



Despite more than a decade of investment, Solar Energy Systems for Agriculture (SESA) deployment remains largely confined to pilots. Kenya leads sub-Saharan Africa in solar water pump adoption, accounting for roughly 65 percent of sub-Saharan Africa's solar water pump market by volume, but the uptake of broader productive use technologies - including cold storage, drying, milling and electric mobility - remains limited (Takase et al., 2021; Adwek et al., 2019). Ethiopia's market is at an earlier stage, with initiatives such as Sustainable Energy for Food and Farming for All (SEFFA), Access to Distributed Electricity and Lighting in Ethiopia (ADELE) and Distributed Renewable Energy-Agriculture Modalities (DREAM) yet to consolidate into a coherent pathway to scale.

Unlocking scale: strategic challenges for solar energy systems for agriculture in Ethiopia and Kenya

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This brief sets out four interlocking issues that must be addressed in concert: (i) the pilot trap; (ii) fragmented policy and institutional architectures; (iii) a chronic financing gap unmet by blended and climate finance; and (iv) underdeveloped private sector capacity, market infrastructure, and after-sales ecosystems — compounded by chronic knowledge and capacity gaps across the value chain. Unless these mutually reinforcing challenges are addressed in concert, both countries risk remaining locked into continued diesel dependence while missing a rapidly emerging multi-hundred-million-dollar productive-use energy market and the climate resilience dividends that a solar transition would deliver for smallholder livelihoods.

On the pilot trap: despite strong technology proof of concept, SESA in both countries remains locked in pilot cycles. Investment must shift toward structured scaling pathways that combine demonstration, business model validation, market activation, and policy reform as mutually reinforcing — not sequential — interventions. On policy and institutional fragmentation: neither country has a dedicated national SESA strategy. The immediate priority is institutionalized inter-ministerial coordination, stable fiscal frameworks, and explicit quality standards for emerging technologies. On the financing gap: agro-solar investments are still perceived as high-risk by commercial financiers, and existing loan products are misaligned with agricultural cash flows. Blended finance vehicles co-designed with local financial institutions, donors, and government risk-sharing facilities offer the most credible path to crowding in private capital. On private sector models: prevailing hardware-only business models concentrate risk on the customer and leave the most valuable segments of the value chain undeveloped. Transition to service-based, bundled models — underpinned by strong after-sales ecosystems — is the foundation of commercially sustainable SESA markets.

Introduction

Solar Energy Systems for Agriculture (SESA) sits at the intersection of three strategic agendas for East Africa: climate adaptation, food and water security, and inclusive economic transformation. Through the Solar Energy for Agriculture Resilience (SoLAR) 2 (2025–2028) initiative, IWMI - with support from the Swiss Agency for Development and Cooperation (SDC) - is working with national partners in Ethiopia and Kenya to strengthen the enabling environment, accelerate finance, build capacity, and validate scaling pathways for socially inclusive and climate-resilient solar agri-technologies. The project builds on IWMI's substantial body of projects and research on solar irrigation barriers and scaling pathways in East Africa, including through IWMI's ILSSI project and related research (Durga et al., 2024), and draws selectively on lessons from SoLAR 1 in South Asia (India, Bangladesh, Nepal and Pakistan), where solar irrigation deployment contributed to restructuring rural energy and water economies at scale. The project also builds on the contributions of other development actors working in this space — including GIZ, SNV, USAID, FAO, and the broader CGIAR network — who have shaped the SESA landscape in Ethiopia and Kenya. IWMI is one among several actors whose collective work informs the analysis presented here.



A solar cell charging a battery in Lukolela, Democratic Republic of Congo. (Photo: Ollivier Girard/CIFOR)

Ethiopia and Kenya stand at a strategic inflection point for Solar Energy Systems for Agriculture (SESA). Both countries have strong solar resources, agriculture-dependent economies, and urgent needs for climate-resilient productive energy. Ethiopia records an average of 5.26 kWh/m²/day, with significant variation across elevations and agro-ecological zones (Mulatu et al., 2023), while Kenya's solar resource is commonly estimated at 4–6 kWh/m²/day (Takase et al., 2021; Adwek et al., 2019). Agriculture contributes 38 percent of GDP in Ethiopia and 33 percent of GDP in Kenya. At the same time, unreliable rural electricity, recurring fuel shortages, volatile diesel prices, post-harvest losses (up to 30 percent for select crops), and climate-induced rainfall variability have exposed the fragility of fuel-based irrigation and post-harvest systems, underscoring the urgency of a solar transition.

Country diagnostics undertaken under SoLAR 2 reveal a striking convergence of constraints limiting SESA expansion across Ethiopia and Kenya. While the maturity of their solar markets differs, both countries face similar structural barriers to scale - and require similarly coordinated responses to overcome them. This brief synthesizes findings from those diagnostics into four strategic issues, framed to inform the next generation of investment, policy, and partnership decisions of the four actor groups most able to influence outcomes.

The audience is deliberately broad. Donors will find a framework for catalytic capital and policy support. Governments and policy makers will find clear entry points for institutional reform and regulatory alignment. The private sector will find strategic insights into emerging business opportunities and scalable delivery models. Financial institutions will find a case for building the underwriting capacity and product pipeline that the agro-solar sector now demands. The brief does not prescribe a single solution. Rather, it sets out a shared diagnosis from which coordinated action can follow.

Issue one: Breaking the pilot trap

A defining feature of the SESA landscape in both Ethiopia and Kenya is the persistence of a pilot trap - the repeated implementation of technically successful demonstration projects that fail to transition into commercially viable markets. In Ethiopia, donor-supported initiatives such as Access to Distributed Electricity and Lighting in Ethiopia (ADELE) and Distributed Renewable Energy-Agriculture Modalities (DREAM) have advanced solar irrigation, solar drying, and decentralised renewable energy services to specific geographies and value chains. Kenya hosts and even wider range of county-level pilots spanning solar-powered cold rooms, irrigation, and electric mobility for transportation of agricultural produce.

Four dynamics sustain the trap. First, pilots are typically designed around specific short donor cycles and a specific geography, with limited continuity between phases. When the funding ends, the market infrastructure built around the pilot — including distribution channels, financial partnerships, and extension services — often dissolves with it. Second, evidence generated from pilots is rarely packaged to inform investment decisions by commercial actors. Critical data on asset performance, unit economics, and customer behaviour insights remain inside project reports rather than feeding into bankable propositions (Hekkert et al., 2007; Spielman et al., 2009). Third, the technology asymmetry within SESA is largely unmanaged: solar water pumps and solar-powered irrigation systems are commercially mature (Negea et al., 2025), while complementary technologies in the post-harvest chain — cold storage, drying, refrigeration, milling, and electric mobility — remain at pilot stage despite high value-chain relevance. Fourth, most SESA deployment in Ethiopia and Kenya remains locked into single-use applications, even though multi-use systems can strengthen the economics of adoption by increasing asset utilization, spreading costs across several productive activities, and giving farmers and enterprises clearer incentives to invest.

The implication is clear: investment must shift from isolated pilots toward structured pathways to scale. This requires concurrent, adaptive action across demonstration, business model validation, market activation, and policy reform — treated as mutually reinforcing rather than sequential interventions, with strategies tailored to the specific barriers and entry points of each technology cluster. A systems approach to scaling is required; linear sequencing of these elements is precisely the logic that perpetuates the pilot trap (Durga et al., 2024). It also requires stronger institutional coordination across government, the private sector, and development partners — moving beyond



Farmers using a solar-powered irrigation system in Ethiopia (Photo: Maheder Haileselassie/IWMI)

project-by-project cycles to build shared strategic platforms — and a deeper engagement with the political economy that shapes who receives investment and under what conditions. Awareness raising and capacity building must be designed at the system level, not calibrated to individual pilot geographies. Most critically, adaptive scaling can be enabled if evidence is generated, packaged, and disseminated as a public good — designed to lower the perceived risk for commercial financiers and operators rather than only to satisfy donor reporting requirements. The decision support tool we are planning to develop SoLAR 2, is one such vehicle — aggregating asset performance data, unit economics, and business model evidence in a form accessible to commercial financiers and operators.

Issue two: A fragmented policy and institutional architecture

Neither Ethiopia nor Kenya currently has a dedicated national strategy for solar energy in agriculture (Mulatu et al., 2023). The result is a policy environment that is permissive in intent but inconsistent in execution. Both countries have, however, embedded renewable energy commitments in their Nationally Determined Contributions and national climate action plans, and Ethiopia holds membership in the International Solar Alliance — providing policy anchors that a dedicated SESA enabling environment framework could build upon.

In Kenya, the recent establishment of the Intergovernmental Committee on Productive Use of Renewable Energy (PURE) represents an important step forward. It signals growing national-level recognition of the productive use agenda and creates a platform for cross-ministerial dialogue. However, its effectiveness will depend on translating coordination into harmonised instruments — particularly the application of Value Added Tax (VAT), import duties, and national accepted quality standards, all of which currently vary in interpretation between national authorities and the forty-seven county governments that hold devolved mandates for agriculture. At the same time, quality standards for emerging SESA technologies, such as cold storage units and solar dryers, remain underdeveloped, exposing the market to substandard imports that risk eroding consumer confidence.

In Ethiopia, the institutional landscape is shaped by the recently established Ministry of Irrigation and Lowlands and the longstanding mandate of the Ministry of Agriculture, alongside the Ministry of Water and Energy and the Ethiopian Standards Authority. While SESA-relevant policy provisions exist across these ministries (Mulatu et al., 2023), they remain weakly coordinated and are yet to be consolidated into a dedicated enabling environment framework for solar energy in agriculture — integrated within existing national development strategies and investment plans. Implementation guidance at sub-national level is similarly thin, leaving regional bureaus with limited operational direction.

Three policy gaps deserve specific attention. First, the absence of dedicated national strategies leaves SESA without measurable scaling targets, dedicated budget lines, or institutional accountability. Second, fiscal instruments — VAT exemptions, import duties, and accelerated depreciation for productive-use assets — are inconsistently applied and frequently revised, undermining the predictability and confidence that investors require. Third, quality assurance and standards regimes continue to lag the pace of technological deployment, particularly for newer productive-use applications. A coordinated reform agenda — anchored in institutionalised inter-ministerial coordination, a stable fiscal framework, and explicit attention to farmer-side adoption barriers including extension service integration, gender inclusion, and land tenure — would significantly de-risk both public and private investment.

Issue three: The financing gap and the promise of blended finance

Financing remains the big greatest constraint to scaling SESA in both Ethiopia and Kenya. In Kenya, high upfront costs place SESA out of reach for most smallholder farmers, while financial institutions remain reluctant to lend due to perceived risks, limited familiarity with the technologies, and a mismatch between standard loan structures and agricultural cash flows. In Ethiopia, a parallel set of constraints applies, compounded by limited foreign exchange availability, weak collateral frameworks, and the near absence of dedicated SESA credit lines at commercial banks.



Installing a solar-powered irrigation system in Danghesta, Amhara region of Ethiopia (Photo: Mulugeta Ayene/WLE CGIAR)



International Water Management Institute researchers display low cost solar pumps during Farmers' Horticultural Day in Ethiopia. (Photo: Liya Dejene/ILRI)

Three structural problems sit beneath these symptoms. First, agro-solar investments are still perceived as high-risk among commercial financiers, partly because the evidence base on unit economics, default rates, and asset performance is thin and not yet aggregated into a form that underwriters can use. Second, the existing financial products are poorly matched to farmer cash flow realities: standard term loans with monthly amortisation do not align with seasonal agricultural income, and few institutions offer pay-as-you-go, lease-to-own, or asset-finance structures suited to productive-use equipment. Third, concessional and climate finance flows, while expanding globally, have not yet been channeled at scale into agro-solar at the farm gate. Major climate finance mechanisms – including the Green Climate Fund (GCF), the Adaptation Fund (AF), voluntary carbon markets, and concessional windows of development finance institutions remain underutilised entry points.

Financing solutions must also be calibrated to market segments. The productive use of renewable energy (PURE) framework distinguishes supply-side instruments (for technology providers and distributors) from demand-side instruments (for end-users), recognising that smallholder farmers, agro-processors, and cooperatives each require tailored products rather than uniform credit lines.

Blended finance offers the most credible architecture for resolving these problems simultaneously. Well-designed structures combine concessional and catalytic capital from donors — through first-loss provisions or credit guarantees — with commercial debt and equity from local financial institutions and impact investors. Such arrangements lower the effective risk-adjusted cost of capital, crowd in private participation, and build the underwriting muscle of domestic lenders. Complementary instruments — agri-cash-flow-aligned loan products, results-based finance for verified adoption, and aggregator-based lending through cooperatives and savings and credit cooperatives (SACCOs) — could further extend reach to smallholders.

For SoLAR 2 and its partners, the implication is to move beyond grant-funded pilots and into the deliberate construction of blended finance vehicles, co-designed with local financial institutions, donors, and government risk-sharing facilities. SoLAR 2 is currently conducting a financing landscape analysis to ensure that blended finance vehicle designs are grounded in the realities of local financial markets, risk appetites, and regulatory constraints. Equally critical is investment in the underwriting capacity of commercial banks, microfinance institutions, and SACCOs so that the SESA portfolio becomes a recognised asset class rather than a one-off project category

Issue four: Beyond hardware — private sector business models and after-sales services

The private sector is the ultimate delivery agent for SESA at scale, yet the prevailing business model in both countries remains narrowly focused on hardware sales. This model concentrates risk on the customer, depresses adoption, and leaves the most lucrative segments of the value chain — financing, service, and performance optimisation — undeveloped. The next phase of market development depends on three interlinked transitions.

From hardware to service

International experience, including early lessons from SoLAR 1 in South Asia, demonstrates the potential of service-based models such as irrigation-as-a-service and energy-as-a-service. However, these cannot be applied directly to East Africa: with over 40 percent of the rural population lacking grid connectivity, service models must be designed for off-grid realities rather than adapted from grid-complementary contexts. Subject to this qualification, irrigation-as-a-service, energy-as-a-service, and bundled productive-use packages remain the most promising direction for market development in both countries.

These approaches distribute risk more equitably between provider and farmer and create the recurring revenue streams on which sustainable enterprises depend. Although pilots of such models exist in both Ethiopia and Kenya, they remain small scale and fragmented. A key structural constraint is asset ownership: hardware providers are frequently unwilling or unable to carry solar equipment on their balance sheets as they scale, requiring either asset-light arrangements or third-party asset finance facilities before service models become commercially viable at scale.

From sales to systems

After-sales ecosystems — technical support, spare parts availability, performance monitoring, and warranty fulfilment — are thin outside major urban corridors. Customers in remote agricultural areas frequently report breakdowns that go unresolved for weeks or months, eroding willingness to pay and the trust of follow-on customers. After-sales should not be treated as a cost centre to be minimised; it is the foundation of customer retention, default reduction, and market expansion.

From selling to bundling

The productive-use value proposition becomes significantly stronger when the technologies are bundled with the complementary inputs and services that make it productive at the farm gate — irrigation with agronomic advisory and quality seed; cold storage with offtake arrangements; solar drying with aggregation and market access. Bundling lifts the willingness to pay and the creditworthiness of the underlying transaction by demonstrating revenue impact (Negera et al., 2025). Aggregators, cooperatives, and off-takers are therefore not peripheral actors but natural partners for such bundling and should be central to private sector strategy. Bundling does not require vertical integration by a single firm. In thin markets with constrained capital, the more viable model is structured coordination among various firms — hardware providers, agronomic service companies, aggregators, and digital finance platforms — each contributing a distinct layer of the value proposition under a shared commercial arrangement.

SoLAR 2 partners can support this transition by co-designing business models with operators, brokering partnerships with financial institutions and aggregators, and generating the operational evidence base that allows new models to attract capital.

Recommendations: A coordinated call to action

The four issues set out above are interlocking. None can be resolved by a single actor, and none will yield to a single instrument. A coordinated response is required across four stakeholder groups.

Donors

- Sustain and expand catalytic capital instruments — first-loss tranches, credit guarantees, results-based finance — that crowd in private finance into SESA.
- Fund multi-year, adaptive scaling programmes rather than discrete project cycles, with explicit commitments to evidence packaging, and commercial market handover.



A farmer in Lemo worda with his newly installed solar irrigation pump (Photo: Petra Schmitter/IWMI)

- Support inter-ministerial coordination platforms in Ethiopia and Kenya, and continue investment in evidence generation, monitoring, reporting and verification (MRV) systems, and south-south learning between South Asia and East Africa.

Governments and policy makers

- Develop and resource a national dedicated enabling environment framework for solar energy in agriculture with measurable scaling targets, dedicated budget lines, and clear institutional accountability - Integrated within existing national development strategies, agricultural investment plans, and Nationally Determined Contributions.
- Harmonise fiscal instruments and regulatory frameworks (VAT, duty, depreciation rules) and establish standing inter-ministerial coordination mechanisms.
- Embed SESA in Nationally Determined Contributions, National Adaptation Plans, and agricultural extension systems; accelerate development of quality standards for emerging technologies.

Private sector

- Diversify from hardware-only models toward service-based and bundled models — piloting and rigorously evaluating their viability and adopting only those demonstrated to be commercially sustainable.
- Invest in after-sales and last-mile distribution as core capabilities, not overheads.
- Partner with aggregators and off-takers to build productive-use packages and engage proactively in standards-setting and quality assurance to protect the market.

Financial institutions

- Build internal agro-solar underwriting capacity and develop loan products that align with agricultural cash flows.
- Participate in risk-sharing and guarantee facilities; treat SESA as a portfolio asset class rather than a project category.
- Position to access climate finance windows (The Green Climate Fund (GCF), Adaptation Fund (AF), voluntary carbon markets) for on-lending into the sector.

Conclusion

Ethiopia and Kenya have moved beyond the question of whether SESA works. The question now is whether the four actor groups identified in this brief will coordinate to resolve the structural constraints that keep the sector confined to pilots and demonstrations. The diagnostic case is clear, the technology pipeline is real, and the policy and finance instruments required to scale are well understood. What remains is the choice to act in concert. SoLAR 2 is designed to support exactly this coordination, and IWMI invites donors, governments, the private sector, and financial institutions to engage as partners in unlocking the next phase of scale.

IWMI — with financial support from SDC through SoLAR 2 (2025–2028) — is generating the evidence, developing the tools, and brokering the partnerships needed to support this transition across Ethiopia and Kenya. This includes strengthening the enabling environment through evidence-based policy design, accelerating finance through innovative instruments and blended finance, building knowledge and capacity, and ground-truthing scaling pathways through living labs. SoLAR 2 is one contribution to a broader ecosystem of actors. Resolving the structural constraints documented in this brief requires sustained, coordinated action from governments, donors, financial institutions, and the private sector — well beyond any single project cycle.



Farmer shows her solar power irrigation system in Opapo orange-flesh sweet potato site visit at Migori county in Kenya. (Photo: Muthoni Njiru/ILRI)

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Project

The Solar Energy for Agricultural Resilience (SoLAR) Phase 2 project 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 the sustainable scaling of socially inclusive and climate-resilient solar agri-tech solutions in South Asia (India and Bangladesh) and East Africa (Ethiopia and Kenya). Read more: www.solar.iwmi.org

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