Tanzania
Solar Irrigation Solutions: Investment Brief

Climate Adaptation Market Opportunities
Agriculture & Food Systems

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GLOBAL CENTER ON ADAPTATION

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ABOUT THE GLOBAL CENTER ON ADAPTATION

The Global Centre on Adaptation (GCA) is an international organisation, hosted by the Netherlands, which works as a solutions broker to accelerate action and support for adaptation solutions from the international to the local, in partnership with the public and private sector, to ensure we learn from each other and work together for a climate resilient future.

ABOUT AFRICA ADAPTATION ACCELERATION PROGRAM

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CONTEXT

This investment brief is part of a regional analysis undertaken by the Global Center on Adaptation, developed in close coordination with partners including CGAP and GCA's downstream financial institution partners under the Africa Adaptation Acceleration Program (AAAP), in collaboration with the consulting firm Pegasys. The analysis showcases rapid, national level climate risk assessments and climate adaptation opportunities for private sector players across Tanzania, Zambia, Kenya and Democratic Republic of Congo in agriculture and food systems. It also estimates the market size for five climate adaptation investment opportunities in Tanzania and Kenya through an investment brief series (Tanzania: solar irrigation, hermetic storage and cold storage for dairy, Kenya – solar dryers and digital climate advisory services). Building on these results, the present brief aims to provide a decision-support resource for *commercial banks, microfinance institutions, and other lenders seeking to assess and integrate climate-related risks and opportunities within their agricultural portfolios.*

Across agriculture and food systems, climate variability is increasingly translating into material credit risk. Erratic rainfall, rising temperatures, and more frequent extreme events affect yields, input efficiency, and post-harvest outcomes. These impacts weaken borrower cash flows and asset values, with direct implications for both clients and lenders, including deteriorating portfolio performance, elevated non-performing loan ratios, and increased volatility in agricultural lending.

The analytical framework underpinning this investment brief series reframes climate adaptation measures as risk-adjusted investment opportunities. It identifies discrete, technologies and services across value chains and assesses their bankability through market sizing, borrower segmentation, and business model analysis. Each brief is structured to align with financial sector requirements, including compatibility with existing lending instruments (e.g. asset finance, value chain finance) and applicability across borrower archetypes such as smallholder farmers, cooperatives, and agri-SMEs.

The investment brief series, focused on Climate Adaptation Market Opportunities in Agriculture & Food Systems, aims to support financial institutions in systematically integrating adaptation into core lending operations, with a view to strengthen client and portfolio resilience while capturing emerging market opportunities.

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INVESTMENT BRIEF: SOLAR IRRIGATION SOLUTIONS IN TANZANIA

Executive Summary

Climate risk is now a credit risk in Tanzania's food system. The nation's profound reliance on **rainfed agriculture** is under severe stress from climate change, marked by erratic rainfall and increasing temperatures. This unpredictability directly compromises the stability of crop yields, translating into **credit risk for financial institutions** and income instability for millions of smallholder farmer households. Without reliable irrigation, farmers are locked into a single annual production cycle, limiting income and inhibiting climate adaptation investment.

For farmers with access to water, solar irrigation solutions are a proven fix. Solar water pumps (SWPs), the critical component of any solar irrigation system, are technologically superior to fossil fuel pumps, offering a decisive competitive advantage. They eliminate recurring, volatile fuel costs and have a near-zero Operational Expenditure (OPEX). Most critically, in tropical climes such as that of Tanzania, solar irrigation solutions enable farmers to cultivate **up to three cropping seasons per year**, transforming low-value rainfed agriculture into high-value irrigated production and dramatically increasing revenue.

The market is **large, segmented, and financeable**. Our analysis estimates the **Total Addressable Market (TAM)** for solar irrigation systems, *which reflects all potentially irrigable land in Tanzania*, at **USD 1.94 billion in 2025**, scaling to **USD 2.5 billion by 2030**. The immediate estimated **Serviceable Available Market (SAM)** is deliberately conservative, targeting *only economically viable smallholder farmers with existing water access*, at **USD 39 million in 2025**, with growth projections up to **USD 77 million by 2030**. This gap represents an addressable upside as infrastructure and credit access expand.

Product fit is straightforward, leveraging instruments banks already use:

- **PAYG Models:** Mobile-enabled payment systems allow farmers to pay off the pump in small, regular instalments, drastically improving affordability and mitigating credit risk by allowing for remote disabling of the asset if payments lapse. USD 300–600 ticket with a 12–24 month tenor.
- **Cooperative & Group Lending:** Lending to established farmer cooperatives provides social collateral and collective responsibility, which leads to historically higher repayment rates. USD 5,000–50,000 with a 24–36 month tenor.

Borrower economics are compelling. The pump's ability to eliminate fuel costs and enable year-round production ensures a quick financial payback period, typically **less than two seasons** coming from an average estimated ~28% ROI (ISF Advisors & Hystra , 2024). This capacity to generate new, stable income streams forms a strong commercial case for financial institutions.

De-risking is a strategic move. For commercial banks and microfinancing institutions, financing solar irrigation is both a **credit risk solution** as well as an adaptation investment. By securing the water access, solar irrigation solutions stabilize yields and generate dry-season income, transforming a highly vulnerable, rainfed borrower with seasonal production capacity into a **resilient, irrigated borrower**, with all year production capacity, thereby improving overall cash flow and capacity to repay existing loans and access new credit.

Development and climate dividends are tangible. Scaling solar irrigation solutions enhance **food security**, improve **dietary diversity** and **nutrition outcomes** for women and children, and achieves **climate mitigation co-benefits** by transitioning farmers to cleaner, renewable and cost-efficient solar energy – when replacing diesel/petrol pumps.

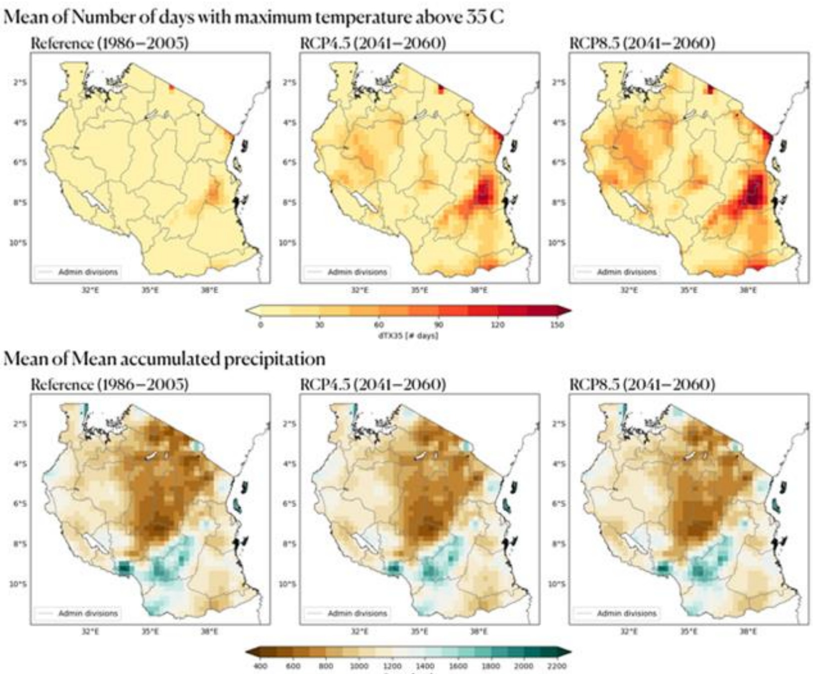
Call to action for banks: Finance acquisition of quality-assured solar irrigation systems to tap a high-growth market, reinforce your core agri-finance business, and advance ESG goals. By converting a silent climate liability into a tangible asset, banks could leverage a strategic entry point that stabilizes their portfolios and strengthens borrowers' resilience.

The Adaptation Challenge

Climate Risk Increases Production Risk

Rising temperature and intensifying drought are the most direct threats to rainfed agricultural production, on which supports most smallholder farmers in Tanzania rely. Average annual temperatures have increased by 1.0 – 1.2 °C over the past three decades, with projections indicating extreme heat exceeding 35 °C becoming routine across the Central plateau and Northern highlands. Elevated temperatures significantly increase crop evapotranspiration, driving soil moisture reduction and water stress, and ensuring that localized rainfall gains are not fully realized. In Western and Southern provinces, where drought hazard is projected to intensify, this creates a direct water deficit for rainfall-dependent farmers that irrigation alone can close. Extreme rainfall events create another risk, intensifying flash flooding and river flooding along the coast, islands (Pemba, Tanga), in the South-Western highlands, and in key agricultural corridors like Arusha, Manyara and Morogoro (see Figure 1 for future scenarios).

Figure 1: Climate hazard projections for Tanzania [1]



Tanzania's agriculture sector is a key pillar of its economy, contributing approximately **25% of GDP and employing 66% of the workforce.** (FAO, 2024) (World Bank, 2019). . Being predominantly rainfed, **climate**

[1] Find more climate hazard maps and climate risk information for Tanzania in: GCA (2026). Tanzania: Rapid Climate Risk and Adaptation Investment Opportunity Mapping. Agriculture and food systems. Partnership: CGAP. Consulting firm: Pegasys Consulting. Developed under the AAAP. Available at https://gca.org/climate-adaptation-investment-markets-in-africa/

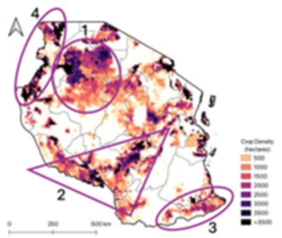
unpredictability directly compromises the stability of crop yields, particularly for staple crops like maize, rice, and cassava, which are crucial for national food security (FAO, 2024).

Additionally these risks are acute in key value chains where Small-Scale Water solutions offer the highest potential for impact, including high-value horticulture, rice cultivation, and market-oriented vegetable production, thereby improving food security. (CGIAR, 2024) The recent El Niño-related floods and Cyclone Hidaya in late 2023 and early 2024 devastated crop production in several key regions, highlighting the acute exposure of the agricultural system to water supply extremes. This volatility translates directly into credit risk for financial institutions and income instability for millions of smallholder farming households (TAREA, 2020).

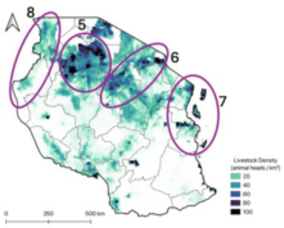
Who Is Affected

The primary affected population are smallholder farmers, particularly in semi-arid and drought-prone regions, who constitute the majority of Tanzania's agricultural workforce. These farmers typically cultivate small plots (often less than two hectares) and rely on manual labour and highly seasonal, rainfed production (World Bank, 2019). Critically, women farmers, who perform the bulk of agricultural labour and household water fetching, face disproportionately high impacts. When rainfall fails, the burden of ensuring water access for both domestic use and supplementary crop irrigation, often involving walking long distances, increases substantially, cementing a cycle of drudgery and lost opportunity (World Bank, 2022). **Without reliable water access, these farmers are locked into a single annual production cycle, limiting income, exacerbating seasonal hunger**, and inhibiting the accumulation of savings necessary for climate adaptation investments (Mekonnen, Choufani, Bryan, Ringler, & Haile, 2022). **Crucially, smallholder farmers** represent a strong potential borrower base for many financial institutions, or **are direct, upstream suppliers to medium and large agricultural processors**, making them integral to the financial sector's exposure to climate-driven production volatility. Additionally, this risk has a geographical concentration in key agricultural zones compounding the risks for communities in those regions (see figure 2).

Figure 2:Tanzania: Key crop production and livestock areas.



1. **Lake Victoria Southern Plateau** – *Rice, maize, groundnuts*
2. **Southern Highlands Corridor** – *Maize, beans, groundnuts*
3. **Southeastern Coastal Plains** – *Cassava, rice, groundnuts*
4. **Albertine Highlands** – *Banana, beans, plantain*



5. **Lake Victoria Southern Plateau** – *Cattle, chicken, goats*
6. **Maasai Steppe Pastoral Corridor** – *Chicken, cattle, goats*
7. **Northeastern Coastal Plains and Islands** – *Chicken, goats, cattle*
8. **Albertine Highlands** – *Chicken, cattle, goats*

**Key three crop commodities in order of production value ($) or number of heads (livestock)*

Systemic Impacts

The reliance on rainfed systems creates systemic risk across the Tanzanian economy. Agricultural output volatility leads to high fluctuations in food prices, particularly staple commodities, which undermines national food security and contributes to persistent rural poverty (World Bank, 2019). At the household level, the lack of reliable water for year-round farming prevents farmers from diversifying into high-value horticultural crops, a crucial pathway out of poverty. Beyond income, irrigation has been shown to improve nutritional outcomes. Research in both Tanzania and Ethiopia indicates that the adoption of small-scale irrigation significantly improves dietary diversity for women and households, and demonstrably improves the weight-for-height z-scores of children under five, directly addressing chronic malnutrition (Mekonnen, Choufani, Bryan, Ringler, & Haile, 2022). Furthermore, **dependence on diesel or petrol pumps for supplementary irrigation, a common coping mechanism, locks farmers into high, volatile operational costs and contributes to greenhouse gas emissions, undermining national climate mitigation goals** (TAREA, 2020).

The deployment of solar-powered water pumping solutions, therefore, serves as a powerful dual-purpose climate intervention. As an **adaptation** strategy, providing reliable water allows farmers to transition from volatile rainfed agriculture to **controlled irrigation, stabilizing yields and diversifying income** against climate shocks. Simultaneously, as a crucial **mitigation** measure, replacing existing diesel and petrol pumps with solar technology eliminates the burning of fossil fuels, avoiding greenhouse gas emissions and supporting national climate targets. This makes secure water access an essential two-in-one solution for resilient and sustainable development.

A Challenge of Adaptive Capacity

The inherent adaptive capacity of **smallholder farmers is severely limited by a lack of capital and access to yield-stabilising technologies**. **Adaptive capacity**, as defined by the Intergovernmental Panel on Climate Change (IPCC), is the ability of a system to adjust to climate change, including variability and extremes, to moderate potential damages or cope with consequences. For smallholder farmers, this capacity is fundamentally constrained by key social, economic, and technological factors, particularly access to financial resources and appropriate technology, creating a critical vulnerability. Traditional irrigation, which covers only a small fraction of Tanzania's total cultivated land, is often gravity-fed or relies on costly, polluting fossil-fuel pumps. Solar water pumps (SWPs) represent a viable technological solution, yet smallholders face an overwhelming initial investment barrier. This is compounded by limited access to appropriate financial products and a fragmented market for quality solar equipment and after-sales service, trapping farmers in a low-productivity, high-risk cycle where they are unable to convert the climate challenge into a financeable business opportunity. (AgriFin, 2020).

In contrast to smallholders, other actors exhibit varied, generally higher levels of adaptive capacity. Industrial and large-scale farmers, backed by significant capital and access to high-end inputs, can more quickly adopt climate-resilient technologies. Their primary adaptive constraint is often regulatory or market related. Agricultural **aggregators and off-takers possess high institutional adaptive capacity; they manage climate risk primarily by diversifying their sourcing geographically** and vertically integrating services (e.g., providing input finance and training) to stabilize their supply chains. **Co-operatives offer a middle ground: their capacity is enhanced by social capital**, allowing for pooled resources, collective bargaining for inputs and finance, and shared knowledge dissemination. However, their technological adaptation remains bottlenecked by the sheer capital required for larger-scale infrastructure, necessitating blended finance solutions to bridge the gap.

Market Inefficiencies and Suboptimal Investment Context

Despite clear climate adaptation benefits and high on-farm returns, the deployment of solar irrigation systems remains far below its potential in Tanzania. Several interlinked inefficiencies continue to constrain market growth and the flow of commercial financing:

Structural Ecosystem Inefficiencies

The solar irrigation distribution and service ecosystem is immature and fragmented, hindering large-scale commercial scaling:

- **Supply Chain and Logistics:** Tanzania’s vast geographic area creates significant logistic troubles, resulting in high last-mile costs and unsatisfactory quality of after-sales service.
- **Capacity and Quality Control:** Local suppliers operate with limited scale and face persistent challenges accessing working capital to import high-quality components, leading to system longevity issues. Furthermore, the absence of universally enforced quality standards allows for

the entry of counterfeit or low-quality systems, eroding farmer trust and increasing the risk of investment failure.

- Under-Resourced Support: Public extension services and private sector field agents remain under-resourced, limiting the ability to train farmers on advanced irrigation techniques (like drip management) and the proper maintenance of solar photovoltaic systems, which is crucial for maximizing the return on the asset.

Financial and Credit Barriers

The core challenge is translating a high-CAPEX asset into a financeable product for the smallholder segment without imposing unsustainable direct debt on the farmer:

- Initial Capital Barrier and Off-taker Solution: The upfront cost of a complete solar system (panels, pump, piping) represents a major investment constraint. Furthermore, direct smallholder debt risks creating a financial burden. Instead, financing models should focus on leveraging off-taker balance sheets, enabling aggregators who benefit from stable supply and de-risked production to carry the debt, thereby treating the SWP not as farmer debt but as a supply chain infrastructure cost that delivers predictable yields, a significant advantage over high-risk rainfed agriculture.

- Mismatched Loan Products: Similar to storage, many traditional agricultural loan products (seasonal or input loans) have repayment cycles of 6–9 months, poorly aligning with the multi-year return profile of a durable asset like a solar pump. This maturity mismatch discourages both uptake by farmers and product development by lenders.

- Risk Modelling Gaps: While solar solutions de-risks the farmer, most commercial banks lack internal risk models and credit scoring tools that accurately factor in the positive impact of reliable irrigation on farm resilience and future repayment capacity. This systemic conservatism leads to overly cautious lending or reliance on traditional collateral, which over 70% of smallholders lack (TADB, 2021).

Information and Capacity Gaps

A lack of reliable data and awareness limits both lender confidence and borrower trust:

- Lender Data Asymmetry: Standardized and transparent data on how solar irrigation adoption impacts borrower repayment performance, and on the subsequent gains in yield and income that build farmer resilience, is still fragmented and not yet systematically integrated into traditional lending models. Few institutions track adaptation-related Key Performance Indicators (KPIs), such as change in water-use efficiency, increase in yields, or reduction in operational expenses due to fuel displacement, or integrate climate risk assessment tools into their agricultural credit models which enable them to accurately price the benefits of adaptation. Beyond institutional tracking limitations, the reliability of these indicators depends on farmers' book-keeping practices, a capacity that is currently weak among many smallholder farmers. That said, a report by Efficiency for Access (a global coalition working to improve affordable access to clean energy), released in 2021, indicated significant improvement in farming outcomes three to nine months after purchase of solar water pumps. In addition to an overall rise in household income for 83% of survey participants, other vital indicators such as increase in volume sold, cost reduction, expansion of land farmed, and price increase all contributed to better returns due to the solar water pumps investment (Efficiency for Access, 2021).

- Farmer Trust and Awareness: While the operational benefits (reliability, low running cost) are valued by farmers, sparse uptake persists due to concerns about the initial cost, inconsistent availability of proven technologies, and a lack of reliable after-sales support. The fear of purchasing low-quality or counterfeit equipment, particularly given the high cost, is a significant barrier to adoption. This reluctance contributes to estimated adoption rates remaining below 5% (ISF Advisors & Hystra , 2024) in key sub-Saharan African markets, with non-financial drivers like low technological literacy and fragmented after-sales networks compounding the challenge.

Underinvestment Gap

Current financing flows for solar irrigation largely originate from donor or project-linked procurement (e.g., World Bank, AGRA pilots), rather than from private credit lines or structured agri-finance. This results in:

- Project Dependency: Commercial bank lending for SWP assets remains very limited, concentrated among a few pilot initiatives. The market has yet to transition from being project-dependent to being a viable, core commercial offering.
- Latent Opportunity: This leaves a massive latent financing gap against a significant Serviceable Available Market for banks (including commercial ones) to capitalize. This inefficiency presents a strategic entry point for investors to build an emerging adaptation finance market with measurable credit, social, and climate benefits by providing structured financing to SWP distributors and financial institutions.

Addressing these constraints through scalable, financeable solar irrigation systems protects both farmers' productivity and banks' balance sheets, converting a silent climate liability into a tangible investment opportunity.

Market Opportunity

From Climate Challenge to Financeable Demand

The increasing climate unpredictability is paradoxically creating an urgent, resilient, and financeable demand for solar irrigation. As rainfall becomes unreliable, the need for supplementary or dry-season irrigation shifts from an optional efficiency measure to an absolute necessity for farm survival and income stabilization (ISF Advisors & Hystra , 2024). This transition **transforms the solar pump from a discretionary purchase into a high-priority, productive asset**. The market is driven by compelling economics. **Irrigation systems in Tanzania enable farmers to achieve up to three cropping seasons per year**, particularly in regions with bi-modal rainfall patterns such as Kilimanjaro and northern zones. The mechanism underlying this intensification relies on complementing the country's two natural rainy seasons—the Masika (long rains from March to May) and Vuli (short rains from October to December) with irrigation dependent production during the intervening long dry seasons, between June and September, when the land would have stayed dormant (World Bank, 2013). Irrigation connects those two peak seasons, allowing a continuous production cycle. **While cereals such as maize and rice typically support two cropping cycles annually, vegetables including tomatoes, onions, cabbages, peppers, and leafy greens are well-suited to this triple cropping system**, with some areas achieving six crops per year under intensive management (Muro, 2017) (World Bank, 2013). This agricultural intensification through irrigation has been documented to contribute significantly to household food security and income generation, with studies showing yields as high as 220 metric tons per hectare for tomatoes compared to rainfed alternatives of less than 40 metric tons per hectare (World Bank, 2013). The viability of three cropping seasons depends critically on consistent water availability and appropriate irrigation infrastructure systems that smallholder farmers can sustain. This clear and demonstrable Return on Investment (ROI) is the foundation of a viable financing market.

The solar irrigation market in Tanzania can be broken down along technical and deployment categories.

Technical Categories – Depth of Water Source

In terms of the core pumping mechanism, the primary categories are:

- Solar Surface Pumps: These pumps are optimal where water is drawn from sources less than 7 metres deep, such as rivers or shallow, hand-dug wells. Their leading models can deliver approximately 800 litres per hour and are generally suitable for irrigating up to **0.5 hectares**. These systems typically retail for **USD315–USD380** for core pump and panel components. It is important to note that this cost often **excludes the cost of developing the water source (e.g., digging a new well or borehole)**, a factor that can significantly raise the initial capital outlay for farmers who do not already have an established source.

- Solar Submersible Pumps: Designed for boreholes or wells up to 50 metres depth, these are necessary where water is deeper or cleaner water is required. They are represented by models with packages starting at **USD600–USD1,000** for typical smallholder-scale deployments (ISF Advisors & Hystra , 2024).

Deployment Categories – Integrated and Scaled Solutions

Moving beyond the pump, two other crucial categories define the scope and efficiency of solar irrigation:

- Integrated Drip Kits and Distribution: This refers to the addition of pipes, drip lines, or sprinklers to the core solar pump system. While a farmer can use a solar pump for flood irrigation, coupling it with a **drip kit** significantly improves **water-use efficiency** and crop yields. When a surface pump is expanded to include distribution infrastructure (pipes, drip kits, sprinklers), total costs typically rise by **USD500–USD1,000 per acre** (ISF Advisors & Hystra , 2024)..

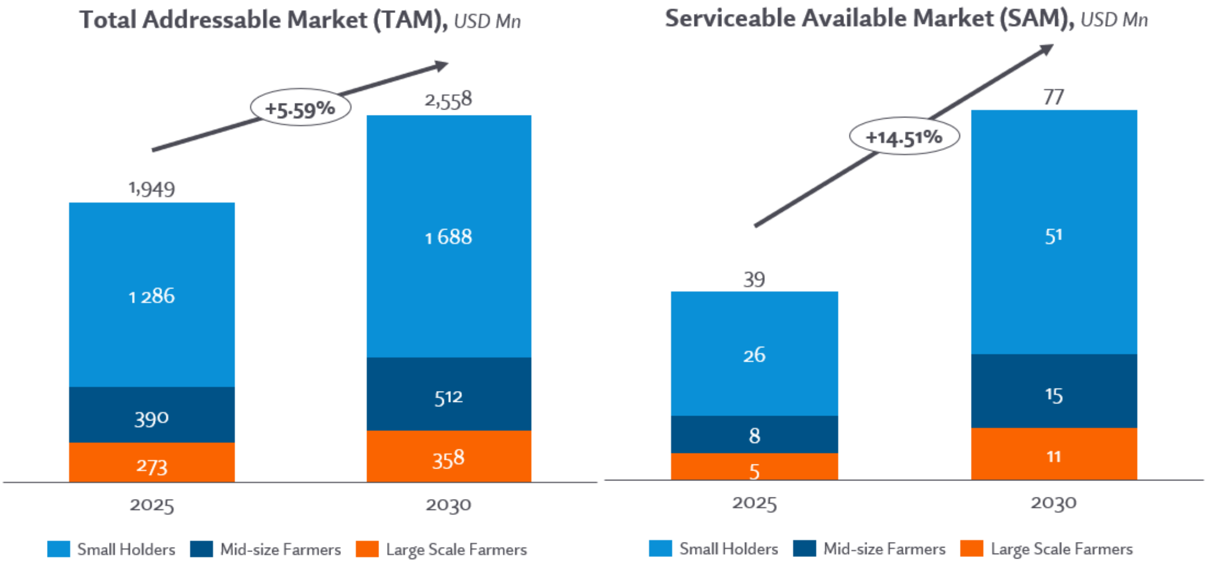
- Community-Scale Solar Schemes: These are larger, typically 5kW to 15kW solar systems designed to irrigate schemes ranging from 5 to 50 hectares. They are structured for shared access among multiple smallholders. While the upfront capital costs are high, the cost per hectare is significantly lower, making them an important mechanism for achieving scale and collective climate adaptation.

Figure 3: Solar Irrigation Solution Variants

A critical factor shaping this opportunity is the **current extremely low penetration of solar irrigation systems** among Tanzania's smallholder farmers, driven by a **mix of financial, technical, and informational barriers** (as highlighted under the Adaptation Challenges section) that have kept adoption well below potential. Fewer than **3 to 4% of the irrigating farmers** currently use solar pumps (GOGLA, 2023). This low number must be viewed in the context of the broader challenge, the estimated percentage of smallholder farmers using irrigation is only **2 to 5%**, significantly lagging the global average of approximately 20% (ISF Advisors & Hystra , 2024). This means the **primary opportunity is not switching from diesel/petrol to solar but enabling the switch from rainfed agriculture to irrigation** for most smallholder farmers. While Tanzania-specific sola water pump penetration data is limited, Machakos County, Kenya - a comparable agricultural zone - provides a useful proxy for analysis. Recent solar water pump consumer awareness campaign in Machakos County, found that diesel-powered water pumps were the most commonly used

(71%) form of irrigation. In comparison, solar water pumps were the least popular at 1% (CLASP, 2023), largely because most smallholder farmers operate on small, rainfed plots with limited access to affordable credit, a barrier that affects the adoption of all high-value equipment, including diesel pumps. The high upfront cost of solar units, typically USD 500 to 2,000, remains inaccessible without asset finance or PAYG models as banks often offer short-term seasonal loans that do not match the multi-year payback profile of solar systems. Limited awareness of solar irrigation's potential to offer a more reliable and cost-effective long-term solution, coupled with a shortage of trained technicians for installation and aftersales service, further constrain uptake.

Figure 4: Estimated Solar Irrigation Market size in Tanzania



These market frictions have created a wide gap between total demand and financeable reach, translating into both a challenge and an investment opportunity. We estimate the Total Addressable Market (TAM) for solar irrigation systems at USD 1.94 billion in 2025, scaling to USD 2.5 billion by 2030, covering all arable land that could benefit from improved water access in the future.

The Total Addressable Market (TAM) for agricultural water solutions, such as solar irrigation, is ultimately defined by the total area of all non-subsistence farmland in the region. This expansive, long-term view is based on the strategic premise that future infrastructure development will progressively enable most commercial farms to receive water in some capacity.

However, for short-term strategic planning, the market size is constrained by existing access limitations. With numerous rivers, lakes and underground water resources, Tanzania has huge potential for irrigated agriculture. Of the total arable land area, 29.4 million hectares have varying degree of development potential for irrigation (National Irrigation Master Plan, 2002) It is estimated that there is 2.3 million hectares of high potential, 4.8 million hectares of medium potential, and 22.3 million hectares of low potential land for irrigation. The immediate, serviceable TAM for farmers who currently have *some* water access is estimated at USD 1.3 billion in 2025, which is projected to grow to USD 1.7 billion by 2030, reflecting increasing infrastructure penetration and economic potential as market conditions mature.

The Serviceable Available Market (SAM), farmers who are economically viable and currently have access to water sources, remains at just USD 39 million in 2025, growing to USD 77 million by 2030. Bridging this gap will require expanding credit access, bundling irrigation finance with input and crop loans, and strengthening last-mile delivery networks. For banks and DFIs, this is precisely where the financing opportunity lies: unlocking a proven technology whose economics make sense, but whose adoption remains limited by access and awareness rather than feasibility.

Segmenting the Opportunity

The Tanzanian market opportunity is substantial. Based on farm size, water source, and financial capacity, the opportunity can be segmented as follows:

1. **Smallholder Farmers (0–5 hectares):** This segment requires portable, lower-lift pumps (up to 300W) often used for shallow wells or river abstraction. This segment is best served by affordable, bundled financing (e.g., via Village Savings and Loan Associations or mobile-enabled PAYG) due to low upfront costs and the rapid, high-margin returns achieved by cultivating **high-value horticulture crops** (e.g., vegetables, fruits). Aggregate TAM: USD 1.2-1.3 billion and Aggregate SAM: USD 24-28 million (Pegasys estimates)

2. **Mid-Size Farmers (5-100 hectares):** This represents the bulk of the market, requiring medium-lift pumps (500W–1.5kW) for borehole or communal scheme use. These customers have higher income potential and are suitable for traditional micro-finance loans or asset-financing tailored for small businesses. Aggregate TAM: USD 380-400 million and Aggregate SAM: USD 6-10 million (Pegasys estimates)

3. **Community/Large Scale Farmers (100+ hectares):** This segment requires communal or high-capacity systems (2kW+), often financed through farmer cooperatives or specialized agricultural development banks. Aggregate TAM: USD 270-275 million and Aggregate SAM: USD 3-6 million (Pegasys estimates).

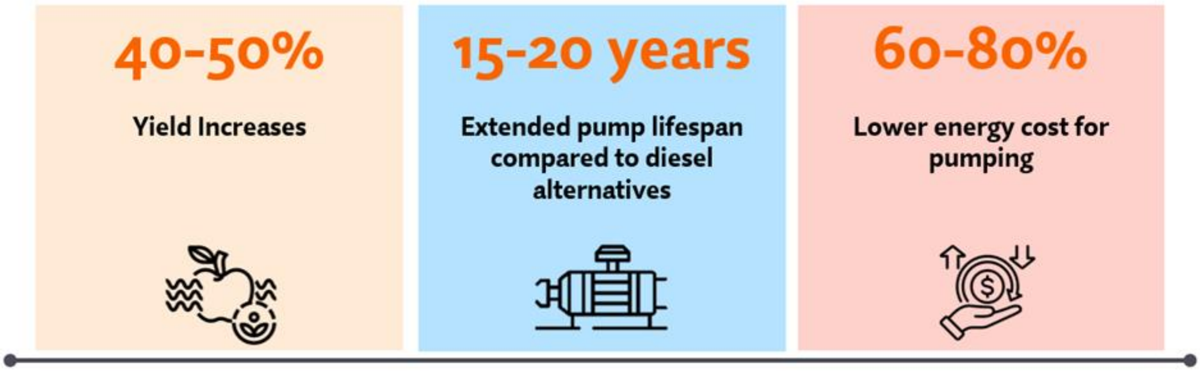
Current sales projections for Sub-Saharan Africa suggest a rapid scaling of the SWP market, indicating a clear trajectory for Tanzania, which benefits from strong solar irradiance and a large agricultural base (IWMI & Efficiency for Access Coalition, 2021). Pegasys estimates utilized a conservative growth rate of 6%, calculated using FAO data, which chiefly accounts for the growth rate of the agricultural sector while adoption was estimated to increase by 100 basis points over the next 5 years.

Technical and Commercial Viability: A Proven Solution, Not a Pilot

Competitive Positioning

Solar water pumping is technologically superior to its main competitor, the diesel/petrol pump, offering a compelling competitive advantage (International Renewable Energy Agency, 2016).

Figure 5: Competitive Positioning of Solar Irrigation



While diesel pumps have a lower initial price, their total cost of ownership is crippling due to recurring, volatile fuel expenses, frequent maintenance, and short lifespans. A small diesel pump can cost over TZS 3.8 million (USD1,500) in fuel over a four-year lifespan, plus generating 487 kg of CO2per hectare annually (TAREA, 2020). In contrast, solar pumps eliminate fuel costs, have significantly lower maintenance needs, and possess a lifespan of up to 20 years for the panels (International Renewable Energy Agency, 2016). This dramatic reduction in Operational Expenditure (OPEX) ensures a quick financial payback period, typically less than two seasons, making the solar pump a robust, climate-resilient investment. The World Bank notes that while diesel generator water pumps have initial system costs (~USD13,000), ongoing fuel costs exceed USD5,000/year. Converting to solar can reduce total life cycle costs by about 36%. Smaller solar pump systems typically range from USD400–USD3,000 with payback periods as low as 1.5 years for smallholder farmers in East Africa.

From Value Protection to Value Creation

Solar irrigation is fundamentally a value-creating intervention. Unlike risk-mitigation tools that focus on loss prevention, SWPs actively transform low-value rainfed agriculture into high-value irrigated production.

- Yield Stabilization and Increase: Irrigation stabilizes yields against drought and dry spells. Additionally, it allows farmers to cultivate high-value crops like vegetables, which command premium prices. Tanzania's high-value horticulture crops such as avocados, chillies, sweet melons, macadamia nuts, berries, and assorted fresh vegetables stand to benefit substantially from solar irrigation by ensuring reliable water supply to enhance yield and quality for export markets. A specific study on irrigated rice production in Tanzania found that the technical efficiency of irrigated rice production was 96% compared to an average of 39% for rainfed lowland systems, demonstrating the substantial productivity advantage irrigation provides. (ISF Advisors & Hystra , 2024)
- Dry Season Production: The most transformative benefit is the enablement of dry-season cropping, allowing farmers to generate income year-round and mitigating the 'lean season' hunger gap. A case study from Chamwino district in central Tanzania documents transformative outcomes. After diesel pump failures compromised water access, smallholder farmers in the AMCOS cooperative installed solar-powered water pumps with drip irrigation. The results showed that "between 2021 and 2022, production more than doubled" for mango farming, with farmers reporting 50-100% seedling survival rates compared to the previous 5-40% survival under water stress. (World Resources Institute, 2025)
- Dietary and Health Uplift: By enabling the cultivation of nutrient-rich vegetables year-round, SWPs contribute directly to household dietary diversity scores, providing a crucial, measurable development impact. An improvement in women's dietary diversity scores of 7.6% was observed in families utilizing solar pump kits. (Mekonnen, Choufani, Bryan, Ringler, & Haile, 2022)

Strategic Targeting of the Market

While solar water pumping offers substantial value, maximizing adoption and mitigating deployment risk requires strategic targeting across three key dimensions. First, from a technical perspective, targeting must be concentrated in areas with verified accessible groundwater or reliable surface water sources. This involves leveraging national hydrological studies and the work of institutions like IWMI to identify and map the most feasible irrigation sites. Second, for the high-value horticulture model to succeed, locations must be in close proximity to urban markets or have established, low-cost transport routes. Since high-value crops are perishable and prone to waste, this market linkage is essential to realize the business model’s profitability (enabling the up to three cropping seasons per year mentioned previously). Third, success is contingent on starting with commercially-oriented smallholders—those with existing market linkages are credit-worthy enough to access financing. As the financing model and operations mature, the addressable market then expands to the smallholder farmers’ base. The two-prong sequenced approach ensures early repayment data can be generated from the most credit-worthy segment before scaling to the borrowers with higher risk.

Business Model and Value Proposition for Financial Institutions

Proven Asset Financing Models

The most successful model for scaling solar irrigation finance asset-based lending combines asset-based lending with **digital technology, including remote monitoring, mobile payment systems, and digital credit scoring.** This enables banks to reach smallholders effectively and manage credit risk remotely. Depending on the model, debt may rest with the smallholder directly (PAYG), with a cooperative (group lending), or with an aggregator/anchor client (value chain finance).

- **PAYG Models:** Leveraging mobile money platforms such as M-Pesa and Tigo Pesa, PAYG models allow farmers to purchase solar pumps through small, regular instalments, often daily or weekly, significantly reducing the high upfront cost barrier. This high-frequency payment structure is typically adapted to either align with constant cash flow from peri-urban vegetable farming or adjusted to 'Pay-as-you-Grow' models that align payments with seasonal harvest income, drastically reducing upfront costs. The pump itself acts as collateral, with embedded remote-control features allowing deactivation in case of default, a strong mitigation tool for lenders. This drastically improves affordability and mitigates credit risk for the lender. Simusolar and SunCulture have successfully deployed PAYG models for smallholder farmers. Simusolar's partnership with CRDB Bank and SolarWorks! has enabled hundreds of smallholders in the Lake and Southern Highlands Zones to access solar pumps on 12–24-month repayment terms, with portfolio repayment rates above 90% (Simusolar, 2023). Similarly, SunCulture's "RainMaker2" PAYG model, which utilizes a flexible 'Pay-as-you-Grow' repayment schedule tailored to farmer cash flows, piloted through the KOSAP results-based financing (RBF) window, has demonstrated how PAYG-linked incentives can make systems affordable for rainfed farmers transitioning to year-round irrigation.

- **Product Bundling:** Financial institutions and agri-value chain actors in Tanzania are increasingly bundling solar irrigation loans with complementary inputs and services, drip irrigation kits, seeds, and extension support, to enhance borrowers' productivity and repayment reliability. For instance, Equity Bank Tanzania, in partnership with AGRA and World Bank's TASAF, introduced bundled loans that finance solar pumps alongside seeds and fertilizer under its "Kilimo Biashara" initiative. This integrated approach improved repayment outcomes by ensuring borrowers generate immediate productive returns from financed assets. Similarly, AgriFin Accelerate's partnerships with irrigation suppliers like Futurepump have tested bundled "Irrigation-as-a-Service" models in Morogoro and Mbeya, where solar pumps are financed together with agronomic advice and market linkage support.

- **Cooperative & Group Lending:** De-risking through aggregation remains a proven approach in Tanzania's agricultural finance. By lending to established Agricultural Marketing Cooperative Societies (AMCOS) or water-user associations (WUAs), banks can extend credit to multiple farmers through a single group entity, leveraging social collateral and collective accountability. The PASS Trust Guarantee Program, which covers up to 80% of loan principal, has enabled several cooperatives to finance post-harvest and irrigation assets, including solar-powered water pumps. For example, in Iringa and Dodoma, PASS-supported AMCOS partnered with NMB Bank to co-finance shared irrigation infrastructure serving up to 100 farmers per group. Similarly, EFTA Tanzania, a leasing company, has piloted cooperative leasing schemes for solar pumps and other productive-use equipment, where the group collectively services the lease using income from irrigated output.

- **Anchor Client Financing (Value Chain Model):** This model leverages the established financial relationship between commercial banks and large, creditworthy "anchor" clients (such as agri-processors, commodity aggregators, or major off-takers) in a value chain. The bank extends credit to the anchor, and the anchor, in turn, provides solar irrigation equipment to its network of smallholder producers (feeder farms). The debt obligation rests solely with the anchor client, significantly reducing the credit risk associated with lending directly to individual smallholders. Repayment from the smallholders to the anchor is secured through guaranteed purchase agreements, crop off-take contracts, or deductions from future produce sales, aligning the finance repayment cycle directly with the productive output of the asset. This mechanism, often referred to as a "value chain approach," ensures both technology adoption and reliable debt service.

Technology Providers (PAYG Pioneers):

- Simusolar: A Tanzanian enterprise pioneering lease-to-own solar irrigation models tailored for smallholders. Its hybrid PAYG model, supported by the KOSAP Results-Based Financing (RBF) facility and USAID Power Africa, has enabled more than 1,500 smallholders to access solar pumps with up to 72% income gains and 40% lower operating costs compared to diesel systems (GOGLA, 2023) (Simusolar Impact Report, 2023)

- SunCulture: Operating regionally across East Africa, SunCulture's Pay-As-You-Grow model integrates mobile-enabled payments, agronomic support, and financing through partnerships with Equity Bank Tanzania and KOSAP's RBF window. Its entry into northern Tanzania in 2023 reflects the company's strategy to replicate its successful Kenya model in underserved irrigation clusters (Sunculture, 2025).

- Futurepump & SolarWorks: Both are piloting low-head solar pump systems in Tanzania's southern highlands and lake zones, working with EnDev Tanzania and GIZ's Water–Energy–Food (WE4F) program to test market uptake and local distribution partnerships (CLASP, 2019)

Financial Institutions & Interventions:

- Vision Fund Tanzania & Equity Bank: Both are collaborating with Energy 4 Impact (now part of Mercy Corps Energy Access) to design dedicated solar irrigation credit products. These include longer tenors (up to 24 months) and flexible repayment aligned with crop cycles, addressing one of the largest barriers for smallholders.

- CRDB Bank & National Bank of Commerce (NBC): Through KOSAP and AfDB Green Growth facility, both banks have joined technical exchanges on renewable energy lending and are exploring structured financing for agri-solar assets via guarantees and blended finance.

Development Partners & Catalytic Finance:

- Energy 4 Impact (with WE4F) is a major player, actively working with finance providers and suppliers (like Simusolar) to trial farmer-friendly financing solutions.
- The World Bank/GPRBA accelerated solar water pumping through a USD4.5 million grant to help 165 villages transition from diesel to solar systems, demonstrating the viability of Result-Based Financing (RBF) for scale.
- The Tanzania Renewable Energy Association (TAREA) is a key advocate, partnering with international bodies to create an enabling environment, including advocating for fiscal incentives (VAT/import duty exemptions on components).

Strategic and Commercial Rationale for Banks

A Credit Risk Solution Disguised as an Adaptation Investment

For banks and microfinance institutions (MFIs) active in the agricultural sector, financing solar irrigation is not merely a portfolio expansion activity; it is a critical strategy to de-risk existing loan portfolios. Climate variability is now a major factor driving agricultural credit default. By providing finance for solar pumps, institutions help farmers secure **consistent access to available water, regardless of rainfall availability;** stabilize their yields, and generate dry-season income, improving their overall cash flow and, crucially, their capacity to repay existing loans and access new ones. **Solar irrigation transforms a highly vulnerable, rainfed borrower into a resilient, irrigated borrower.**

Profitability and Portfolio Diversification

Solar irrigation asset finance offers an attractive, profitable revenue stream. This is reaffirmed by the Tanzania Investment Centre who estimates indicative returns of 20-25%. (Tanzania Investment Centre, 2022) The asset's long lifespan, verifiable installation, and the productive cash flow it generates allow for extended loan tenors (e.g., 18–36 months) that can be priced competitively while maintaining high margins. This is especially evident when compared to traditional alternatives like diesel-powered pumps which incur 33-50% higher lifetime costs. (IFPRI, 2025)

Furthermore, this product allows banks to diversify away from purely seasonal, crop-cycle-dependent lending into an all-weather asset finance portfolio. **This diversification reduces concentration risk** and aligns the bank's strategy with the persistent, growing demand for climate adaptation solutions.

Alignment with Green and ESG Finance Mandates

The investment clearly aligns with the growing global and national pressure on financial institutions to meet Environmental, Social, and Governance (ESG) and Green Finance mandates. Solar irrigation finance provides a tangible, verifiable metric for both climate adaptation (by stabilizing yields) and mitigation (by replacing diesel with cleaner energy). This direct alignment makes the portfolio highly attractive to development finance institutions (DFIs), impact investors, and green bonds, potentially unlocking access to cheaper, longer-term concessional capital that the bank can then on lend.

However, the investment strategy must consciously mitigate potential **maladaptation** risks. A key risk, especially evidenced in contexts like India, is the potential for **over-pumping,** subsequent water table depletion and soil subsidence, as the zero marginal running cost of solar pumps can incentivize wasteful water usage compared to diesel. To ensure long-term, sustainable impact, the bank's financing approach should be paired with strong **water governance and extension services** (provided by the public sector, NGOs, or private suppliers) that integrate water-efficient irrigation practices, such as drip or sprinkler systems, and promote **water-saving crop choices** alongside solar pump adoption. This integrated approach will ensure the climate benefits are realized without causing long-term environmental harm.

A Low-Competition, High-Impact Market Entry Point

While the overall agricultural finance market is competitive, asset finance for solar irrigation remains a niche, high-growth area with relatively few dedicated commercial players. **By moving early, a financial institution can establish market leadership in a critical adaptation sector**. The high social and climate impact, stabilizing food security, empowering women, and reducing emissions, offers substantial reputational benefits and a clear differentiation strategy. **Some Tanzanian financial institutions are already taking early steps** to support asset finance for solar irrigation. Notably, collaborations like those facilitated by the ELICO Foundation and partners are testing business models that enable smallholder farmers in regions such as Iringa and Dodoma to acquire solar-powered irrigation systems on credit or through irrigation-as-a-service. These pioneering efforts demonstrate growing recognition of solar irrigation's critical role in climate adaptation and agricultural productivity. As such, financial institutions that fail to innovate risk not only missing a high-growth market opportunity but also losing reputational standing as leaders in supporting sustainable and resilient agriculture in Tanzania.

Development and Climate Adaptation Benefits

The rapid, strategic deployment of solar irrigation solutions represents a critical intervention with significant benefits including both socioeconomic development and climate resilience. Each of these benefits has a direct financial gain for potential lenders: food security improvement lowers potential for loan defaults; empowering women farmers unlocks DFI capital with gender-lens; SDG alignment attracts concessional co-financing; and the climate co-benefits (adaptation and mitigation) enable green bonds issuance.

a. Enhancing Food Security and Reducing Climate Risk

Solar irrigation directly increases the resilience of food production by decoupling crop yields from erratic rainfall. SWPs enable previously rainfed farms (and crops) to adapt to water stress and unpredictable rainfall patterns, improving yields and profitability. This enables consistent, year-round cultivation of staple and nutritious crops, increasing both household food reserves and market supply stability. The shift from rainfed to irrigated farming can double or triple yields per unit of land (FAO, 1999), ensuring that more production reaches the consumer, particularly during periods of climatic stress.

b. Gender Empowerment and Inclusive Growth

The adoption of solar water pumps (SWPs) has gender-transformative effects. In traditional systems, women bear the majority of the time-consuming and labour-intensive burden of fetching water for both domestic and agricultural use. SWPs significantly reduce this drudgery and time poverty, saving women an average of 4.5 hours per week on water collection alone, freeing up their time for education, income-generating activities, or participation in community decision-making. Furthermore, access to irrigation empowers women farmers with control over high-value vegetable plots, leading to increased control over income and improved household dietary outcomes (Efficiency for Access and 60 Decibels., 2021)

c. Economic Efficiency and Market Stability

Solar irrigation drives economic efficiency by replacing expensive, polluting, and maintenance-heavy fossil fuel use with free, clean solar energy. Compared to diesel alternatives, solar pumps cost 2.5x less over their lifetime and can reduce CO_2 emissions by 3480 kg annually. (SwitchON Foundation, 2024) T This operational efficiency increases farm profitability and transfers savings back into the local economy. At a macro level, the adoption of irrigation, powered by solar, increases predictable output and reduces price volatility in local markets, contributing to overall economic stability (FAO, 2024).

d. Environmental and Climate Mitigation Co-Benefits

The environmental benefits are significant:

- Climate Mitigation: Every solar pump that replaces a diesel pump avoids the associated CO_2 emissions, supporting Tanzania's Nationally Determined Contributions (NDC) goals.
- Water Management: When coupled with efficient water delivery systems (like micro-drip irrigation), SWPs promote significantly better water-use efficiency compared to traditional flood irrigation (Phali, Mudhara, Ferrer, & Makombe, 2022).When combined with drip irrigation and/or other systems farmers are able to achieve 40-80% water savings. (Burney, Woltering, Burke, Naylor, & Pasternak, 2010)
- Air Quality: Eliminating diesel/petrol use reduces local air and noise pollution in farming communities.

e. Alignment with National and Global Goals

The scaling of solar irrigation is strongly aligned with key national and global development agendas:

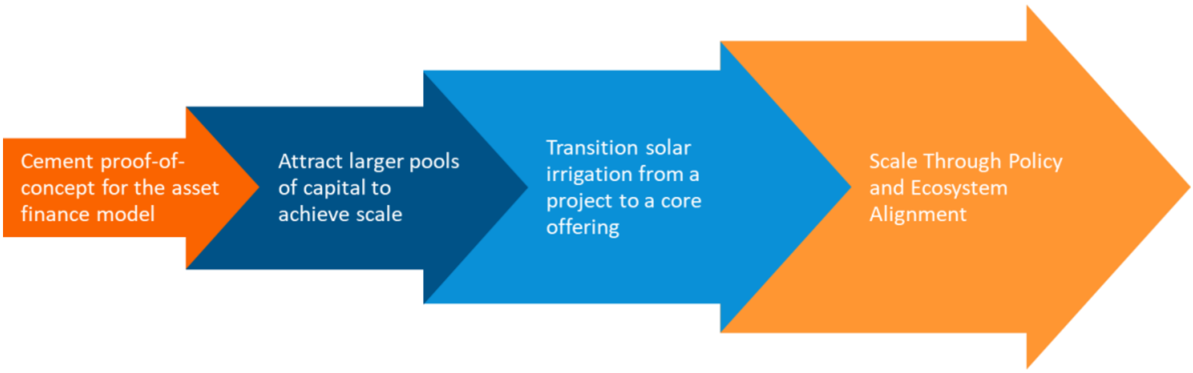
- **Tanzania's Agenda:** It supports the "Kilimo Kwanza" (Agriculture First) initiative and the country's Irrigation Master Plan by promoting efficiency and expanding irrigated land.
- **SDGs:** It directly contributes to SDG 1 (No Poverty), SDG 2 (Zero Hunger), SDG 5 (Gender Equality), SDG 7 (Affordable and Clean Energy), and SDG 13 (Climate Action).

Implementation and Scaling Pathway

Scaling the adoption of SWPs from niche intervention to a national market force requires a coordinated, multi-stakeholder strategy that a **leading commercial bank** can catalyse. The pathway to mass adoption is anchored in addressing three primary systemic constraints:

1. overcoming the initial investment barrier for smallholder farmers **(Addressing the high upfront cost through tailored asset finance products)**.
2. establishing a robust, quality-assured supply chain **(Ensuring farmers have access to reliable, warrantied systems and after-sales support)**; and
3. ensuring the long-term sustainability of the underlying groundwater resource **(Water use governance – Mitigating the risk of resource depletion)**. This implementation strategy outlines a phased approach focusing first on de-risking financial products, followed by market and ecosystem alignment, and culminating in policy frameworks that secure the long-term viability of solar-powered agricultural irrigation growth.

Figure 6: Scaling Pathway for Solar Irrigation



Step 1. Pilot Lending and Demonstration Projects

The initial phase should focus on establishing a proof-of-concept for the asset finance model, not the technology itself.

- **Focus Areas:** Target regions with **scientifically proven shallow groundwater** or reliable surface water access, such as the Lake Zone or selected areas within the Southern Agricultural Growth Corridor of Tanzania (SAGCOT), **and where a clear market exists for high-value or high-yield crops to ensure farm profitability and loan repayment. Water availability is a primary precondition for lending.**
- **Partners:** Select 1–2 reliable solar water pump suppliers with strong after-sales networks (e.g., those supported by TAREA) and **leverage the Bank's own existing** established rural outreach **network.**
- **Action:** Launch a pilot with 500–1,000 smallholder farmers, offering a structured loan product with a maximum 36-month tenor **(chosen to align with the typical productive life of a crop and to**

minimize the bank's initial exposure and asset depreciation risk in a new asset class) and embedded mobile PAYG/remote monitoring to validate repayment capacity, collect critical data on default rates, and refine risk pricing. Design a parallel pilot that finances agricultural off-takers (e.g., aggregators, processors) on the condition they sign guaranteed minimum-price contracts with smallholder farmers. This secures a market for the farmers and provides secondary comfort for the smallholder loan. The pilot should embed targeted Technical Assistance (TA) from the start, focusing on training farmers in water-efficient irrigation techniques to maximize pump productivity, reinforce the repayment capacity, and ensure sustainability of the water source. Proactive Policy Advocacy: Partner with the Ministry of Water/Relevant Regulatory Body to proactively highlight the risk of maladaptation and promote the early development and enforcement of sustainable groundwater abstraction policies. This protects the Bank's investment and prevents resource depletion.

- Measure: KPI setting. Examples of KPIs may include: repayment rate, farmer income rise, water utilization rate, groundwater level (audited quarterly or biannually for sustainability purposes). KPIs should have specific numbers attached as targets.

Step 2. Aggregation and Co-Financing Partnerships

Successful pilots must be quickly followed by efforts to attract larger pools of capital to achieve scale.

- Financial Leverage: While the Bank can act today by financing off-takers and their suppliers (see Step 1), sustained scale can be accelerated by securing concessional lines of credit or first-loss guarantees from Development Finance Institutions (DFIs) and NGOs (e.g., AfDB, GCF, Aceli). This support is used to further de-risk the commercial bank's portfolio, allowing them to offer more favourable rates and longer tenors to farmers.
- Technical Assistance (TA): Partner with NGOs (e.g., AgriFin, IWMI) to provide targeted TA to both the financial institution (on structuring the asset finance product and on targeting the investments to appropriate geographical locations) and the farmers (on water-efficient irrigation techniques) (AgriFin, 2020).
- Policy Advocacy: Collaborate with the Tanzania Renewable Energy Association (TAREA) to advocate for the official recognition of SWPs as agricultural implements eligible for tax exemption, reducing the final cost for the farmer.

Step 3. Embed Adaptation Lending in Core Agri-Finance Products

Once the viability is proven and the bank's confidence in the asset class is established, solar irrigation finance must transition from a project to a core offering.

- Mainstreaming: Integrate SWP finance as a standard, eligible asset under the bank's existing green finance or sustainability-linked loan categories.
- Internal Capacity: Develop internal risk models and credit scoring tools that factor in the positive impact of irrigation on farm resilience, allowing for risk-based pricing that rewards climate adaptation.
- Distribution: Utilize existing channels, such as agricultural extension officers and established MFI networks, to rapidly scale the lending product across the bank's national footprint.

Step 4. Scale Through Policy and Ecosystem Alignment

Sustained, systemic scale requires broad-based regulatory and institutional support.

- **Government Buy-in:** Leverage the renewed focus on agriculture transformation, specifically the **Agriculture Sector Development Programme (ASDP-II)**, to secure public-private partnerships that subsidize the system's capital expenditure or lower the cost of credit.
- **Water Management Policy:** Support the Ministry of Water in developing and enforcing sustainable groundwater management and abstraction policies to ensure the long-term viability of the investment and prevent resource depletion or degradation due to maladaptation. (IWMI & Efficiency for Access Coalition, 2021).
- **Standards Enforcement:** Collaborate with the Tanzania Bureau of Standards (TBS) to develop and enforce quality standards for SWP components, protecting consumers and preserving market integrity.

Impact Tracking Integrate key KPIs into lending programs, loss reduction (%), repayment rate (%), and value preserved (USD), to measure adaptation impact and attract green capital inflows. The effectiveness of adaptation investments must be measured not only by initial uptake but by tangible outcomes linked to financial stability. To address this, key performance indicators (KPIs) for lending programs must integrate A&R outcome measurements that the bank can directly link to both credit risk reduction and customer resilience.

A&R Outcome Measurements for Financial Institutions:

Resilience Component	Outcome Metric (Customer Resilience)	Financial Translation (Bank Risk Reduction)
Reduced Sensitivity	**Loss Reduction (%):** Decrease in yield/asset loss from climate shocks (e.g., drought, flood) compared to a control or baseline, demonstrating reduced operational sensitivity.	**Reduced Probability of Default (PD):** Stabilized borrower cash flow, leading to improved repayment rate (%), lower default risk, and fewer restructured loans.
Increased Adaptive Capacity	**Value Preserved (USD):** Increase in market value of collateral or productive assets (e.g., livestock, equipment, harvested crops) due to protective measures (e.g., cold storage, irrigation).	**Reduced Loss Given Default (LGD):** Higher recoverable value of collateral and faster post-shock recovery time, minimizing potential loan losses.
Systemic Stability	**Access to Services (%):** Percentage of customers retaining access to critical services (e.g., digital advisory, energy, water) immediately following a major shock.	**Portfolio Stability:** Lower covariance of defaults across the portfolio during climate events, reducing systemic risk concentration.

Integrating these key A&R outcome measurements, such as **Loss Reduction (%)** and **Value Preserved (USD)**, into lending programs is essential. This not only allows the bank to internally track de-risking benefits but also serves as the necessary evidence base to attract concessional or green capital inflows from external investors who require demonstrable climate impact. This approach aligns with frameworks from organizations like GOGLA, which emphasize measuring the positive adaptation and resilience impact of investments to drive scale.

RESOURCES

This brief directly builds on the following technical report:

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