Paris-Aligned National Determined Contributions (NDC) and National Adaptation Plans (NAPs). It will support wider global declarations on food and water systems, such as the COP28 UAE Declaration on sustainable agriculture, resilient food systems and climate action, and the Water Resilient Food Systems launched at COP29. These stress that any path to fully achieving the long-term goals of the Paris Agreement must include agriculture, water and food systems. SoLAR phase 2 will also enhance a focus on Gender Equity and Social Inclusion (GESI), including promoting women leadership, specialized training and extension activities of smallholders and women, improving their access to finance and market and promoting women entrepreneurship through farmer producer groups and micro-enterprises. The work will support contributing to several SDGs including SDG 2, 5, 6, 7 and 13.

Situational Analysis for Phase 2

This section is a summary of literature, reviews of policy documents related to relevant aspects of renewable energy (with a focus on solar related policies, which currently mostly target solar irrigation pumps, SIPs) and relevant groundwater and agricultural policies that intersect with solar for agriculture policies and programs; as well as views of major stakeholders who were consulted during country consultations. A longer synopsis is attached in Annex 1. This is followed by a summary of key achievements and lessons learnt from Solar Phase 1 (for South Asia) and current programs (for East Africa) which also contribute to the wider situational analysis and design for Phase 2.

Current policies and scope for solar energy/irrigation

India

India's solar energy potential, estimated at 5,000 trillion kWh per year, could play a crucial role in meeting its target of 450 GW of renewable energy by 2030[3]. To promote solar energy, the Government of India launched Jawaharlal Nehru National Solar Mission (JNNSM) in 2010, initially aimed for 20 GW of solar power by 2022, later revised to 100 GW in 2015. In 2018, the Gujarat state government launched the Surya Shakti Kisan Yojana (SKY) to provide grid-connected solar irrigation for farmers, including provisions for selling excess electricity. Additionally, many states have piloted both grid-connected and off-grid solar pumps, later subsumed under the Pradhan Mantri Kisan Urja Suraksha Sevam Utthaan Mahabhiyan (PM KUSUM) scheme, launched in 2019. The objective of the scheme is to promote the use of renewable energy in the agricultural sector and offer the benefits of solar farming to Indian farmers. There are three components of the scheme which aims to add Solar capacity of about 34,800 MW by March 2026 with the total Central Financial support of CHF 3550 million. Table 1 below provides a summary of key solar irrigation programs in India.

As of the 2023-24 financial year, progress across PM KUSUM's three components has been slow. For instance, according to a report published by the Centre for Science and Environment, the scheme has achieved only 30% of its target and is unlikely to meet its 2026 goal.

[3] Pandey et al., 2012; Nandi, 2021c

First, the high upfront costs of solar pumps make them unaffordable for many farmers. Additionally, free and unmetered electricity continues to be provided to farmers, making it difficult to convince them to invest in solar pumps despite long-term benefits. Securing loans is also a significant barrier, as farmers must pledge their assets, and banks are hesitant to offer collateral free loans due to likelihood of defaults in the sector and lack of secondary market for the assets. Furthermore, there is limited awareness among farmers about the wider benefits and applications of solar energy in agriculture (e.g. cold chains, solar drying), a lack of technical training, and inadequate outreach programs to promote their adoption. Considering these challenges, we have carefully outlined a set of activities for the second phase aimed at scaling up the adoption of solar energy systems in agricultural settings across India.

Table 1: Existing Government of India programs on Solar [Irrigation]

Scheme	Description
Surya Shakti Kisan Yojana (SKY)	Launched in 2018 in Gujarat, it provides grid-connected solar irrigation for **4,321 farmers**, with clean energy and the ability to sell excess electricity. • **Financial model**: 5% farmer contribution, 30% central subsidy, and a 65% state-backed loan, repayable over 7 years at 6% interest. Farmers earn Rs. 3.5/kWh (DISCOM) plus Rs. 3.5/kWh (state support for 7 years) from surplus energy sales. • **Technical model**: Solar capacity is set at 1.25 times the pump load, with 12-hour daytime electricity for SKY farmers and 8-hour supply for non-SKY farmers. Under SoLAR Phase 1, IWMI signed an MoU with Gujarat Urja Vikas Nigam Limited (GUVNL), the implementing agency, to conduct a comprehensive impact assessment of the SKY scheme and provided day-long training sessions for 2,000 farmers.
Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM KUSUM)	• Launched in 2019 by the Ministry of New and Renewable Energy (MNRE), it aims to reduce diesel use in agriculture, enhance water and energy security, boost farmer incomes, and lower pollution. • **Financial Model**: At least a 30% subsidy (central and state) for SIPs and a 50% central subsidy for Northeast, Sikkim, J&K, Himachal Pradesh, Uttarakhand, Lakshadweep, and A&N Islands. **Components**: • PM KUSUM A: Decentralized solar plants (up to 2 MW), 10,000 MW target, for unused or cultivable land. • PM KUSUM B: Off-grid SIPs (up to 7.5 hp), 14 lakh targets, for areas without grid supply. • PM KUSUM C: Grid-connected SIPs (up to 7.5 hp), 35 lakh targets, for areas with grid access. It includes both individual grid-connected SIPs (PM KUSUM C1) and feeder-level solarization (PM KUSUM C2). Under SoLAR Phase 1, IWMI initiated collaboration with the MNRE, serving as a knowledge partner in organizing a national conclave on the PM KUSUM scheme.

Bangladesh

In response to its climate challenges, Bangladesh is increasingly focusing on renewable energy solutions for agriculture, particularly solar irrigation pumps (SIPs). Following the 2022 energy crisis, the Prime Minister announced a national goal to replace all 1.2 million diesel-powered irrigation

pumps in Bangladesh with solar-powered alternatives. The 2023 Bangladesh ADB roadmap for solar irrigation[4]. Estimates that achieving full replacement will require the installation of 45,000 SIPs at an estimated cost of 1.8 billion USD. While this transition is challenging, it is essential for reducing Bangladesh's reliance on costly diesel imports, as the country currently imports over 90% of its petroleum products. This initiative also aligns with Bangladesh's NDC commitments under the UNFCCC, with the government's mitigation plan targeting 176 MW of solar irrigation under the unconditional scenario and an additional 164 MW under the conditional scenario[5].

However, unlike India's PM-KUSUM scheme, there is no single overarching government scheme for solar irrigation in Bangladesh. All SIP schemes are implemented through different government departments and with financial support from Government of Bangladesh or international donors. Currently there are three key implementation models in the country: Fee-for-service, Individual Ownership, and Community Managed systems. These three models (Table 1) implemented by four main organisations constitute 97% total SIPs installed and 99%of installed SIP capacity. There are also other organisations like Department of Agricultural Extension (DAE), Local Government Engineering Department (LGED), Bangladesh Rice Research Institute (BRRI) etc. that have some smaller fully subsidised SIP schemes.

While SIPs can be an attractive mitigation option for Bangladesh, providing significant co-benefits for farmers, one of the main challenges remains very high capex costs. Although most SIPs in Bangladesh are driven by private sector investment, reducing costs and increasing energy returns from these systems is essential to enhance their appeal. Additionally, tapping into global climate finance for SIPs is crucial, given their potential role in climate change adaptation. To address this, innovative financial and institutional models should be developed, especially targeting smallholder, marginal, and women farmers. These can look beyond current irrigation models, looking to support cold chains, water heating, solar dryers etc. Equally important is ensuring sustainable usage without negatively impacting groundwater resources. In Bangladesh, groundwater depletion is a serious concern, prompting the government to introduce the tubewell permit system in 2018, aimed at maintaining minimum distances between tubewells and preventing groundwater overuse. There are fears that cheaper irrigation access through solar pumps could exacerbate groundwater over-extraction. Therefore, it is vital to scale SIPs in tandem with sustainable agricultural and irrigation practices and incorporating surface water solar pump models as a key part of the solution. Importantly there is a lack of studies on applications for solar energy beyond just irrigation in the agricultural sector.

Kenya

In Kenya, smallholder farmers face significant challenges in boosting their agricultural yields and productivity. Irrigation offers an option to improve food security and sustain livelihoods in Kenya, where 86% of land is classified as Arid and Semi-Arid Lands (ASALs)[6]. According to the National Water Master Plan 2030, irrigation potential in Kenya is estimated at 1.2 million ha. However, only about 3% of arable land in Kenya is irrigated, which is below the Sub-Saharan Africa average of 7%. The rest is rainfed production that relies on bimodal unpredictable rainfall. Smallholder farmers produce the majority (78%) of Kenya's food, but existing efforts towards irrigation focus mainly on

[4] Asian Development Bank, Road Map to Scale Up Solar Irrigation Pumps in Bangladesh (2023–2031)
[5] MoEFCC 2021
[6] Kalele et al., 2021

large-scale farms, led by the public sector and private commercial farms. The Kenya's National Irrigation Services Strategy (2022-2026) indicates that less than half of the current land under irrigation is under community-based irrigation schemes. The large-scale public and community-based irrigation schemes have over the years been affected by operational and maintenance challenges.

Kenya has an average of 5-7 sunshine hours each day providing high levels of insolation - about 4-6 kWh/ m2/day (Rotich et al., 2024). The country has an estimated solar potential of 15,000 MW with highest potential concentration solar power (CSP) in Northern Kenya, particularly Marsabit and Turkana Counties (Gathu et. al, 2017). However, small scale irrigation is mainly carried out using petrol or diesel pumps, which could lead to growth in carbon dioxide and particulate matter pollution. International development agencies promoting use of solar energy have mostly targeted solar home systems rather than SESA[7] .

Kenya has several initiatives aimed at improving energy efficiency and conservation including Sessional Paper No. 4 of 2004 on Energy, Energy Act 2019, and the Energy Management Regulations 2012. The 2020 Kenya National Energy Efficiency and Conservation Strategy (NEECS) enhances ongoing efforts by providing a roadmap towards setting and achieving energy efficiency goals. The Finance Act, 2021 reinstated critical Value Added Tax (VAT) exemptions on renewable energy products including solar, making solar technology more affordable and accessible. The Energy (Mini-Grid) Regulation of 2021 establishes a framework for mini-grid development and initiatives such as the Kenya Off-Grid Solar Access Project (KOSAP) aim to accelerate the deployment of solar energy solutions in Kenya and expand energy access to underserved areas.

Irrigation management in Kenya is anchored on the Irrigation Act 2019 and the subsequent Irrigation (General) Regulations 2021 which provide for the development, management, and regulation of irrigation to support sustainable food security and socio-economic development. Under the National Water Master Plan 2030, the Government of Kenya aims to irrigate an additional 803,000 hectares by 2030.

NGO projects play a key role in expansion of solar irrigation in Kenya. The Kenya Smallholder Solar Irrigation Project (2011-2017), funded by USAID and implemented by Winrock International – aimed to pilot and demonstrate solar irrigation technology in Kenya. British International Investment (BII) and Shell Foundation have recently partnered with SunCulture to provide a 25-40 per cent reduction in upfront product cost for solar irrigation products and reach 9,000 more smallholder farmers[8.] Consultations[9] with country governments have also shown strong interest in prioritizing solar irrigation in initiatives such as the World Bank funded Financing Locally Led Climate Action (FLLoCA) Programme. Initiatives such as the Kenya Innovative Finance Facility for Water (KIFFWA) provide early-stage capital and technical assistance to support the creation of viable water investment opportunities. In addition, programs by organisation such as IFAD support programs on solar in agriculture.

Despite existing programs, a recent consultation involving government and private sector stakeholders by CLASP showed that barriers to uptake need to be improved to further scale policy efforts and bring benefits of solar to end users:

[7] Dalberg, 2020

[8] British International Investment announces new climate finance investment at COP28 - British International Investment (bii.co.uk)

[9] Conversations held with the Siaya County department of Water, Environment and Natural Resources

- Prioritize development of irrigation solutions that are high-performing, low-cost, require low maintenance, and can work under low solar irradiance.
- Bundle financing solutions for solar pumps with other irrigation equipment, such as drip irrigation kits, water harvesting & storage structures.
- Create centres of excellence/demonstration centres for experiential learning targeting smallholder farmers, including village-based champion farmers who can serve as ambassadors and trainers for fellow smallholder farmers.
- Leverage the existing network of local technical installers by building their capacity through training and certification to build a healthy installation and aftersales support ecosystem.

Ethiopia

Irrigation development is acknowledged as one of the key strategies for building climate resilience in rainfed agriculture, given increasing climate variability and change in Sub-Saharan Africa (SSA)[10]. For the region, small-scale irrigation holds large potential to ensure food and nutrition security, and income generation[11]. However, despite the well-documented benefits of irrigated agriculture, including poverty reduction, enhanced food and nutrition security, and improved agricultural productivity, its development in the region has remained low, at around 6% of total cultivated area[12]. The reason for the slow expansion of irrigation includes the absence of institutional and policy support, the high cost of irrigation development, unclear land tenure, which reduces incentives for structural investments, poor market linkages, and lack of financial capacity for more intensive, irrigation-supported agriculture[13]

Ethiopia is estimated to have an irrigation potential of about 5.7 million ha in all scales (Haile and Kasa, 2015; Awulachew, 2010). However, development of irrigation in Ethiopia is currently only about 15% of the potential, of which the largest proportion is from small-scale irrigation schemes (which are smallholders). In Ethiopia, a large potential exists to expand solar PV-powered small-scale irrigation; estimated at about 3,835,000 ha (Schmitter et al. 2018). Over the last decade, efforts have been made to expand the adoption of solar pumps in Ethiopia. IWMI and partners through different projects have promoted solar pumps along with water management practices for example in the Central Rift Valley basin. Solar-based irrigation is also piloted and promoted by other actors including the Agricultural Transformation Institute (ATI), the Ministry of Irrigation and Lowlands (MILL), NGOs such as Farm Africa, and regional state offices. However critical assessments of the impacts and user perspective are largely lacking. Based on recent consultations and studies conducted by IWMI in the region, there is significant demand for irrigation bundling services – which refer to a package of solar-based irrigation technologies and services, tailored to address barriers to farmer-led irrigation. This bundle includes solar-powered pumps, flexible financing options like pay-as-you-own (PAY-OWN), and pre- and after-sales support services designed to be scalable and adaptable to local needs[14]. It is therefore of interest to understand the impacts of the interventions from the targeted farmer's viewpoints. Despite the high potential of and strong demand for wider adoption of solar-

[10] Zougmor´e et al., 2018
[11] Otoo et al. 2018
[12] (Pavelic et al., 2021)
[13] (Wazed et al., 2018; Durga et al., 2024).
[14] https://www.iwmi.cgiar.org/blogs/public-private-partnerships-are-making-solar-powered-irrigation-accessible-to-smallholder-farmers/

based irrigation bundles in Ethiopia, scaling efforts have often been slow to pick up, and innovation adoption remains limited.

The Ethiopian government has been actively promoting renewable energy for irrigation and mechanization to boost agricultural productivity. In 2018, the Ethiopian Agricultural Transformation Institute, in collaboration with the Ministry of Agriculture (MoA), initiated a tax reform policy. This effort included a cost-benefit analysis to identify and list essential irrigation and mechanization equipment eligible for tax exemption. Consequently, in 2019, the Ministry of Finance enacted a landmark tax reform, eliminating nearly all duty taxes on irrigation and mechanization equipment, including solar pump technologies and accessories for irrigation. Currently, the Ethiopian Standards Agency is developing standards for imported solar pumps, though this remains in the draft phase and requires further support to ensure robust and effective implementation. The on-going work on the standards requires further consultations with various stakeholders, inputs from experts and contextual findings. In addition to existing policy and on-going standard work mentioned above, the Agricultural Water Management Task Force—where IWMI serves as secretary—is actively working to initiate policies, develop strategies, and create platforms for stakeholder dialogue to promote solar energy. For example, the task force, in collaboration with IWMI, donors, and other stakeholders, were able to facilitates regular discussions on solar pump tax policy implementation and the draft Public-Private Partnership (PPP) strategy drafted by the Ministry of Agriculture in Ethiopia. The existing platform and regular stakeholder consultation workshops require further support.

Overall, in all four program countries, significant progress has been made in the last decade on promoting solar irrigation. However, progress and implementation are varied, and differences include:

- The regulatory environment: South Asia generally has more structured and centralized policies for renewable energy compared to East Africa, where policies can be more fragmented.
- The investment environment: There is more substantial investment and institutional support for solar in South Asia, particularly in India. However, the private and NGO sectors support for small-scale solar is more vibrant in East Africa, particularly in Kenya
- Scale of Implementation: East Africa relies more on small-scale, decentralized solar solutions, while South Asia often emphasizes larger-scale projects integrated into national energy policies and grid connectivity and storage solutions are promoted.

These differences will be reflected in designing the varying outcomes and outputs for each country.

Link to international/national policies

The outcomes, outputs and activities of SoLAR will have synergies with several other programs and projects, including various SDC funded projects in East Africa and South Asia.

All countries have National Development Contributions (NDCs) for reducing GHG emissions through promotion of renewable energy. India, Bangladesh, Kenya, and Ethiopia also explicitly mention solar in general, and SIPs in particular in their NDC submissions. National Adaptation Plans (NAPs) have been submitted by Ethiopia and Bangladesh and both include solar irrigation pumps particularly in the context of water security.

- In Bangladesh NAP, expanding solar based renewable energy and particularly irrigation pumps are mentioned as an entry point for adaptation, with case studies of portable SIPs used in the Chittagong Hill Tract to demonstrate their relevance to climate resilience.

- In India, MoEFCC has initiated preparation of India's NAP wherein Thematic Working Groups (TWGs) have been constituted across 9 sectors and Water is one of the sectors. IWMI sits on this TWG and will be involved in the sectoral strategy for Water.
- In the Ethiopia NAP, small scale solar pumps are referenced in the context of water security. The Agricultural Water Management task force with members including the Ministry of Agriculture, FAO, IFAD and IWMI (as a secretary in the task force) has initiated the solar pump standardization and multi-stakeholder platforms for policy initiative and scaling.
- In Kenya, while there is no explicit mention of solar in their NAP, energy is seen as an enabler for the realization of Kenya's Vision 2030, which seeks to transform the country into a newly industrializing middle-income country. Under vision 2030, the government aims to promote development of renewable energy as an alternative source of energy, which includes generation of energy from solar and promotion of low-cost irrigation technologies.

The findings will also align with the national food aand nutritional security policies, and growth and development policies of the four countries via efficient, sustainable, cost-effective and cost-effective water management practices such as multi-cropping, crop diversification, improving water-use efficiency, and livestock-rearing (e.g. pond fisheries and poultry), as well as technical capacity building for the stakeholders. The findings will directly align with Kenya and Ethiopia's National Food and Nutrition Security policies by strengthening their safety nets around food production against climate change impacts, e.g. increasing warming and erratic rainfall, promoting risk management and self-reliance, and enabling the transition towards climate-smart agriculture. In Bangladesh, building upon the learnings of the Phase 1, Phase 2 activities directly align with the long-term National Food and Nutrition Security Policy Plan of Action (2021-2030), which aims at integrating the use of environmentally friendly irrigation technologies with the use of stress-tolerant high-yielding varieties, livestock and fishery management, and strengthening capacities of extension workers, inclusion of poor farmers, women and youth. Bangladesh has also shown direction in using solar energy to reduce poverty in rural areas within initiatives such as the Solar home system program. Similarly, in India, Phase 2 aligns with the Agricultural Policy of India in promoting technological solutions for enhanced productivity, water resource management, and farm value-addition, especially among smallholders, and ultimately feeding into the National Food Security Act (2013), which provides food access rights to the population. There are strong links with India's National Rural Livelihoods Mission (DAY-NRLM) which is a flagship program of the Ministry of Rural Development for promoting poverty reduction through building strong institutions for the poor, particularly women, and enabling these institutions to access a range of financial services and livelihoods.

Ultimately, the work is also pertinent towards global ambitions such as meeting Paris Agreement Goals, Global Goal on Adaptation (GGA), and Sustainable Development Goals (SDGs); through its impacts on water food energy environment and livelihoods, the program aligns with several SDGs, including Goal 1 -End Poverty, Goal 2 – Zero Hunger and Improved Nutrition, Goal 5 – on Gender Equality and empowerment of women, Goal 6 – Clean Water and Sanitation, Goal 7 – Affordable and Clean Energy, Goal 13 – Climate Action.

Link to programs/initiatives/donors

There are several international donors who support SESA programs in East Africa and South Asia, a number of whom IMWI is already working with. These include: ADB supported programs on solar energy for agriculture, particularly SIPs in Bangladesh, in India GIZ, World Bank and IFAD supported programs on solar in agriculture. This phase of work will forge knowledge partnerships with agencies conducting research, implementing small pilots on SIPs, agrivoltaics among others, and will seek

links with key development programs e.g. International Solar Alliance (ISA), Food and Agriculture Organization (FAO), International Renewable Energy Agency (IRENA), CEEW, International Development Enterprise (IDE), Winrock, ICIMOD. Some of our main partners – e.g. IDCOL in Bangladesh and are accredited by Green Climate Fund (GCF). In East Africa solar programs are mainly supported by donors and organizations (such as the World Bank, GIZ, and IFAD), but also government agencies which are actively funding and implementing programs aimed at enhancing solar energy adoption in agriculture for smallholder farmers. Additionally, several agencies are conducting research and field pilots focused on solar pumps in the region. We aim to establish knowledge partnerships with these organizations, such as the ISA, FAO, IRENA, and others like Winrock International. Key partners in this effort, such as the African Development Bank (AfDB) and the GCF, are crucial in facilitating investments and ensuring the scalability of solar solutions across East African countries. A complete list of partners is provided in Description of the partner organizations, their roles, experiences, added value, capacities and limitations.

The program will also seek enhanced convergence with IWMI programs and CGIAR initiatives. Under the new CGIAR 2025-2030 portfolio, the program will likely be homed under the 'Scaling for Impact' Science Program (SP) – and SoLAR – 2 and its objectives align well with the key areas of work under this SP[15].

CGIAR Scaling for Impact Program

Scaling for Impact will be CGIAR's first program fully dedicated to scaling land, food, and water systems innovations. By 2030, Scaling for Impact will leverage systems and financing to support over 62 million people, including 30% women, youth, marginalized and un under-represented groups, who will gain access to innovations that enhance their livelihoods and health.

Specifically, through its climate change impact area the Program will align with CGIAR's Global Targets on climate change mitigation with adaptation co-benefits to reduce GHG emissions and enhance carbon sinks. Area of Work (AoW) -1 will identify and prioritize country demand signals for scaling low-emission climate solutions with adaption co benefits, such as low-emission rice varieties and livestock breeds, conservation agriculture**, solar irrigation**, improved livestock management, reforestation, afforestation, and the restoration of degraded lands and wetlands, among others. AoW-2 will develop scaling pathways and evaluate these for climate outcomes and scaling effectiveness based on local demand. AoW-3 will address scale challenges in enabling environments and AoW-4 will amplify scaling through IFIs, impact investment, and corporate social responsibility funds.

In addition, Solar – 2 will have touch points with other SPs including, (i) Sustainable Farming, (ii) Climate Action, (iii) Policy Innovations. The project will also leverage tools and approaches developed under three accelerators (i) Gender Equality and Inclusion, (ii) Digital Transformation, and (iii) Capacity Sharing.

This will be in addition to several existing bilateral and initiative projects in East Africa and South Asia. Some Programs are listed below for reference, but these are subject to change following a

[15] This is subject to final confirmation following the CGIAR restructure in January 2025

restructuring of the CGIAR at the end of this year. Details of leveraging the work for in-kind contributions are included in section 'Resources'.

Table 2: Programs and Initiatives likely to support SoLAR Phase 2

Monitoring land and water productivity by Remote Sensing (WaPOR Phase 2) (East Africa)
IWMI - Tata Water Policy Research Program Action Research on Water for Livelihoods
Water Security and Climate Adaptation in Rural India - Phase 3
Digital Innovations for Water Secure Africa (DIWASA) - Phase 2
Feed the Future Innovation Lab for Irrigation & Mechanization Systems
Impact of Solar Irrigation Expansion on Water Abstraction in Kenya (Shell Foundation)
Irrigation as a Service: Viability for small-scale producers in East Africa (BMGF)
TA for sustainable water abstraction in East Africa (SunCulture)
Feed the Future Innovation Lab for Irrigation and Mechanization Systems-Irrigation as a service - [TBC]
Water Resilience Tracker (FCDO)
Agri PV in India
CGIAR Multifunctional Landscapes Science Program [TBC]
CGIAR Climate Action Science Program [TBC]
CGIAR Scaling Program [TBC]
CGIAR Shared Capacity Program [TBC]
CGIAR Sustainable Farming Program [TBC]
CGIAR Sustainable Finance [TBC]
Agroecological Approaches to Building Resilience of Livelihoods and Landscapes (Agroecology TPP)
Indian Council for Agricultural Research (ICAR)

The project will have regular knowledge exchanges with SDC country offices and platforms including REPIC (Renewable Energy, Energy and Resource Efficiency Promotion in Developing and Transition Countries). It will work with *responsAbility*, a Swiss impact investor fund through linkages with the CGIAR Sustainable Finance team (ImpactSF). To promote the benefits of solar on food security and community resilience, the program will aim to work alongside alliances that work in project countries such as *'SufoSec'* – aimed at implementing shorter supply chains, local agro-ecological production, climate change adaptation and participatory research to support food security and resilience.

The project will leverage networks like the International Renewable Energy Agency (IRENA) the International Solar Alliance (ISA) and African Union; and partner with leading projects on solar-agri tech in the four countries such as, such as ADB, World Bank, IFAD and impact investors and financial institutions.

Phase One Results and Lessons Learned

Solar Energy for Agricultural Resilience (SoLAR) – Phase 1 was launched in 2019 in South Asia – India, Pakistan, Nepal and Bangladesh. Owing to the current delivery profile and delays due to Covid, activity on SoLAR-1 will run until December 2024. The program has delivered in line with expectations, has been well received within participating national governments and has proven its ability to respond and adapt delivery to lessons learned, and to be agile to respond to new opportunities.

It is an example of a successful SDC funded program that aims to sustainably manage the water-energy and climate interlinkages in South Asia through the promotion of solar irrigation pumps (SIPs). The main goal of phase one was 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.

Program Learnings and Implications for the new phase

The fundamental need for this program has only strengthened since SDC's initial support was provided. SoLAR – 1 was set up specifically to provide improved empirical evidence, understand, validate and test actions and approaches to solar irrigation to support government policies on solar irrigation in South Asia. As the Intergovernmental Panel on Climate Change's (IPCC) March 2023 Synthesis Report shows, limiting warming to 1.5-2°C above pre-industrial levels will require a three-to-six-fold increase on current levels of climate change mitigation investment to 2030, with investment in clear energy a critical enabler to closing this investment gap. Low- and Middle-Income Countries (LMICs) require formidable capital investment in clean energy technologies.

The program learnings have shown that transitioning to solar-based irrigation provides various benefits to farmers, besides mitigating diesel-driven carbon emissions in agriculture – e.g. in Bangladesh, SIPs reduce farmers out of pocket expenses for buying irrigation water, irrigation from SIPs saves time and labor costs, SIPs enable supplementary irrigation during late monsoons. These wider benefits hold value for countries updating their NDC and NAPs.

Below are key learnings from phase 1 of solar for South Asia.

South Asia

The project has built a strong and multifaceted evidence base for developing and implementing contextually suited SIP policies while accounting for diversity in the socio-economic context, institutional capacities, bioclimatic (agricultural, water and energy) conditions, and local and national SIP policies in South Asia. Key achievements are as below:

- **Rigorous evidence generation supported formulation of SIP policy and programs in project countries, including improvements in Gender Equity and Social Inclusion (GESI) outcomes.** For instance, in Nepal, Alternate Energy Promotion Centre (AEPC) modified its subsidy selection criteria, requiring that women farmers receive one out of every three subsidy allocations made at the local municipality level; in Pakistan, outcome of the groundwater vulnerability index developed by the SoLAR team, through an additional funding of 105K from the World Bank is duly apprising the Government of Punjab on 'Punjab Resilient and Inclusive Agriculture Transformation (PRIAT).
- **SoLAR's capacity-building interventions have improved awareness and effectiveness of ongoing SIP programs.** A day-long training session provided to SKY beneficiaries in Gujarat, India resulted in improved understanding of SIPs demonstrated through increased [solar] energy generation. This improvement stems from increased knowledge about the technical and operational aspects of SIP through training. In Nepal, 50% of 54 participants in capacity-building workshops were women, helping to introduce more women to the solar irrigation sector. This demonstrates the need for well-designed interventions to support government programs on solar irrigation (e.g. SKY and PM-KUSUM in India).
- **Impact assessment studies of Solar Irrigation Pumps (SIPs) demonstrated critical adaptation co-benefits through increased income, crop diversification, lower cost of irrigation, reduced drudgery for women, among others**. In India, on-grid SIPs have increased farmers' incomes by an equivalent of 34% of their total crop income. In Nepal, off-grid SIPs have led to diversification of cropping patterns towards water-intensive crops and

are largely using ground water for irrigation. In Bangladesh SIP's have led to time and labor savings in irrigation that translate into a 3-% increase in profitability estimated for summer paddy (approximately 30% increase). This provides a robust evidence base for scalability of solar in regions where it is suitable and shows relevance of the strategy for climate resilience.

- **The project launched and commissioned first of its kind pilots on grid integration** in Nepal and Bangladesh using learnings from India. In Bangladesh within 15 months of intervention from 6 pilot sites, 138000 units of solar energy exported to the national grid. The sponsors earned ~7.4 lakhs BDT till date and the estimated savings for Government's Power Development Board on electricity subsidy is calculated to be close to 7 lakh BDT. In Nepal, a grid-connected solar irrigation pilot was commissioned in January 2023 in partnership with AEPC, NEA, Chhipaharmai Rural Municipality, and the Farmer's User Group. The 20 kWp Solar array was constructed by combining eight 1-2 kWp individual systems. Farmers involved in the pilot project have reported that diesel use has decreased due to increased pumping hours and the eight farmers are also selling irrigation water to 8-16 farmers in their neighboring fields. This provided crucial information on the feasibility of grid-integrated SIPs in Bangladesh and Nepal. This has led to fruitful discussions on the future of SIPs with donors like KfW.
- **Strong impact driven early research findings on the impacts of solar irrigation on groundwater** will lay the foundation for future work on the relationship between solar energy and groundwater. This helps to address the oft-raised question around the sustainability of solar irrigation as a longer-term solution. Studies in both India and Bangladesh highlighted that there is no significant behavioral change observed in groundwater application for the same crop going from diesel to solar (Bangladesh) and electric to solar (India), and the modelling study highlighted the likely impact under different scenarios. However, these results reflect the specific context and situation of the study areas in Bangladesh and Gujarat where solar pumps are being installed. These findings contribute to the need for context-specific learnings in global discourses on solar irrigation.
- **Cross-country learning from the project has been instrumental and the project is fostering regional knowledge integration effectively**. This has been done through knowledge forums and facilitating exchange visits between countries. National forums were held in regular intervals in India, Bangladesh, Pakistan and Nepal with participation from key government and non-government stakeholders. The forums outlined key project findings and identified opportunities for solar irrigation going forward. A three-day Global Forum in Kathmandu, Nepal brought together over 200 key stakeholders from across 20 countries to discuss the growing body of work and evidence in South Asia on solar, promote south-south collaboration and explore options for the future scaling up of global ambitions around effective and sustainable use of solar energy in agriculture. This has **fostered strong regional connections with key partners** (including ISA, MNRE, GUVNL/GERMI, IDCOL, NEA, APEC, PARC), to co-create knowledge, react to policy demand and create spaces for discussions around solar irrigation.
- Through the innovation fund grant has **shown that there are a number of technical and financial innovations and ways which solar energy can be used for agriculture beyond SIPs**., for example solar powered greenhouses, dryers, sensors and control systems, and electric vehicles.

The program has also brought to focus several areas for further study and support. Engagements with policymakers in phase one and in the run up to proposal development has shown that, if ambitious targets - such as, PM-KUSUM in India and the Bangladesh PM's announcement to eliminate diesel pumps in Bangladesh are to be met, then there is a need to better understand how to improve the enabling environment for implementation and scaling [Global Forum 2024 Report].

Consultations with policymakers have shown that there are a lack of tools and capacity provided to policymakers and practitioners on the context-driven nature of scaling solar and mobilizing finance [National forum reports for Bangladesh and India].

Findings from Mid-term evaluation of SoLAR

An independent party assessed the outputs and outcomes of the SoLAR project from its January 2020 start until March 2023 through a mid-term evaluation, completed in August 2023. The report highlighted key impacts of the program and provided recommendations for the project's final year and summary of findings shared in Annex 2.

1. Greater focus on work that supports **policy development** and impact; SIPs should align with broader development strategies in the countries e.g. India's Atal Bhujal Yojana, which promotes groundwater recharge in a water security planning framework
2. SIPs are still largely subsidy-dependent programs, which provides ample scope for **targeted, evidence-based innovation in subsidy design and consumption**. For greater private sector involvement, risks associated with financing and scaling need strong and supportive policy environments.
3. **Using integrated water-energy-food nexus approaches**; Viewing SIPs as a multi-purpose vehicle for achieving food and livelihood security, sustainable groundwater management, climate adaptation, and carbon mitigation.
4. **Mainstream GESI** into all regional work and provide innovative implementation platforms to better promote solar irrigation among women and marginal farmers; focus on identifying women leaders and groups that are innovators and can serve as role models in their communities around SIPs
5. **Improve science communication to policy makers and capacity building** to local governments, and end users to develop strategies for the future of solar irrigation.

These recommendations have been taken on board in designing phase 2 of SoLAR, including through supporting policy development and change, particularly within the context of wider development policies and programs e.g. India's State Livelihood Missions (see outcome 4); developing targeted finance models depending on context (outcome 2.); integrating solar suitability and WEF nexus impact into decision-support tools (outcome 1), mainstreaming GESI into all outcomes, and ensuring our policy communication is suitably accounted for within our deliverables.

East Africa (Kenya and Ethiopia):

While East Africa was not included in phase one of solar, IWMI has been implementing solar energy projects, largely pertaining to solar irrigation pumps (SIPs). The proposed work in East Africa will build off work and lessons learnt from programs such as, Innovation Lab for Small Scale Irrigation (ILSSI), Africa Rising in Sub-Saharan Africa, Livestock and Irrigation Value Chain for Ethiopia (LIVES) and Nature for Development. The projects' key achievements include:

- **Evidence generation for solar pump promotion and adoption:** due to results of the work in ILSI and Africa rising, IWMI has showed that innovation scaling is successful when one or more core innovations (e.g., solar powered irrigation pumps) are bundled with complementary innovations (e.g., pay-as-you-go financing and pre- and after-sales services) that improve the enabling environment for adoption. Furthermore, the results in Ethiopia and Ghana showed that to ensure success of scaling, market segmentation is a precondition to develop best-fit bundles for different farmer groups and efficiently match demand and supply.

- **Scalable solar-based irrigation bundles:** Scalable irrigation bundles are identified including Digital credit assessment tool, Flexible payment arrangement, well digging and maintenance services, and Web-based pump maintenance system**.**
- **Private-led solar pump irrigation**: Private irrigation technology and service providers and agricultural value chain actors play a crucial role in farmers' decision to invest in and adopt the innovations. Connecting farmers with these actors and creating market linkages are thus key conditions to reach scale.
- **Policy and institutional influence**: through the regular multistakeholder platform and dialogue created among the key stakeholders (government agencies, donors, development partners, and the private sector) through different IWMI projects, in Ethiopia the government reviewed, assessed, and developed a tax exemption policy in 2019 specifically for SPIPs and other renewable energy.
- **Increase awareness on solar pump technology and its services**: due to several trainings among farmers in Ethiopia and Ghana to increase awareness on the importance of solar pump technology and its usage.

Key takeaways from projects and stakeholders' consultation in East Africa

Our ongoing work in East Africa has also presented prospects and opportunities for promoting the sustainable use of SIPs through technology and inclusive policies. Key takeaways to designing phase 2 of SoLAR are as below:

- **Understanding customers' (farmers') realities**: Stakeholders in the scaling pathway[16] need to systematically assess the realities that enable or hinder farmers' adoption of the proposed technologies. These include farmers' current knowledge and experience, farmers' opportunity costs, Technology requirements and main bottlenecks in farmers' enabling environment.
- Initiate (and when available strengthen) multi-stakeholder platforms with the mandate to identify and bridge knowledge access gaps, **create capacity development and policy recommendation within the WEF Nexus**. This creates awareness of stakeholders involved in SPIS promotion and implementation.
- Implementing **blended financing instruments** (e.g., through programs) that catalyze the solar irrigation supply chain by de-risking operational (mature) local players within the technology-finance-agriculture input space.
- Create initiatives to promote and scale sustainable SPIS through i**ncreasing synergies between private and public sectors** in the implementation of efficient strategies.
- Promote and de-risk existing successful **business models** such as PAYGO to create a deeper market penetration and enhance end-user's access and affordability. There is a need also to include microfinance institutions, agri-business, or impact investors.
- **Enhancing capacities of various stakeholders:** this includes to increase the capacity of financial institutions, local and regional business in the field of SPIP and agriculture through training courses and exercises to enable efficient evaluation of SPIS applications and create different levels and scales of knowledge sharing to include low-income farmers, rural women, youth.

[16] Scaling pathways refer to the strategies, processes, and actions taken to scale the adoption of innovations, practices, or technologies beyond their initial scope.

Phase 2 Proposition

Impact Hypothesis and Theory of Change

Goal

Using key learnings from ongoing work in South Asia and East Africa, the second phase of the Solar Energy for Agricultural Resilience (SoLAR) program will make significant and attributable contributions to water, energy, food and climate security for people, ecosystems and businesses. The impact hypothesis for this second phase of work is - if we want to **strengthen the enabling environment and unlock investments for sustainable scaling of socially inclusive and climate-resilient solar agri-tech solutions in South Asia (India, Bangladesh) and East Africa (Ethiopia, Kenya),** then it requires working closely with multiple stakeholders and institutions in a dynamic and interactive manner to ensure supportive policies, institutions and markets.

Following a successful phase one in South Asia, the program will expand its reach to include countries in **East Africa**, to build upon lessons learnt and provide a model for south-south collaboration and learning on solar energy. Ethiopia and Kenya[17] will be included in the program alongside phase one countries - Bangladesh and India. In all four countries, there is a burgeoning policy and private sector interest for scaling SESA (see Section on 'Situational Analysis').

Phase 1 of the program largely focussed on solar irrigation pumps (SIPs). In Phase 2, where relevant and applicable, the scope will be broadened to explore wider applications of solar energy systems for agriculture (SESA) - this could include solar powered machinery, crop drying, water heating, cold storage, lighting, and pest control. These applications can help improve efficiency, reduce costs, and promote sustainability in agricultural practices.

Similar to phase 1, this phase of work leverages project resources within the broader strategic programs at IWMI including Water, Climate Change and Resilience (WCCR), Water Growth and Inclusion (WGI), and the CGIAR Science programs (see links to international programs under 'Situational Analysis' and 'Resources' section for details).

Outcomes

The program outcomes will support in strengthening governance structures, systems and enabling policies to remove barriers to scaling and financing of solar energy for agriculture and food systems in South Asia and East Africa.

It will deliver across four main outcomes in four selected countries - South Asia (India, Bangladesh) and East Africa (Ethiopia, Kenya):

- **Outcome 1- Evidence-based policy design**: Policymakers embed water energy food interlinkages in a socially inclusive manner, to enhance effectiveness of solar agri-tech programs
- **Outcome 2- Accelerating finance:** Climate-smart and socially inclusive financing solutions for scaling solar agri-tech are co-developed and launched.

[17] Ethiopia and Kenya were selected following a thorough assessment of needs, ambition on solar [political environment and need from host government], potential for impact [adaptation/mitigation], IWMI and CGIAR networks, incubating environment [private sector vibrancy], in consultation with SDC.

- **Outcome 3- Capacity building:** Strengthened knowledge, capacities and south-south collaboration leads to greater uptake of solar agri-tech applications.
- **Outcome 4- Solar Scaling through Living Labs:** Existing platforms and living labs are assessed and optimized for scaling solar agri-tech bundles.

The four outcomes together cover key elements needed to unpack barriers to increase adoption of solar energy for agriculture (SESA) - policy, finance, capacity and optimizing (Figure 1). The resulting outputs and activities will work together synergistically in a logical and effective way, ensuring that the program goals and impact are achieved. Outcome 1 will develop decision-support tools and principles for effective scaling for policymakers, Outcome 2 will enhance these tools by introducing innovative financing options. However, without adequate capacity and buy-in from end-users, challenges to scaling solar will remain. Therefore, Outcomes 3 and 4 will leverage findings from Outcomes 1 and 2 to ensure that stakeholders are informed and equipped to utilize these innovations. Outcome 4 will focus on optimizing scaling of SoLAR program outputs through working closely on synergies with existing platforms and living labs, such that sustainability of the innovations are well embedded beyond the timeframe of this program.

Deliverables including, decision-support tools, methodologies, products will be co-designed with key partners (Government, private sector, implementing agencies) with the aim to ultimately embed within their programs and operations. As necessary, IWMI and CGIAR can also host digital tools and products.

Figures 1, 2 and 3 represent the theory of change and interconnections between the outcomes, outputs and activities, and these are further described in logframe (Annex 7).

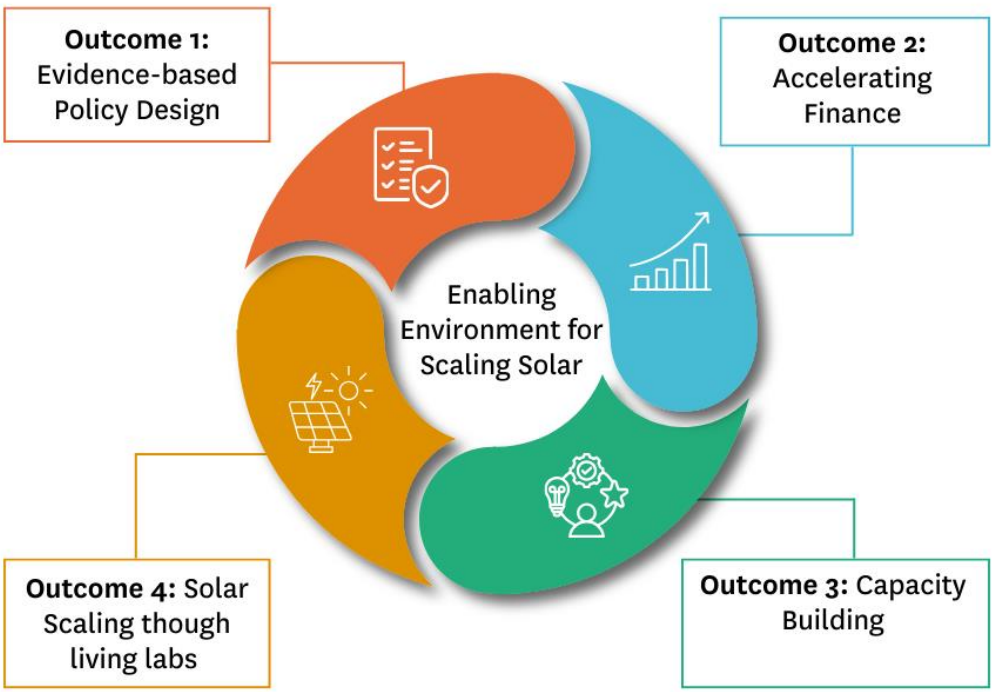

Figure 1: Four outcomes supporting improvements in the enabling environment for scaling solar

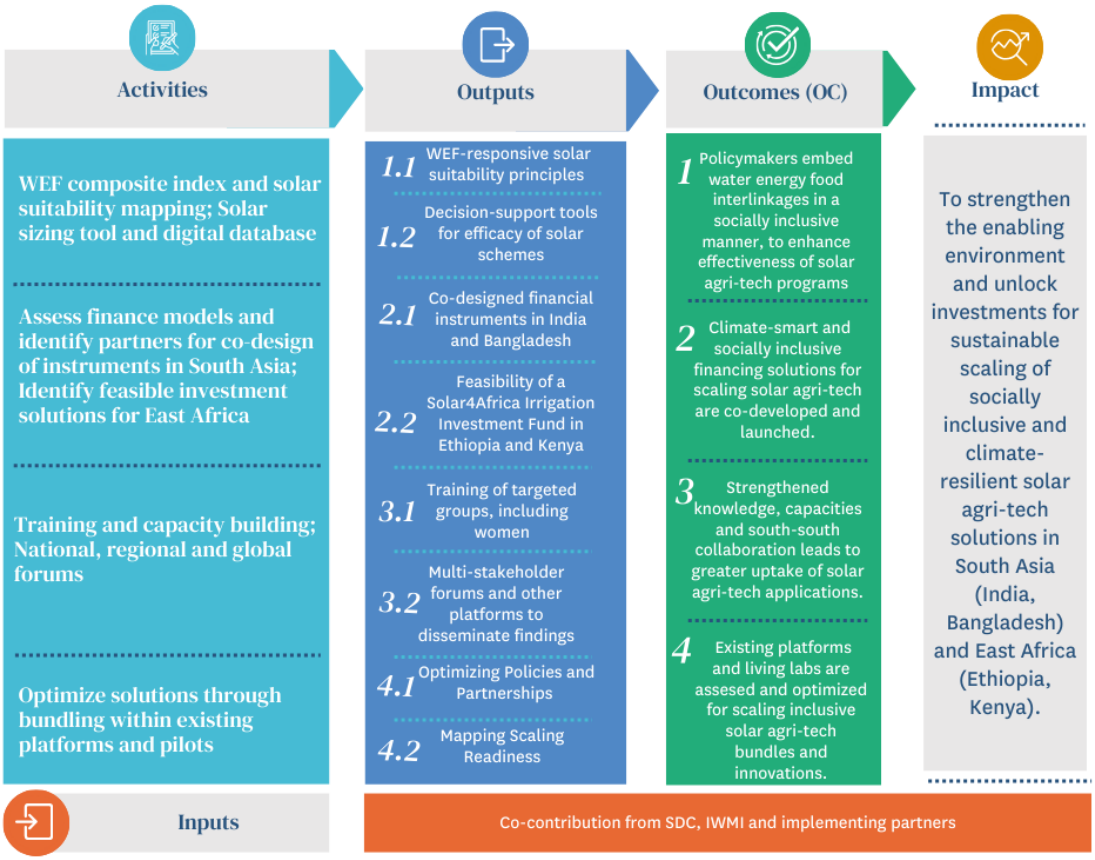

Figure 2: Theory of Change

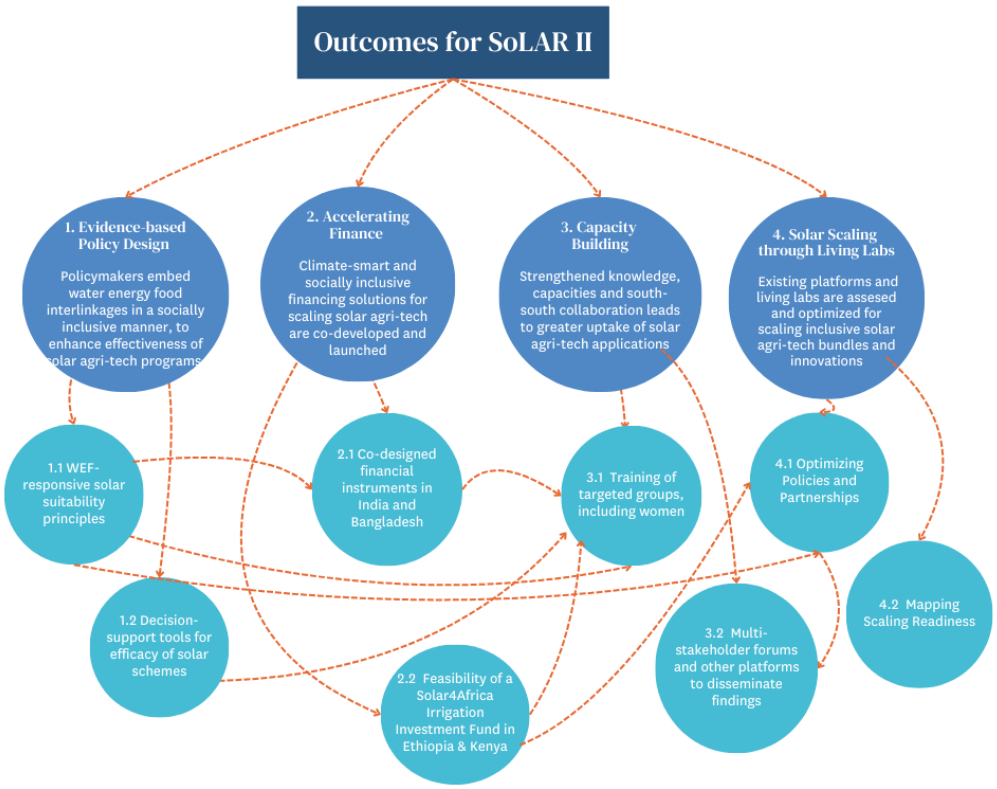

Figure 3: Interconnections between Outcomes and Outputs

Outputs and Activities

Outcome 1

Policymakers embed water energy food interlinkages in a socially inclusive manner to enhance effectiveness of solar agri-tech programs.

Under this outcome, Output 1.1 will produce solar suitability maps that will incorporate gender-responsive Water-Energy-Food (WEF) sector principles[18] (synergies and trade-offs). Using the indicators and contextual analysis of OC 1.1, Output 1.2 will produce decision-support tools for governments, implementors and investors to aid deployment of solutions.

Output 1.1 Design Water-Energy-Food-responsive solar suitability 'principles' for effective and efficient solar energy applications in agriculture

Summary:

- *This output will assess the implications of solar expansion in agriculture on the WEF sectors and identify policy levers to maximize synergies (e.g. enhance agricultural production and nutritional security) while minimizing trade-offs (e.g. groundwater overexploitation).*
- *Findings will be integrated into a comprehensive water-energy-food-solar suitability (WEF-SS) framework and composite index to provide overall and sector-specific policy 'principles' that will be easy to deploy for governments.*

[18] The WEF-SS maps will be context-specific due to the nature of indicators needed, and the geographic and socio-economic differences within each project country – e.g. socio-economic, groundwater vulnerability etc. Thus this outcome will provide policymakers with 'Principles' of effective WEF-SS integration that can help tailor the tools to their requirements.

- *Insights (including developed WEF-SS maps) from this work will be transferred to partners equipping national and local governments and implementing agencies with the (scientific or data-based) evidence needed to make informed decisions for scaling solar in the respective agricultural systems.*

Key Deliverables for Output 1.1

- *Report on Composite WEF (Water-Energy-Food) index to assess the impact of different solar and associated WEF interventions, accounting for climate change, across sectors.*
- *Water-Energy-Food-Solar Suitability (WEF-SS) composite maps to assess and recommend spatially differentiated SIP models for different regions.*
- *Country policy briefs on WEF-responsive solar suitability tool and 'principles' for uptake for prioritizing policy and investment decisions.*

In South Asia, Phase one of SoLAR generated first of its kind evidence on the impacts of Solar Irrigation Pumps (SIPs) across multiple dimensions: groundwater sustainability, crop diversification, irrigation costs, emissions, and farmer incomes in India and Bangladesh. However, these results were specific to two regions—Gujarat in India and the northwest of Bangladesh—and focused on two specific models of SIP upscaling: on-grid systems in India and the centralized fee-for-service model by IDCOL in Bangladesh. To date, no comprehensive study has evaluated all Water-Energy-Food (WEF) factors for solar irrigation suitability mapping in India and Bangladesh. Existing efforts on suitability mapping have typically focused on one dimension, mostly technical, which includes assessing feasibility of solar irrigation based on available solar irradiance[19] , land suitability[20] or rely solely on considering groundwater risks based on groundwater vulnerability maps[21].

In East Africa, the integration of WEF factors into irrigation suitability mapping remains at a nascent stage. IWMI has worked on solar suitability tools and maps developed alongside the Water Land and Ecosystems CGIAR research program. Several project partners, i.e. solar manufacturing and distribution companies are already using the maps to expand their distribution and supply chains[22].These have primarily focused on assessing the technical feasibility of solar irrigation, such as solar irradiance levels and land suitability[23] . While some efforts have considered water resource availability, they often lack a comprehensive approach that integrates the WEF nexus to evaluate the impact of SESA on food security, nutrition, income, gender, and climate resilience of small holder farmers.

Following consultations with policymakers, during Phase one of SoLAR, efforts began to address this gap by developing integrated spatial datasets at the district level and a framework to integrate the same for developed WEF sensitive solar suitability mapping. These datasets combine information

[19] Müller, J., Mitra, I., Mieslinger, T., Meyer, R., Chhatbar, K., Gomathinayagam, S., Giridhar, G., 2017. Towards building solar in India - A combined mapping and monitoring approach for creating a new solar atlas. Energy for Sustainable Development 40, 31–40. https://doi.org/10.1016/j.esd.2017.05.004; Mahtta, R., Joshi, P.K., Jindal, A.K., 2014. Solar power potential mapping in India using remote sensing inputs and environmental parameters. Renewable Energy 71, 255–262. https://doi.org/10.1016/j.renene.2014.05.037

[20] Hasan, A.S.M.M., Kesapabutr, P., Möller, B., 2024. Bangladesh's pathways to net-zero transition: Reassessing country's solar PV potential with high-resolution GIS data. Energy for Sustainable Development 81, 101511. https://doi.org/10.1016/j.esd.2024.101511;

[21] CGWB, 2023. National Compilation on Dynamic Ground Water Resources of India, 2022. Central Ground Water Board (CGWB), Department of Water Resources, RD & GR Ministry of Jal Shakti, Government of India. Faridabad, India

[22] https://cgspace.cgiar.org/items/ed8352b6-4e8b-488b-9df3-04b42406722a

[23] Petra et al., 2018

from the WEF sectors with socio-economic data, including gender, to create solar suitability maps accounting for WEF interactions. The Phase two work will build on this foundation to assess the solar suitability of various models sensitive to WEF interactions, incorporating additional constraints (e.g., political economy, farmers capacity, gender, nutrition) for a more holistic approach. It also brings together tool developers, users, and beneficiaries into conversations about indicators for assessing inclusion.

Activities under this output will first develop a framework for understanding WEF aspects in agricultural settings (1.1.1), and then develop easy 'principles' for policymakers designing solar programs to follow (1.1.2).

1.1.1: A Water-Energy-Food composite index for solar in agriculture (with emphasis on solar irrigation[24]) application in Agriculture supports policy makers

To maximize synergies and avoid trade-offs across WEF sectors during scaling solar energy applications, it is crucial to assess the overall and sectoral impact of different solar models through a composite WEF index. For example, off-grid solar systems might increase both energy and water consumption, while also improving their accessibility. This will have positive impact on food and nutritional security, land productivity, accessibility for women and marginal farmers, and resilience if deployed in rainfed regions. However, the magnitude of these impacts will vary across regions, and there may be negative trade-offs associated with increased water and energy consumption. This activity will focus on developing a comprehensive WEF index those accounts for sectoral interactions, as well as the effects of solar upscaling and climate change within the WEF sector. The index will enable the comparison of different solar expansion models and scenarios in the project countries, helping to optimize synergies while minimizing trade-offs. Indicators will be created for each sector—water, energy, and food—to guide this evaluation.

Phase two will extend analysis from Phase 1 and ILSSI and Africa Rising projects to include additional solar models, such as off-grid systems, feeder-level solarization, and community-based solar, along with additional impact on agricultural and nutritional outcomes, including, input use, farm income, climate resilience, adaptation and mitigation. It will generate evidence on how these diverse solar irrigation models influence farmers' behavior on water (e.g., irrigation practices, groundwater conservation), agricultural decisions (e.g., cropping pattern, input use) and energy use which is crucial for assessing the local and regional effects of solar irrigation on water, food and energy security.

Figure 4 presents a schematic overview of these indicators for developing a composite WEF index. The developed framework and composite index will be used to assess WEF implications of select solar irrigation models (assessed in phase 1 and 2) in project countries.

[24] Solar irrigation is emphasized due to concerns around groundwater exploitation and land-use change outlined in the 'Context' section.

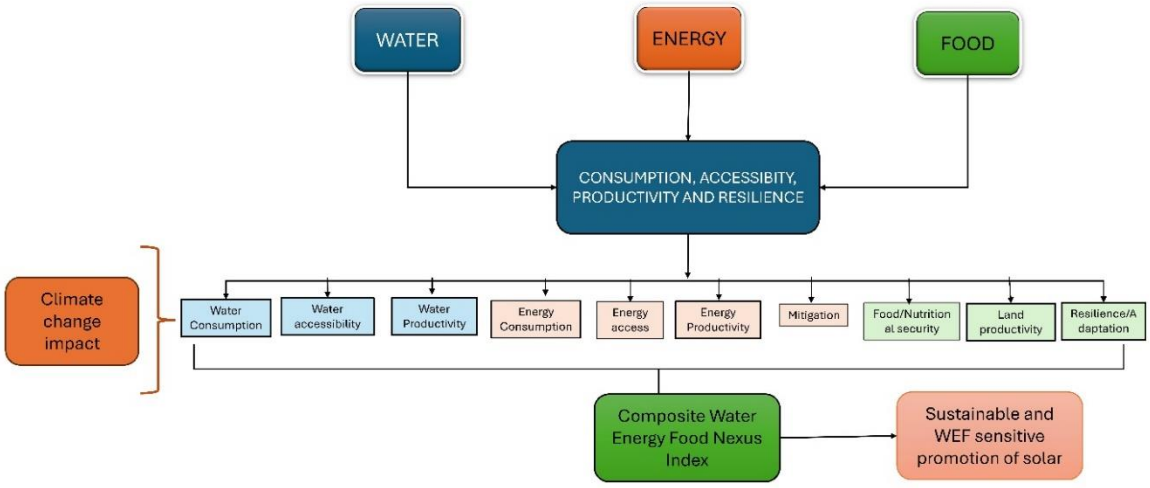

Figure 4: Diagram depicting tentative indicators for WEF index

Figure 5: Range of factors influencing solar suitability

1.1.2.: Water-Energy-Food-Solar Suitability (WEF-SS) composite maps for India, Bangladesh, Ethiopia and Kenya

Given significant investments are needed to set up solar, there is a need for developing context and location specific solar irrigation implementation strategy. Using findings from Activity 1.1.1, this activity will carefully map solar irrigation suitability across project countries considering multifaceted factors across WEF sectors including opportunities for climate adaptation and mitigation underpinned by sustainability of groundwater resources. Indicators to assess each factor influencing solar suitability will be identified and further developed in consultation with stakeholders to ensure applicability. This will be used to assess the suitability of different SIP models accounting for sustainability and equitability (e.g., gender and socially inclusive solar upscaling). For example, implementation of off-grid SIPs has different effects on WEF sectors, compared to on-grid SIPs.

This will also include accounting for farmers socio-economic factors incorporating gender and social differentiation for varying impact and capabilities, existing market and political economy that

supports or constraints scaling of different solar irrigation models. For example, in the context of solar upscaling, integrating gender and social equity can transform access and benefits of the solar energy for marginalized groups. This is especially true as women farmers and socially disadvantaged groups often have limited access to WEF resources due to financial, land ownership, or societal constraints. The context specific solar suitability maps will integrate available socio-economic datasets accounting for these indicators while recommending spatially differentiated solar irrigation models to include Gender and Social equity interventions such as targeted subsidies and financing, capacity building and training and gender sensitive institutional support among others.

The developed maps will also help identify with opportunities and constraints associated with context specific indicators for policy development, capacity building (see output 3.1 and 3.2) and prioritizing investments (see output 2.1 and 2.2). The findings from this study will be optimized through pilot studies and field interventions under Outcome 4.

Output 1.2: Decision-support tools are developed to support efficacy of solar schemes for policymakers and practitioners

Summary

- *In this output, we will support the design of tools such as the Solar sizing tool and real-time digital databases to improve effectiveness of solar policies and schemes*
- *The tools will be informed by a thorough assessment of technical, biophysical, and socio-economic factors (as identified through analysis in OP 1.1), E.g. optimal size of solar irrigation pumps to preferential financial arrangements, ownership and services (see OC 2.1 and 2.2).*
- *Insights from this work will ultimately be embedded within government and implementing organizations as decision-support tools for policymakers and practitioners ensuring maximum effectiveness when designing solar energy systems to avoid wastage of resources while meeting energy needs adequately.*

Key Deliverables for output 1.2

- *A fully functional online solar sizing tool and user manual tailored to the specific country contexts, and usable by end users, implementors and policymakers.*
- *For India, a live digital database of key indicators for PM-KUSUM implementation, using site-specific criteria from OC 1.1*
- *At least 1 training per country with implementing officials including women and follow up consultations per country with at least 20 participants from different implementing agencies on the use of SIP sizing tool*

1.2.1. Build upon IWMI's Solar Sizing tool for greater uptake and inclusivity

The design of SESA, particularly determining the optimal panel capacity (that does not lead to either excess or under capacity) is dependent on many factors which require rigorous scientific analysis. It is a challenging task, not least because farmers' demand for energy is a complex, derived demand. Keeping in view huge investments by governments in solarization of agriculture (for instance in India), design of solar sets based on scientific protocols has a key role in large scale adoption of SESA. Several technical, biophysical (e.g., soil type, water availability), and social factors (e.g., farmer

income levels, landholding sizes, financial arrangements) govern the pump set size, which needs to be properly accounted while designing a matching solar pumping system. The right sizing helps in providing a total cost estimate for the system, including the solar panels, inverter, batteries, and installation costs which is important for budgeting and planning. If used adequately, it also helps identify incentives and financing options for end users.

In Bangladesh for instance, there is no such decision support tool that can assist implementers (either government or private sector agents) on optimal design of solar pumps that are being installed. In many cases, the panel capacity is twice the pump capacity for installed systems. However, this practice may result in over-sizing, which could lead to inefficiencies in terms of wastage of installed capacity (For comparison, under SKY in Gujarat the approved panel size in 1.25 times the pump size in hp, i.e. ~1.7 times the pump size in KW).

Having a decision support tool would substantially help implementers to make that decision with scientific rigor and not lead to wastage. There is also an opportunity, assuming existence of demand, to use the tool beyond its current irrigation support parameters, and identify co-benefits such as potential for cold storage, agrivoltaics'. To ensure the inclusivity of the tool, the GESI Multi-Dimensional Inclusivity Index (MDII)[25] developed by IWMI will be used.

Working with government and private sector stakeholders, synergies with IWMI's existing work in East India and Nepal (supported by GiZ)[26] will be developed. IWMI has received expressions of interest in this work to develop similar tools for other countries in Asia and Africa, including governments, International Solar Alliance (ISA), and the ADB. The SIP sizing tool for Nepal was launched at the SDC-SoLAR 2024 Global Forum.

- In Bangladesh: Collaborating with SREDA (Sustainable and Renewable Energy Development Authority) and other implementing agencies, updating the existing sizing tool from India for the specific conditions of Bangladesh. The tool can be integrated with the National Solar Help Desk maintained by SREDA (https://www.nshd.sreda.gov.bd/). Through the trainings undertaken on using the SIP sizing tool for government implementing agencies and DAE extension officials (under OC2), efforts will be made to ensure that the tool is integrated into the SIP planning of implementing agencies beyond the project period.
- In India: The primary aim will be to support government through the provision of a live digital database of key indicators. This will be done in collaboration with the Ministry of New and Renewable Energy (MNRE). The plan is to host this platform on the PM KUSUM portal, replacing the existing beneficiary list webpage. This new platform will provide real-time data on key indicators, enhancing monitoring, transparency, and decision-making for stakeholders involved in the scheme.
- In Ethiopia, scaling of SESA – targets both the public and private sector[27]. The solar sizing tool will cater to both public-sector scaling efforts and private-sector interests, ensuring that

[25] The MDII is guided by eight principles, including accessibility, transparency, methodological rigor, adaptability, intersectionality, simplicity, flexibility, and clarity. It faces challenges such as complexity and diverse user needs, addressed through Artificial Intelligence (AI) integration, offline accessibility, and a participatory feedback approach. Evolving beyond an index, the MDII now offers multiple functions like certification, predictive analysis, and strategic guidance for digital innovation, using AI to meet future inclusiveness needs. For details, see https://gender.cgiar.org/publications/development-conceptual-framework-version-20-multidimensional-digital-inclusiveness

[26] https://www.iwmi.cgiar.org/blogs/solar-irrigation-pump-sip-sizing-tool/

[27] Public oriented scaling requires a detailed understanding of the local agricultural landscape, socio-economic conditions, and technical requirements. The government is subsidizing and promoting the solar pumps among different regions in the

it aligns with broader policy goals while addressing market dynamics. It will leverage and work on existing projects with the Ministry of Agriculture (funded by World Bank) and PACT project (being financed by IFAD), with the Agricultural Transformation Institute (ATI) on the DREAM project and Solar Suppliers Association from the private sector on their on-going solar projects.

- In Kenya: due to greater private sector led scaling, the expansion of solar requires a nuanced understanding of both financial and technical factors that influence the selection, adoption and scaling. There are for instance, solar sizing tools and calculators, such as PowerAfricaSolar and the IALA solar calculation tool, that provide a cost estimate for the system. However, inadequate sizing has been identified as a major risk. e.g. for isolated mini-grid systems, funders and regulators transfer risks to private developers and operators. As a result, the latter face risks regarding demand estimation, funding and regulatory aspects when sizing mini grids. In turn, they adapt their methods and business models, sometimes transferring risks to end users, leading to low-income customers often bearing the costs of ill-suited sizing. Using a well-rounded analytical approach, and lessons learned from India, as identified above, will support in mitigating some of this risk.

1.2.2 Develop guidelines and training for use of tools

The tool will be validated through consultations with solar pump manufacturers, industry experts, national-level policymakers, state nodal (for India) and implementing agencies to ensure it aligns with on-ground realities and policy objectives. The tool will then be developed based on user inputs and feedback, including the GESI MDII.

An online tool or app will be created, complete with a user manual to facilitate easy access and usability by implementers. This will allow for widespread adoption of the tool by field personnel and decision-makers alike. At least one training session per country for implementers and end users from various agencies will be conducted, ensuring that they are equipped to use the app effectively for optimizing solar irrigation pump systems. A comprehensive user manual for the solar sizing tool, including design and instrumentation guidelines will also be developed for use beyond the timeline of this program. This will be in place to support and guide implementation of the toolkit.

The developed WEF-SS maps (output 1.1) and digital sizing and online tools (output 1.2) will be co-designed and transferred to key partners such as MNRE, ISA, NITI Aayog, UP-NEDA in India; and National Solar Help Desk maintained by SREDA (https://www.nshd.sreda.gov.bd/) and IDCOL in Bangladesh; Management information System in the Ethiopia Food Systems (FSRP) under the Ministry of Agriculture, which play leading roles in solar energy upscaling and policy development. A suitable partner will be identified in Kenya in the first year of the program[28](See OC 4.1.2). This approach will follow the same model of co-development and hosting done for developed solar pump sizing tool in India which is hosted by MNRE.[29] As required, IWMI and the CGIAR will also be able to host or maintain digital tools until a suitable agency is identified and adequately trained. and IDCOL in Bangladesh; Management information System in the Ethiopia Food Systems (FSRP) under the

country. While the private scaling mainly focuses on using an innovation bundle approach with financial arrangements, ownership, and services.

Ministry of Agriculture, which play leading roles in solar energy upscaling and policy development. A suitable partner will be identified in Kenya in the first year of the program [30] This approach will follow the same model of co-development and hosting done for developed solar pump sizing tool in India which is hosted by MNRE.[31] As required, IWMI and the CGIAR will also be able to host or maintain digital tools until a suitable agency is identified and adequately trained.

Outcome 2

Climate-smart and socially inclusive financing solutions are co-developed and lead to scaling of solar energy systems for agriculture.

Given the differing contexts within which solar systems are promoted in the two program regions, two distinct outputs are proposed for South Asia and East Africa:

- Under Output 2.1, financial solutions will be proposed keeping in mind the subsidy driven context within which SESA are currently promoted in India and Bangladesh. It will focus on understanding needs and gaps in financing structures (2.1.1), followed by co-developing financial instruments with partners (2.1.2).
- Under Output 2.2, financial solutions will be proposed for a solar4africa irrigation investment fund, building on existing work in Ethiopia and Kenya on mobilizing innovative financing options for irrigation.

Output 2.1: Financial instruments are co-developed to improve equitable access to technology, finance, and markets in India and Bangladesh

Summary

- *Through this output we will support efforts to address the large financing gap in the agriculture sector and identify suitable enabling conditions within the publicly driven subsidy-heavy solar models in India and Bangladesh*
- *The findings will help identify/co-design investment solutions and partnerships to support greater mobilization of finance into scaling existing solar programs beyond SIPs. It also looks to support farmers' ability and willingness to pay for these systems.*
- *This output focusses on India and Bangladesh and insights from this work will support practitioners find solutions to financing Agri-tech and climate solutions, as highlighted in their NDC/NAPs.*

Key Deliverables for output 2.1

- *Report analyzing the effectiveness and scalability of selected solar business models, with a focus on access for women, smallholders, and marginalized communities. [IN; BG]*
- *Workshop summary report capturing feedback, validation outcomes, and proposed revisions to the subsidy mechanism based on stakeholder inputs. [IN; BN]*
- *A report presenting results of the choice experiment on institutional and financial models for SIPs. [IN; BG]*

[30] A 6 month inception phase is proposed under Outcome 4 to identify key partners in Kenya and Ethiopia.
[31] https://pmkusum.mnre.gov.in/#/sip-sizing-tools.

- *A feasibility study/policy note on various market-based models (e.g., pay-as-you-go, earn-first -pay-later) with recommendations for scaling of SESA. [IN; BG]*
- *Strategy document outlining potential funding partnerships with SRLMs and FPOs, including a financial framework that addresses barriers to financing solar irrigation pumps [IN]*
- *Research report detailing the technical and economic feasibility of alternative approaches for increasing return on solar investments through alternative uses of energy; and identifying necessary policy actions [BG]*

2.1.1. Assessments of promising financial market and non-market-based instruments/business models

In India, government schemes like PM KUSUM offer significant subsidies and financial incentives to boost solar pump adoption among farmers. For example, under the PM KUSUM scheme, central financial assistance is 30%, while state financial incentive ranges from 30% to 60%. This results in a total financial subsidy ranging from 60% to 90%. Despite this, government has achieved only 30% of its target for off-grid installations, while on-grid implementation has been significantly poorer, with less than 1% of the target achieved. Large upfront costs of paying for solar pumps remain a significant barrier, particularly for smallholder farmers e.g. accessing loans is a challenging task for women and small/marginal farmers. Additionally, the PM KUSUM scheme relies on a self-targeting principle for pump disbursement, which is currently not well-targeted. As a result, vulnerable farmers are less likely to receive pumps compared to larger farmers. Furthermore, a lack of awareness among farmers about the benefits of this technology remains a key barrier, limiting their ability to apply for subsidies and, consequently, receive pump allotments. To this end we will look to:

- Assess innovative and GESI responsive models that leverage support from State Rural Livelihood Missions (SRLMs), Farmers Producer Organizations (FPOs), and Self-Help Groups (SHGs) to unlock new opportunities:
    - Community-based irrigation models: In solar phase one, the program is testing two co-financed community-based solar irrigation business models with women's Self Help Groups (SHGs) under State Rural Livelihood Mission (SLRM) in Mandla, Madhya Pradesh alongside the One-CGIAR Agro-ecology (AG) initative. The first model follows an "earn first and pay later" approach, while the second requires a minimal upfront payment, set at 10% of the pump cost. In the second phase, the project will assess the investment recovery time, livelihood benefits, and scalability of community-based solar irrigation through the PM KUSUM program and other government initiatives. Additionally, in Mandla district, 27 community-based solar irrigation pumps have been installed with support from various projects and funding sources. These models will be evaluated alongside the One-CGIAR AG Initiative with a focus on identifying challenges and outlining strategies for scaling up solar.
    - Market-based models like revolving fund, pay-as-you-go and earn first-pay later to explore scalable solutions that can make solar more accessible to disadvantaged farmers, including women. This will be done alongside partners such as Solar phase one innovation fund grantees and private sector collaborations with organizations such as Oorja solutions.
- Conduct choice experiments to gauge farmers' willingness to pay for solar pumps, which will help in designing financing options to make solar energy more affordable.
- A workshop involving implementing agencies - (MNRE, state governments like Uttar Pradesh, Uttarakhand, and Telangana), the private sector (e.g., Oorja Solutions), financial

institutions National Bank for Agriculture and Rural Development (NABARD), public and private sector banks, Power Finance Corporation, and other key actors such as NITI Aayog - will be organized to identify a set of financial models and instruments to be tested on the ground (in OC4).

In Bangladesh, one of the key steps in attracting private sector investment is to make the Return on Investment (RoI) on solar higher while lowering costs. Also, as articulated in the ADB Solar roadmap, SESA financial models that attract the poorest without being completely dependent on subsidy can be a very crucial entry point for scaling solar and attracting international finance.

Due to political will, currently, the predominant model for SESA is promotion of SIPs through the country's IDCOL's fee-for-service model, where private sector entities invest in solar pumps and act as irrigation service providers for farmers. This model assumes that private investment will make solar irrigation profitable and self-sustaining without subsidies. However, the success of this model depends on high irrigation demand to ensure a RoI, leading to its concentration in areas with large pumps servicing up to 50 farmers. So firstly, there is need for policy research that can support alternative uses of IDCOL solar pumps to use the excess energy that is currently being wasted and increase return on investment for investors. And secondly, this model is unsuitable to remote regions, very poor marginalized farmers, and areas with low irrigation demand where private sector investment is unlikely. Alternative models are necessary for these under-served regions - with assured and accessible irrigation they can ensure food-security for marginalized groups, including women/remote regions, specifically in the face of climate change.

Furthermore, entire value chains have developed to increase efficiency and reduce waste—such as cold storage, mechanical processing, and irrigation. But these solutions are under-resourced and lack easy access to sufficient finance. Changing this dynamic by directing climate finance towards SMEs has potential to transform the rate at which communities adapt to climate change, while also delivering increased benefits. To address these challenges, we propose two sub-activities in Bangladesh

- **Exploring alternative institutional and financial models for micro-SIPs (small-scale solar irrigation pumps) targeted at smallholder farmers and women-led farming groups** in remote regions. Currently there are sporadic pilots on portable foldable SIPs through BRRI in Barishal and mobile SIPs on boats in Bangladesh Char land. DAE is planning to introduce micro-SIPs in the Chattogram Hill tract region. These portable micro-SIPs are targeted to women and tribal farmers in remote regions but these schemes are mostly fully subsidized. For scaling such micro-SIP models it is important to identify institutional and financial models that are less dependent on subsidy with private sector involvement and sustainable on a longer basis. Micro-SIPs have been successfully implemented in other countries through models such as pay-as-you-go, earn-first pay-later, and group ownership via revolving funds. These models could be particularly relevant for areas like Sylhet, the Chittagong Hill Tracts (CHT), and women-led agricultural ventures.
    - We will assess these models through a choice experiment to identify the most suitable approach for micro-SIPs in Bangladesh. The findings will be validated in the national workshop to identify the most suitable model involving government (DAE, BRRI, BADC, IDCOL, BMDA, BARC, SREDA), private sector players (Khetworks, Futurepump, IDCOL sponsors like GAZI, WAVE etc.), donors (KfW, World Bank, USAID) and civil society representatives. Following which a suitable model will be tested under OC4.

- **Exploring alternative mechanisms to enhance the return on investment (ROI) for solar** will encourage greater financial mobilization from private entities. Additionally, with donor focus on reducing subsidy dependence, these measures would attract more international finance to support SIP scaling with less focus on subsidy. A key challenge identified in the first phase of the project is underutilization of excess energy generated by IDCOL solar irrigation pumps during non-irrigation periods. To address this, we piloted grid integration, allowing surplus energy to be fed into the national grid increasing the RoI for private investors. We will further this through a systematic short study to identify approaches for increasing RoI and widening our scope of solar energy applications of IDCOL solar pumps.

Specifically, these alternatives to increase RoI will be need-based around options like the feasibility of used batteries as storage of excess energies that can repurposed for lower-energy applications (like powering household lighting or small community devices); potential of agrivoltaics, use of agri-machineries etc. We will engage with key stakeholders, including IDCOL, SREDA, and BREB to optimize grid integration of IDCOL solar pumps, based on continuing monitoring of the grid integration pilots from SoLAR phase 1 and using findings of the ongoing analysis from the usage pattern.

2.1.2.: Co-design climate-smart financial instruments/business models with existing and new partners from the private sector and governments

Following on from the findings of activity 2.1.1, Conducive government policy supporting the cost reduction of solar technologies will be needed. In many markets where fossil fuels are artificially cheap—especially diesel—levelling the playing field in the form of either reduced fossil subsidies, tax exemptions or subsidies that further lower the costs of solar may be necessary so they can compete.

In India, building on insights gained from Phase 1 of the Surya Shakti Kisan Yojana (SKY) model—where high demand for solar pumps was observed—there is a need to develop a comprehensive implementation roadmap and incorporate it into national policies. The lessons from SKY provide valuable insights into how solar pump adoption can be scaled up, particularly for small and marginal farmers who face significant financial constraints.

One of the key innovations in the SKY model was the introduction of bank-guaranteed loans for farmers through India's National Bank for Agriculture and Rural Development (NABARD). This approach made it easier for farmers to access solar pumps without bearing the full financial burden upfront. However, under the PM KUSUM scheme, there have thus far been no such innovations.

In this phase, the project will work with NABARD to co-design financial instruments that specifically cater to smallholders. This is a challenging task, as providing loans to small farmers poses a significant risk for the government, given the political economy and potential for loan defaults. Despite this, SKY program's success shows that about 60% of farmers were able to generate positive income even after repaying their loan instalments. This suggests that the financial risk is concentrated among the remaining 40%.

- To better quantify this risk, the program will assess how many of these farmers have successfully repaid their loans and how many have defaulted. This analysis will provide a clear picture of the potential risks involved.
- It will also assess the broader benefits the government can gain from reducing power subsidies. By promoting solar energy, the government can save on the cost of subsidized electricity, which

farmers currently use. These financial savings, coupled with an understanding of the risks, will provide a strong basis for designing a robust financial strategy for PM KUSUM 2.0.

Additionally, refining financial models will involve assessing farmers' willingness to accept different financing mechanisms. These insights will help ensure that the models proposed under PM KUSUM 2.0 are viable and aligned with farmers' preferences, particularly for smallholders and women who are most vulnerable to financial risks. By refining these models, we can create solutions that are both sustainable, inclusive and scalable.

In Bangladesh, based on findings of Activity 2.1.1, we will work with key stakeholders (IDCOL, private sector players and other government organizations and donors) to co-develop a detailed implementation roadmap for the suitable institutional and financial models of micro-SIPs in Bangladesh targeting small-holders and women farmers. The roadmap will not only detail the financial and institutional modality of the proposed approach but also identify key stakeholders and their roles and responsibilities at each step. The roadmap will also identify suitable geographical locations for such micro-SIPs, based on current cropping pattern, existing SIP programs, socio-economic characteristics of farmers, water source availability, access to other energy sources etc. Based on this activity we will pilot the identified model under activity 4.1.

Output 2.2: A strategy is developed for a Solar4Africa Irrigation[32] Investment Fund in Ethiopia and Kenya

Summary

- *This output will assess the landscape of investment opportunities for scaling Solar-Powered Irrigation Systems in Ethiopia and Kenya*
- *The findings will provide insights on existing financial instruments and mechanisms, including what works, what doesn't, and areas for value addition through specified financial support.*
- *The work will provide a roadmap to operationalize the most suitable solar-powered irrigation investment solution(s), laying the groundwork for financiers to support selected solution(s).*

Key Deliverables for output 2.2.

- *Ethiopia and Kenya Investment and Financing Landscape Assessment Report for Irrigation. This will include country-level market analysis and prioritization, identifying key financial challenges and opportunities for investment and insights on existing financial instruments and mechanisms, including what works, what doesn't, and areas for value addition through specified financial support.*
- *Demand and Supply Side Market Assessment Report:*
  - *An assessment of business models for selected value chains, including financial sustainability projections and risk assessments.*
  - *Feasibility assessment of the range of investment solutions suitable for identified business models*
  - *A shortlist of up to three proposed investment solutions, informed by business model matching and ranked according to opportunities and challenges*
- *Final Investment Solution Feasibility Report for Ethiopia and Kenya:*

[32] The focus on this output is kept to solar irrigation to keep the investment value chain straightforward, and likelihood of investor interest, following research on existing success and funding model, and policy foci in Sub-Saharan Africa. Through the initial feasibility assessment, if there are options to expand the scope beyond irrigation, this output can be revisited.

    - *A detailed evaluation of the most promising investment solution, including market opportunity, investment strategy and structure, key stakeholders, and integration of social and environmental considerations (including climate change and gender equality) into the investment strategy.*
    - *A comprehensive implementation plan detailing the necessary data infrastructure and partnerships required for implementation.*
- *A practical roadmap for the transition to the investment phase, outlining key milestones, performance indicators, and contingency plans*

Both Ethiopia and Kenya face challenges in achieving self-sufficiency in food production due to low productivity and changes in climate. Without a stable livelihood, farmers cannot afford to invest in inputs and tools that could raise their productivity (e.g., high quality seeds, fertilizer, post-harvest processing, cold storage), and they remain shut out of consumer and financial markets. Smallholder productivity is a notoriously difficult problem to solve, and while solar irrigation is a feasible solution adoption more widely due to affordability. Smallholder farmers have uncertain cash flows and most do not have access to formal banking services. While Climate-Smart Agriculture (CSA) interventions in Africa are necessary to build resilience for smallholder farmers, they are often not sufficient as they are too expensive to operationalize for the mass market.

Scaling solar irrigation systems in Ethiopia and Kenya requires substantial financial investment and a supportive financing landscape. The assessment will identify existing opportunities, gaps, and challenges, while mapping the roles of key stakeholders, including investors, government agencies, micro-finance, and the private sector.

This feasibility study is primarily about unlocking the potential of Ethiopia and Kenya's agriculture sector that stands to benefit from adoption of solar irrigation. By incorporating GESI considerations, it aims to design climate-smart financial instruments and business models that address the entire solar pump and irrigation agriculture value chain and associated risks while fostering inclusive access. It aims to systematically address these barriers by identifying the existing challenges to scaling solar irrigation in Ethiopia and Kenya with a focus on unlocking investment. It seeks to explore the most promising business models, investment pathways and strategic value chains that can benefit from enhanced irrigation resilience. Additionally, this output will identify key stakeholders necessary to develop appropriate financial instruments and pathways to scale the technology, ultimately proposing a pathway to a successful investment strategy.

This output has been co-designed with the CGIAR Hub for Sustainable Finance (or ImpactSF), which was established to build off the CGIAR scientific expertise and extensive network to accompany private investors through the transition to sustainable and climate resilient food, water, and land systems. *ImpactSF* serves as a key technical partner for sustainable finance actors, integrating science-based impact KPIs in all areas of the investment lifecycle. Through ImpactSF, the program will also work with '*responsAbility*', a leading impact asset manager, which launched a 106 million USD climate-smart food systems investment solution with KfW as anchor investor and in partnership with the CGIAR**.** These partnerships will enhance the development of feasibility assessment.

2.2.1: Investment and Financing Landscape Assessment Report for SESA in Ethiopia and Kenya

A comprehensive market scoping of the investment and financial landscape in the irrigation sector will be conducted for Ethiopia and Kenya. This report will work closely with partners including **Ethiopian** Solar Energy Development Association (ESEDA), private sector such as SunCulture, FuturePump, CLASP among others and aims to understand the financial perception by industry

players, identify successful financing models, recognize inefficiencies in existing models, and determine which financial instruments and mechanisms are best suited to scale the technology. A shortlist of options will be prioritized based on IWMI's existing and proposed solar suitability analyses (OC 1.1) combined with demand/supply side analysis and assessment of market size for investment.

2.2.2 Feasibility Assessment of Most Promising Investment Solutions and a Final Investment Solution Recommendation

This activity will assess and rank the most promising investment solutions in solar-powered irrigation based on the demand and need for financing. This activity will review existing business models that scale solar powered irrigation and assess how they are being funded. Through a detailed stakeholder engagement with SMEs, financial intermediaries, ecosystem stakeholders, and potential investors (public and private), an investment readiness analysis and ranking of a range of investment solutions, including feasibility of financial institutions to finance solar irrigation technology. This will include:

- **Value Chain Analysis**: Map key actors and activities within the irrigation ecosystem, identifying bottlenecks and opportunities for improvement.
- **Business Model Identification**: Identify existing and potential business models suitable for scaling solar irrigation, considering different revenue streams, cost structures, and customer segments.
- **Climate Financial Modeling and Risk Assessment:** Evaluate the economic viability and scalability of selected business models.
- **Business Model Matching**: Link demand-side needs with supply-side solutions to inform the selection of viable investment channels.
- **Investment Solution Ranking:** Identify and rank the most promising investment solutions based on demand-side need and supply side constraints.
- **Stakeholder Interviews and Focus Group Discussions**: Gather insights on market preferences, challenges, and opportunities.

Finally, the selected solution will be refined by preparing a more detailed investment plan and roadmap for transition to the investment phase, engaging key stakeholders.

Outcome 3

Increased knowledge sharing, capacity building and south-south collaboration leads to greater uptake of solar energy innovations.

This outcome supports increased regional knowledge sharing and capacity building for GESI responsive and groundwater aware SESA policies and practices and promotes south-south knowledge exchange. The outputs and activities relate closely with capacity development and dissemination of deliverables from OC1, OC2 and OC4. It engages and empowers stakeholders to ensure that proposed innovations are accessible, inclusive, and effectively used. It increases knowledge and capacity of stakeholders, particularly farmers, to the wider livelihood applications of SESA, such as increased food security, nutritional diversity and health benefits.

Output 3.1: Targeted groups, including women, are trained on tools created

Summary

- *Through this output we will conduct needs assessments, produce customized curricula, and interactive training methods which are essential components of effective capacity building.*
- *Through building capacity both of implementors and farmers, the findings will help support longer-term knowledge and capacity for inclusive and effective solar energy systems.*
- *Insights from this work will ultimately support implementing agencies in overcoming adoption barriers and closing the gap between policy and practice.*

Key Deliverables for output 3.1.

India

- *Training module for energy extension agents (KUSUM-Mitra), ensuring they are equipped with the technical and communication skills needed to promote SESA and support farmers.*
- *Policy brief based on the pilot's findings, and a roadmap to institutionalize the KUSUM-Mitra model within the broader agricultural extension framework, with a specific focus on supporting vulnerable farmer groups.*
- *A final impact assessment journal article detailing the causal effects of the energy extension agent model on solar demands (e.g. captured through application for subsidized SIP under PM-KUSUM C1), adoption (allocation of subsidized SIPs under PM-KUSUM C1) and the socio-economic and livelihood outcomes for farmers.*

Bangladesh

- *A policy note based on a needs assessment study to identify required training modules for key stakeholders as needed*
- *Training module developed for implementing inclusive community managed SESA systems*
- *At least 2 trainings to be conducted with implementing officials from different government agencies, with at least 20 participants*
- *Training module developed for solar energy extension support in Bangladesh*
- *At least 2 trainings conducted by DAE officials and other implementing officials with atleast 20 participants including women.*

Ethiopia and Kenya

- *Training curricula tailored to the needs of extension agents (specific to government agencies and agents from the private sector;*
- *At least 2 trainings to be conducted with the extension agents (ToT) with at least 20 participants in each training including women.*
- *Scaling brief and Roadmap: Develop a Scaling Brief summarizing key insights based on the pilot's findings, accompanied by a comprehensive roadmap to institutionalize capacity-building initiatives for Extension Agents across government and private sector.*

Through OC1, the program supports identification of evidence-based tools for supporting policy making, while in OC2, business and financial models are proposed for scaling SESA. However,

successful implementation of policies and practices that relate to solar relies heavily on comprehensive capacity building of target stakeholders - policy makers, implementors, financers and end users/farmers.

Thus, to support and enhance uptake of recommendations from OC1 and OC2, Outcome 3 will aim improve knowledge and capacity, depending on context, at various levels of implementation - including policymakers, implementors, financiers and farmers.

3.1.1.: Training and capacity development to farmers, implementing officials and local technicians

In India, in Phase 1, capacity building programs in India focused on SKY beneficiaries in Gujarat and showed the significance of well-designed trainings to support uptake and improvements in energy outcomes and income generation. In Phase 2, capacity building efforts will aim to support and enhance implementation of the national PM-KUSUM (see Table 1) and associated development schemes (such as National Rural Livelihood Mission, see OC 4.2.1) through interventions at multiple levels, targeting key stakeholders involved in the process.

- For implementing officials, such as those from MNRE and various state departments, training is designed to equip them with tools like composite WEF index, SIP sizing and digital platforms (OC 1.1 and OC 1.2) and financial instruments (OC 2.1) that can improve the efficiency of scheme.
- For local technicians from the private sector, we focus on training them with new innovations, such as hybrid solar systems, to ensure they stay updated with technological advancements.
- Agricultural extension agents, including women and those from Krishi Vigyan Kendras (KVKs) and state agriculture departments, will receive training on the advantages and challenges of SESA including SIPs, guidance on the operational aspects of these systems, as well as building awareness on key secondary livelihood benefits of adopting SESA, relating to income generation, food security, nutritional diversity and health.
- For farmers, training focuses on using solar technology efficiency to optimize energy use, agricultural productivity and livelihood support. We will also ensure trainings are tailored to women farmers, through separate targeted trainings as required.

In Bangladesh, for non-IDCOL solar schemes in Bangladesh[33] most initiatives are led by government agencies such as the BADC, the BMDA, and the DAE, with the systems being community managed[34]. However, for such community-based models to function sustainably and inclusively, strong institutions need to be established at the local level to support them. Unfortunately, officials responsible for setting up and managing these community systems are often under-equipped and inadequately trained to fulfil their roles effectively. Based on initial needs assessments, targeted training programs will be conducted focused on orientation, management, administration, and troubleshooting approaches for the government agencies tasked with implementing SESA, and supporting farmers understand the livelihood benefits of SESA beyond its energy security and

[33] While IDCOL model is the most prominent, there are many other community managed fully subsidised solar irrigation schemes implemented by different Government agencies like BADC, DAE, BMDA, BRRI, LGED etc. These SIP systems are often low-lift pumps or dugwells and in most cases using surface water. These are managed by Water Users' Associations. There are also BREB installed individual owned grid-connected solar irrigation pumps.

[34] ADBs scaling roadmap - these group managed SIPs as implemented by BADC, BMDA and LGED are expected to play a significant role, since IDCOL SIPs aren't suitable for all locations and instead farmer group-managed and surface water using solar pumps are seen as good options to promote by the government (in the solar roadmap (ADB 2023), out of 45000 SIP systems, it is suggested to prioritize solar low-lift pumps (28000) and solar DTWs (2000) implemented by government agencies and managed by farmer groups).

mitigation potential. A particular focus of capacity building will be on equipping implementing agencies with decision support tools, i.e. tools developed under OC 1.1. OC 1.2, OC 2.1, such as the WEF-SS composite maps, to help implementers identify suitable geographical locations for application of specific financial models, as well as the solar sizing tool for optimal design, among others. The training will also focus on community mobilization and governance issues prioritizing effective formation of inclusive and capable water users' associations (particularly women farmers and other marginal groups) to manage these systems (as identified under OC 2.1). And will also include aspects of gender sensitization of solar schemes for implementing officials to address the inherent bias that often constrains the gender-inclusiveness of government schemes. Finally, the trainings will ensure officials are suitably capacitated on communicating the wider benefits of SESA on community resilience to climate change – e.g. through increased income, livelihood diversification, food and nutritional security and ultimately health. This will be targeted at government agencies responsible for implementing community managed SESAs as this will have significant implications on future scaling of these models.

In this activity we will not be training farmers[35] instead our focus will be on training implementing officials. This will enable better targeting and management of these systems maintained by the implementing agencies thus benefiting water buyers. Also, under OC 4, there will be a component of training farmers directly on Alternate Wetting and Drying (see OC 4 for details).

In Ethiopia and Kenya: one of the major obstacles towards scaling SESA is the lack of knowledge and capacity of targeted segments of the key stakeholder community. Due to this, private companies struggle to find a skilled workforce for sales and distribution, service provision, and repair and maintenance. These challenges increase risks and costs for private companies, public agencies, farmers, and ultimately scaling of technologies. Thus, we seek to strengthen capacity in the business ecosystem for scaling different modalities. This is achieved through increasing the capacity of local government extension support services or private sector agents as they are in direct and regular contact with farmers.

This program will conduct a needs assessment to understand levels of knowledge and capacity required. Following this, will look at:

- Collaborating with universities, vocational training institutes and experienced private sector partners to increase capacity of businesses working in the field of SESA and agriculture, by strengthening their solar energy competences (design, installation, maintenance, and pre- and post-sale services). Work with FSRP and PACT projects in Ethiopia will be leveraged.
- Increase the capacity of financial institutions at the local level through training courses and exercises to enable efficient evaluation of SESA applications
- Co-develop targeted training and capacity building which includes Business incubation for innovation commercialization.
- Integration of SESA knowledge and analytical skills into educational curricula (such proposing option of integrating solar pump into vocational school curriculum); or others as needed
- Synthesizing the different tools developed by the program to training material and to prepare at least two training sessions in Ethiopia and Kenya.
- Integrating experiences in India and Bangladesh and enhance cross country and cross regional collaboration. The trainees will be clustered based on their background and level of services they provide to users and adjust the type and intensity of training accordingly.

[35] Following Phase 1, the key gap is found to be with capacity of implementing officials, and through them impacts on farmers will be stronger.

- Training of farmers on safe usage of SESAs, irrigation scheduling, choice of profitable crops, good agricultural practices for increased productivity, financial management training, livelihood benefits of solar and training of water user associations on governance issues and management of SESA. In Ethiopia, training for farmers will be conducted in collaboration with the FSRP and PACT projects under the Ministry of Agriculture. The FSRP's Farmer-led Irrigation Development (FLID) project specifically targets smallholder farmers. We will leverage these projects, along with partnerships with microfinance institutions and the private sector to deliver farmer training. In Kenya, we have identified key partners, including Sun Culture, Future Pump, Jomo Kenyatta University of Agriculture and Technology (JKUAT), and the National Irrigation Authority. The specific projects for collaboration will be identified during the first six months of the project.

3.1.2: Training of Trainers (ToTs) and Energy Extension Agents

The goal of this approach is to ensure extension agents and solar technicians/trainers are equipped with the necessary skills to train users on installation, maintenance and repair, and to also provide information on the wider applications and benefits of SESA. As a result, when new solar schemes are launched by other government agencies or through private investments, these agents will be able to train farmers, and technology operators on how to properly maintain their systems and share with them information on the various -co-benefits of adopting them – e.g. adaptation co-benefits, nutrition and food diversity. We will also ensure gender considerations are taken into consideration and women trainees, and extension agents are identified and supported.

In India the concept of extension agents[36] has been present for a while but under different circumstances. Currently, there is no formal institutional mechanism to support the widespread adoption of SESA in India. Awareness is primarily raised through newspaper and television advertisements, which are insufficient to effectively communicate the advantages of SIPs and how they can transform farmers' livelihoods. These limited outreach methods often fail to reach the most vulnerable and smallholder farmers, who would benefit the most from the technology. In Phase 1, the capacity-building intervention focused on the technical and financial aspects of grid-connected SIP implemented for beneficiaries of the SIP scheme in Gujarat, specifically providing post-SIP adoption training to farmers. However, in Phase 2, the goal is to implement capacity-building interventions prior to SIP adoption to increase both demand and adoption. Between SoLAR 1 and 2, the project aims to uniquely address challenges at both the pre- and post-adoption stages.

Under this project, we are introducing the concept of '*KUSUM-Mitra' – and potentially 'Mahila Kusum Mitra'* (Women agents) - extension agents for the government solar scheme (PM-KUSUM). For instance, the state of Uttar Pradesh's recent plan to implement 10,000 grid-connected solar irrigation pumps under PM KUSUM C1 (see Table 1), this pilot aims to test and scale the "Energy Extension Agent" model, ultimately enhancing the reach and effectiveness of solar adoption across the country. The project will leverage KVKs, state agriculture departments, and other extension bodies to actively disseminate information about solar energy and its uses in agriculture, provision of technical support, and ensuring that farmers (particularly women farmers) are fully aware of the financial (OC2), water-energy-food linkages (OC1), and livelihood benefits identified through previous outputs. The pilot's findings will help us create a comprehensive roadmap to

[36] They are responsible for sharing knowledge and information with farmers to help them make decisions about energy, crops and water management strategies. They work with research scientists to develop communication tools and introduce technologies that are best suited to a farmer's geographic area.

institutionalize the promotion and adoption of SESA, ensuring that the technology is accessible, better understood, and integrated into the long-term plans of socio-economic development of India.

Description of Kusum-Mitra intervention

This initiative will be implemented in 24 KVKs, with each KVK covering four villages, totaling 96 villages. These villages will be divided into two groups of 48 villages each: a treatment group and a control group. In each treatment village, there will be two intervention approaches. The first is a focused intervention targeting 20 farmers per village (10 medium and large farmers and 10 small and marginal farmers, with a minimum of 6 women farmers). Energy extension agents will visit these farmers directly to provide knowledge on the advantages and benefits of grid-connected SIPs, financial model (OC2), water-energy-food linkages (OC1), followed by support from JAN SEVA KENDRA agents to assist in the application process.

The second intervention involves information dissemination via mobile phones to reach the remaining farmers. This includes educational materials and videos explaining the application process for grid-connected SIPs, reaching an estimated 200 farmers per village (the average number of farmers per village), or a total of 9,600 farmers in the treatment group.

After the impact assessment of energy extension agents, all developed materials will also be shared with farmers in the control group, reaching an additional 9,600 farmers. In total, this intervention will directly reach 960 farmers, with an additional 19,200 farmers reached through mobile dissemination. Through this initiative, the project aims to directly impact demand generation, as measured by the number of farmers applying for subsidized SIPs under PM KUSUM C1, and the adoption of SIPs, indicated by the number of farmers who receive the subsidized units.

The project will collaborate and establish MoUs with the Indian Council of Agricultural Research (ICAR) to leverage its KVK network across each district, enabling the nationwide scaling of the energy extension agent concept, and Uttar Pradesh New and Renewable Energy Department (UPNEDA), the implementing agency for PM KUSUM C1.

In Bangladesh, there is currently no concerted government effort to create a robust infrastructure base for SESA training or to incorporate such modules into ongoing extension activities. The operation, maintenance, and institutional development of SIPs and the wider uses and applications of solar are currently managed independently by each implementing agency for their respective installed pumps, as our findings in phase 1 showed.

DAE serves as the primary government extension arm, providing training on aspects of agriculture and water management practices. As part of this initiative, we will develop a comprehensive training module focused on the repair and maintenance of SESAs, but also on wider climate adaptation benefits offered. The module will be developed based on those created for India in Phase 1 but adapted to be relevant to the local context. We will incorporate lessons for farmers on the linkages of water-energy-food nexus (OC1) to enable efficient use of resources. The module will also specifically focus on the capacity building needed for micro-SESA users, emphasizing the financial model for micro-SESA developed under OC2, which targets women and other marginalized groups. This will be followed by a 'Training of Trainers' (ToT) program for DAE personnel. While our primary target for this extension activity would be DAE, we will also consult with other Government implementing agencies like BADC and BMDA for inclusion of their implementing officials to be trained for these 'Training of Trainers' (ToT) programs.

By developing these training resources and integrating them into the government's extension framework, the program will lay the foundation for a sustainable, long-term support system for SESA in the country. This initiative can become the backbone of future extension activities, ensuring that the necessary expertise is readily available as solar irrigation continues to expand across Bangladesh.

In **Kenya and Ethiopia**, extension agents and technicians from the private sector play a key role in creating awareness and pre- and post-sale services and associated financial solutions across Kenya and Ethiopia. However, they are not systematically trained and integrated into the scaling of solar programs. This requires coordination with public and private sector agencies in the selection of extension agents and technicians at county or district levels who are responsible for supporting farmers and agribusinesses. Ultimately this is crucial since the the extension agents would in turn provide trainings for farmers in their respective local communities (Kebeles), see section 3.1.1 training of farmers.

As part of the integration, a comprehensive training curriculum will be developed for these agents (see OC 3.1). The curriculum will focus on the technical aspects of solar energy systems, agronomic practices, and irrigation technologies, equipping agents with the knowledge to guide farmers not just on the technical aspects of SESA but also its wider benefits for their livelihood and adaptation to climate change – in particular food and nutritional diversity. Additionally, the curriculum will include financial management training to help agents facilitate access to credit, loans, and other financial products (as identified in OC 2.2) that can support smallholder farmers in adopting SESA. It will also highlight the potential broader uses of solar energy systems in agriculture, beyond irrigation.

To ensure the integration of the agencies and sustainability of the trainings, we need to integrate the curricula into the existing program of trainings for the extension agents. The integration of the curricula will be further supported by OC 3.2.2.: South-South knowledge exchange/key partner

meetups. The existing knowledge and experience in India and Bangladesh will provide feedback for Kenya and Ethiopia and vice versa.

Output 3.2: Multi-stakeholder forums and other platforms held to disseminate findings across all target countries

Summary

- *Though regular national, regional and global forums, we will demonstrate key lessons learned on the effectiveness of solar as a viable strategy for sustainable agri-food systems*
- *Provide a platform for policymakers, public and private sector partners, scientists and farmers to exchange ideas and experiences on key barriers and opportunities in the uptake of solar irrigation taking gender and social inclusion into consideration.*
- *The forums and knowledge exchanges will support sharing of innovative ideas and strategies for supporting south-south collaboration to suitably scale equitable and inclusive SESA globally, including ideas for future support and impact.*

Key Deliverables for output 3.2.

- *At least 2 national policy forums will be conducted with policy hackathons built in, where necessary.*
- *2 global/regional forums will be conducted over a four-year period*
- *Findings and recommendations from these forums will be documented through reports*

3.2.1: National Forums and hackathons

The project countries will regularly organize national policy forums to solicit feedback from national, provincial and local policy makers, and to disseminate information on findings from OC1, OC2, OC3 and OC4. In phase 1, national policy forums were found to be a successful way of disseminating findings from the study to key stakeholders. The frequency of these national policy forums will be need based, but not less than 2 such policy consultation forums in each country during the 4-year span of the project.

In addition, policy hackathons will be curated at a national/regional level to focus on specific and emerging knotty policy issues that are more suited to an event where participants can workshop ideas in a more organized manner. Policy hackathons will bring together experts in specific fields of study with other stakeholders to rapidly develop solutions to identified problems through the harnessing of their collective knowledge and brainstorming.

We will seek to organize at least one hackathon in each country with relevant stakeholders during the project period. A succinct workshop report will be prepared to capture the discussions and key action areas for the future.

3.2.2 Regional/Global forums and south-south knowledge exchange

All SoLAR project partners will meet twice in the four-year period and share information on project progress as a part of a global knowledge forum and partner's meet. In the first year (2025), this could include in-person inception meeting.

This meeting will be attended by the SoLAR-SA Steering Committee, who will review project progress and provide feedback. This will be a platform for project partners to come together and exchange information and knowledge on various aspects of the project.

The forums can take place at a regional or global scale, depending on several situational variables, including emerging areas for work through the program, and need for south-south exchanges. In these SoLAR forums, where in addition to participants mentioned above, relevant regional, global and national stake holders such as government representatives from key countries, ISA, IRENA, FAO, AfDB, World Bank, ADB, IFAD, SAARC, MNRE, CEEW, SunCulture, Davis & Shirtcliff Group and private solar companies will participate and showcase their work on use of solar power in agriculture. Country representatives from Swiss Embassies and SDC representatives from the four project countries will be invited to these Forums. This will be held together with the annual partners' meet and steering committee meetings to reduce duplication of costs and efforts. These events will be supported through various knowledge dissemination products such as videos, newsletters and policy/issue briefs.

During these forums, as feasible, field visits and exchange visits between South Asia and East Africa will be arranged to sites where SESA has been implemented. The South-South (S-S) exchanges will foster practical, on-the-ground knowledge transfer between countries. In the exchange stakeholders from East Africa (Kenya and Ethiopia), including government officials, private sector representatives, and practitioners, will visit India or Bangladesh. They can visit field sites of phase 1 SoLAR and gain field insights into use of grid-connected and feeder-lever solarization in Gujarat, India and the grid-integration pilot in Gazi, Bangladesh. Officials can also visit micro-grid pilots supported by SoLAR 1 Innovation Fund (IF) Grantee – CiNi and explore solar-based dairy farming with hydroponic fodder by Urmul Seemant Samiti in Rajasthan[37]. In Mandla, Madhya Pradesh, support for women's participation in Solar can be explored – e.g. a SoLAR phase 1 funded pump installed, where tribal women farmers have formed a Water User Group to operate the system.

Similarly, counterparts from India and Bangladesh can visit East Africa (Ethiopia/Kenya) to learn from local implementation efforts, fostering a bi-directional exchange of knowledge and experience. Officials from Bangladesh and India will be able to gain insights on increasing participation of private sector in scaling off-grid solar, through visiting sites where bundling solutions have been implemented.

These exchanges will allow participants to share both successes and challenges, gaining valuable insights into best practices and potential pitfalls.

Outcome 4

Existing platforms and living labs[38] are assessed and optimized for scaling solar agri-tech bundles

All four countries have existing platforms/initiatives/policies (e.g. PM-KUSUM scheme in India, IDCOL's business model in Bangladesh, SHIDEP, PACT in Ethiopia, EnDEV in Kenya and Ethiopia) where tools and business models developed in preceding sections can be positioned in a synergistic manner.

First, there is a need to validate and optimize, where needed, existing platforms and enhance oft-neglected policy aspects of the solar energy value chain. Second, the innovations recommended through OC1, OC2 need to ready to be 'scaled' through these existing platforms and living labs.

[37] https://solar.iwmi.org/innovation-fund-awardees/

[38] in the context of this proposal living labs are programs/initiatives that are being continually honed and implemented in real-life contexts using iterative feedback processes. Examples include PM-KUSUM, NRLM, Krishi Vigyan Kendra (KVK) platform [IN], IDCOL's business models [BG], platforms for implementing micro-SIPs by the DAE and BRRI [BG], PACT [ET], SHIDEP [ET], NSSID [ET]; IFAD [KE]. In Ethiopia and Kenya, following a six month inception phase, additional platforms for impact will be identified.

Under Output 4.1, smaller and overlooked policy needs identified through OC1, OC2 and OC3 but also through our phase one findings in South Asia and ILSSI, Africa Rising and CGIAR initiatives in East Africa, can be assessed and validated – e.g. regulations for Ethiopia's tax exemption policy. Output 4.2 will focus on scaling readiness of tools and innovations, to be optimized in the context of existing platforms. Findings will be disseminated and discussed with key stakeholders through capacity building and forums (OC3.1 and OC 3.2).

Output 4.1: Policies and Partnerships are optimized

Summary

- *Linked to OC1 and OC2, and findings from Phase 1 and other projects, emerging policy recommendations will be validated and tested through assessments and consultations.*
- *In Kenya and Ethiopia, a 6-month inception phase will help identify and forge key partnerships with existing platforms, and stakeholders including government agencies, and the private sector[39].*
- *Outputs will support governments and implementing agencies enhance their existing policies and frameworks.*

Key Deliverables for output 4.1.

India

- *A policy review on rules and regulations for solar system sustainability, after-sales service, and e-waste management.*

Bangladesh

- *Assessment report on specific policy issues hindering SESA scaling in Bangladesh, including PV waste management, managing simultaneous grid and solar expansion, tax and import duty policies, and groundwater use regulations.*

Ethiopia and Kenya

- *In Kenya and Ethiopia, launch an inception phase to identify key partners and platforms*
- *Report for Kenya on institutional landscape analysis and policy implementation for the scaling of SESA solutions*
- *Ethiopia Comprehensive Policy Implementation Assessment Report: It aims to provide actionable recommendations for the Ministry of Agriculture to streamline processes and enhance service delivery for private sector actors, thereby improving policy effectiveness and fostering an enabling environment for scaling solar pumps.*
- *Guidance Document on Solar Pump Standardization for Ethiopia: A supplementary guidance document to support the Ethiopian Standards Agency.*

Activity 4.1.1: Partner Analysis and Mapping

In Kenya and Ethiopia, working with our current partners, such as Sunculture, The Davis & Shirtliff Group, and IFAD, the program will first structure an inception phase during the first six months of implementation to ensure a nuanced, context-specific approach that identifies and addresses local

[39] In India and Bangladesh, the program has forged a number of key partnerships with relevant stakeholders through phase 1 forums. While IWMI has a presence in Ethiopia and Kenya, this inception phase will help launch solar phase 2 in-country and identify and strengthen platforms and partnerships that the project can leverage

scaling readiness. It serves as a strategic groundwork period, designed to establish a clear, collaborative framework and validate the most impactful approaches for scaling solar solutions.

This phase will allow for a thorough partner analysis and mapping, contextualized needs and market assessment, and leverage existing platforms to identify the entry points and added value of our program. These activities will be synchronized in our activities of 1.2 and 2.2. During this phase, engagement with multiple partners will be prioritized - the private sector, such as Future Pump, as well as the Irrigation Authority, SNV, and other relevant stakeholders to align activities with existing market dynamics and innovation needs.

Building on the foundational partnerships identified here, activities in Ethiopia and Kenya will utilize outputs from OC1.1 and OC1.2 on solar suitability mapping to guide targeted irrigation interventions, ensuring solar pump deployment aligns with local climate, water, energy dynamics, and socio-economic context of farmers. Additionally, findings from OC2.2 on business model development and value chain analysis will guide the inception phase by identifying and prioritizing feasible financial structures, such as pay-as-you-go models, that meet the unique needs of smallholders and other value chain actors in Kenya. Thus, OC2 will support the co-development and implementation of adaptable business models with the private sector and government entities. Thus, by aligning these efforts with OC1 and OC2 outputs, we can ensure a strong, evidence-based approach that maximizes the potential for sustainable adoption and long-term impact of solar-based irrigation solutions across Kenya's agricultural landscape.

Activity 4.1.2: Policy Assessment for Sustainable Scaling of Solar Energy Solutions in Agriculture

In India, the significant increase in the adoption of SESA in the last decade has raised critical second-generation concerns about their sustainable use and the management of solar PV waste. In response, the Ministry of Environment, Forest, and Climate Change introduced the E-Waste (Management) Rules, 2022, incorporating solar PV waste management. As solar programs expand, a comprehensive policy analysis is crucial to develop sustainable practices for their use and tackle the growing environmental challenge of solar PV waste. This includes assessing compliance with guidelines for waste processing, inventory management, and material recovery, ensuring both economic gains and environmental protection. Additionally, we conduct a systematic validation of rules and regulations on after-sales service and e-waste management.

In Bangladesh: To support our outputs on increased RoI and private sector finance mobilization (OC 2.1), a focused activity will be undertaken on specific policy issues hindering the scaling of SESA in Bangladesh. This will involve identifying key challenges and proposing actionable steps for relevant departments to address them. The activity will include direct engagement with stakeholders such as SREDA, the Ministry of Agriculture, the Ministry of Power, IDCOL, and the Ministry of Finance, to ensure policy recommendations for scaling are incorporated. Key issues to be addressed include PV waste management, managing simultaneous grid and solar expansion, tax and import duty policies, and groundwater use regulations.

In Ethiopia, following the 2019 tax exemption policy, implementation has been very slow and inconsistent, impacting private sector and scaling of SESA. During multi-stakeholder dialogues organized by IWMI on projects, private sector representatives highlighted the lack of clear guidelines and administrative hurdles that complicate compliance and policy uptake by different implementing agencies including The Ethiopian Revenues and Customs Authority (ERCA). To address these challenges, this output will conduct an in-depth assessment of the policy's implementation

guidelines, rules and regulations and key issues in the implementation, helping the Ministry of Agriculture streamline processes, enhance service delivery to private sector actors, and assess the policy's effectiveness. This assessment will not only support in creation of an enabling environment for the scaling of the solar systems but also will further support the on-going solar-pump standardization being developed by the Ethiopian Standard Agency.

In Kenya, several policies and strategies have been put in place to improve energy efficiency and conservation and encourage the use of renewable energy products, especially solar. For instance, tax exemptions on renewable energy products were re-introduced in 2021. Dialogues with private sector technology providers brought out the need to extend these exemptions to other components of SESA. Kenya's policies also show a strong commitment to the development, management, and regulation of irrigation for increased food production, but implementation is lacking. There are also multiple government agencies involved in water management, usually with a lack of clarity on jurisdictions and working in silos. Besides, county governments that are meant to domesticate national policies often develop their own county-level water policies and strategies aligned with specific donor requirements. To achieve policy coherence, there is need for a comprehensive assessment of existing policies and strategies relevant for the scaling of SESA.

Output 4.2: Scaling Readiness is mapped and tested in the context of existing platforms

Summary

- *Linked to OC1 and OC2, working alongside existing initiatives, placing citizens at the heart of innovations, test and validate whether innovations are 'scalable' under existing conditions, particularly focusing on women and marginal farmers*
- *The findings will work on narrowing down 'best-fit' solutions to promote greater benefits and support scaling efforts.*
- *The validating and optimizing of recommendations from this program will ultimately support governments and implementing agencies in better understanding how their programs and platforms translate in the real world and what further changes need to be made to ensure effective scaling of solar energy systems.*

Key Deliverables for output 4.2

India

- *Report on assessment of how bundling solar with water-efficient technologies affects farmers' irrigation behavior, groundwater use, and crop productivity*
- *A policy brief with a strategic roadmap for scaling bundling of SIPs with micro-irrigation systems across states, to feed into PM-KUSUM and its various implementing authorities.*

Bangladesh

- *Pilot a micro-solar financial model in least 2 locations with appropriate stakeholders and research note on the pilot experience, identifying improvements needed for scaling and the policy support through key government agencies (BADC)*
- *Pilot bundled AWD solutions for SESA using groundwater with alternative incentive mechanisms and policy brief outlining findings and making recommendations to IDCOL and donors on bundling AWD with SESA*
- *A policy note on the potential of carbon credits for AWD adoption in IDCOL SIP command areas*

Ethiopia and Kenya

- *A series of demand-supply linkage workshops; Set up groups to engage partners*
- *Create awareness (OC3); demonstrate and increase outreach (OC1).*
- *Establish user accounts to manage payments; and increase sales of PAY-OWN pumps (OC2)*
- *Co-develop data-driven tools to enable inclusive business (OC1); facilitate systemic changes in scaling SESA in Kenya and Ethiopia (OC1 and OC2).*

The outputs of OC1 and OC2 provide several recommendations for sustainable and GESI-responsive scaling. OC 2.1 and OC 2.2 provide suggestions to support decisions on the kinds of investments, activities, and partnerships that are required to overcome key bottlenecks. However, successful scaling of innovations requires a significant amount of political will and importantly momentum to ensure that ultimately 'best-fit' solutions that are affordable for farmers and other value chain actors are promoted.

Scaling readiness assessments conducted in partnership with key stakeholders in the respective countries are one way to ensure the tools and recommendations developed by this program are not 'stand-alone' and can be sustained beyond the timeline of the project. This will support validation of recommended decision support tools (OC 1.1 and OC 1.2) while also ensuring they are suited to leveraging the work started by existing platforms and programs. Where needed, MoUs and partnership agreements will accompany research on existing projects and living labs.

4.2.1. Identify solutions for bundling innovations

In India, this activity will include collaborating with the Haryana government to test findings from OC1 by bundling water-efficient technology with the disbursal of SESA in the state of Haryana. Additionally, the project will investigate how improved access to irrigation through SESA and water savings from efficient technologies impact the income and livelihood security of women, particularly those from Self-Help Groups. Outputs, once suitably validated, can be incorporated with the Haryana State Rural Livelihood Mission (HSRLM).

The National Rural Livelihood Mission (NRLM) is a poverty alleviation program in India that aims to improve the quality of life for rural poor households. The NRLM mobilizes rural poor households into Self Help Groups (SHGs) and provides them with long-term support. The NRLM's core belief is that the poor have the desire and capabilities to come out of poverty. The NRLM also aims to improve access to financial services.

SESA offers users more than just a source of renewable energy; it offers climate resilient growth opportunities including livelihood diversification, food security and nutritional diversity, access to technology and financial resources for marginal groups. There is a unique opportunity through India's NRLM and State Livelihood Missions, such as the HSRLM to embed this connection for less siloed and more integrated development.

Haryana state was chosen for three main reasons: first, Haryana is among the most groundwater-stressed regions in India, making water-efficient solutions especially relevant and impactful. Second, Haryana has been one of the top-performing states in terms of PM KUSUM implementation, showcasing strong commitment and capacity in adopting SESA initiatives. Third, Haryana's allocation criteria for SIPs favor farmers using micro technologies, aligning with the objective of promoting sustainable water management practices. In Phase one, the program examined the effect of grid-connected SIPs on irrigation behavior and groundwater use in Gujarat. In this phase, it will assess the impact of off-grid SESA on farmers' behavior and how bundling solar innovations with micro systems

identified through OC1 and OC2 influences their energy usage practices, but importantly helps support food security and rural livelihoods.

Like in phase 1, collaboration with ICAR's existing platform of Krishi Vigyan Kendras (KVKs) will be key to offering extension services (OC3) to farmers and women SHGs. This initiative aims to enhance farmers' understanding and adoption of these technologies, ensuring both that the technologies and farmers are ready to scale and can maximize the benefits of solar systems while promoting sustainable water use practices, and promoting food and nutritional diversity.

Innovation bundling in India through State Livelihood Missions

Description of Pilot:

HSRLM is an autonomous body set up under the Rural Development Department, Government of Haryana (GoH) to implement India's National Rural Livelihood Mission in the state. The HSRLM is focused on creating social and human capital for vulnerable communities and aims to improve livelihoods by diversifying income-generating activities. Decision-support tools developed under OCI will further optimize the mission of NRL and HSRLM, particularly by including bundled solar innovations to support livelihoods in the state.

Through this pilot, the goal is to integrate SESA decision-support tools and financial outputs from OC1 and OC2 with HSRLM. More than 100,000 off-grid SIP allocations have been made under PM KUSUM Component B in Haryana, a region already stressed by groundwater depletion. In implementing Component B, the Haryana state government has introduced eligibility criteria requiring that farmers install micro-irrigation systems (e.g., drip or sprinkler irrigation) and/or underground pipelines (UGPL) before qualifying for solar pump installations. Additionally, solar pumps cannot be installed in areas notified by the Central Ground Water Authority (CGWA).

While these interventions aim to mitigate groundwater over-extraction, there has been no formal assessment of their broader impacts on water usage, energy consumption, crop production, nutritional diversity, and food security. There is a need to evaluate how programs like PM KUSUM can be integrated with existing rural livelihood missions to enhance their effectiveness. Such integration could be especially beneficial for women smallholders, who generally have less access to irrigation. Additionally, assessing the impact on nutritional diversity—through potential shifts in cropping patterns—would provide valuable insights into how these programs contribute to more balanced and resilient food systems.

This pilot study is especially relevant as it provides an opportunity to (1) evaluate the effectiveness of bundling micro-irrigation systems with SESA and assess whether this approach leads to more sustainable water usage, and (2) use findings from the pilot to support HSRLM's efforts in promoting rural livelihoods through diversification and access to financial services.

Insights gathered will not only inform policymakers on the effectiveness of these interventions but will also provide valuable lessons for other regions seeking to scale SESA sustainably within India's broader development programs.

Bangladesh: Piloting Bundled solution for sustainable scaling: The proposed pilot in Bangladesh will attempt to bundle water efficient practices with SESA through an incentive mechanism (identified in OC 2.2) for adoption. The integration of water- and energy-saving technologies bundled with SESA is essential for sustainable scaling of solar, as identified in OC1. One such technology, Alternate Wetting and Drying (AWD)[40], has been proposed as a solution to reduce groundwater usage for paddy irrigation if incentivized through water pricing. Studies have also shown that AWD has several co-benefits including improving the nutritional quality of rice[41]. But uptake of AWD among diesel irrigation farmers in Bangladesh has been low. Bundling solar (as replacements for diesel) with AWD offers dual benefits: clean energy, more efficient water management and improved livelihood benefits (through increased income). Unlike decentralized diesel pumps, which involve many small water sellers, SIPs in Bangladesh are centralized systems with large command areas, serving nearly 50 farmers per system. This centralization creates an opportunity to incentivize AWD adoption on a larger scale, addressing both energy and water sustainability challenges.

Bangladesh Pilot on AWD

Description of Pilot: The program will work with IDCOLs existing network of SIPs and its sponsors to pilot the bundling of AWD interventions with SIPs. Through this pilot, we will provide the necessary training and capacity building at selected sites for AWD adoption and develop a mechanism to incentivize AWD within SIP command areas. In consultation with stakeholders, we will explore two approaches for incentivizing AWD. In one approach, sponsors would receive a rebate on their loan repayment linked with the share SIP command area converted to AWD. In another approach, farmers would be directly incentivized with a rebate on their irrigation tariff if they implement AWD on their plots.

The target of this pilot will be the IDCOL sponsors and farmers buying water from SIPs. During the pilot, these incentives would be subsidized through the project. Simultaneously, in partnership with IDCOL, we will conduct exploratory studies to establish a carbon credit mechanism for AWD adoption, which could partially or fully finance the incentives offered for AWD uptake. In this pilot we will target we will have 5 SIPs with just AWD training for farmers, 5 IDCOL SIPs with training and incentive to farmers and 5 SIPs with training and incentive to sponsors.

Bangladesh Micro-SESA pilot

Under OC2.1, we aim to identify suitable models for micro and small SESA, specifically targeting poor and marginal farmers in remote regions. Based on the models identified through our study, we propose a proof-of-concept pilot for micro-SESA models in at least one location in partnership with relevant agencies. For instance, if we determine that a pay-as-you-go (PAYG) model—where farmers pay for usage and gradually repay the capital cost over time, eventually owning the SESA system—fits the local context, we will collaborate with local suppliers to customize the technology and pilot it with 5-6 farmers. This pilot can then be showcased for broader adoption. Alternatively, if a model involving MFI (microfinance institution) women's groups, where loans are used to purchase small SESA, is considered viable, we will work with organizations like DAE or BRRI, which are already implementing micro-SESA projects in Bangladesh, to pilot this approach. We will also collaborate with the appropriate MFI groups that can serve as partners for such a pilot. The objective of this pilot will be to fine-tune the technical features, refine its institutional and economic aspects identify scaling barriers and determine the type of policy support needed for success.

[40] AWD is a water-saving technique that can reduce water consumption by 30–35%. It involves periodically draining a field to a certain level and then re-flooding it. Farmers use a perforated tube to monitor the water level and determine when to irrigate. It is an alternative irrigation technique to continuous flooding

[41] A few studies including Song et al (2021) have shown that AWD may improve the nutritional performance of milled rice by increasing amino acids and phenolic acids and decreasing lipids and alkaloids.

Ethiopia: In Ethiopia, IWMI will partner with the Ministry of Agriculture, IFAD, World Bank, Agricultural transformation Institute (ATI) and private sector. Additional collaborations will be sought in the first 6 months after project launch (see OC 4.1.2). The project will use a co-identified market linkage pathway for scaling solar-based technology and service 'bundles'. The pathway builds on earlier IWMI research and experience, which shows that innovation scaling is successful when one or more core innovations (e.g., solar-powered irrigation pumps, solar cold storage facilities) are bundled with complementary innovations (e.g., pay-as- you-go financing services and/or digital irrigation scheduling tools) that improve the enabling environment for adoption. Bundling these solutions, such as SESA with pay-as you- go financing, has been shown to improve the enabling environment for adoption.

Together with partners we will identify existing pilots in each country, and co-design a demand supply linkage scaling pathway to scale the solar based bundle with other partners. Operationalizing the demand-supply linkage scaling pathway consists of four components:

1. Establish sales and service networks: This is a core component of the scaling pathway and aims to upgrade the existing network of actors involved in supplying solar-powered irrigation pumps. This includes to organizing a series of demand-supply linkage workshops (OC 3.1 and OC 3.2); Set up groups to engage partners (when possible, using WhatsApp group); Capitalize on existing networks and projects by offering commissions
2. Increase visibility and outreach: the key activities include creating awareness (OC 3.1); demonstrate pumps and increase outreach (OC1.1, OC1.2).
3. Capitalize on sales and contracts: the third pathway includes to identify and engage with potential new clients for the irrigation bundle; establish user accounts to manage payments; and increase sales of PAY-OWN pumps (OC2.2)
4. Facilitate sustainability and inclusivity: the final steps include to co-develop data-driven tools to enable inclusive business (OC1.2); facilitate systemic changes in scaling solar-based irrigation in Kenya and Ethiopia.

In Ethiopia, the PACT program has allocated around USD 10 million to improve smallholder farmers' access to solar in five different regions in Ethiopia: Amhara, Oromia, The Southern Nations, Nationalities, and Peoples' Region (SNNRP), Sidama and Somali. The outcomes from OC 1.1 on solar suitability map and OC 2.2 on business models and value chain would enable the project to identify suitable areas and context specific SESA bundles. More importantly, findings from capacity building and knowledge sharing (OC 3.1) will be shared to enhance the capacity of extension agents and farmers awareness on the importance of SESA beyond its use for irrigation – for instance support for livelihood diversification, food security and building climate resilience.

The program will also collaborate with the Smallholder Irrigation Development and Expansion Project (SHIDEP), a platform focused on Adoption of Resource Efficient Irrigation Technologies. Capacity development is the key component of the project and outcomes OC 2.2 and OC 3.1 would directly provide support for the project. SHIDEP provides a strategic framework that enables us to validate and optimize tools and outcomes, creating a living lab environment that tests real-world applicability and performance.

The applications of the above exemplary projects are being applied with the private sector (technology suppliers), and microfinance. For example, IWMI has been working in Ethiopia with Green Scene Energy, Mirco-finance and Farm Africa to apply SESA-based bundles through Nature-

based Solutions for Sustainable and Inclusive Development (NSSID) program. However, it lacks a risk assessment component which would be completed and validated by results from OC2.

Further, the inception phase conducted as part of OC 4.1.1 will support identifying additional 'living labs' and development program platforms that can be optimized through findings from project outcomes.

Description of the partner organizations, their roles, experiences, added value, capacities and limitations

All activities mentioned in previous sections will be implemented in close collaboration with government partners in each of the four partner countries. Below is a description of our partner organizations and their roles.

IWMI will also leverage work on current and 'future' projects in the four countries, in addition to placing this program within the CGIAR Science Programs.

Partners in Bangladesh

Based on the planned outcomes and activities under phase 2 in Bangladesh, we are seeking to continuing existing partnerships and build new partnerships with several key organizations. These collaborations will be instrumental in facilitating the effective implementation and scaling of the project. The organizations we plan to collaborate with are:

Infrastructure Development Company Limited (IDCOL): will be our key partner for OC 4 for the field implementation pilots - IDCOL is a government owned financial institution set up in 1997. IDCOL's aim is to encourage private sector participation in infrastructure and energy projects, and they are currently the largest financier for renewable energy projects in Bangladesh. IDCOL is also the primary agency working for mainstreaming of solar pumps.

In phase one, they were our key partner for the implementation of different activities and pilots. In phase two we will continue this partnership primarily for the proposed field pilot of bundling AWD within SIP command area. Additionally for all the policy research regarding scaling and increasing return on investment for solar pumps will involve their close collaboration in the design and uptake of recommendations. For the work on developing financial models for micro-SIPs we will explore with IDCOL potential for inclusion of that model in their current portfolio.

IDCOL works with all relevant stakeholders in the solar irrigation sector including the government, SREDA, private companies, solar pump manufacturers, NGOs, development partners, academics and the farmers of Bangladesh. IDCOL is an approved GCF affiliate/grantee. IDCOL's vast experience in this sector, coupled with a capable workforce and extensive network with both micro level and national scale stakeholders make them an ideal partner for working in Bangladesh.

Department of Agricultural Extension (DAE): is Government's largest agricultural extension service provider in Bangladesh. They also have SIPs implemented through their existing schemes. In the SOLAR first phase the training given to farmers under IDCOL SIP command area on solar technology and improved agricultural and irrigation practices were done through DAE officials. They will be a key partner for the capacity building activities proposed under phase 2 in Bangladesh (OC 3). They are also starting a micro-SIP program in the hill tract region of Bangladesh for poor and marginal farmers and women farmers. Our financial model for micro-SIPs will be in developed in consultation with DAE.

Bangladesh Agricultural Development Corporation (BADC): BADC under the Ministry of Agriculture is a key department that is responsible for agricultural development in the country, and they are a critical department in ensuring irrigation access to farmers mostly through different minor irrigation

schemes in the country. For both our policy research (OC4) and capacity building activities (OC3) we will explore formal collaboration with them.

Sustainable And Renewable Energy Development Authority (SREDA): SREDA is the regulatory agency for renewable energy in Bangladesh. In phase 1, we regularly engaged with them. We will build a closer partnership with SREDA for the actual uptake of the solutions and recommendations proposed through our action research under phase 2 – OC1 and OC4

Ministry of Social Welfare (MSW), Government of Bangladesh: The ministry is the ministry focusing on development of livelihoods for the poor, women, children and people with disabilities. Collaborating with them will support and link up work on the livelihood co-benefits of implementing solar energy for agriculture programs.

Partners in India

Based on the planned outcomes and activities, we are seeking to establish new partnerships with several key organizations. These collaborations will be instrumental in facilitating the effective implementation and scaling of the project. We have already initiated communication with some of these organizations, and they have expressed interest in being part of this initiative. The organizations we plan to collaborate with are:

Ministry of New and Renewable Energy (MNRE), Government of India: MNRE will play a crucial role in guiding national policy alignment and supporting the expansion of SIPs under the PM KUSUM scheme, ensuring the adoption of renewable energy in agriculture is sustainable and inclusive.

Agriculture Extension Department, Indian Council of Agriculture Research (ICAR), Government of India: Partnering with ICAR's extension services will help integrate SIP adoption into the agricultural extension infrastructure, focusing on educating farmers and providing technical support.

Ministry of Rural Development, Government of India (MoRD): collaborating with the National and State Rural Livelihood missions will support in highlighting and mainstreaming the livelihood benefits of solar energy schemes for agriculture.

Uttar Pradesh New and Renewable Energy Development Agency (UPNEDA), Government of Uttar Pradesh: UPNEDA will be a key partner in the on-ground implementation and testing of SIP models in Uttar Pradesh, allowing us to pilot institutional mechanisms for SIP dissemination and capacity building.

Department of New and Renewable Energy, Government of Haryana (HAREDA): Given Haryana's emphasis on integrating micro-irrigation with SIPs to address groundwater sustainability, this department's involvement will be critical in implementing and assessing bundled interventions.

National Bank for Agriculture and Rural Development (NABARD), Government of India: NABARD's expertise in agricultural financing will be vital in designing tailored financial instruments for smallholders, addressing the challenges of credit access for farmers adopting SIPs.

Power Finance Cooperation (PFC): Power Finance Corporation Ltd. is an Indian public sector company engaged in infrastructure finance activities.

Indian Renewable Energy Development Agency (IREDA): IREDA is an Indian public sector enterprise which provides financial assistance and other services to projects related to renewable sources of energy and energy efficiency/conservation.

Grassroot organisations such as PRADAN to support engagement with smallholder farmers, collecting data to assess the effectiveness of interventions, gather farmer feedback, and provide evidence to inform policy recommendations.

These partnerships will be integral in aligning the project's goals with national and state-level strategies, ensuring the sustainable scaling of solar irrigation technologies across India.

Partners in Phase 1

GERMI is promoted by Gujarat State Petroleum Corporation Limited (GSPCL) as a center of excellence in the energy sector. It has four key mandates – research and development; consultancy; training and education. GERMI is a registered Society and Trust under the Societies Registration Act, 1860 and the Bombay Trust Act, 1950. It is also a recognized Scientific and Industrial Research Organization (SIRO) by the Department of Department of Scientific and Industrial Research (DSIR), Government of India. GERMI has been a key player in the design of Government of Gujarat's solar policies, including the Dhundi-inspired *Suryashakti Kisan Yojana*. IWMI and GERMI have been working closely on climate-smart promotion of solar irrigation in Gujarat since 2013-14.

As an advisor to the Energy and Petrochemicals Department of the Government of Gujarat; and as one of the key architects of SKY, GERMI is keen to track its performance and help the government improve its implementation. GERMI also has a strength in developing and conducting training programs on solar – including design, operations and maintenance of solar PV modules. GERMI will thus play a key role in helping the project develop "*lead solar farmers' training program*" (as part of activity 3.1.1).

Gujarat Urja Vikas Nigam Limited (GUVNL) is the holding company which has the state electricity corporation, transmission corporation and the four distribution companies – *Madhya Gujarat Vij Company Limited* (MGVCL), *Uttar Gujarat Vij Company Limited* (UGVCL), *Paschim Gujarat Vij Company Limited* (PGVCL) and *Dakshin Gujarat Vij Company Limited* (DGVCL) – as its subsidiaries. Along with Gujarat Energy Development Authority (GEDA), GUVNL is the key stakeholder and decision maker for energy and renewable energy in Gujarat. As the nodal agency for implementing SKY, IWMI's partnership with GUVNL will be crucial for carrying out project activities in SKY feeders and for sharing insights and results for improved SKY uptake and effectiveness (activity 2.2.2).

Partners in Ethiopia

Ministry of Agriculture (MoA)- Ethiopia: The Ministry of Agriculture in Ethiopia plays a critical role in advancing sustainable agricultural practices and improving food security in the country. The ministry has been working on solar pump and IWMI has been collaborating with them for over a decade (including solar pump projects). Thus, the partnership focuses and leverage on solar pump initiatives, particularly through the Participatory Agriculture and Climate Transformation Programme (PACT), which is funded by IFAD and the Food Systems Resilience Programme (FSRP) project financed by the World Bank. These projects aims to enhances access to efficient irrigation solutions. Collaborating with the Ministry can significantly leverage these projects, promoting the adoption of solar pumps to boost agricultural productivity and resilience among smallholder farmers. Alongside with the MoA, we work together with the Agricultural Transformation Institute (ATI). We work with ATI with the DREAM project and leverage our activities. We will consult with MoA on several outputs under all four outcomes.

Green Scene Energy (GSE) is a women-led company founded in 2016, dedicated to providing affordable and premium solar energy solutions throughout Ethiopia. GSE have cultivated strategic partnerships with retailers, micro-finance institutions, Ethio-telecom, and Purpose Black Ethiopia to

distribute cutting-edge solar lighting and productive use products through a convenient PAY Go model. In Addition, GSE, specializes in the installation of large-scale solar solutions, including mini grids, leveraging their expertise in civil construction and electromechanical works. Their impressive track record includes the successful implementation of solar Mini grids and commercial and institutional solar system exceeding 720 kWp+ and 1.6MWh battery capacity and will support this program in OC 2.2 and OC 4.1 and 4.2.

The Ethiopian Solar Energy Development Association (ESEDA) is dedicated to promoting solar energy adoption in Ethiopia. It serves as a collaborative platform for businesses, investors, and experts to foster clean energy solutions and sustainable practices. ESEDA advocates for its members, shapes energy policy, facilitates networking, and provides valuable industry insights and training. Through these efforts, ESEDA aims to enhance investment opportunities and drive a transition toward a greener, renewable energy future for Ethiopia (OC 2.2).

Bahir Dar University (BDU) is collaborating with **Cambridge University and the Innovation Lab for Small-Scale Irrigation (ILSSI)** to provide small, solar-powered water pumps for irrigating vegetables and cash crops. Its program also aims to make solar-based irrigation systems more accessible by conducting research to reduce costs, making them affordable for smallholder farmers. This includes advancing the science behind halide Perovskite photovoltaic (PV) cells to improve performance and stability, as well as customizing power electronic motor drives to increase efficiency and meet the specific needs of Ethiopian smallholders. The initiative takes an Inclusive Innovation approach, co-designing the entire system with end users to ensure it is locally appropriate, effective, and reduces manual labor, particularly for women farmers. The university has been working with IWMI with different projects and will work with the team under OC 1.1, 1.2 and 2.2.

Partners in Kenya

In Kenya, we will build on existing partnerships in the deployment of small-scale irrigation solutions, but also develop new partnerships for scaling of Solar Irrigation Pumps (SIPs). The partners we plan to collaborate with will include:

Private sector are the key partners in Kenya through providing SIPs and complementary innovations adapted to farmer needs, training of technicians, extension staff and end users, flexible financing options. The following are the key partners we are envisages to work in the projects

Sun Culture Kenya focuses on providing solar-powered solutions for smallholder farmers, offering off-grid solar irrigation systems that improve access to water, lighting, and energy for mobile charging. Their products include affordable payment plans like "Pay-As-You-Grow," making the technology accessible to farmers with limited upfront capital. Further it helps to increase crop yields and reduce water usage, contributing to sustainable agriculture and economic growth in rural communities.

Future Pump is a Kenya-based company that designs, manufactures, and distributes solar-powered water pumps for smallholder farmers. Its flagship product, the SF1 solar pump, is tailored for small farms and helps farmers access reliable, clean irrigation while reducing dependence on costly and polluting fuel-powered alternatives. The SF1 is portable and easy to maintain, capable of pumping water from shallow sources like wells or rivers.

CLASP (Efficient Appliances for People and the Planet): CLASP works to improve the energy and environmental performance of the appliances. They will undertake end-user education and awareness, technology performance data and qualitative feedback, market linkages. CLASP drives technology innovation and catalyzes appliance market growth, putting efficient, affordable, high-

quality appliances and equipment within reach of low-income families and communities, as well as smallholder farmers.

Jomo Kenyatta University of Agriculture and Technology (JKUAT): The institution focuses on training, research, and innovation in fields such as agriculture, engineering, technology, and entrepreneurship. It works with development of training materials and curricula, capacity building, and will support with developing materials for OC 3.1 and OC 3.2.

National Irrigation Authority (NIA): Established on August 16, 2019 by the Irrigation Act No. 14 of 2019 as a successor institution of the National Irrigation Board. The authority looks to support sustainable food production and sustainable irrigation practices by clearly outlining the roles of national and county governments in facilitating irrigation activities in Kenya.

State Department of Energy and the **Rural Electrification and Renewable Energy Corporation (REREC)**: Key players in the Kenyan electricity sector that is involved in projects like the Kenya Off-Grid Solar Access Project (KOSAP).

The program will work closely with both NIA and REREC in the inception phase of OC 4.1. Further, as outlined in OC 4.1, key government and private sector partners key to implementation will be identified during the first six months of program implementation.

The table below maps out key partners against outcomes. This list of partners is not exhaustive and as the implementation phase of the program begins there will likely be some minor changes and additions.

Table 3: Initial Mapping of partners against outcomes

Country	Partner	OC 1	OC 2	OC 3	OC 4
India	MNRE	X	X		
	ICAR			X	
	UPNEDA	X	X	X	
	HAREDA				X
	NABARD		X		
	PFC		X		
	IREDA		X		
	PRADAN		X		
	GERMI			X	
	MoRD	X	X	X	X
Bangladesh	IDCOL		X		X
	DAE			X	X
	BADC	X		X	
	SREDA	X	X		
	MSW	X	X	X	X
Ethiopia	MoA	X	X	X	X
	GSE		X		X
	ESEDA		X		
	BDU/ILSSI	X	X		
Kenya	SunCulture	X	X		X
	Future Pump	X	X		X
	CLASP			X	
	JKUAT			X	

	NIA	X			X
	REREC	X			X

International and CGIAR partners

The program will also partner with a number of international initiatives, programs and donors, including CGIAR's new science programs. Details are provided in the sub-section – 'link to programs/initiatives/donors' under the 'situational analysis' section.

Description of the poor and vulnerable target group

Similar to Phase 1, we will work directly with government implementing partners. A major focus of this project will be on inclusion and suitability of solar. Through these efforts, we will influence solar energy policies in ways that will help enhance outreach of solar to vulnerable groups, including women and small and marginal farmers.

Outreach

Our direct beneficiaries are the government organizations who will also be our partners. We will work in four countries – in India, Bangladesh, Ethiopia and Kenya. We will seek to influence policies and practices of our main partners, which, in turn, through their projects, will benefit farmers. These agencies are responsible for either formulating SIP related policies or implementing SIP projects. We will also directly work with farmers, solar technicians and businesses through our research and capacity building programs.

Level of the intervention (micro, meso, macro)

The primary interventions in this phase will be at a macro level – at the level of policy and impact with validating and testing done at Meso and Micro levels.

Organization, Management and Administration

This will be a four-year project, starting in January 2025 and ending in December 2028. The tentative yearly breakdown of output and deliverables will be shared as annex 3 "Deliverables Timeline"
This project will be implemented by a team of inter-disciplinary researchers and practitioners from IWMI and partner organizations. Short biography of all key project members along with the proposed team structure is attached as Annex 4.

The inter disciplinary 'core team' of researchers from IMWI and CGIAR has been constituted to plan, steer and implement the project in collaboration with identified partners in project countries. The inter-disciplinary team includes country leads, senior scientists and researchers with expertise in water resources management, impact assessment, scaling, innovations and business models, gender &social inclusion.

Following a similar resource-sharing co-contributions model to SoLAR Phase 1, shared resources will ensure this phase of work leverages project resources within IWMI's strategic programs of work including Water, Climate Change and Resilience (WCCR), Water Growth and Inclusion (WGI), and the CGIAR Science programs (see 'Situational Analysis for Phase 2' and 'Resources' section for details on projects).

Dr. Darshini Ravindranath, Senior Researcher will be the Project Leader and will serve as the main contact point for the project and be responsible for the strategic direction and overall project

management and delivery across all outcomes. She will be supported by Dr. Muluken Adamseged, Senior Researcher who will be Deputy Project Lead.

A Project steering committee (PSC) will guide and advise project implementation, as needed. At a country level, Country Project Management Committees (CPMC) will be formed which will include key in-country stakeholders from government and private sector. The PSC and CPMC groups will be constituted in the first 6 months of the project following initial consultations across the four countries.

Administrative arrangements (accounting, financial management, external audit)

All IWMI projects are governed by the Organization's proactive Quality Management System (QMS). The QMS underpins IWMI's approach to the implementation of research and development projects. Program processes and procedures are mainstreamed by IWMIs corporate services for people management, quality assurance, information technology, financial management and accounting, procurement, and contracting.

Financial Management
IWMI uses SAP accounting system. Main modules used are Financial Accounting, Project Systems, Asset Accounting and Material Management. IWMI used CGIAR financial guidelines for accounting and is fully compliant with IFRS requirements.

Financial statements and other Management reports are prepared monthly. Reports comprise Statement of Financial Position, Statement of Activities, Statements of Changes in Equity, Cash flow Statements and notes to the financial statements. Donor receivables are also monitored regularly. Donor financial reports are prepared as per the given deadlines in the donor agreements.

IWMI's head of internal audit reports functionally to the Audit Committee of the IWMI Board of Governors and administratively to the Director General IWMI. The internal audit department prepares risk-based audit plan. Following are the planning considerations which Internal Audit takes into account while developing the audit plan for IWMI: Risk assessment information; Dollar materiality (Budget amount and spending); Quality of internal controls; Degree of stability (Organization restructuring / change in management); Completed and planned external assurance reports; Changes in laws and regulations; Areas which had not been audited and/or included in the previous audit plans; and Expectations of Board of Trustees and Management

IWMI's annual external audit is currently undertaken by KPMG Sri Lanka (Chartered Accountants). IWMI prepares its financial statements based on CGIAR Financial Guidelines and financial statements based on IFRS. Recommendations of auditors are implemented and followed up regularly through established controls. IWMI's Annual Financial Reports are publicly available on our website: www.iwmi.org .

Resources

Overall budget
The total budget of this program, including SDC contribution and all in-kind contribution from IWMI and its various partners is CHF 11,74,1334 of which the contribution of SDC is CHF 4599741 or ~ 39% of the total budget (Table 4). Tables 5 and 6 show the country wise and output wise budgets respectively. Annex 5 shows the detailed budget for the project.

Table 4. Overall budget with matching contribution

Budget	Year 1 (Jun-Dec'25)	Year 2	Year 3	Year 4	Total (CHF)	% Contribution
SDC Contribution	694395	1531965	1120716	1252665	4599741	39.18
IWMI in-kind contribution	1176711	1386380	1412054	1026948	5002093	42.60
Partners Co-contribution	342320	706035	706035	385110	2139500	18.22
Total	2599698	3612435	3234775	2694684	11741334	100.00

Table 5: Region and country wise budget

	Values in CHF					
	Year 1	Year 2	Year 3	Year 4	Total (CHF)	%
India	1,08,558	2,58,511	1,60,712	1,81,287	7,09,069	
Bangladesh	1,16,206	2,25,572	1,72,894	1,87,973	7,02,644	
Asia	***2,24,764***	***4,84,083***	***3,33,605***	***3,69,261***	***14,11,713***	***35%***
Ethiopia	2,08,438	4,17,223	3,20,327	3,55,451	13,01,439	
Kenya	1,74,983	4,33,807	3,20,022	3,64,035	12,92,847	
Africa	***3,83,421***	***8,51,030***	***6,40,350***	***7,19,486***	***25,94,286***	***65%***
Sub-total, Direct Costs including RCQC/RSS	**6,08,185**	**13,35,112**	**9,73,955**	**10,88,746**	**40,05,999**	**100%**
13% OH - IWMI costs	68,551	1,62,595	1,23,643	1,37,995	4,92,784	
5% OH - Partner costs	4,043	4,219	1,143	1,362	10,768	
Sub-total, including OH	**6,80,780**	**15,01,926**	**10,98,741**	**12,28,103**	**45,09,550**	
2% CGIAR Levy	13,616	30,039	21,975	24,562	90,191	
Grand Total	**6,94,395**	**15,31,965**	**11,20,716**	**12,52,665**	**45,99,741**	

Table 6. Output and outcome wise budget

		Values in CHF						Values in CHF				
		Year 1	Year 2	Year 3	Year 4	Total (CHF)	%	Asia	Africa	Asia (South-South)	Africa (South-South)	Total (CHF)
Output 1.1	Design WEF-responsive solar suitability 'principles' for effective and efficient solar energy	57,750	1,20,650	76,175	70,227	3,24,802		1,51,099	1,73,703	-	-	3,24,802
Output 1.2	Decision-support tools are developed to support efficacy of	51,294	98,302	1,02,993	88,106	3,40,695		1,44,146	1,96,549	-	-	3,40,695
Outcome 1	***Policymakers embed WEF responsive and social inclusion principles to enhance efficiency***	***1,09,044***	***2,18,952***	***1,79,168***	***1,58,333***	***6,65,497***	***17%***	***2,95,245***	***3,70,252***	***-***	***-***	***6,65,497***
Output 2.1	Financial instruments are co-developed to improve equitable access to technology, finance, and	65,160	75,333	63,257	50,379	2,54,129		1,91,611	56,062	6,456	-	2,54,129
Output 2.2	A strategy is developed for a Solar4Africa Irrigation Investment	1,48,833	1,98,989	1,09,562	68,531	5,25,914		28,493	4,78,052	-	19,369	5,25,914
Outcome 2	***Climate-smart and socially inclusive financing solutions for scaling solar agri-tech are co-***	***2,13,992***	***2,74,322***	***1,72,819***	***1,18,910***	***7,80,043***	***19%***	***2,20,104***	***5,34,114***	***6,456***	***19,369***	***7,80,043***
Output 3.1	Targeted groups, including women, are trained on tools	67,090	1,34,023	1,22,348	1,02,864	4,26,325		1,59,586	2,14,220	24,728	27,791	4,26,325
Output 3.2	Multi-stakeholder forums and other platforms held to	62,783	3,29,880	84,052	3,34,983	8,11,698		34,931	1,12,051	3,06,816	3,57,900	8,11,698
Outcome 3	***Strengthened knowledge, capacities and south-south collaboration leads to greater***	***1,29,873***	***4,63,903***	***2,06,400***	***4,37,847***	***12,38,023***	***31%***	***1,94,518***	***3,26,271***	***3,31,544***	***3,85,690***	***12,38,023***
Output 4.1	Policies and partnerships are	29,256	71,639	89,151	65,909	2,55,955		96,936	1,42,805	-	16,215	2,55,955
Output 4.2	Scaling readiness is mapped and tested in the context of existing	37,699	1,17,825	1,29,378	1,03,156	3,88,059		1,76,893	1,94,951	-	16,215	3,88,059
Outcome 4	***Existing platforms and living labs are assesed and optimized***	***66,955***	***1,89,464***	***2,18,530***	***1,69,065***	***6,44,014***	***16%***	***2,73,829***	***3,37,755***	***-***	***32,429***	***6,44,014***
PM Support	***Program Management***	***88,321***	***1,88,471***	***1,97,038***	***2,04,593***	***6,78,422***	***17%***	***66,129***	***4,80,005***	***23,888***	***1,08,401***	***6,78,422***
Sub-total, Direct Costs including RCQC/RSS		**6,08,185**	**13,35,112**	**9,73,955**	**10,88,746**	**40,05,999**	**100%**	**10,49,825**	**20,48,397**	**3,61,888**	**5,45,889**	**40,05,999**
13% OH - IWMI costs		68,551	1,62,595	1,23,643	1,37,995	4,92,784		1,28,021	2,46,751	47,045	70,966	4,92,784
5% OH - Partner costs		4,043	4,219	1,143	1,362	10,768		3,252	7,515	-	-	10,768
Sub-total, including OH		**6,80,780**	**15,01,926**	**10,98,741**	**12,28,103**	**45,09,550**		**11,81,098**	**23,02,664**	**4,08,934**	**6,16,855**	**45,09,550**
2% CGIAR Levy		13,616	30,039	21,975	24,562	90,191		23,622	46,053	8,179	12,337	90,191
Grand Total		**6,94,395**	**15,31,965**	**11,20,716**	**12,52,665**	**45,99,741**		**12,04,720**	**23,48,717**	**4,17,112**	**6,29,192**	**45,99,741**

Reflections on cost-effectiveness analysis (CEA) and, where possible, cost-benefit analysis (CBA)

With CHF ~4.6 million investment from SDC and IWMI of CHF 5,002,093, the project will also leverage funds from large programs of governments and private sector investment as shown in the previous section. Table 7 below presents the estimated matching partner budget contributing to overall project budget. The detailed CBA is shared in **Annex 6**

Table 7: Partners In-kind/Leverage contribution

Partner	Country	Year 1	Year 2	Year 3	Year 4	Total (USD)	Total (CHF)
UPNEDA	India	200000	200000	200000		600000	513480
MNRE	India		150000	150000	150000	450000	385110
IDCOL	Bangladesh		75000	75000		150000	128370
DAE	Bangladesh		100000	100000	100000	300000	256740
BADC	Bangladesh		100000	100000		200000	171160
MoA	Ethiopia	50000	50000	50000	50000	200000	171160
Green Scene	Ethiopia	50000	50000	50000	50000	200000	171160
Sun culture	Kenya	50000	50000	50000	50000	200000	171160
National Irrigation Authority	Kenya	50000	50000	50000	50000	200000	171160
Total		**400000**	**825000**	**825000**	**450000**	**2500000**	**2139500**

In Phase 1, the project committed for IWMI and partners co-funding of CHF 14,89,600 and is likely to achieve it. This was made possible through having convergence with a number of CGIAR and IWMI donor led projects/initiatives such as The Agroecology Initiative, PRIAT Pakistan, Nexus gains, Transforming Agrifood Systems in South Asia (TAFSSA), Nexus Gains Initiative, GIZ-supported IWMI-CInI-Sustain+ collaborative action research project among others.

For IWMI-In kind the contribution of CHF 5002093 will be leveraged from programs/projects listed in Table 4 above. In addition, programs that offer co-benefits will be included during the program duration. During the development of annual plans, we will confirm the source of in-kind for that year.

On cost-benefit, recent research has shown that investments in programs like SoLAR can yield high returns. The average payback period for SIPs varies from 6-10 years in the two regions. SoLAR 1 has shown that a 1 megawatt (MW) solarized feeder can potentially create CHF 52'000 as additional income for farmers; produce 1.5 million kwh of green energy, reduce 12'300 tCO2eq of emissions, and save CHF 640'000 of electricity subsidies in India. SoLAR 1 demonstrated that capacity-building interventions for these farmers can further increase their income. Replacing just a quarter of the 8.8 million diesel irrigation pumps with SIPs in India—requiring an investment of about USD 3.3 billion—would reduce emissions by 11.5 MtCO2eq per year (30% of Switzerland's annual GHG emissions). Investing USD 10 million in solar conduction dryers in India would reduce emissions by 1.6 MtCO2eq per year. Evidence from SunCulture in Kenya shows that total expected carbon credits generated in Kenya over 7 years is expected to be around 1.9 million, with a total expected customer price reduction of 17-25%. In Bangladesh, upscaling to 45,000 SIP systems would add up to 1,000-megawatt peak (MWp) of solar capacity to the country, avoiding 900,000 metric tons of carbon

dioxide equivalent (MtCO2e) emissions every year. Farmers connecting their SIP systems to the power grid could recover up to 80% of their contribution from the sale of their surplus electricity over a 20-year period. The exported electricity to the grid is valued at $40 million per year of income to farmers and sponsors.

Overall, for policymakers, the transition to solar-powered agricultural systems aligns closely with countries NDCs under the Paris Agreement, offering both economic and environmental benefits to farmers, distribution companies (where relevant) and local governments. While there remain gaps in quantifying benefits of wider applications of solar and adaptation benefits, Solar 1 findings have shown that investment in SESA can significantly reduce dependency on conventional energy sources, providing farmers with a sustainable livelihood solution while simultaneously addressing agricultural energy demands. Cost-benefit analysis is available at Annexure 6.

Risk Management

IWMI's Risk Management Policy provides the framework to IWMI staff on implementing an Institute-wide risk management process, which comprises the following elements:

- Communicating the Institute's overall risk management strategy;
- Defining the responsibilities within the Institute for risk management;
- Implementing a framework for identifying potential events, assessing risks and opportunities and selecting responses, thereby reducing the occurrence of surprises and related costs or losses while at the same time ensuring opportunities are not inadvertently missed.

The risk policy framework provides, among other things:

- A basis for more explicit consideration of the acceptable levels of risk (the "risk appetite") in the Institutes' strategy setting and implementation;
- A method for assessing the interrelated impacts of risks in different areas. Risks for individual departments may be within the departments' risk tolerances, but taken together may exceed the risk appetite of the Institute as a whole;
- Guidance on how the analysis of risks that are jointly managed with other CGIAR Centers and System units, and entities external to the CGIAR, should be incorporated into the Institute's risk assessments;

An initial risk assessment for this project has been undertaken during the Phase 1 of the project ended 31 Dec 2024 during project implementation and proposal development. There are a number of risks that could impact on the success of the Project and these risks have been identified in Annex 6. In mitigating these risks, early identification and analysis, as well as the involvement of SDC and government agencies in each of the implementation countries in the identification of the most appropriate solutions, are essential which will be ensured during regular CPMC and PSC meetings.

The key risks for this project can be classified into three types:

1. **Contextual risks:** This may emanate from natural disasters (floods), political fragility and diplomatic tensions. Pilot interventions and capacity building events will be restricted to regions that are not disaster prone or politically sensitive. In order to avoid any on-going diplomatic tensions between project countries, IWMI country offices will directly implement project activities in partnership with the national partners while the knowledge exchange events will be organized as convenient.

2. **Programmatic and Institutional risks:** Management of the multi-country project with multiple national partners makes the project steering and management quite challenging. IWMI Regional Project Leader will closely coordinate with country offices and country partners to mitigate this risk. In Kenya and Ethiopia the program will kick off with a 6 month inception phase to identify key partnerships and strengthen relationships with key stakeholders.

3. **Financial risk** – Risk of inflation or economic fluctuation in interest rates, or large fluctuation in USD to CHF exchange rates. IWMI Finance will monitor rates on a weekly basis, should drastic shifts, especially in exchange rates occur, PMU will discuss with SDC Project Manager and decide on next steps

All risks would be monitored through our quarterly country-project management committee meetings, and then shared with the PSC if not resolved. We will take advice from our PSC and from SDC on best ways of mitigating any additional emergent risks.

The detailed risk assessment is in **Annex 7**

This Statement of Approach to monitoring and evaluation (M&E) is intended to set out the core principles and the key aspects of the M&E system design to be applied specifically for this project.

Monitoring and Evaluation

The M&E approach for the project has the following objectives:

- To provide consistent information to all stakeholders about project progress and indicate where changes in design and management are required over the project period
- To provide lessons learnt from project design and implementation strategies for better planning, possible replication, sustainability of interventions and engagement with partners

Project progress as per the theory of change will be evaluated every six months with respect to a) progress made, and b) the path forward. Key indicators are linked to the project deliverables mapped against activities related to outputs and outcomes. Logframe will be used for project monitoring presented in **Annex 8.**

Monitoring will take place through two interrelated processes. (1) The formal assessment of progress on milestones on a quarterly basis under individual country plans will take place every quarter during country project management committee meetings and meetings of project steering committee on bi-annual basis. (2) IWMI will report against the Deliverable Based Framework developed in line with Theory of Change. on semi-annual and annual basis, which will review the project context and relevant changes and provide a summary of progress towards the outcomes. Assumptions and risks included in the framework will also be regularly reviewed and updated based on the current in-country situational analysis.

Given the significant role of government partners for uptake and scaling, the project team will work closely with the responsible government agencies. On a yearly basis, IWMI will convene a national level workshop including government partners to reflect upon the project's successes and limitations against the impact and outcome statements.

The repository of database for all activities will be maintained in standard formats as agreed with SDC and will be shared on an annual basis. In addition, SDC will commission an external evaluation in Year 3 of the project. IWMI will provide annual financial statements to SDC which will be linked to the project ToC.

Annexure 1: Situational Analysis

Annexure 2: Summary SoLAR-SA Mid-Term Evaluation Report (August 2023)

Annexure 3: Deliverables timeline

Annexure 4: Organogram and Short bios

Annexure 5: Detailed budget

Annexure 6: Cost-Benefit Analysis

Annexure 7: Risk framework

Annexure 8: Project logframe

References

R.B. Zougmor´e, S.T. Partey, M. Ou´edraogo, E. Torquebiau, B.M. Campbell, Facing climate variability in Sub-Saharan Africa: analysis of climate-smart agriculture opportunities to manage climate-related risks, Cah. Agric. 27 (2018), https://doi.Org/10.1051/CAGRI/2018019.

N. Van Maanen, M. Andrijevic, Q. Lejeune, L. Rosa, T. Lissner, C.F. Schleussner, Accounting for socioeconomic constraints in sustainable irrigation expansion assessments, Environ. Res. Lett. 17 (2022), https://doi.org/10.1088/1748-9326/ac77a5.

P. Pavelic, M. Magombeyi, P. Schmitter, I. Jacobs-Mata, Sustainable Expansion of Groundwater-Based Solar Water Pumping for Smallholder Farmers in Sub-saharan Africa, Efficiency for Access Coaltion, Washington, DC, USA, 2021.

S. Mohammed Wazed, B.R. Hughes, D. O'Connor, J. Kaiser Calautit, A review of sustainable solar irrigation systems for Sub-Saharan Africa, Renew. Sustain. Energy Rev. 81 (2018) 1206–1225, https://doi.org/10.1016/j.rser.2017.08.039 .

Durga, N., Schmitter, P., Ringler, C., Mishra, S., Magombeyi, M. S., Ofosu, A., Pavelic, P., Hagos, F., Melaku, D., Verma, S., Minh, T., & Matambo, C. (2024). Barriers to the uptake of solar-powered irrigation by smallholder farmers in sub-saharan Africa: A review. *Energy Strategy Reviews*, *51*. https://doi.org/10.1016/j.esr.2024.101294

Kafle, K.; Omotilewa, O.; Leh, M.; Schmitter, P. 2022. Who is likely to benefit from public and private sector investments in farmer-led irrigation development? Evidence from Ethiopia. The Journal of Development Studies 58(1): 55–75. https://doi.org/10.1080/00220388.2021.1939866

International Water Management Institute (IWMI). 2023. Scaling solar-based irrigation in Ghana's Upper East Region: a demand-supply linkage approach. Adaptive Innovation Scaling - Pathways from Small-scale Irrigation to Sustainable Development. Colombo, Sri Lanka: International Water Management Institute (IWMI). 8p. (IWMI Water Issue Brief 22). doi: https://doi.org/10.5337/2023.201

IWMI
International Water Management Institute
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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 15 countries and a global network of scientists operating in more than 55 countries.