Gender Insights

Solar Irrigation for Agricultural Resilience (SoLAR)

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SoLAR
Solar Irrigation for Agricultural Resilience

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Photographs used in this report were provided by the communications teams in India, Pakistan, and Nepal.

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Acknowledgement: The Solar Irrigation for Agricultural Resilience (SoLAR) in South Asia project 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 the project is to contribute to climate-resilient, gender-equitable, and socially inclusive agrarian livelihoods in Bangladesh, India, Nepal and Pakistan by supporting government efforts to promote solar irrigation. This project responds to government commitments to transition to clean energy pathways in agriculture. All countries in this project have Nationally Determined Contribution (NDC) commitments to reduce greenhouse gas (GHG) emissions and SIPs can play a significant role in reducing emissions in agriculture.

The project is supported by the Swiss Agency for Development and Cooperation (SDC). Read more: **solar.iwmi.org**

Context

Rural women in South Asia face systemic barriers including limited land ownership, low access to credit, and restricted participation in water governance. The Solar Irrigation for Agricultural Resilience (SoLAR) project, implemented across India, Bangladesh, Nepal, and Pakistan (2020–2025), advanced gender equality and climate-resilient livelihoods through inclusive solar irrigation (SIP) promotion. The program strengthened institutional capacities, generated gender-disaggregated evidence, and influenced policy frameworks that make renewable energy transitions more inclusive. The project embedded Gender Equality and Social Inclusion (GESI) across design, implementation, and monitoring—linking technology adoption with empowerment through:

- Tailored capacity-building and outreach.
- Inclusive financial and subsidy models.
- Partnerships with women's groups, Self-Help Groups (SHGs), and cooperatives.
- Policy dialogues embedding gender into solar and irrigation planning.

Women and marginalized farmers benefitted from increased irrigation access, enhanced technical and financial skills, participation in local water-energy markets and equitable financial mechanisms. The project influenced gender-responsive policies, promoted women-led enterprises, and demonstrated measurable improvements in income, skills, and agency.

Project Overview

Goal

To contribute to climate-resilient, gender-equitable, and socially inclusive agrarian livelihoods by promoting solar energy solutions in agriculture.

Countries Involved

India, Bangladesh, Nepal, Pakistan (SoLAR-SA); Ethiopia, Kenya (Africa Initiative)

Partners

Alternative Energy Promotion Centre (AEPC)
Infrastructure Development Company Limited (IDCOL)
Gujarat Urja Vikas Nigam Limited (GUVNL)
Gujarat Energy Research & Management Institute (GERMI)
Pakistan Agricultural Research Council (PARC)
Nepal Electricity Authority (NEA)
MWU
Ministry of Water, Sanitation and Irrigation, Government of Kenya
SunCulture
Sustainable Energy for Smallholder Farmers (SEFFA)
Collectives for Integrated Livelihood Initiatives - CInI
Environment Conservation Society (SwitchON Foundation)
NGO Forum for Public Health

Methodology

Quantitative evidence from household surveys, monitoring data, and adoption statistics (2020–2025).

Qualitative methods: Focus Group Discussions (FGDs), Key Informant Interviews (KIIs), case studies, and participatory observations.

Country-specific GESI frameworks integrated into project logframes.

Cross-country synthesis to identify patterns, enabling factors, and context-specific barriers.

Examples:

Bangladesh: 12 IDCOL SIP locations examined through purposive sampling of diverse locations. 12 sex-disaggregated focus group discussions across 6 locations with 60 participants (even gender split) to identify barriers and opportunities for SIP-derived livelihoods.

India: A primary survey of 800 farmers in Rajasthan assessed the socio-economic characteristics of SIP beneficiaries and examined the gendered impacts, with a specific focus on outcomes for women farmers.

Why GESI for Solar Energy Scaling?

Gender Equality and Social Inclusion (GESI) is vital for scaling solar energy as it broadens access, enhances adoption, and ensures equitable benefits. By empowering women and marginalized groups through inclusive financing, training, and policy integration, GESI drives more sustainable, climate-resilient, and just energy transitions.

1. Enhances Adoption and Sustainability:
Inclusive approaches ensure that both women and marginalized groups can access, operate, and maintain solar technologies—broadening user bases and improving long-term adoption rates.

2. Expands Economic and Social Impact:
When women participate as users, entrepreneurs, and service providers, solar irrigation leads to higher farm productivity, diversified livelihoods, and increased household incomes.

3. Bridges Access and Affordability Gaps:
Gender-responsive financing and collective ownership models overcome barriers like lack of land, credit, and information, enabling equitable participation in clean energy transitions.

4. Strengthens Policy and Institutional Outcomes:
Integrating GESI in solar programs—such as AEPC (Nepal), IDCOL (Bangladesh), and PM-KUSUM (India)—makes national energy policies more inclusive, accountable, and socially responsive.

5. Drives Climate-Resilient and Just Transitions:
Empowering women and vulnerable groups in solar energy systems not only reduces emissions but also ensures that climate benefits are distributed equitably, supporting just and resilient energy transitions.

Cross-country Overview

India

Barriers: Women's lack of land ownership limits their eligibility for PM-KUSUM solar irrigation subsidies, preventing independent access to solar pumps and formal financing.

Enablers: SHG networks and gender-focused training supported inclusive adoption and local entrepreneurship.

Results:

- Collective and women-managed SIP models enhanced income (20–50%), confidence, and decision-making power
- Increased cropping intensity and off-farm enterprises improved women's economic status.

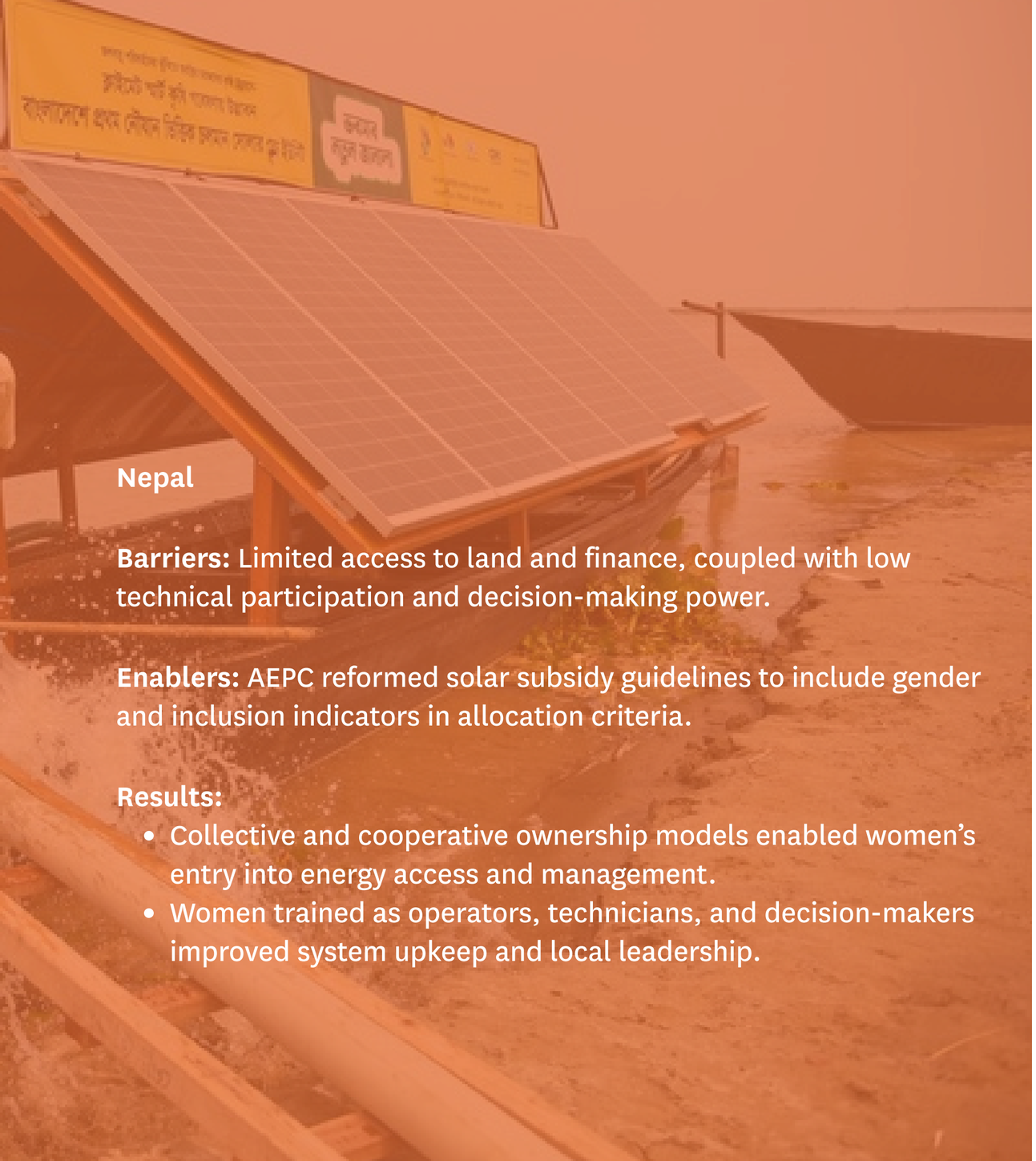
Bangladesh

Barriers: Low participation of women in technical and maintenance roles due to social norms that perceive solar engineering as a male domain, restricting women's entry into green energy jobs.

Enablers: Institutional Mainstreaming (IDCOL) embedded GESI targets in its solar irrigation program, promoting women's participation.

Results:

- Awareness campaigns and flexible credit terms improved affordability for women and youth.
- Involvement in water user groups increased women's mobility, recognition, and voice in community decisions.



Nepal

Barriers: Limited access to land and finance, coupled with low technical participation and decision-making power.

Enablers: AEPC reformed solar subsidy guidelines to include gender and inclusion indicators in allocation criteria.

Results:

- Collective and cooperative ownership models enabled women's entry into energy access and management.
- Women trained as operators, technicians, and decision-makers improved system upkeep and local leadership.

Pakistan

Barriers: Cultural mobility restrictions prevent women from attending field demonstrations, training, or engaging with vendors, limiting their awareness and uptake of solar technologies.

Enablers: Engagement with women's agricultural cooperatives and microfinance institutions can expand access.

Results:

- Solar water pumping pilots began integrating gender awareness, though not yet at scale.
- Inclusion of gender-responsive targets in provincial renewable energy and agricultural schemes could accelerate equitable scaling.

Outcomes

India

Women-led SHG Solar Models: In Mandla (Madhya Pradesh), two community-based solar lift irrigation systems managed by SHGs empowered 28 women farmers. Water User Association earned ~INR 10,000/year via water sales; crop diversification shifted to vegetables and wheat. Women also installed a solar rice mill, reducing drudgery and boosting off-season income.

Capacity Building: Under Gujarat's SKY scheme, 253 farmers (including women) trained as Mahila KUSUM Mitra improved O&M skills, energy literacy, and local leadership.

Gender-targeted Innovative Financing Pilots: (10% contribution, 30% loan, 60% subsidy).

Grid-connected SIPs: Women included SKY farmers saw a 27% rise in income and 23% higher energy evacuation. Gender sensitization integrated in training and scheme evaluation.

Bangladesh

Inclusive Pilots: Seven grid-integrated SIPs launched with IDCOL, generating energy exports and influencing financing policy, thereby enhancing women's economic opportunities in service and maintenance roles.

Gender-focused Recommendations: Focused on Char, Hill Tracts, and Sylhet to identify access constraints for women and smallholders. Policy brief "Solar Energy and Livelihood Programs for Women" recommended targeted subsidies and inclusive training.

Capacity Building: 120 farmers trained (40% women) in crop scheduling, solar O&M, and efficient irrigation.

Policy Shift: IDCOL and KfW adopted gender-responsive recommendations for future investments.

Nepal

Subsidy Reforms: AEPC's revised GESI-responsive subsidy criteria improved women and smallholder access. It allocated 1 of 3 SIP subsidies to women, and launched community SIPs for landless groups.

Capacity Building: 157 technicians trained (41% women); bilingual manual (English–Nepali) institutionalised with AEPC.

Grid Pilot: First net-metered SIP-enabled women-led group (Sourya Urja Krishak Samuha) to manage irrigation and energy sales, improving leadership visibility. Studies revealed significant diesel displacement (61% reduction), enabling cost savings and productivity gains.

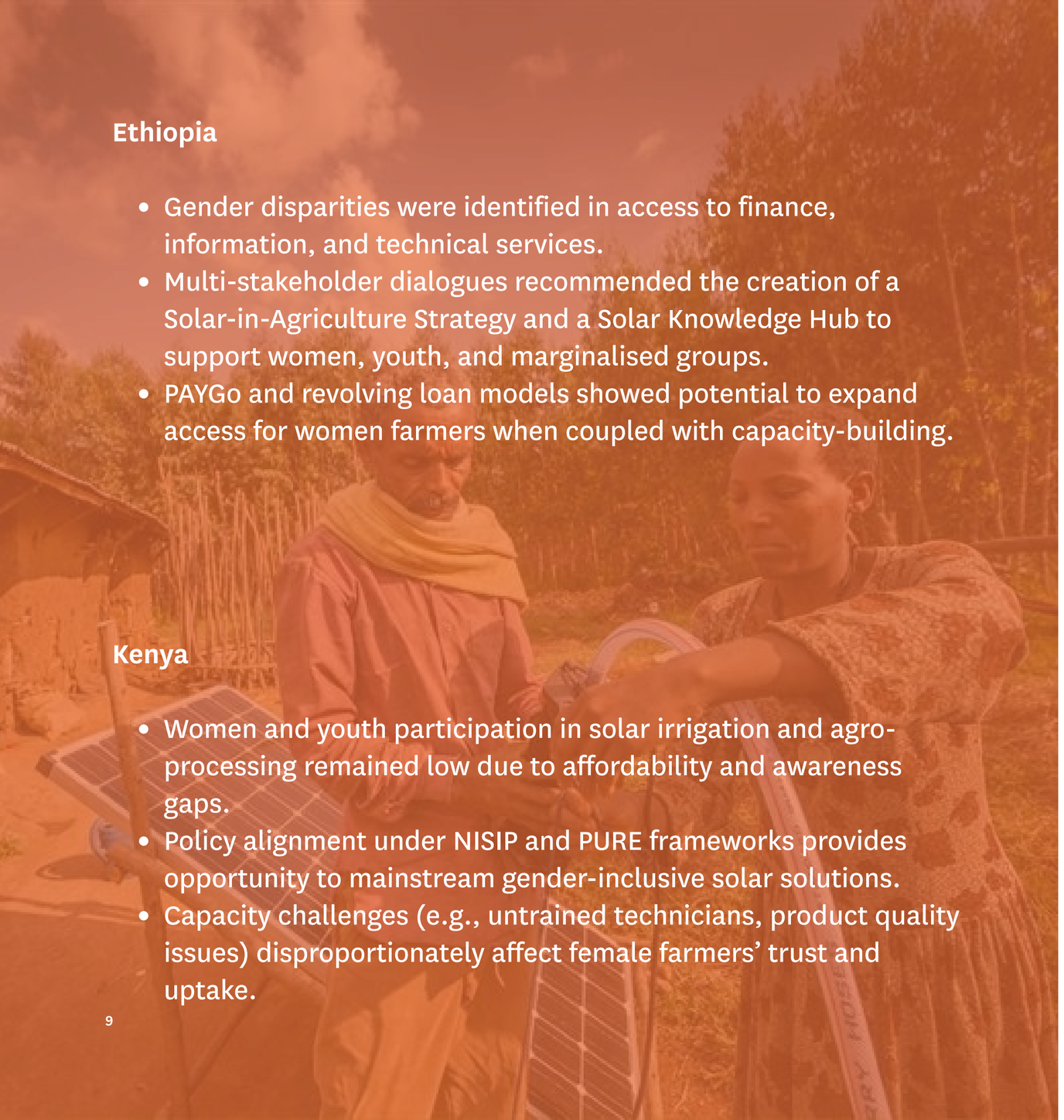
Policy Advocacy: Gender equity mainstreamed in AEPC's solar irrigation strategy. GESI monitoring prompted new provincial outreach models to strengthen equitable access.

Pakistan

Gender-friendly Irrigation Pilots: PARC-led demonstrations improved women's engagement in farm water management.

Capacity Building: Four national training sessions enhanced gender-balanced participation and improved technical literacy among female technicians and rural youth.

Policy and Tools: Gender integrated in solar mapping and sizing tools (Punjab, Sindh, Balochistan, Khyber Pakhtunkhwa).



Ethiopia

- Gender disparities were identified in access to finance, information, and technical services.
- Multi-stakeholder dialogues recommended the creation of a Solar-in-Agriculture Strategy and a Solar Knowledge Hub to support women, youth, and marginalised groups.
- PAYGo and revolving loan models showed potential to expand access for women farmers when coupled with capacity-building.

Kenya

- Women and youth participation in solar irrigation and agro-processing remained low due to affordability and awareness gaps.
- Policy alignment under NISIP and PURE frameworks provides opportunity to mainstream gender-inclusive solar solutions.
- Capacity challenges (e.g., untrained technicians, product quality issues) disproportionately affect female farmers' trust and uptake.

Key achievements include:

- **Empowerment through Solar Irrigation:** Women-led solar irrigation models in India and Bangladesh enhanced income (by 20–50%), decision-making power, and entrepreneurial confidence.
- **Policy and Institutional Reforms:** Gender and social inclusion (GESI) targets are integrated into national programs such as AEPC (Nepal), PM-KUSUM (India), and IDCOL (Bangladesh).
- **Inclusive Financing Innovations:** Tested models like Earn First, Pay Later and First Loss Default Guarantee, improving affordability via women's SHGs and gender-responsive finance schemes.
- **Capacity Building:** Over 3,500 farmers and 300 technicians trained—around 30% women and youth—strengthening local technical and leadership capacity.
- **Environmental and Livelihood Gains:** Women-led solar irrigation systems saved ~26 tons of CO_2 annually and supported crop diversification and new rural enterprises.
- **South–South Learning:** Evidence-supported developing informed strategies across regions to address gendered barriers in finance, policy, and capacity for equitable scaling.

Lessons Learned

- Bundled solutions (technology + finance + capacity) yield greater gender impact. Embedding GESI principles early enhances program ownership.
- Gender-inclusive financing (e.g., revolving funds, pay-later models) drives adoption.
- Gender-responsive training enhances women’s participation in energy systems.
- Women’s collectives and SHGs are effective intermediaries for scaling equitable solar access adoption.
- Policy coherence between energy, water and agriculture is essential for equitable benefits. Sustained policy engagement is vital for institutionalising gender equity.
- Intersectional inclusion (considering gender, caste, ethnicity, and youth) enhances overall equity.
- Context-specific approaches are critical—what works where(www).

Recommendations

India

Promote women-led solar irrigation enterprises by linking Self-Help Groups (SHGs) and Farmer Producer Organizations (FPOs) with targeted subsidies and credit support under PM-KUSUM to enhance women's ownership and income opportunities.

Bangladesh

Integrate women into the solar value chain by developing tailored technical training and entrepreneurship programs through IDCOL and local NGOs, enabling women to serve as system operators, technicians, and service providers.

Nepal

Introduce gender-responsive financing mechanisms—such as collateral-free group lending and performance-based subsidies—to expand women's access to AEPC's solar irrigation schemes.

Pakistan

Leverage women's agricultural cooperatives and microfinance networks to deliver gender-targeted awareness, training, and financing for solar irrigation, ensuring women's visibility in provincial renewable energy programs.

Institutionalise Gender-Responsive Systems:
Embed gender-disaggregated monitoring and evaluation across solar and climate programs to track equitable benefits and accountability.

Expand Inclusive Financing Mechanisms:
Scale gender-targeted financial models—such as concessional loans, revolving funds, and PAYGo—to improve women's access to solar technologies.

Build Women's Technical and Leadership Capacity:
Strengthen women's training, entrepreneurship, and participation in solar irrigation governance and value chains.

Foster Collaboration and Policy Alignment:
Promote South–South learning among women innovators and encourage policy convergence across energy, agriculture, and water ministries for integrated GESI outcomes.

Case Studies

India – SwitchON: Mini Solar Pumps for Women Farmers (MSP4WF)

Objective: Empower small and marginal women farmers in West Bengal by creating solar assets in their names and diversifying livelihoods.
Solution: Identified and trained 20 women farmers; formed Water User Groups; introduced First Loss Default Guarantee (FLDG) financing to enable affordable solar pump ownership.
Results: Women gained asset ownership, improved crop diversification, and achieved higher incomes; reduced CO_2 emissions; established a replicable financial ecosystem supporting women-led solar irrigation.

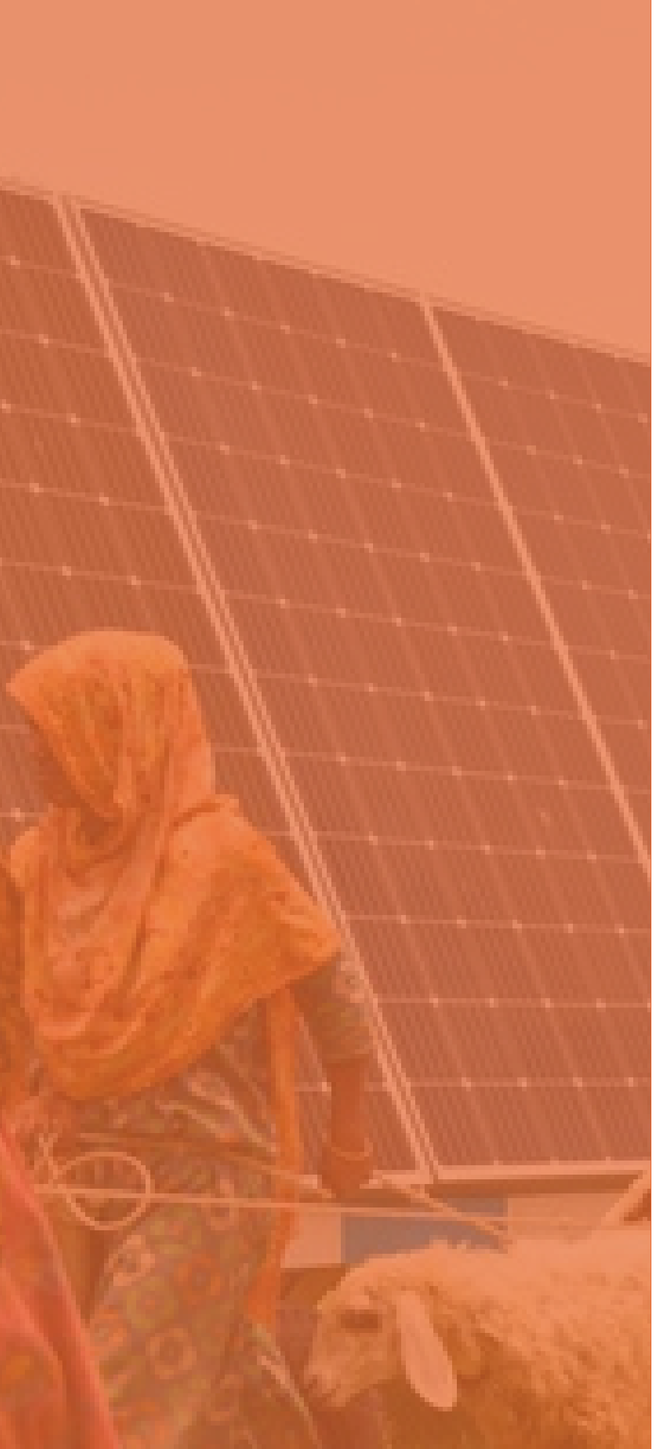
India – PRADAN: Community-Based Solar Lift Irrigation for Tribal Women Farmers in Mandla, Madhya Pradesh

Objective: To improve irrigation access and livelihood opportunities for tribal women farmers in rainfed areas by promoting community-managed solar lift irrigation systems and inclusive business models.
Solution Implemented: A pilot intervention was carried out in two tribal-dominated villages—Kevlari and Chimkatola—where over 75% of farmers lacked reliable irrigation. Two innovative business models were tested:

- Earn First, Pay Later model allows deferred payment through water sales.
- 10% Upfront Contribution model with recovery from collective revenues.
- Women-led Water User Associations (WUAs) were established—15 members in Kevlari and 13 in Chimkatola—to manage, operate, and maintain the systems.

Results and Impact:

- Each WUA earned and saved over INR 10,000 (USD 115) from collective water sales.
- Farmers diversified cropping patterns from rainfed cereals to wheat and vegetables, increasing profitability.
- Women farmers demonstrated growing financial confidence, leading collective plans to install a solar-powered mini rice mill for off-season income.
- The initiative fostered behavioural change, shifting perceptions from risk aversion to proactive leadership in renewable energy and enterprise management.



Bangladesh - Solar Energy and Livelihood Programs for Women

Objective: Assess how SIPs can become more gender-inclusive by identifying barriers, opportunities, and livelihood models that support women's participation in the renewable energy transition and strengthen women's economic empowerment.

Solution: Assessed different SIP models and used gender-disaggregated discussions and livelihood pilots (chicken farming, fisheries, goat rearing) to understand women's experiences with solar-powered opportunities. It recommends gender-responsive strategies—such as inclusive engagement, targeted training, equitable financing, and improved resource access—to integrate women into SIP ownership, management, and solar-driven enterprises.

Results: While SIPs offer potential for renewable-energy livelihoods, women benefit less due to mobility, land, training, and decision-making barriers. With targeted policies, stronger training, and inclusive financing, SIPs can meaningfully advance women's economic empowerment.

Nepal – Gham Power: Off-Grid Bazaar for Solar Irrigation Systems

Objective: Enhance access to affordable solar irrigation for smallholders, especially women, through digital tools and financing solutions.

Solution: Installed seven solar water pumping systems with sensors and remote monitoring; introduced Off-Grid Bazaar—a digital platform offering financing, agri-advisory, and performance monitoring.

Results: Increased farm efficiency and women's income; reduced CO_2 emissions; empowered women through data-driven agriculture and continuous capacity building.

Pakistan – PARC: Responsive Drip Irrigation (RDI) for Vulnerable Communities

Objective: Improve the livelihoods of water-scarce and dugwell-dependent communities using energy-efficient solar irrigation systems.

Solution: Piloted solar-powered Responsive Drip Irrigation (RDI) integrated with optimised solar pumping at seven sites, including four women farmer sites.

Results: Achieved up to 68% water savings; reduced drudgery and improved productivity for women; positioned RDI as a gender-friendly, climate-smart irrigation innovation for dry regions.

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