POWER FOR ALL

From Farm to Market: Tackling Value Chain Inefficiencies with Decentralized Renewable Energy in Uganda and Ethiopia

November 2025

Contents

Acknowledgements

Power for All is a global campaign accelerating market transformation in the energy sector to end energy poverty faster through decentralized renewable energy (DRE). Decentralized renewables, particularly solar appliances and systems for households, businesses, and productive use, offer the fastest, most affordable, and cleanest path to modern energy for all. Power for All drives innovation, shapes markets, and advances policy to achieve that goal.

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1. Introduction

1.1 Background and Context

Uganda and Ethiopia are agrarian economies: agricultural performance is central to national development. Uganda has a population of about 50 million people, and Ethiopia has about 120 million. Both are mostly young, rural populations: roughly 3 quarters of citizens live in rural areas, and agriculture is the main source of employment (Gashaye, Liu, & Li, 2025; World Bank, 2025). Agriculture contributes 24% of GDP and 68% of employment in Uganda (ITA, 2023), and about 30% of GDP and nearly 80% of employment in Ethiopia (Wade, 2020).

Access to modern infrastructure is uneven. Electrification has improved in recent years, but there are significant rural–urban disparities. In 2023, electricity access in Uganda was at 76% in urban areas and 42% in rural areas, while in Ethiopia the rates were 94% and 43%, respectively (ESMAP, 2025). This rural energy gap limits productivity and the modernization of agriculture, which remains the backbone of food security and rural livelihoods in both countries.

In this context, decentralized renewable energy (DRE) has emerged as an alternative to centralized grid expansion. Unlike grid-based systems, reliant on large-scale plants and transmission infrastructure, DRE is generated and distributed on a small, local scale, close to where it's consumed. Productive use of energy (PUE) refers to energy uses that generate income, particularly in agriculture, like electric-powered machinery for milling or processing.

DRE can increase productivity and income through irrigation, mechanization, milling, refrigeration, and related functions (Power for All & CLASP, 2024; FAO, 2021; ENDEV, 2021; Efficiency for Access, 2023). In Ethiopia, electrification of smallholder agriculture, through technologies like solar water pumps, grain mills, and chillers, is estimated to represent an economic opportunity of approximately USD $4 billion (Wade, 2020).[1]

But barriers remain. Financing constraints limit adoption by smallholders, and systemic challenges in agricultural value chains often reduce the effectiveness of energy interventions. Where farmers lack reliable storage or access to markets, for example, increased production enabled by irrigation or mechanization may not translate to higher incomes (FAO, 2023).

These dynamics highlight the importance of addressing energy access alongside other structural constraints, and the need to look at gaps across the value chain, rather than just focusing on (increasing) production.

1.2 Methodology and Scope

This study focuses on 4 strategically chosen value chains: dairy and matooke in Uganda, and maize and teff in Ethiopia. These commodities were selected because of their importance for national food security and rural livelihoods, and because of the potential for productivity gains if energy constraints are reduced. Our analysis considers all stages of the value chain: production, post-harvest handling, processing, transport, and marketing. We then identified where energy access is most critical for reducing losses and adding value.

The research employed a mixed-methods approach:

» **Primary fieldwork** was carried out in Uganda and Ethiopia. This involved focus group discussions with smallholder farmers and cooperative members, and key informant interviews with stakeholders like farmers,

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processors, transporters, distributors, DRE companies and market vendors, as well as experts from universities and government agencies working in these sectors. To ground the analysis in the real world, our team also observed production, processing and trade in off-grid settings.[2]

» **Secondary research** drew on peer-reviewed studies, government statistics, institutional reports (e.g. FAO, CLASP), and prior Power for All work. This provided benchmarks on yields, losses, technology adoption and energy access.

This approach ensured that qualitative insights from stakeholders were anchored in quantitative evidence, allowing cross-context comparisons while preserving local specificity. While a comprehensive financing gap analysis was beyond the scope of this study, a targeted review of secondary literature and existing programs was conducted, to capture key constraints and opportunities at the nexus of energy and agriculture. A dedicated section on financing (Section 6) summarizes these findings. The findings from this report, including the cost-benefit analysis developed by this study, can provide a basis for future finance-focused work.

1.3 The Motivation: The Nexus Between Energy Access and Economic Development

Existing research has established how energy enables specific agricultural processes, like irrigation, mechanization, storage and processing. But most studies either treat energy access in general terms, or focus on isolated interventions. Few attempt to systematically align energy solutions with the full set of inefficiencies along agricultural value chains.

This report seeks to fill that gap, by analyzing 4 value chains end-to-end. We map where bottlenecks coincide with energy gaps that DRE can realistically address - bottlenecks like low yields due to reliance on rainfall, high post-harvest losses, costly processing, and poor market access. By linking these inefficiencies to tailored DRE interventions, our analysis moves beyond siloed approaches to demonstrate how energy and agricultural upgrading must support each other.

This approach:

1. Identifies which technologies are most relevant at each stage of the chain (e.g. solar pumps at production, dryers and hermetic storage post-harvest, solar mills and mini-grids at processing, electrified transport and digital tools at the market interface).
2. Identifies the priority technological interventions — by using a scorecard to quantify both feasibility of the intervention and its economic impact (from quick, low-cost wins at the farmgate to high-capital investments that anchor structural transformation).
3. Provides an evidence base for integrated policy and investment planning, showing how energy access can be mainstreamed into agricultural development strategies.

The report's findings are relevant to all key players in the four value chains, including: farmers, transporters, and other agricultural workers; private sector stakeholders (like DRE companies); financial institutions; donors; and energy and agriculture policymakers. It highlights the benefits of a coordinated approach to rural development.

When coupled with PUE such as irrigation, milling, refrigeration, and mechanization, DRE can boost yields, cut losses, and create new income and employment opportunities.

2. Powering Uganda's Dairy Value Chain

2.1 Introduction

The dairy sector is key to Uganda's agricultural economy, contributing around 9% of agricultural GDP and supporting rural livelihoods, food security, and national income (Makerere University, 2024). Under the Dairy Development Authority, the sector has grown steadily: milk production has increased by over 50% between 2018 and 2023, to 3.85 billion liters, due to higher productivity in the Central and Southwestern regions (Dairy Business Middle East & Africa, 2024). Uganda's exports were worth USD $264.5 million in FY 2022/23, making it a net exporter in East Africa (DDA, 2023).

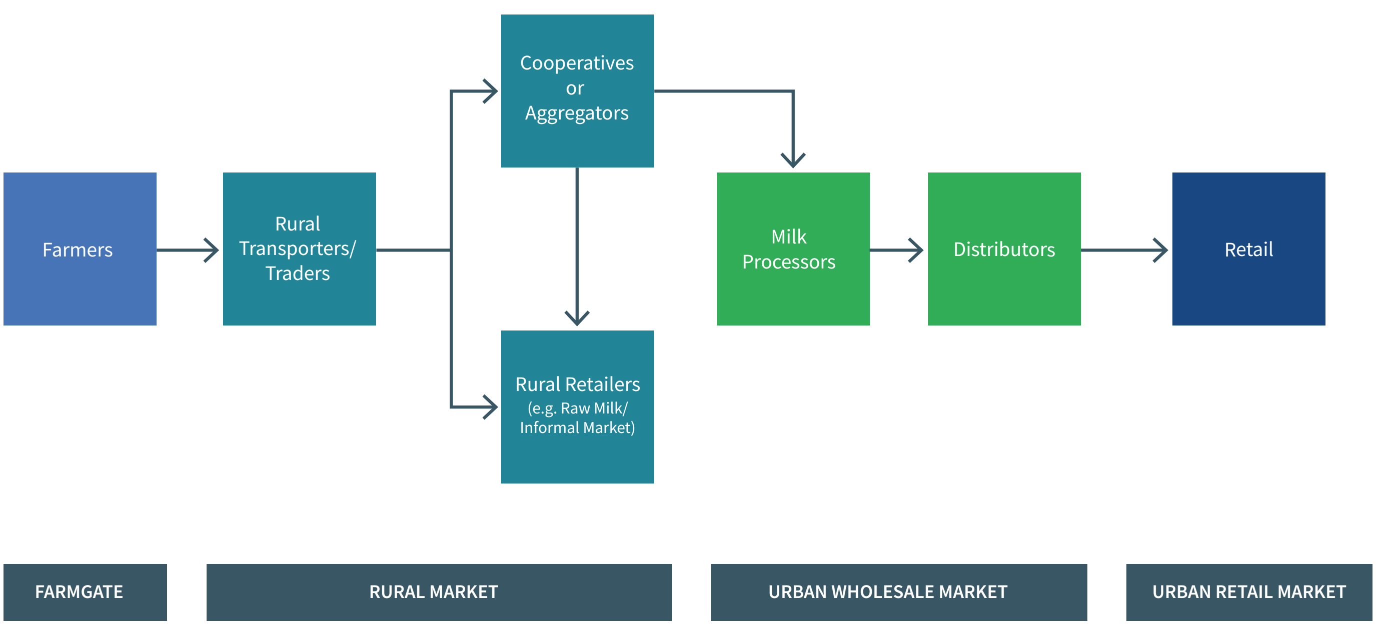
Despite this, inefficiencies and infrastructure gaps persist. Smallholders, who produce 95% of Uganda's milk, face poor access to veterinary care, feed, water, and cold storage. Downstream, transport bottlenecks, seasonal shortages, informality, and processing concentration (oligopoly) limit competitiveness. Across the value change, energy poverty[3] is the most binding constraint (Expert Interviews, 2025). Rural electrification is at just 42% and is unreliable, hindering key activities like milking, chilling, transport, and processing (ESMAP, 2025). DRE offers a viable solution, but adoption of solar-powered chillers, cold rooms, and processing equipment remains low.

2.2 The Dairy Value Chain: Overview

Uganda's dairy value chain is a complex network of formal and informal actors. Formal channels handle only 34% of marketed milk, while informal channels dominate, supplying affordable raw milk to consumers but limiting processors' throughput (Ariong & Van Campenhout, 2023). This creates seasonal shortages, reduces processed output, and undermines export competitiveness (Kanire et al., 2024).

Figure 1 shows a simplified version of Uganda's dairy value chain. There's a more detailed description, including the key actors, the economics, and specific examples from Ugandan farms, in the Appendix. Most farmers are smallholders based in Western and Central Uganda, who produce under 5 liters per cow on average, with regional disparities (6.6 liters in the Central region versus 2.9 liters in Karamoja). Milk not consumed on-farm is sold to rural transporters, traders, or directly to neighbors, with quality often dictating whether it enters formal or informal markets (DDA, 2023).

FIGURE 1: DAIRY VALUE CHAIN IN UGANDA



Note: Value chain mapping developed by Power for All based on primary and secondary research.

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Milk collection centers (MCCs), usually cooperatives or aggregators, aggregate and cool milk before it's sold to processors. Uganda has 729 registered MCCs, totaling 791 coolers and 2.76 million liters of capacity (DDA, 2023). Larger MCCs test quality with analyzers, while smaller cooperatives rely on farmer honesty[4], with testing deferred to processors. Rejected milk is diverted to informal markets (Expert Interviews, 2025).

Processing turns raw milk into consumable and value-added products, and connects producers to domestic and regional markets. Uganda's installed capacity is 2.9 million liters per day, but the actual output is lower, due to seasonal fluctuations, quality issues, and competition from informal channels. The sector has 130 processing facilities, but is dominated by the 3 largest ones: Pearl Dairy (500,000 L/day), Sameer Agriculture and Livestock Ltd (250,000 L/day), and JESA Dairy (100,000 L/day) (Ariong & Van Campenhout, 2023). Most small and medium processors focus on pasteurized milk, yogurt, ghee, and local products like "bongo."

The sector's transport infrastructure includes 193 registered milk tankers (78.6% insulated) and 145 processing facilities of varying scale (Ariong & Van Campenhout, 2023). Processed products reach consumers through processor-owned or third-party distribution networks, ending at supermarkets and small shops and with street vendors.

Each year, Uganda's dairy sector earns USD $264.5 million in exports and contributes over USD $1 billion to the country's GDP, but its inefficiencies are great.[5] Farmgate prices range from USD $0.19–0.55 per liter, with smallholders in informal channels earning the least. Medium-scale farms with better cattle breeds and feed earn 7 times more, highlighting a productivity gap. Energy costs make up 8–12% of final product prices, showing that efficiency along the value chain is key for competitiveness (Expert Interviews, 2025).

2.3 Value Chain Inefficiencies

Dairy is one of Uganda's most dynamic agricultural sectors, but inefficiencies persist at each stage of the value chain: on-farm production, collection, processing, and retail. On farms, water scarcity, feed inefficiencies and labor-intensive practices limit productivity. At the collection stage, cold-chain gaps and diesel dependence lead to high product rejection rates and significant losses. Processors often can't work to capacity, with frequent outages and seasonal supply fluctuations that make prices less competitive. Downstream, limited access to reliable refrigeration limits products' shelf lives, consumer confidence, and export readiness. A summary of the key inefficiencies and opportunities identified across the dairy value chain is provided in Table 1 below.

TABLE 1: SUMMARY OF KEY INEFFICIENCIES ACROSS THE DAIRY VALUE CHAIN

Stage	Key Inefficiencies	Energy Opportunities
Farm	Water scarcity, costly diesel pumping, feed inefficiency, manual fodder cutting, poor hygiene from lack of lighting	Solar water pumps, solar-powered chaff cutters, solar lighting
Collection	No cold storage, diesel reliance at MCCs, frequent outages, bacterial spoilage	Solar-powered milk chillers, solar dryers for value addition
Processing	Underutilized installed capacity, outages causing spoilage, seasonal volatility	Dairy cluster mini-grids, energy-efficiency retrofits (solar water heating, variable speed drives, heat recovery)
Retail/Markets	No cold storage, product shelf life halved, low consumer price premium due to poor quality, weak export readiness	Solar kiosks, IoT-enabled cold chain monitoring, decentralized micro-cold storage

2. Powering Uganda's Dairy Value Chain

ON-FARM PRODUCTION INEFFICIENCIES

Water scarcity remains the largest production risk, with dry-season output dropping by up to 50%. Farmers without electricity for pumping spend 3-4 hours daily collecting water — time lost to other productive work — while those using diesel pumps face monthly costs of USD $14-22. Sometimes, expensive short-term emergency measures are also needed: in Kiboga District, one cooperative purchased a 10,000-liter water bowser for USD $1,360, repaid over 6 months, to hydrate cows.

A lack of electricity also slows down feed processing and milking. Without mechanized chaff cutters, feed production efficiency falls by 30%, as farmers spend 2–3 hours daily manually cutting grass. The inability to process and store feed also prevents farmers from bulk buying during surplus periods, raising costs. And without reliable lighting, both milking productivity and hygiene are undermined, with a higher risk of contamination during early or late milking times. The latter results in lower milk quality (Expert Interviews, 2025).

COLLECTION AND STORAGE INEFFICIENCIES

Cold chain gaps are the largest single barrier to efficiency and value addition across the value chain. Without access to milk chillers or refrigerated storage, farmers are forced to sell their milk immediately after milking, limiting bargaining power and locking them into lower-value informal markets. MCCs like Dwaniro Dairy Cooperative stop accepting milk after 10:30 am, and in non-grid areas, rejection rates are 3 times higher than in electrified zones, due to temperature violations (Expert Interviews, 2025).

Without cold chain infrastructure, even modest increases in production risk waste, which discourages investment in improved practices. Cold storage, in this context, is not a luxury, but a missing link that prevents smallholders from moving up the value chain. More than half of Uganda's 729 MCCs are not grid-connected, forcing reliance on diesel generators that cost USD $680-952 monthly for a 5,000-liter facility (Expert Interviews, 2025). And even among the grid-connected, power outages — averaging 3 per week — break the cold chain, leading to quality degradation, and ultimately milk rejection: when not refrigerated, milk's bacterial count increases by 200% within just 4 hours. As milk is unsuitable for higher-value processing, farmers are then forced to sell lower-value raw milk or result in complete losses. The economic impact extends beyond immediate losses, to include damaged relationships with processors and lower future prices.

PROCESSING INEFFICIENCIES

At the processing stage, Uganda's installed capacity of 3.4 million liters per day is underutilized, with actual throughput averaging 2.3 million liters (68.7% of installed capacity) (DDA, 2023). This is due to the combined effects of inconsistent milk supply and unreliable electricity. Large processors operating below capacity face higher fixed costs per unit, reducing profits and limiting investment in technology or expansion. Field research shows that power outages, which cause equipment stoppages and quality degradation, are estimated to contribute to 10–15% of production losses. Annual spoilage rates of 2–6% —worth roughly USD $16 million — likely understate the full economic impact, as they exclude lower-value products (DDA, 2023).

Seasonal fluctuations exacerbate the problem, with capacity utilization ranging from 30% in the dry season to 80% in the wet season. This volatility disrupts workforce stability, means workers lose skills, and deters investment in export-oriented production, since this demands consistent volumes and quality. Concerns over energy reliability also discourage investment in value-added products, such as yogurt, that require precise temperature control.

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MARKET ACCESS AND RETAIL INEFFICIENCIES

In Uganda's informal dairy sector, post-harvest milk losses are substantial. This is mainly due to spillage and spoilage, caused by poor access to markets, poor milk handling practices, and irregular power supplies (Katongole, 2023). At the retail level, most milk in Uganda is sold in the informal market, with formal channel distribution accounting only for about 9% of production. Over 35% of retail outlets lack reliable cooling systems, and small retailers cannot afford backup power systems or independent refrigeration units (DDA, 2023).

These infrastructure gaps directly impact product quality and shelf life. The total bacterial count in milk from collection centers was significantly higher than in milk at farms, with only 13.3% of samples from centers meeting the microbiological criteria for processing for human consumption (Sugino et al., 2023). Without reliable cooling, shelf life is effectively halved, limiting geographic reach and forcing retailers to operate on compressed timeframes and to sell raw milk rather than processed products, which increases risks and reduces profitability (Expert Interviews, 2025).

This drives a cycle that limits value addition and sector development. Quality lapses reduce consumer trust and demand for processed milk products. Equally, informal marketing channels and inconsistent quality standards limit Uganda's export readiness. Evidence from the region, however, shows that there's consumer demand for quality-assured dairy. In Uganda's southwestern milk shed[6], for example, processors have expressed willingness to pay for higher quality milk, and there is a demonstrated 20–30% consumer premium for assured quality (Ariong et al, 2024).

2.4 Energy Opportunities and Cost-Benefit Analysis

DRE has immense potential across the value chain. It enables farmers to secure water and feed, cooperatives to extend cold storage, processors to stabilize throughput, and retailers to deliver safe, high-quality products. Some interventions, like solar lighting and chaff cutters, deliver immediate payback and quality improvements. Others, like solar chillers, dairy cluster mini-grids, and energy-efficiency retrofits, unlock systemic gains that reduce costs and expand market access. Through strategic, sequenced DRE investments, Ugandan dairy could shift from an inefficient, subsistence-oriented system to a resilient, competitive, and export-ready sector.

ON-FARM PRODUCTIVITY: WATER, FEED AND HYGIENE

Solar water pumps are often the best way to address water scarcity. They're available through the Uganda Energy Credit Capitalisation Company (UECCC) program until 2027. They can reduce irrigation costs by 90% and stabilize milk yields — though their upfront costs (USD $1,100–3,800) are out of reach for smallholder farmers, requiring cooperatives or other types of financing.

Each year, Uganda's dairy sector earns USD $264.5 million in exports and contributes over USD $1 billion to the country's GDP, but persistent inefficiencies continue to hinder its growth.

Meanwhile, solar-powered chaff cutters can improve feed efficiency by saving farmers time and money. Costing USD $500–700, they improve feed digestibility, boost milk yields, and will break even in 1-2 years. And finally, solar lighting systems for early and late milking periods (USD $400) pay for themselves in under a year by reducing contamination and helping farmers to access formal markets, where premium prices are offered for higher-quality milk (Expert Interviews, 2025).

POST-HARVEST HANDLING AND COLLECTION: COLD CHAIN AND VALUE ADDITION

Solar-powered chillers are a powerful cold storage solution. Direct-drive solar systems with thermal storage can cool 500–5,000

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Through strategic, sequenced DRE investments, Ugandan dairy could shift from an inefficient, subsistence-oriented system to a resilient, competitive, and export-ready sector.

liters of milk per day, eliminating reliance on diesel and reducing spoilage. Converting Uganda's 291 diesel-reliant MCCs to solar would require a USD $5.8 million investment, with a payback in just over 2 years[7] and annual savings of USD $2.3 million in fuel costs plus USD $1.2 million in prevented losses. Solar chillers also improve farmer bargaining power by extending shelf life, allowing cooperatives to delay sales until prices improve. Pairing chillers with handheld, solar-powered analyzers and simple Internet of Things (IoT) temperature logs at MCCs can further raise quality assurance without grid dependence. And extended holding times take the pressure off transport, enabling bulk routing and fewer, fuller tanker runs.

Solar dryers also offer a complementary opportunity for value addition in the dairy value chain. Drying dairy prevents spoilage and increases shelf stability, reducing losses. But equally, solar driers can be used to make processed products, like powdered milk and casein, which have higher values added than (unprocessed) milk, so can diversify revenue streams.

PROCESSING AND VALUE ADDITION: CLUSTER RELIABILITY AND EFFICIENCY

Mini-grids designed for dairy clusters — 5–10 km catchments of farms, MCCs and processors — can increase the capacity utilization of processors and MCCs, while extending electrification to surrounding households. Though capital costs are high (USD $300,000–400,000 per cluster), the internal rates of return are 18–22% per year. That makes them commercially attractive, when dairy operations provide anchor demand (Expert Interviews, 2025).

Cluster mini-grids should also bundle energy-efficient retrofits, like solar water heating, heat recovery systems, and variable-speed drives. These can cut processing energy costs by 30–50%, with paybacks under 2 years. These savings improve Ugandans' competitiveness against other East African producers, and free capital for further investment.

MARKET ACCESS AND RETAIL: SHELF LIFE, QUALITY AND TRUST

At the retail level, cold chain gaps can be filled by decentralized solar kiosks and IoT-enabled cold storage. These are among the most affordable cooling technologies, costing $500-2,000, with short payback periods (2-3 years). Cold storage at the retail level can extend shelf life, reduce spoilage, and enable vendors to charge a 20–30% premium for quality-assured products. Beyond domestic markets, these technologies are prerequisites for meeting export standards, so would help Uganda to expand its regional and international sales.

COMPARATIVE COST–BENEFIT ANALYSIS OF ENERGY OPPORTUNITIES

While each intervention addresses a different bottleneck in Uganda's dairy value chain, their relative costs, payback periods, and systemic impacts vary widely. Low-cost technologies such as solar lighting and chaff cutters provide immediate productivity and quality improvements at the farm level, while higher-capital assets like solar chillers and cluster mini-grids require more coordination, but dramatically reduce milk spoilage and enable access to new markets. Table 2 synthesizes the economics and co-benefits of the most relevant DRE technologies, providing a comparative lens for prioritization and sequencing.

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TABLE 2: COMPARATIVE COST-BENEFIT ANALYSIS OF KEY SOLAR INTERVENTIONS ACROSS THE DAIRY VALUE CHAIN

Stage	Intervention	Problem Addressed	Typical Cost (USD)	Annual Benefits	Payback Period	Non-Monetary Benefits
Farm	Solar water pumps	Dry-season yield drops; high diesel and labor costs	$1,100–3,800	Stable milk yields; diesel savings; labor savings	~5 years	Drought resilience; time savings
Farm	Solar chaff cutters	Manual feed cutting - 30% feed inefficiency	$500–700	+30% feed efficiency; higher milk yields	1–2 years	Reduced drudgery, especially for women
Farm	Solar lighting	Poor hygiene/ contamination during milking	$400	Improved quality; reduced spoilage	<1 year	Safer work; access to formal markets
Collection	Solar milk chillers	Spoilage and diesel costs at MCCs	$8,000–25,000	USD $2,176 per year diesel savings; 15–30% spoilage reduction	2–3 years	Farmer bargaining power; CO_2 savings
Collection	Solar dryers[8]	Spoilage; lack of value addition	$500–1,500	Reduced spoilage; entry into new products	1–2 years	Diversification; shelf-stable products
Processing	Dairy mini-grids	Grid unreliability; underutilized plants	$300,000–400,000 per cluster	Stable supply; value addition enabled	7–10 years	Rural electrification; export competitiveness
Processing	Energy efficiency retrofits	High energy costs in processing	$50,000–100,000 per site	30–50% savings in energy cost	<2 years	Capital freed for reinvestment
Retail and Markets	Solar kiosks and IoT cooling	Short shelf life; quality distrust	$500–2,000	Extended shelf life; premium prices (+20–30%)	2–3 years	Consumer trust; export compliance

Taken together, these interventions show that DRE solutions are not just about reducing energy costs, but about restructuring Uganda's dairy sector around efficiency, quality, and resilience. Quick-win tools, like lighting, chaff cutters, and solar chillers, can be rolled out rapidly, delivering immediate savings and stabilizing farmer incomes. In parallel, cluster-level mini-grids and processing efficiency upgrades prepare the sector for scale, unlocking consistent throughput, export readiness, and greater competitiveness in regional markets. Sequencing these investments, from fast-payback farm tools to cooperative and processor-level systems, ensures that gains are both inclusive and sustainable, positioning dairy as a pillar of Uganda's agricultural transformation.

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2.5 Recommendations and Next Steps

Energy access drives competitiveness, resilience, and growth. Sequencing interventions from quick-win technologies to larger infrastructure creates a clear pathway for the sector to move from vulnerability to value creation, while building the institutional and financial foundations for long-term transformation.

Quick-Win Technologies at Farm-Level. Low-cost solutions like solar chaff cutters and lighting should be prioritized. These systems pay back in 1-2 years, directly increase milk yields, reduce contamination, and ease women’s labor burdens.[9] Solar water pumps, while more capital-intensive, are critical for resilience in the dry season. With UECCC’s subsidy window open through 2027, there is a time-bound opportunity to expand pump adoption through cooperative procurement and Pay-As-You-Go (PAYGo) repayment models.

Scaling Cold Storage at MCCs. Solar-powered chillers are the single most impactful way to reduce losses and improve bargaining power. Converting Uganda’s 291 diesel-reliant MCCs could save USD $2,176 per center annually in fuel and prevent quality-related rejections. And the barriers are not only financial, but managerial: weak cooperative governance In Uganda’s dairy sector undermines confidence in shared assets. Interventions should bundle investment with governance training, digital inventory systems, and technician networks. Blended finance — mixing concessional loans, carbon credit revenues, and cooperative equity — can lower upfront costs while ensuring sustainability.

Strengthening Processing Reliability and Efficiency. Mini-grids for dairy clusters are essential to reduce underutilization of processing plants and enable value addition. While capital-intensive, their economics are sound (internal rates of return of 18–22%) when anchored in high-volume production areas. Early projects should be de-risked through donor guarantees and targeted tariff frameworks that balance commercial viability with affordability for households. Demonstration of successful dairy clusters, like the Mbarara-Kiruhura Southwestern Milk Shed, will be critical to crowd in private developers.

Expanding Tailored Finance. The single biggest barrier across the value chain is misalignment between smallholder cash flows and upfront costs. UECCC-style subsidies could be extended to productive-use equipment beyond household solar, as a temporary measure to start momentum, while guarantee schemes could de-risk cooperative lending. Embedding repayment into milk delivery contracts and supply chains can reduce transaction costs. Climate finance, carbon credits, and adaptation funds offer additional funding sources for larger infrastructure like mini-grids and chillers.

Technology Demonstration and Market Development. Perceptions of risk remain high. Farmers are more likely to adopt these technologies when they see neighbors stabilize yields with pumps or secure better prices through cold storage.

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Sequencing investments, from fast-payback farm tools to cooperative and processor-level systems, ensures that gains are both inclusive and sustainable, positioning dairy as a pillar of Uganda’s agricultural transformation.

Establishing demonstration hubs in high-output districts can showcase benefits, provide training, and anchor service networks. At the same time, partnerships with processors and exporters can help create assured markets for higher-quality milk, strengthening the business case for adoption.

Celebrating Proven Dairy Finance Models. Uganda’s dairy sector has already demonstrated successful financing innovations that should be scaled. In 2020-2022, SNV’s TIDE project helped 12 southwestern cooperatives secure USD $1.8 million from Uganda Development Bank, providing 960 farmers access to credit at 14% annual interest — 3 times more affordable than informal rates (SNV, 2021). By structuring dairy loans around seasonal cash flows and providing hands-on technical support through field visits, PostBank Uganda has seen 80% agricultural portfolio growth since 2020. At the processing level, Pearl Dairy’s IFC-GAFSP-backed model shows how off-taker co-financing works at scale: with an USD $8 million investment, Pearl established 28 milk collection centers and now sources from over 10,000 farmers, offering extension services and guaranteed loan repayments taken directly from milk proceeds. This model helped Uganda become East Africa’s leading dairy exporter (IFC, 2025).

Infrastructure financing is advancing through Heifer International’s Power Purchase Agreement model for solar chillers, which allows 5 cooperatives in Kiboga and southwestern Uganda to avoid upfront costs and pay only for electricity consumed, with projected savings of US $576,000 over the assets’ lifetime. These successes — combining cooperative strengthening, risk-sharing, and cash flow alignment — provide replicable blueprints for transforming dairy from subsistence to export competitiveness. The challenge now is strategic coordination: formalizing processor-backed financing partnerships with Sameer and JESA following Pearl’s example, extending the UECCC RBF program to productive dairy assets, and integrating proven cooperative governance models into all technology investments.

3. Powering Uganda's Matooke Value Chain

3.1 Introduction

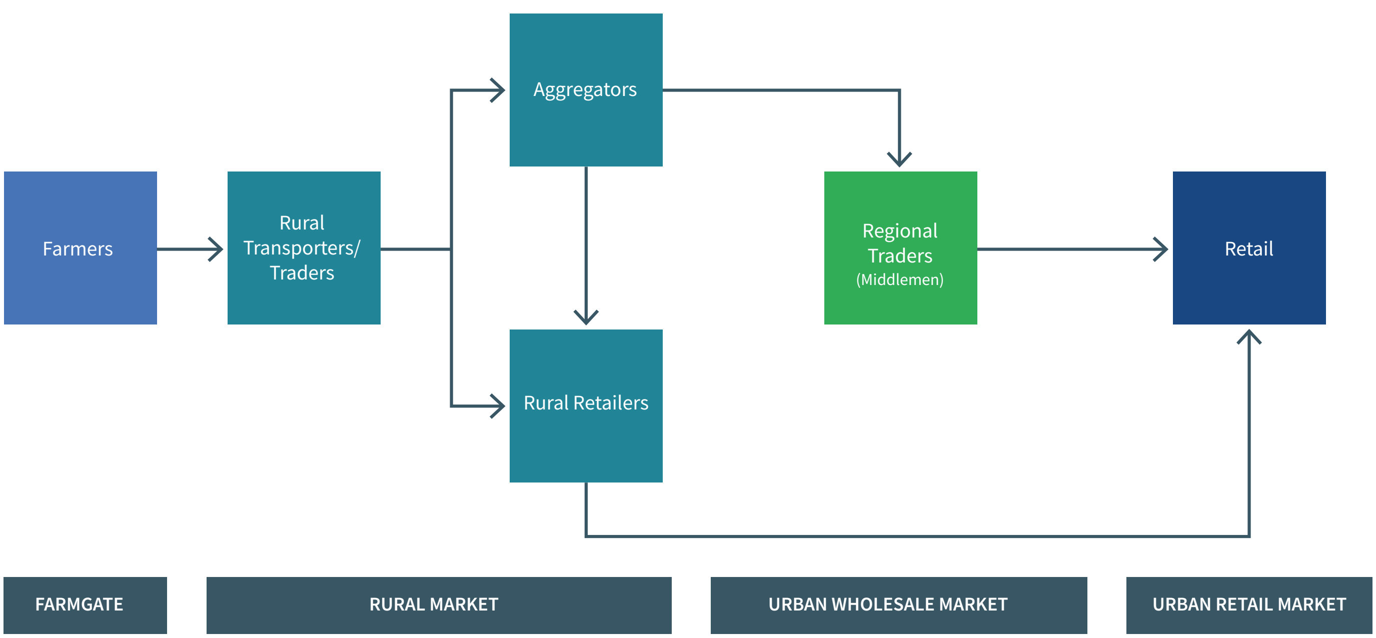
Matooke, East Africa's signature cooking banana, is both a cultural symbol in Uganda, and a key pillar for food security and rural livelihoods. It accounts for nearly 30% of the nation's daily caloric intake, and it's cultivated by millions of smallholder farmers - playing a central role in household consumption and local economies (Lee, 2023). Despite its ubiquity and resilience, the matooke value chain remains largely informal, undercapitalized, and inefficient, leading to persistent productivity gaps, significant post-harvest losses, and limited income generation for producers. Yields average just 5–30 tons per hectare, far below the estimated potential of 60–70 tons. Thai is largely due to minimal input use, labor-intensive practices, and a near-total absence of mechanization or irrigation (Expert Interviews, 2025; Lee, 2023).

The bulkiness and perishability of matooke, combined with high transport and logistics costs, further limit the value chain's development. Without access to reliable cold storage or drying technologies, farmers are forced to sell quickly — often at unfavorable prices, or after incurring losses. Fragmented markets and limited bargaining power exacerbate the issue, especially in the absence of cooperatives, transparent pricing, or standardization.

3.2 The Matooke Value Chain: Overview

At the heart of the matooke sector lie the smallholder farmers, who generally cultivate 1-10 acres each. Interviews conducted through this research reveal that a typical smallholder works without machinery or electricity, relying heavily on manual labor, sometimes aided by a handful of casual workers during peak periods. Fertilizer use varies widely: some farmers use organic mulching or homemade fertilizers, while others avoid inputs due to cost or access challenges.

FIGURE 2: MATOOKE VALUE CHAIN IN UGANDA



Note: Value chain mapping developed by Power for All based on primary and secondary research.

3. Powering Uganda's Matooke Value Chain

Production cycles last roughly 9 months, with the unique advantage that harvesting can occur any month of the year, providing a steady, though modest, income stream. Monthly outputs vary considerably, from 20 bunches per month on a small 1-acre farm to 80 bunches on a 10-acre medium farm.[10]

Postharvest losses range dramatically. Some farmers experience minimal losses (0-5%), due to careful handling or immediate sale, while others lose up to half of their harvest, due to a lack of drying, storage, or proper transportation facilities (Expert Interviews, 2025). This variability indicates uneven capacity for postharvest management, linked closely to labor availability, transport access, and infrastructure.

Once harvested, matooke is primarily sold at the farm gate or local markets. Middlemen and local traders dominate the marketing landscape, often purchasing at low prices and reselling in urban centers like Kampala, adding layers of cost and inefficiency. Market prices fluctuate seasonally and geographically, with farmers often expressing frustration about low farm-gate prices squeezed by intermediaries.

3.3 Value Chain Inefficiencies

While matooke farming provides steady income and food security for millions of Ugandan households, systemic inefficiencies reduce the crop's economic potential. These cut across the value chain: in production, low productivity, pests, and reliance on rainfed cultivation constrain supply; in transport, bulky perishable bunches and high logistics costs drive spoilage and erode margins; in aggregation and trading, weak storage, limited bargaining power, and poor coordination keep farmers as price-takers; and in retail, spoilage and informal market systems limit both quality assurance and value capture. Collectively, these inefficiencies limit farmers' incomes, weaken resilience, and hinder the sector's ability to scale. Table 3 summarizes these, as well as opportunities for DRE.

TABLE 3: SUMMARY OF KEY INEFFICIENCIES ACROSS THE MATOOKE VALUE CHAIN

Stage	Key Inefficiencies	Energy Opportunities
Farm	Manual labor, no mechanization, low business literacy, seasonal price dips	Solar irrigation, chaff cutters, lighting, training programs
Transport	Poor roads, difficult terrain, urban traffic, low value-to-volume ratio	Cold storage
Aggregation	No cold storage, spoilage, logistical constraints from matooke's bulkiness	Solar cold rooms at cooperative centers
Retail	No storage, informal markets, fragmented distribution, low profit margins	Solar kiosks, micro cold storage units

3. Powering Uganda's Matooke Value Chain

ON-FARM PRODUCTIVITY INEFFICIENCIES

On farms of all sizes, a clear pattern emerges: farmers' lack of business orientation limits decision-making based on output optimization. Most farmers interviewed have never calculated their profit margins or disposable income in detail. For small-holder farmers, bookkeeping is rare, and few consider labor time or water access as opportunity costs. There is little reinvestment in productivity-enhancing assets, and strong dependence on traditional practices like manual mulching, hand irrigation, and informal market sales. As a result, even medium-sized farms often operate like subsistence units.

The greatest constraint for matooke farms is water scarcity. During the dry season, yields can fall by up to 50%, forcing farmers to sell small volumes at depressed prices. Without electricity, many spend 2-4 hours each day collecting water manually, while others pay up to USD $1,360 per season for trucked water, an unsustainable emergency measure. In addition, tools like chaff cutters or even wheelbarrows are often missing, with labor tasks performed manually or aided by livestock. This results in high labor demands, especially for women, and caps the scale at which farmers can operate profitably.

Another critical inefficiency is seasonal price volatility, exacerbated by the lack of irrigation. Most matooke farmers rely on rain-fed cultivation with little mechanization or irrigation. The result is suboptimal yields and high labor requirements. During dry months, output drops significantly (up to 50%), constraining supply (Expert Interviews, 2025; Lee, 2023). Farmers unable to water their crops or store harvested bunches are forced to sell during gluts at lower prices, reducing income.

TRANSPORT, AGGREGATION AND STORAGE INEFFICIENCIES

Moving matooke from farms to markets is both costly and inefficient, largely because of the crop's bulkiness and low value-to-volume ratio. Farmers in districts like Kibingo and Rwampara report steep terrain and difficult access routes that make it physically challenging to get produce out of farms, especially during the rainy season. On the road, congestion on routes to Kampala delays delivery further, and increases the risk of spoilage. Because fresh matooke must be sold within days of harvest, farmers often feel compelled to accept whatever price traders offer at the farm gate.

These challenges are amplified at the aggregation stage. Traders typically collect bunches from scattered farms and rush them to town markets, but without reliable cold storage the product must be sold quickly. Postharvest losses across the supply chain range from 20% to 45% (Lee, 2023), with spoilage concentrated during collection and trading. The bulkiness of matooke, with individual bunches weighing over 20 kg, adds to logistical inefficiencies and discourages coordinated bulk sales. Middlemen frequently exploit this dynamic, extracting value from farmers who lack the means to hold their produce.

RETAIL AND MARKET INEFFICIENCIES

At the retail end, matooke is trapped in informal markets, which are localized and infrastructure-poor. Vendors often lack adequate space or facilities to store unsold produce, increasing the risk of losses. Unlike tomatoes or dried grains, matooke cannot be easily stacked or processed in small stalls, so vendors may avoid overstocking, limiting their sales potential.

These markets are also highly fragmented, with few wholesalers or centralized distributors. This prevents economies of scale and results in thin margins for vendors, further discouraging investment in storage or logistics upgrades.

3. Powering Uganda's Matooke Value Chain

Despite its ubiquity and resilience, the matooke value chain remains largely informal, undercapitalized, and inefficient, leading to persistent productivity gaps, significant post-harvest losses, and limited income generation for producers.

3.4 Energy Opportunities and Cost-Benefit Analysis

DRE technologies offer a set of targeted solutions that directly address the bottlenecks in Uganda's matooke sector. From stabilizing production with irrigation to reducing postharvest losses through cold storage and drying, and from easing labor with small-scale mechanization to extending market reach via improved lighting, these technologies offer both quick-win interventions and longer-term infrastructure. Critically, their payback periods and non-monetary benefits show that energy is not an ancillary input but a catalyst for higher productivity, stronger resilience, and new income opportunities across the value chain.

ON-FARM PRODUCTIVITY: IRRIGATION AND SMALL-SCALE MECHANIZATION

Solar-powered irrigation pumps offer an immediate productivity gain: they stabilize yields year-round, save labor time, and allow farmers to capture higher off-season prices. As a result, payback periods are quite short (2-4 years), and not relying on either rainfall or diesel (which has fluctuating prices) reduces volatility for farmers.

Small-scale solar mechanization technology, like cutters and peelers, reduces drudgery, improves product consistency, and can pay for itself in 2-3 years through saved labor and higher-quality outputs.

POST-HARVEST HANDLING AND AGGREGATION: COLD ROOMS AND DRYING

Solar-powered cold rooms at cooperative centers can extend matooke shelf life by several days, reducing spoilage and giving farmers bargaining power to negotiate prices or coordinate bulk sales. Energy-enabled drying and cold storage unlock multiple high-value markets. Export markets offer the highest returns: Uganda's Presidential Initiative for Banana Industrial Development (PIBID) successfully exports matooke flour under the "Tooke" brand to the United States, Japan, Germany and Canada, with international buyers attracted to its gluten-free properties for soups, sauces, and bakery products. PIBID pays farmers USD 0.095/kg for processing-grade bananas—up to 8 times more than fresh farmgate prices. Domestically, school feeding programs represent substantial demand, with the World Food Programme increasing local procurement fivefold, and the Ugandan Government developing its first National School Feeding Policy. Studies show that matooke porridge helps address malnutrition among Uganda's 2 million chronically malnourished children under 5 years old (Kajura, 2019). Hotels, restaurants, hospitals, and humanitarian relief programs in drought-prone regions provide additional institutional demand for shelf-stable flour and products processed from matooke.

MARKET ACCESS AND RETAIL: KIOSKS, STORAGE AND HOUSEHOLD ENABLERS

DRE-powered micro cold units or solar kiosks can help reduce spoilage and improve profitability in infrastructure-poor settings, but their adoption requires cooperative or municipal-level investment models. At the household level, simple solar systems provide benefits that extend beyond lighting. Farmers report working in early morning and late evening hours with little or no light, increasing the risk of injury and reducing efficiency. Solar lighting and charging extend safe working hours, improve security, and enable mobile money and digital connectivity — both of which are critical for participating in modern agricultural markets.

3. Powering Uganda's Matooke Value Chain

COMPARATIVE COST–BENEFIT ANALYSIS OF ENERGY OPPORTUNITIES

The range of DRE interventions for matooke varies in scale, cost and timeframe, but it offers a clear path for sector transformation. Quick-win tools like dryers, processing mechanization, and household lighting deliver immediate benefits with short payback periods, while larger cooperative-level investments like irrigation systems and cold rooms tackle systemic risks and open access to premium markets. Table 4 highlights how each intervention performs on cost, returns, and broader livelihood impacts, providing a framework for sequencing investments that balance feasibility with transformative potential.

TABLE 4: COMPARATIVE COST-BENEFIT ANALYSIS OF KEY SOLAR INTERVENTIONS ACROSS THE MATOOKE VALUE CHAIN

Stage	Intervention	Problem Addressed	Typical Cost (USD)	Annual Benefits	Payback Period	Non-Monetary Benefits
Farm	Solar water pumps	Dry-season yield drops (up to 50%), price volatility	\$1,000–3,000	+30–50% yield stabilization; +10–20% higher off-season prices	2–4 years	Saves 2–4 hrs per day; improved drought resilience
Farm	Solar mechanization (e.g., cutters, peelers)	Manual labor burden, low productivity	\$500–1,500	Higher product quality; reduced labor costs	2–3 years	Reduced physical burden (especially for women)
Aggregation	Solar cold rooms	High postharvest losses (20–45%); inflexible sales	\$5,000–20,000	15–30% spoilage reduction; +10–15% higher prices	3–4 years	Bargaining power; access to urban/ export markets
Aggregation	Solar dryers	Spoilage, lack of value addition	\$500–1,500	Reduced spoilage; entry into flour/ chip markets	1–2 years	Extended shelf life; market diversification
Retail/ Household[11]	Solar lights and charging	Unsafe or inefficient early and late labor; poor digital access	\$200–400	Extended hours; better communication	1–2 years	Education; mobile banking; improved security

DRE can reposition matooke from a subsistence crop to a driver of rural resilience and market growth. Low-cost, fast-payback tools deliver immediate income gains and reduce household vulnerability. Larger investments in irrigation systems and cold rooms, unlock the structural changes needed to reduce losses, stabilize prices, and expand into higher-value markets. Sequencing these interventions — from household-level adoption to cooperative-scale infrastructure—provides a clear roadmap for farmers, the private sector (e.g. DRE companies), financial institutions, donors, and policymakers, among others, to catalyze transformation. By embedding financing models, cooperative strengthening, and demonstration hubs into this pathway, Uganda can create a more resilient, competitive value chain for the sector.

3.5 Recommendations and Next Steps

The cost–benefit analysis shows that DRE technologies can increase income, reduce waste, and improve resilience in the matooke value chain. Scaling these interventions will depend on key enabling levers, including financing, institutional capacity, and market development.

Financing. The technologies assessed, from USD $200 household kits to USD $20,000 cooperative cold rooms, exceed the means of most smallholder farmers. Yet the economic case is strong: irrigation stabilizes yields by up to 50% in dry seasons, cold rooms cut spoilage by 20–30%, and dryers break even in as little as 1 year. Strategic partnerships with PostBank Uganda and Centenary Bank, which have successfully financed agricultural value chains, can structure loans around harvest cycles. Uganda Development Bank's UGX 6.4 billion (USD $1.8 million) cooperative lending program, and the government's Agricultural Credit Facility (which offers 50% risk-sharing and subsidized rates), provide proven pathways for larger investments. UECCC's Results-Based Financing facility, launched in December 2024, should be extended to productive-use assets like dryers and cold rooms. For smaller technologies, EnerGrow's PAYGo model (USD $50-5,000) can accelerate adoption. So can leasing equipment to cooperatives, through organizations like aBi Trust. Blended finance models tapping climate funds and carbon credits can reduce upfront barriers while ensuring commercial viability.

Institutional capacity. Shared technologies like cold rooms and dryers are only as effective as the institutions managing them. Interviews repeatedly highlighted weak cooperative governance, poor accountability, and trust deficits. Embedding investments in strong cooperatives and pairing them with governance training, digital inventory tools, and food safety protocols is essential. To ensure reliable maintenance, it's equally important to build networks of rural solar technicians and local service providers. Companies like Instollar, a Nigerian firm that matches highly qualified workers to existing opportunities, are essential to address workforce gaps.[12]

Demonstration and market development. Often, adoption is limited by fear of financial risk. Farmers who have witnessed neighbors stabilize yields with irrigation, cut losses with cold storage, or create new income streams with drying are significantly more likely to adopt. Demonstration hubs in high-output districts can reduce perceived risk, provide training and after-sales service, and anchor new business models. But demonstration must be tied to market development: solar dryers and cold storage only create value if they're linked to buyers in urban markets, institutional procurement, or export contracts. Partnerships with traders, wholesalers, and exporters are essential to ensure that energy-enabled production upgrades translate into income gains.

Strategic sequencing. Low-cost, quick-win interventions like solar dryers, mechanization tools, and household lighting should be scaled first to deliver immediate returns and build farmer confidence. More capital-intensive solutions like irrigation and cold rooms should follow, embedded in strong cooperatives and supported by blended finance. This sequencing can progressively shift matooke from a subsistence-oriented crop to one with a commercially competitive, climate-resilient value chain.

By aligning financing with farmer cash flows, strengthening cooperative governance, and pairing demonstration with market access, all the matooke value chain stakeholders can unlock the potential of DRE. These are not abstract reforms: they directly address the 20–45% postharvest losses, seasonal yield drops of up to 50%, labor drudgery that limits scale, and fragmented markets that suppress farmer incomes. With catalytic investment and coordinated policy support, matooke can evolve from a low-margin subsistence staple into a driver of rural prosperity and national food security.

4. Powering Ethiopia’s Maize Value Chain

4.1 Introduction

Maize is Ethiopia’s most widely produced cereal crop, cultivated mainly by smallholder farmers. Roughly 9 million farmers grow maize on a total of 2 million hectares, producing over 6 million tons annually (Chala & Deso, 2024). Ethiopia is the largest maize producer in East Africa, and maize contributes around 20% of national calorie intake. Despite steady progress, average yields of about 4.2 tonnes per hectare are less than half of yield potential. Smallholders achieve only 30–40% of optimal yields due to low use of improved seeds and fertilizer, minimal mechanization, and reliance on rainfed production ((Power for All, 2022; Chala & Deso, 2024).

Downstream, the maize value chain faces equally significant inefficiencies. Post-harvest losses average about 20% of maize, which is lost due to poor drying, pest damage, and spoilage (APHLIS, 2019). In 2019, an estimated 1.26 million tonnes of maize were lost post-harvest in Ethiopia – equivalent to over USD $392 million, or 1.2% of national agricultural GDP (APHLIS, 2019). Farmers often lack access to reliable drying technologies and must store maize in traditional structures prone to pests, mold, and moisture ingress (Román et al., 2020; World Food Bank, 2018). As a result, stored grain can deteriorate rapidly, with studies in some regions recording insect-related maize losses as high as 20–30% in traditional storage (Temesgen & Getu, 2023). And since most smallholders have limited access to markets or storage finance, they sell immediately after harvest when prices are lowest, forfeiting income that better timing and aggregation could capture. Overall, Ethiopian maize farmers receive a disproportionately small share of the end-market value; they often have the lowest profit margin in the value chain (Galtsa et al., 2022).

These productivity and value chain challenges have real consequences. For rural communities, they translate to depressed farm incomes, heightened food insecurity, and lost opportunities for value addition. Improving the system means addressing inefficiencies at each stage, from field to market. Here, DRE can be a game-changer.

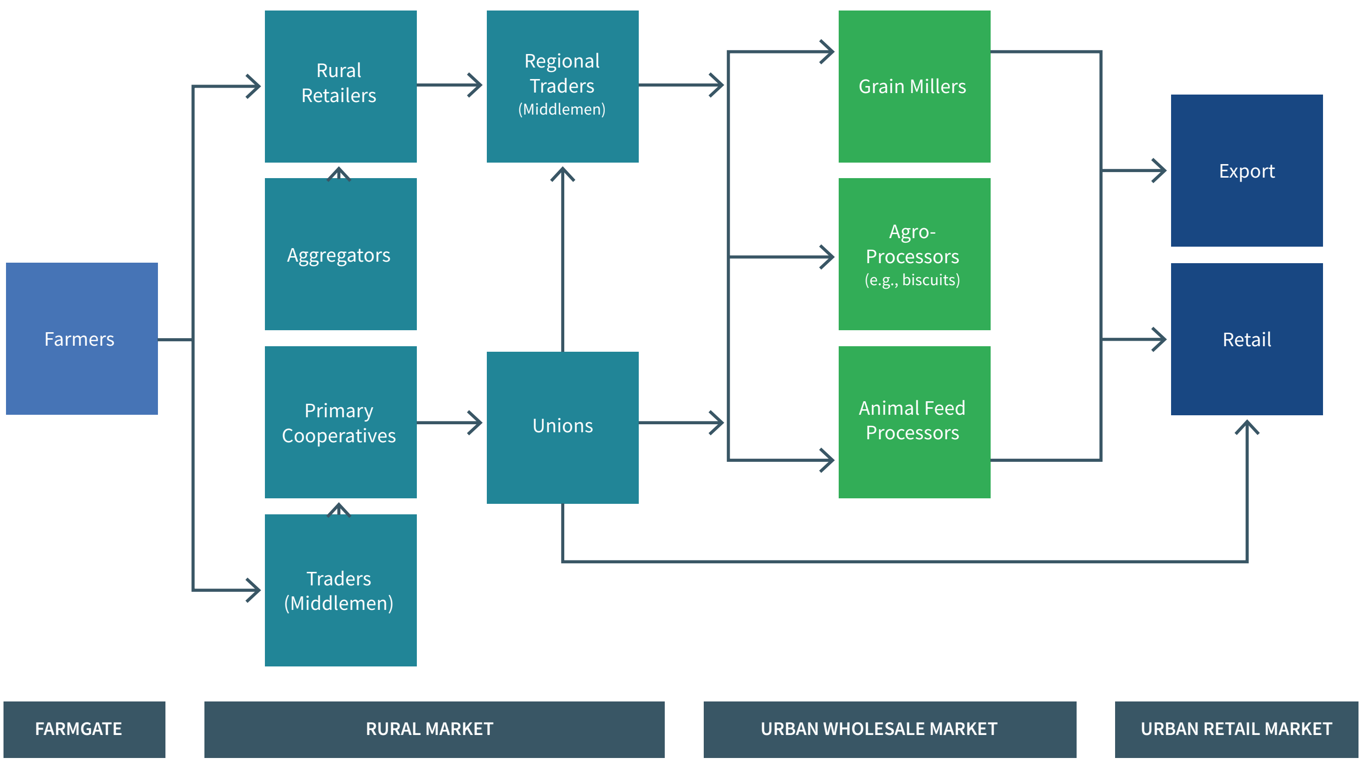
Ethiopian maize farmers receive a disproportionately small share of the end-market value; they often have the lowest profit margin in the value chain.

4.2 The Maize Value Chain: Overview

Maize in Ethiopia flows from millions of small farms through a multi-step journey before reaching end users. Production is dominated by smallholder farmers, who often cultivate maize on plots under 1 hectare, primarily during the main Meher rainy season. Most maize is rainfed, planted around June and harvested from October onwards. Farmers mainly grow white maize varieties for their own consumption and for local markets. In fact, maize is a dual staple and cash crop: about 3 quarters of produce is kept for household consumption, underscoring its role in farm family diets, while the surplus is sold to generate income (Chala & Deso, 2024). Immediately after harvest, farmers dry maize cobs in the sun (often on mats or bare ground) and manually shell the kernels, or in some cases store unshelled cobs for gradual consumption and sale.

4. Powering Ethiopia's Maize Value Chain

FIGURE 3: MAIZE VALUE CHAIN IN ETHIOPIA



Note: Value chain mapping developed by Power for All based on primary and secondary research.

When farmers do sell maize, it usually moves through informal aggregation channels. Village-level traders or collectors go farm to farm after harvest to buy maize in small quantities. Lacking on-farm storage and needing cash, many farmers sell immediately at the farmgate, often in unprocessed form for low prices (World Food Bank, 2018). These intermediaries assemble loads and transport the grain (by pack animals, small trucks, or even bicycles) to larger market centers or primary cooperatives. A minority of farmers are members of agricultural cooperatives. Cooperative marketing remains limited, accounting for less than 10% of total marketable maize surplus (Belete, 2024).

After initial collection, maize is often processed before it reaches consumers. Rural households commonly mill a portion of their harvest at local milling stations – small diesel or electric hammer mills found in towns – to produce flour or meal for injera, bread, or porridge. A significant share of maize is consumed in whole grain form or as homemade flour in rural areas, meaning that milling is often a decentralized, service-based part of the chain. Small mill operators typically serve farmers and petty traders for a fee, and many of these mills depend on unreliable grid power or costly diesel generators, especially in off-grid small towns. Energy outages or fuel shortages can disrupt local processing, forcing farmers to travel farther with their grain.

Once maize enters wholesale and retail markets as grain or flour, it flows to consumers through several channels. Urban demand for maize comes from low-income households (who use maize flour as a cheaper alternative to teff or wheat), institutions (schools, prisons, etc), and feed manufacturers. The grain moves through wholesale traders in regional hubs (like Jimma, Nekemte and Bahir Dar) and into terminal markets like Addis Ababa's Merkato. Maize marketing is shaped by seasonal price fluctuations – post-harvest gluts push prices down, while lean-season shortages see prices rise significantly. Without effective storage or credit, most smallholders can't capitalize on higher prices later in the year. A portion of Ethiopian maize also moves through food aid and strategic grain reserves; the government or relief agencies occasionally procure maize to distribute in food-insecure areas. Meanwhile, exports of maize are minimal but not negligible – Ethiopia has exported to neighboring countries in surplus years, given that non-GMO white maize is preferred regionally (Chala & Deso, 2024). Nonetheless, regional trade is opportunistic and constrained by Ethiopia's focus on domestic food security.

4.3 Value Chain Inefficiencies

Ethiopia's maize value chain remains largely informal and domestic, starting with dispersed smallholder production and ending with household and urban consumption. At each stage, structural gaps in technology and infrastructure reduce efficiency and value capture. Table 5 summarizes the main bottlenecks and the corresponding DRE opportunities.

TABLE 5: SUMMARY OF KEY INEFFICIENCIES ACROSS THE MAIZE VALUE CHAIN

Stage	Key Inefficiencies	Energy Opportunities
Farm	Manual labor; low mechanization; delayed land prep; heavy reliance on rainfall	Solar-powered irrigation; service-based mechanization (two-wheel tractors)
Post-Harvest	Inadequate drying; health risks;[13] labor-intensive shelling	Solar dryers; mechanical shellers; hermetic storage
Storage and Aggregation	Traditional storage; weak cooperatives; premature sales at low prices	Community cold/dry storage powered by DRE; cooperative-level energy-enabled aggregation
Processing and Value Addition	Costlier diesel-based milling; outages in grid mills; limited diversification into fortified flour or animal feed	Solar-powered hammer mills; mini-grids for agro-processing hubs
Marketing and Digital Access	Poor price transparency; limited digital platforms; weak credit access; farmers remain price-takers	DRE-powered connectivity for digital tools and telecom; market info systems

ON-FARM PRODUCTION INEFFICIENCIES

Low farm-level productivity is the most significant constraint in Ethiopia's maize value chain. Land preparation and planting are predominantly carried out with manual labor or animal traction, which limits the area that farmers can cultivate and frequently delays operations beyond the optimal planting window. With only about 3.7% of farmers accessing machinery, key tasks like plowing and sowing are often slowed by labor bottlenecks (Borgen Project, 2018). These delays contribute to yield gaps across the sector.

Dependence on rainfall increases the challenge. Only about 5% of Ethiopia's irrigable land is currently equipped for irrigation, leaving most maize farmers highly exposed to rainfall variability (Power for All, 2022). This restricts production to a single main harvest per year and creates vulnerability to droughts and delayed rains. As a result, national maize yields average about 4 tonnes per hectare — barely a third of their potential (Expert Interviews, 2025). Together, these inefficiencies constrain productivity, cap annual output, and perpetuate Ethiopia's dependence on smallholder subsistence systems.

STORAGE AND AGGREGATION INEFFICIENCIES

Once maize is harvested, drying, handling, and storage have their own challenges. Since farmers usually rely on sun-drying maize on bare ground or mats, grain is vulnerable to rewetting, pests, and fungal

4. Powering Ethiopia's Maize Value Chain

contamination. In Ethiopia's diverse agroecological zones, high humidity or untimely rains during harvest exacerbate the problem; maize stored or shelled at >13–14% moisture content is especially susceptible to mold and aflatoxin contamination (Román et al., 2020). Traditional storage structures compound these risks. Studies have shown relative humidity levels above 90% inside conventional maize stores for more than 4 weeks post-harvest, conditions that foster fungal growth and rapid spoilage (Román et al., 2020).

Most of Ethiopia's postharvest maize losses, which are estimated at 20%, occur during on-farm handling and storage (APHLIS, 2019). The lack of affordable drying technologies and mechanical shellers leaves farmers reliant on labor-intensive and risky practices that degrade both quantity and quality.

Traditional storage options, including cribs, polypropylene bags, and in-home storage, also expose maize to rodents, pests and moisture. Temesgen and Getu (2023) report that insect-related maize losses can reach 20–30% in traditional storage systems. Faced with these risks, many farmers sell maize immediately after harvest at depressed prices, often flooding the market and forfeiting higher incomes later in the season.

Aggregation mechanisms remain weak. In some areas, only about 5% of marketable maize surplus is estimated to pass through cooperatives (Belete, 2024), leaving most smallholders unable to bulk grain, delay sales, or bargain collectively. As a result, farmers are frequently forced to sell at low prices to traders who later store and resell at higher prices. Additional losses occur during transit and at market storage facilities, further reducing the product's value from harvest to market.

PROCESSING AND MARKET ACCESS INEFFICIENCIES

At the processing and marketing stages, inefficiencies relate to limited access to reliable energy, weak value addition, and poor market integration. Many rural areas lack local maize processing beyond basic hammer milling. Where mills exist, they often depend on unreliable grid electricity or costly diesel generators. Diesel-based milling can be 2-3 times more expensive per unit of output than grid-based milling (Expert Interviews, 2025), and ultimately, these costs are borne by farmers and consumers. In off-grid towns, mill operators may restrict hours or capacity due to fuel costs, forcing farmers to travel long distances for milling. Limited local processing also limits diversification into higher-value products like fortified flour, grits, or animal feed, which could improve farmers' margins and create rural jobs.

Market inefficiencies reinforce these constraints. Smallholders frequently sell maize without knowing prevailing prices beyond their locality. Weak access to credit further prevents them from storing grain and timing sales for better returns. Use of digital market information systems in the sector is limited, due to uneven rural network coverage, though mobile phone ownership has grown substantially in recent years (Klapper & Rolston Rawlins, 2023). In the absence of reliable price signals and links to buyers, farmers often accept the first offer from local traders, leaving them as price-takers and limiting income.

Together, these issues restrict profits for Ethiopia's maize farmers. Without affordable and reliable energy for processing, and without transparent and accessible markets, rural economies remain locked into a cycle of low-value production and dependence on informal traders.

4.4 Energy Opportunities and Cost-Benefit Analysis

DRE provides an integrated response that aligns with the maize sector's specific needs from production, storage and processing to market access. The following section outlines how these interventions map onto each stage of the value chain.

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ON-FARM OPPORTUNITIES: MECHANIZATION AND IRRIGATION

Farm-level productivity remains the greatest bottleneck. Maize yields average ~4 tonnes per hectare, less than a third of their potential, due in part to slow plowing and planting processes. Irrigation is similarly underutilized.

DRE-enabled mechanization and irrigation could transform this. Access to solar-powered water pumps and electric two-wheel tractors (operated through service models) allows farmers to expand their areas of cultivation, improve timeliness, and mitigate rainfall variability. Studies in the Arsi Zone show that mechanization can increase farm incomes by up to 70%, while solar irrigation enables double cropping and stabilizes yields in dry spells (Abebe et al., 2024). These interventions also reduce drudgery, especially for women, and create the possibility of growing higher-value crops alongside maize.

POST-HARVEST OPPORTUNITIES: DRYING, SHELLING AND STORAGE

Maize has significant post-harvest losses, mostly due to inadequate drying and poor storage. Since farmers often dry maize on open ground, it's vulnerable to rain, pests, and fungal contamination. Improper storage at >13–14% moisture allows aflatoxin proliferation, degrading quality and posing public health risks. Traditional cribs and polypropylene bags further expose grain to rodents and spoilage, forcing many farmers into premature sales at harvest-time when prices are lowest.

DRE technologies offer affordable and scalable alternatives. Solar dryers accelerate moisture reduction and lower contamination risks, while mechanical shellers save days of manual labor and reduce grain breakage. Hermetic bags, though not energy-dependent, complement these technologies by enabling safe long-term storage and reducing pest damage. Together, these interventions allow farmers to postpone sales until higher-price periods, raising their profits by 15–30% while also increasing food safety (Expert Interviews, 2025).

PROCESSING OPPORTUNITIES: LOCAL MILLING AND VALUE ADDITION

At the processing stage, the sector is also constrained by limited energy access. In off-grid areas, diesel-powered hammer mills dominate, raising costs by 30% when compared to grid-connected mills, which restricts access (Expert Interviews, 2025). Limited local processing reduces opportunities for value addition into flour, grits, fortified meals, or animal feed.

Solar-powered hammer mills and mini-grids for agro-processing hubs can reduce milling costs, improve reliability, and unlock local enterprise opportunities. For example, installing a solar-powered community mill can serve hundreds of households, cutting costs for farmers while generating jobs. At scale, this infrastructure could also support diversification into higher-value products, strengthening rural economies and reducing reliance on imports for processed foods.

> **DRE technologies allow farmers to postpone sales until higher-price periods, raising their profits by 15–30% while also increasing food safety.**

MARKET OPPORTUNITIES: DIGITAL ACCESS AND CONNECTIVITY

A final opportunity lies in improving market efficiency. Currently, as mentioned, smallholders are often forced to sell without knowledge of prevailing district or regional prices, making them price-takers in transactions dominated by traders. Weak connectivity further limits access to digital tools that could bridge this gap.

Energy access underpins digital inclusion: with reliable electricity, telecom towers function consistently and farmers can charge phones without difficulty. Digital platforms represent an exciting opportunity to transform smallholder agricultural

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markets (ISF Advisors & RAF Learning Lab, 2021). Mobile penetration in Ethiopia has expanded in recent years, but rural coverage remains uneven, and no official data distinguishes between urban and rural connectivity levels (GSMA, 2024). In maize-growing areas, integrating DRE with digital service hubs can help overcome this, and increase the returns on maize production, storage, and processing investments.

COMPARATIVE COST–BENEFIT ANALYSIS OF ENERGY OPPORTUNITIES

The economics of DRE technologies show clear opportunities for the sector - from low-cost, rapid-payback tools that safeguard harvest value, to more capital-intensive systems that unlock productivity growth, enable value addition, and strengthen market integration. This analysis both quantifies costs and returns, and highlights the sequencing logic: immediate interventions that protect incomes today, medium-term solutions that build resilience, and longer-term investments that underpin competitiveness. Table 6 summarizes typical costs, financial returns, and non-monetary benefits for the most relevant DRE interventions in the maize value chain.

TABLE 6: COMPARATIVE COST-BENEFIT ANALYSIS OF KEY SOLAR INTERVENTIONS ACROSS THE MAIZE VALUE CHAIN

Stage	Intervention	Problem Addressed	Typical Cost (USD)	Annual Benefits	Payback Period	Non-Monetary Benefits
Farm	Solar irrigation and mechanization	Low yields; rainfall dependency; drudgery	Pump: $3,000; service-based tractor: $20–30/ha	+70% income; +1–2 t/ha yields	2–3 years	Drought resilience; women's labor savings; potential double cropping
Post-harvest	Solar dryers and shellers	20% losses; mold; manual shelling	Dryer: $2,000–5,000; sheller: $200–400	Loss reduction 10–20%; +15–30% prices from delayed sales	1–3 years	Improved food safety; reduced aflatoxin; time savings
Post-harvest	Hermetic storage bags	Pest and moisture losses; premature sales	$2–3 per 100 kg bag	Loss reduction 5–10%; better seasonal arbitrage	<1 season	Household food security; lower health risks
Processing	Solar-powered hammer mills	High milling costs; limited value addition	$5,000–10,000 (community)	Milling cost savings 30%; +10–20% farmer margins	3–5 years	Local jobs; women's time savings; enterprise development
Processing	Mini-grid hubs (digital and processing)	Grid unreliability; weak market linkages	>$20,000	Stable processing; +15–25% revenues via digital tools	4–6 years	Export readiness; transparency; community empowerment

4. Powering Ethiopia's Maize Value Chain

Low-cost, rapidly scalable technologies, like hermetic bags or dryers, should drive immediate action, protecting crop value at the harvest stage. In the medium term, investing in processing and digital integration will enable farmers to capture greater margins.

Together, these technologies show that DRE is not marginal, but foundational, for transforming Ethiopia's maize sector. Quick-win interventions like hermetic storage, solar dryers and shellers deliver immediate food security benefits and income protection. Higher-capital investments in irrigation, mechanization and processing hubs, when coupled with digital integration, create the conditions for yield expansion, value addition, and higher rural employment. Sequenced this way, interventions move the maize sector from protecting today's harvest to building tomorrow's competitiveness.

4.5 Recommendations and Next Steps

For Ethiopia's maize sector, the pathway from pilot projects to meaningful scale requires more than technical solutions. It calls for a sequenced strategy: first protecting value at harvest, then boosting productivity on-farm, and finally enabling higher-value processing and market integration. Innovations in finance, cooperative governance, and demonstration hubs will be key to this.

Protecting Harvest Value through Drying and Storage. Reducing post-harvest losses is the most immediate and impactful first goal. Hermetic storage bags are low-cost and pay for themselves in less than a season, but adoption is limited by low awareness and distribution. Scaling them through cooperatives and agro-dealers could rapidly improve both food security and farmers' incomes. Complementary technologies, like solar dryers and mechanical shellers, add further benefits, from lowering aflatoxin risks to reducing the drudgery of manual shelling. With upfront costs of USD $200-5,000, these interventions require blended finance and cooperative-level governance to ensure their sustainability, and financial support for most smallholders, who can't meet the upfront costs. Pairing investments with training in grain handling, recordkeeping, and inventory management would help de-risk adoption.

Boosting Productivity with Irrigation and Mechanization. Due to Ethiopia's reliance on manual labor and rainfed cultivation, yields are capped at about 4 tonnes per hectare. Solar irrigation pumps and electric two-wheel tractors can raise farm incomes by up to 70%, and can enable double cropping in some areas (Abebe et al., 2024). Again, most smallholders can't afford the upfront costs - but PAYGo models, seasonal repayment schemes, and donor-backed guarantees can make these technologies viable. Stronger coordination with financial institutions and the private sector are essential to unlock scale. Commercial banks, microfinance institutions, and leasing companies can design tailored loan products or credit lines for DRE providers and service cooperatives, while risk-sharing facilities and blended finance can help de-risk lending. The IWMI-Vision-Fund-Green Scene Energy Model described in Section 6.4 is an example of this.

Here, private distributors and technology suppliers can be catalysts: they can develop service-based business models that lower adoption barriers for farmers. Strategic engagement with sector platforms like the Ethiopian Solar Energy Development Association (ESEDA) can further accelerate uptake, by linking private initiatives with government programs and policy dialogues. This will ensure alignment with national electrification and agricultural transformation goals. The Green Climate

4. Powering Ethiopia's Maize Value Chain

Fund's USD $45 million program for solar pumps is an existing platform that can be aligned and scaled for high-potential maize clusters.

Enabling Value Addition through Local Processing. Reliance on diesel-powered hammer mills means farmers are price-takers in a low-value chain. Solar-powered hammer mills, at USD $5,000–10,000 for community-scale units, can cut costs, increase farmer margins by 10–20%, and generate rural employment. At a larger scale, mini-grids for maize clusters can power both milling and digital services, creating hubs of rural enterprise. These are high-capital investments, however, with governance risks. Early donor-backed pilots, paired with concessional loans and cooperative training, are needed to validate business models and attract private capital before widespread rollout (Expert Interviews, 2025).

Building market integration through digital access. This can amplify the returns of investments at all earlier stages. Weak connectivity and information asymmetry currently lock farmers into disadvantageous sales, often at harvest-time when prices are lowest. Reliable energy access allows rural telecom towers and digital platforms to function, providing transparent price data and connecting farmers directly with buyers. While feasibility in Ethiopia remains constrained by patchy network coverage, pairing mini-grids with digital service hubs can bridge this gap. Donor-supported partnerships between energy providers and telecom companies will be critical to move from pilots to scalable systems.[14]

These interventions should be applied in a clear sequence. Low-cost, rapidly scalable technologies, like hermetic bags, dryers and shellers, should drive immediate action, protecting crop value at the harvest stage. In the medium term, investing in processing and digital integration will enable farmers to capture greater margins and enter competitive markets. By aligning these interventions with financial instruments, cooperative capacity building, and demonstration hubs, Ethiopia can shift maize from a vulnerable subsistence crop into a resilient driver of rural livelihoods and national food security.

The pathway to scale depends on the coordinated engagement of public and private actors. On the private sector side, companies like Enrich Agro Industry PLC, which processes maize and other cereals into fortified foods, and emerging cooperative-led feed processors, can create stable market outlets that incentivize production upgrades. Meanwhile, strategic partnerships with ESEDA would align donor and private-sector investments with government priorities, accelerating DRE adoption across maize clusters, and anchoring Ethiopia's transition toward cleaner, more resilient agro-processing systems (Expert Interviews, 2025; IFDC & CGIAR, 2024).[15]

In the public sector, Uganda's Ministry of Agriculture (MoA), Ministry of Water and Energy (MoWE), and the Agricultural Transformation Institute (ATI) can integrate DRE solutions into existing mechanization and irrigation programs, while the Development Bank of Ethiopia and microfinance institutions can design tailored credit lines for solar pump and milling enterprises.[16] International partners like the International Fertilizer Development Center (IFDC) and CGIAR provide strong technical foundations for scaling improved input use, while local cooperatives and unions can establish demand aggregation and cost-sharing models.[17]

5. Powering Ethiopia's Teff Value Chain

5.1 Introduction

Teff (Eragrostis tef) is Ethiopia's most culturally significant and widely consumed cereal, part of the staple diet of more than 50 million people (Gebrehiwot & Ndinda, 2024). Smallholders produce over 85% of the global supply, concentrated in Oromia and Amhara, which together account for nearly 88% of global production (Adepoju et al., 2024). Though it's the world's smallest grain, teff is central to rural livelihoods, generating roughly USD $500 million annually — second only to coffee as a cash crop (Gebrehiwot & Ndinda, 2024).

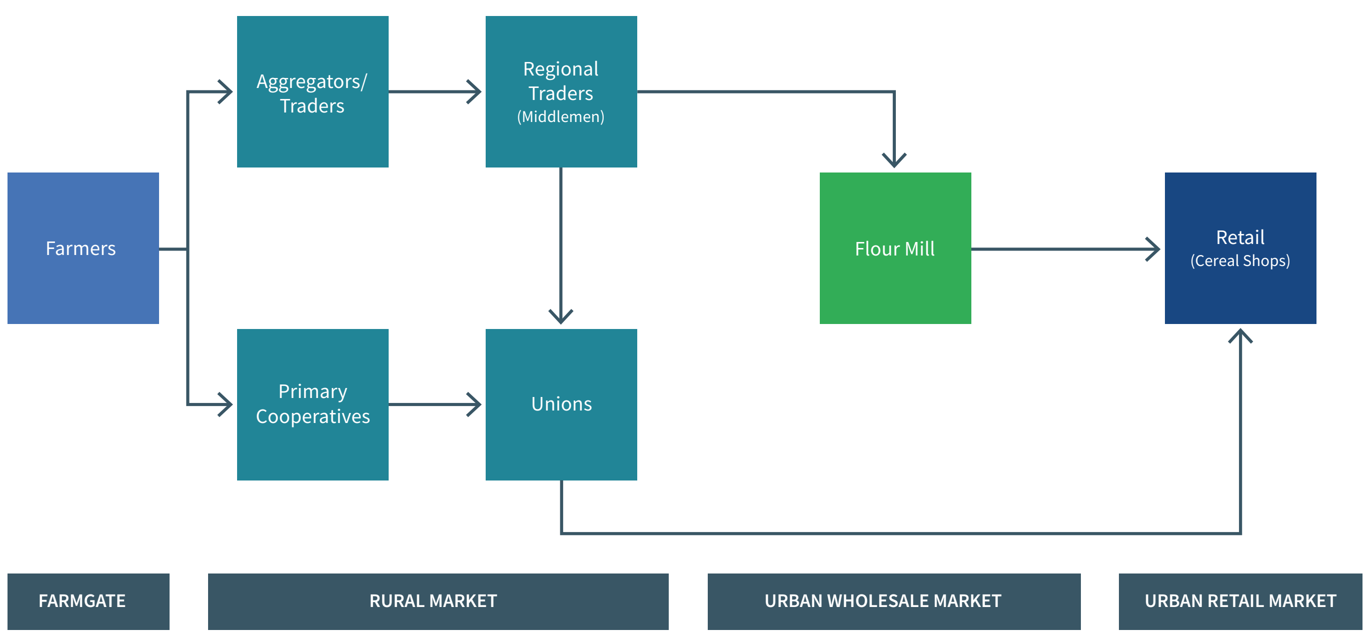
Despite this, teff's value chain is characterized by manual labor, rainfed cultivation, and minimal value addition. Farmers typically cultivate plots under one hectare, using family labor and traditional practices. Post-harvest, teff flows through brokers and informal traders who take a disproportionate share of its value, leaving producers with about 29% of the final retail price (Expert Interviews, 2025). Domestic consumption dominates. Exports are restricted to processed injera and niche gluten-free products, due to a ban on raw grain exports (Minten et al., 2013).

Teff's resilience and gluten-free profile have drawn global attention, positioning it as a potential climate-smart supergrain (Adepoju et al., 2024). Unlocking this potential requires tackling inefficiencies in mechanization, irrigation, storage, and processing — gaps where DRE could play a catalytic role.

5.2 The Teff Value Chain: Overview

Over 6 million smallholders cultivate teff under rain-fed conditions (Gebrehiwot & Ndinda, 2024). Production is labor intensive, with farmers ploughing with oxen, sowing by hand broadcasting, and harvesting manually. This leads to excessive seed use, low yields (1.6 t/ha on average), and high labor costs (Adepoju et al., 2024). Irrigation is rare, leaving farmers highly vulnerable to rainfall shocks.

FIGURE 4: TEFF VALUE CHAIN IN ETHIOPIA



Note: Value chain mapping developed by Power for All based on primary and secondary research.

5. Powering Ethiopia's Teff Value Chain

After harvest, brokers dominate farmgate purchases, often outcompeting cooperatives by offering immediate cash. Storage remains rudimentary, with 5–13% of production lost to pests, weather, and theft (World Bank, 2021–22; Expert Interviews, 2025). Cooperatives and unions can help farmers bulk grain and invest in storage or milling technologies, but their reach is limited by weak governance and liquidity constraints.

Processing is minimal. Most teff is milled locally for household injera production using diesel mills or manual methods. Industrial-scale milling and product diversification are limited, and transport inefficiencies add layers of cost. Poor rural roads, diesel shortages, and informal checkpoints inflate consumer prices to 2 or 3 times farmgate levels (Expert Interviews, 2025).

Teff is thus both a staple and a relative luxury. Urban households spend around 14% of food budgets on teff, compared to 8% in rural areas (World Bank, 2021–22). The retail system remains largely informal, with limited standards for hygiene, payments, or traceability. Despite teff's growing international reputation, Uganda's export restrictions on raw grain limit international market opportunities (Expert Interviews, 2025).

5.3 Value Chain Inefficiencies

Teff's value chain, though culturally and economically central, is constrained by inefficiencies at every stage. It's Ethiopia's least mechanized crop, with farmers reliant on traditional practices that limit yields and increase labor burdens. Post-harvest, inadequate storage exposes grain to pests, moisture, and contamination, eroding quantity and quality. At the market end, high transport costs, weak cooperative structures, and limited processing capacity prevent farmers from capturing more value. Together, these constraints depress farmer incomes and restrict teff's broader economic potential. Table 7 summarizes key inefficiencies and DRE solutions, with detailed discussion in the subsections that follow.

TABLE 7: SUMMARY OF KEY INEFFICIENCIES ACROSS THE TEFF VALUE CHAIN

Stage	Key Inefficiencies	Energy Opportunities
On-Farm	Manual land prep with oxen; hand broadcasting; manual threshing; high seed use; low yields; rainfed reliance	Line sowing, small-scale threshers, solar irrigation
Storage and Aggregation	Rudimentary storage; weak cooperatives; governance/liquidity challenges; aflatoxin risk	Hermetic bags, ventilated community storage, solar drying
Processing	Reliance on diesel/manual milling; limited value addition; high milling costs	Solar-powered mills, cooperative milling hubs
Transport and Market	High logistics costs (poor roads, diesel shortages, checkpoints); weak market info; brokers dominating farmgate	Electric motorbikes, digital platforms (enabled by DRE)

5. Powering Ethiopia's Teff Value Chain

ON-FARM PRODUCTION INEFFICIENCIES

Farmers still plough with oxen, broadcast seed by hand, and thresh manually. This results in inefficient seed use (25–30 kg/ha, versus. 15–20 kg with line sowing), lower yields, and high labor burdens (Expert Interviews, 2025). Rain-fed reliance exposes farmers to rainfall variability and yield volatility.

STORAGE AND AGGREGATION INEFFICIENCIES

Post-harvest losses average 5–13% nationally, with higher rates in humid zones. Poor drying practices and rudimentary storage expose teff to pests, rotting, and mycotoxin contamination (World Bank, 2021–22; FAO, 2019). Farmers can improve aggregation and storage by forming cooperatives, but governance challenges, liquidity constraints, and competition from brokers limit their effectiveness (Expert Interviews, 2025).

PROCESSING, TRANSPORT AND MARKET INEFFICIENCIES

Teff processing is limited to small-scale milling and household-level injera production. Diesel-powered mills raise costs, while unreliable supply chains force households to travel long distances. At the same time, poor road infrastructure and fuel shortages increase the cost of moving teff to urban markets. Consumers pay up to 3 times the farmgate price, while farmers capture only 29% of retail value (Expert Interviews, 2025). Export opportunities remain untapped due to Ethiopia's grain export ban and limited investment in gluten-free value-added products.

5.4 Energy Opportunities and Cost–Benefit Analysis

DRE can powerfully address the structural inefficiencies that hold back Ethiopia's teff sector. From the farms to markets, energy gaps mean labor-intensive cultivation, high post-harvest losses, costly milling, and transport bottlenecks that inflate consumer prices. DRE can unlock productivity, reduce waste, and create new income streams. The following subsections examine these opportunities, demonstrating how targeted investments can shift teff from a low-productivity subsistence crop to a resilient, value-generating staple.

ON-FARM OPPORTUNITIES: MECHANIZATION AND IRRIGATION

Small-scale mechanization, like line sowing equipment and threshers costing USD $335–445, can reduce seed use by up to 40%, increase yields by 20–30%, and save significant labor time. This can generate additional income of USD $150–200/ha, which can cover investment costs in 2–3 years (Expert Interviews, 2025). Adoption, however, is constrained by upfront costs, cultural preferences, and a lack of locally adapted designs.

Solar irrigation represents another transformative pathway. Yields average only 1.6 t/ha under rainfed conditions, but can rise to 2.5–3.2 t/ha with irrigation (World Bank, 2020; Power for All, 2022). Pumps covering 2–3 ha cost USD $1,500–2,500, with paybacks in 3–5 years, but affordability and service access remain barriers. Regional pilots in Ethiopia and elsewhere in East Africa show that long-term viability depends on aligning concessional finance with extension services and market access (FAO, 2021). When scaled, mechanization and irrigation together reduce drudgery, raise productivity, and improve resilience against rainfall variability.

POST-HARVEST OPPORTUNITIES: DRYING, THRESHING AND STORAGE

Weak drying practices and poor storage allow fungi like *Aspergillus* and *Fusarium* to thrive, producing aflatoxins that resist processing and pose severe health risks, including liver damage and carcinogenic effects (FAO, 2019). Affordable threshers reduce contamination risk by minimizing soil contact, while ventilated community storage improves preservation. Hermetic bags, costing USD $2–3 per 100 kg, deliver near-instant payback by reducing losses by

5. Powering Ethiopia's Teff Value Chain

5–10% (Adepoju et al., 2024; Gebrehiwot & Ndinda, 2024). These interventions not only safeguard food security and household income, but also improve food safety, protecting consumer health and enhancing teff's market value.

PROCESSING OPPORTUNITIES: MILLING AND VALUE ADDITION

Most farmers sell raw grain, while injera preparation occurs at household or vendor scale. Milling is dominated by diesel mills, which raise costs by 30% compared to grid-based systems (Expert Interviews, 2025). Solar-powered community mills (USD $8,000–12,000) can therefore cut milling costs by 30%, create rural jobs, and diversify local economies.

Solar mills also reduce women's labor burden, expand access to processed products, and open pathways to niche markets like gluten-free exports. However, success depends on cooperative or SME-led governance models and blended finance, since upfront capital at the scale needed is beyond the reach of individual farmers. Over time, investments in solar milling could anchor rural industrialization and expand Ethiopia's export competitiveness.

TRANSPORT OPPORTUNITIES: ELECTRIC MOBILITY AND LOGISTICS

Transport inefficiency is among the toughest constraints in the teff chain. Electric motorbikes, at USD $1,200 per unit, save operators USD $220–380 annually in fuel and maintenance. Regional examples underscore their potential. In Uganda, GOGO Electric employs hundreds of staff, operates in 150+ locations, and demonstrates the scale of an electric transport industry (Expert Interviews, 2025). Ethiopia could replicate models like this, reducing diesel imports, improving air quality, and creating thousands of green jobs. While transport requires higher upfront investment and government coordination, especially to set up charging stations, it's a systemic lever that could drive efficiency across the entire chain.

COMPARATIVE COST–BENEFIT ANALYSIS OF ENERGY OPPORTUNITIES

While inefficiencies across the teff value chain are pervasive, several targeted DRE interventions can offer strong economic and social returns. Table 8 below summarizes the main opportunities, highlighting their costs, financial benefits, payback periods, and broader non-monetary impacts.

TABLE 8: COMPARATIVE COST–BENEFIT ANALYSIS OF KEY INTERVENTIONS IN ETHIOPIA'S TEFF VALUE CHAIN

Stage	Intervention	Problem Addressed	Typical Cost (USD)	Annual Benefits	Payback Period	Non-Monetary Benefits
Farm	Line sowing and threshers	High labor, seed wastage, low yields	$335–445	+20–30% yields; 40% seed savings	2–3 years	Labor/time savings, better land-use
Farm	Solar irrigation	Rainfed reliance, yield volatility	$1,500–2,500 per pump (2–3 ha)	+1–1.6 t/ha yield gain	3–5 years	Drought resilience, climate adaptation
Post-harvest	Improved storage and hermetic bags	5–13% losses, aflatoxin risk	$2–3 per 100 kg bag	Loss reduction 5–10%	<1 season	Food safety, food security
Processing	Solar-powered mills	High milling costs, diesel reliance	$8,000–12,000	Milling cost savings 30%; new local enterprises	4–6 years	Jobs, women's time savings, export potential
Transport	Electric motorbikes	High fuel costs, unreliable supply	$1,200	$220–380 savings; doubled incomes for drivers	3–5 years	Cleaner air, reduced imports, green jobs

5. Powering Ethiopia’s Teff Value Chain

Taken together, these interventions show that farm-level mechanization and irrigation deliver immediate productivity gains, and transport and milling investments unlock longer-term structural transformation. Sequenced well, DRE-enabled solutions can shift teff from a subsistence crop toward a climate-smart supergrain with both domestic food security and global market potential.

5.5 Recommendations and Next Steps

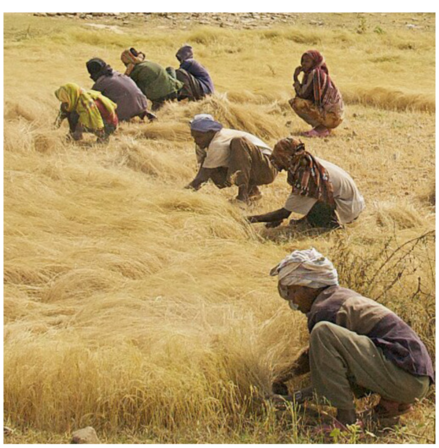
Short-term priorities should focus on protecting value at the harvest stage through mechanization and improved storage; medium-term actions should increase productivity via solar irrigation; and longer-term investments should enable value addition and systemic transport solutions. By aligning this with financing and institutional capacity, Ethiopia can unlock teff’s potential.

Protecting Harvest Value with Mechanization. Labor-intensive land preparation, hand broadcasting, and manual threshing are inefficient and require high seed use. Affordable, small-scale mechanization can reduce seed requirements by up to 40%, raise yields by 20–30%, and cut drudgery. At typical costs of USD $335–445, these tools can pay back in 2–3 years, especially if they’re deployed through cooperative rental schemes or service providers.[18] Financing models like PAYGo and equipment leasing can lower upfront barriers, while demonstration projects can build confidence among conservative farmers.

Boosting Productivity with Solar Irrigation. Teff yields average just 1.6 t/ha under rainfed cultivation, but irrigation can lift output to 2.5–3.2 tonnes per hectare and enable off-season cropping. Solar pumps, which cost USD $1,500–2,500 (serving 2–3 ha), are a commercially viable solution, with payback periods of 3–5 years. However, affordability, farmer conservatism, and lack of after-sales support remain barriers (Expert Interviews, 2025). Concessional finance, cooperative procurement models, and targeted extension services are critical to accelerate adoption. Donor-backed programs, like those already piloted for other crops, will also be useful here (Lefore, Closas, & Schmitter, 2021; GIZ, 2023).

Enabling Value Addition with Solar Milling. Currently, milling remains costly, diesel-dependent, and fragmented, leaving most farmers as raw grain sellers. Community-scale solar mills (USD $8,000–12,000) can cut milling costs by 30%, create rural jobs, and unlock opportunities for product diversification, including gluten-free teff for niche export markets. Feasibility is lower in the short term due to capital needs and governance requirements, but pilot projects in strong cooperatives or SME clusters can validate business models.

Strengthening Market Integration and Digital Access. Market inefficiencies remain pervasive: smallholders often sell immediately at harvest without knowing prevailing prices, making them price-takers. Through reliable DRE, rural telecom towers and digital service hubs allow farmers to access real-time price data, connect directly with buyers, and use mobile-enabled payment and finance platforms. International benchmarks suggest revenue gains of 15–25% from improved transparency and reduced trader margins (ISF Advisors & RAF Learning Lab., 2021). Though feasibility is constrained by patchy rural networks, pairing digital services with mini-grid hubs



Short-term priorities should focus on protecting value at the harvest stage through mechanization and improved storage, while longer-term investments should enable productivity growth and value addition.

and cooperative aggregation can amplify the returns from mechanization, irrigation, and milling. To scale this, donor-backed energy–telecom partnerships are critical.

Addressing Systemic Transport Constraints. Transport inefficiency is one the greatest constraints in the value chain, with high fuel costs and poor logistics raising consumer prices to 2–3 times farmgate levels. Electrifying moto-transport offers a first step: at USD $1,200 per bike, operators can save USD $220–380 annually in fuel and maintenance, with 3-5-year paybacks. But the real transformation requires systemic action — factories, financing, and infrastructure to support an electric transport industry. A government-led, donor-supported program modeled on Uganda's GOGO Electric could generate thousands of green jobs, reduce fuel imports, and reshape logistics beyond the teff sector.

Taken together, these recommendations offer policymakers and donors a roadmap for action.

Delivering on this roadmap will require coordinated action from government, private, and development partners. The Agricultural Transformation Institute (ATI) can provide technical assistance and policy coordination, while the Sasakawa Africa Association (SAA) supports farmer training on small-scale threshing and sowing technologies.[19] Private enterprises like Ture Teff, Africa's first mechanized teff milling and packaging plant, and Enrich Agro Industry PLC, which sources teff from cooperatives for value-added products, can anchor investments in solar milling and agro-processing.[20] To integrate solar-powered irrigation, milling, and e-mobility into government electrification and agricultural transformation frameworks, strategic collaboration with ESEDA will be key. Finally, partnerships with financial institutions and cooperative unions will ensure inclusive access to equipment, credit, and markets, turning national policy objectives into scalable outcomes across Ethiopia's teff-growing regions (Expert Interviews, 2025; SAA, 2024; ESEDA, 2025).

6. Financing the Agri-Energy Nexus

In this section, we offer a cross-cutting analysis of financing challenges and opportunities for DRE and PUE in agricultural value chains. While each of the 4 chains analyzed — dairy, matoke, maize, and teff — face distinct production and market dynamics, the financial constraints and structural gaps are largely similar. Our high-level analysis reflects that.

6.1 Affordability Barriers and Credit Gaps

A consistent thread through the analysis of the 4 value chains: innovative business models and access to finance are needed to scale DRE and PUE in agriculture. Key technologies like solar irrigation pumps, cold storage units, agro-processing mills, and electric transport require high upfront costs that far exceed the budgets of most smallholders and agri-SMEs (Beyond the Grid Fund for Africa, 2023). These appliances are typically more expensive than farmers' annual income, creating an affordability gap (Expert Interviews, 2025).

ETHIOPIA'S AGRICULTURAL FINANCE LANDSCAPE

In Ethiopia's agriculture sector, the annual demand for credit is an estimated USD $18.5 billion. Ethiopia's financial institutions meet only 2% of this - creating a massive financing gap that particularly affects smallholder adoption of DRE technologies (The Reporter Ethiopia, 2025).

For maize and teff farmers specifically, this credit gap manifests in several ways:

» Collateral constraints: Cooperative Bank of Oromia has become the most prominent private financer in the sector, but banks still require land or fixed assets as collateral, which most maize and teff farmers lack under customary tenure systems.

» Seasonal misalignment: The predominant small-scale nature of teff and maize farming means that farmers primarily receive income during harvest periods (October-December), making fixed monthly loan repayments difficult.

» Financial awareness gaps: Despite the proven benefits of solar irrigation for increasing maize yields, farmers' awareness of financing options for solar pumps is limited.

UGANDA'S PRODUCTIVE USE FINANCE LANDSCAPE

Uganda presents a more developed infrastructure for DRE financing, but significant gaps persist for dairy and matoke value chains. Commercial banks and even microfinance institutions often view the off-grid agricultural sector as high-risk and demand excessive collateral from borrowers. This problem is compounded by the fact that customary tenure is the dominant system, constituting about 80% of total land, leaving most farmers without formal titles that could serve as collateral (Mwesigye & Barungi, 2021).

And within the dairy value chain, only large cooperatives can access bank credit, leaving smaller MCCs dependent on costly diesel generators. In the case of matoke, the predominantly informal nature of matooke markets makes it difficult for farmers to demonstrate creditworthiness, limiting access to formal financing for solar dryers or cold storage.

6.2 Aligning Finance with Agricultural Realities

To overcome affordability barriers in smallholder agriculture, financing structures must be tailored to the sector's specific dynamics. Their effectiveness depends on how well financial products align with key variables: payment schemes that match seasonal income flows, ownership models that balance autonomy and risk, risk-mitigation mechanisms like credit guarantees or insurance to incentivize lending, and

6. Financing the Agri-Energy Nexus

off-take agreements that provide revenue certainty. Below, we analyze how these principles apply in practice.

TEFF AND MAIZE IN ETHIOPIA: SEASONAL REVENUE MATCHING

Financing must be aligned with crop calendars and income patterns. Harvests take place in November to January, and financing must accommodate:

» Seasonal repayment schedules which allow farmers to pay during harvest months.
» Working capital loans for cooperative-level solar milling equipment that can serve multiple farmers.
» Insurance products protecting against weather risks that affect teff's rainfed cultivation.

DAIRY AND MATOOKE IN UGANDA: LEVERAGING ESTABLISHED VALUE CHAINS

Uganda's relatively more developed dairy value chain infrastructure creates different financing opportunities:

» Milk delivery contract-backed loans for solar chillers at MCCs, using predictable milk sales as collateral.
» Cooperative equity participation models where farmer groups contribute 25-30% upfront costs while accessing concessional loans for the remainder.
» Processor-backed financing where large companies like Pearl Dairy co-invest in upstream cold chain infrastructure.

Due to its informality, the matooke value chain demands different financing models:

» Asset-based leasing for solar dryers and mechanization tools through agricultural input dealers.
» Mobile-money-enabled PAYGo systems leveraging Uganda's high mobile penetration.
» Group lending models that enable matooke farmers to share access to cooperative-level cold storage.

6.3 Emerging Financing Models and Innovations

A range of business models and financing mechanisms have been piloted to address these structural constraints. They vary by who owns the asset, who provides the service, and who carries the credit risk (Aminu et al., 2024):

» PAYGo: Farmers acquire appliances like pumps or chillers through small, mobile-enabled installments.
» Fee-for-service and leasing models: Cooperatives or providers own the equipment, charging users for access.
» Off-taker co-financing: Agribusinesses or processors invest in equipment, recouping costs through service fees or higher-value procurement.
» Results-based financing (RBF): Grants reduce capital costs, but disbursements require the achievement of predefined results.
» Blended finance: Donor or concessional capital is combined with commercial lending to reduce risk and lower costs.

Across models, aggregation is a recurring theme. By pooling demand through cooperatives, service providers or processors, technologies can achieve sufficient utilization to justify financing.[21] These models are increasingly being tested in practice, with a growing body of pilots and programs in Ethiopia and Uganda. While their design varies according to institutional structures and market maturity, the underlying principles of risk-sharing, aggregation, and alignment with agricultural income cycles are consistent. The next section shows how these financing mechanisms are being operationalized in Ethiopia and Uganda, offering a basis for evaluating their scalability and long-term sustainability.

6.4 Institutions, Intermediaries and Risk Mitigation

Commercial banks in Uganda and Ethiopia remain cautious about lending for the off-grid agricultural sector. Most see DRE and PUE as untested markets and demand high collateral requirements that smallholders, cooperatives, and early-stage agri-SMEs can't meet. Purpose-built intermediaries and donor-backed facilities are filling some of the gaps.

Policy frameworks play a critical role in shaping these financing flows. In Ethiopia, the National Agriculture Investment Plan (NAIP) proposes strengthening microfinance networks and potentially creating an Agricultural Bank of Ethiopia to expand rural lending (Ethiopia Ministry of Agriculture, 2021).

6. Financing the Agri-Energy Nexus

ETHIOPIA'S EMERGING PUBLIC-PRIVATE PARTNERSHIPS

Ethiopia's Government has ambitious plans to enhance the agricultural productivity, food security and income of smallholder farmers, through public-private partnerships for the widespread adoption of solar pump-based irrigation. The IWMI-VisionFund-Green Scene Energy Model is a successful pilot, demonstrating viable scaling pathways (IWMI, 2024).

According to the agreement, a beneficiary farmer and IWMI cover 25% each for a solar pump, while the other 50% of the money comes from a microfinance institute. This model has successfully deployed pumps to 40 farmers across Sidama, Central Ethiopia and Oromia, proving that:

- Cost sharing reduces individual farmer risk while maintaining ownership incentives.
- VisionFund is a trusted microfinance institution. It serves over 1.3 million clients in Ethiopia, with a strong network of 112 branches, providing the scale needed for rural technology deployment.
- Government coordination through agricultural offices provides technical support and maintenance.

This model could be adapted for teff mechanization and maize post-harvest equipment.

UGANDA'S INTEGRATED TECHNOLOGY-FINANCE PLATFORMS

Uganda has developed more sophisticated models linking technology providers, financiers, and end-users. For example, as well as the UECCC's RBF scheme in Uganda, EnerGrow's Productive Use Financing offers loans to households and micro, small, and medium businesses (MSMEs), for assets valued between USD $50-5,000. Its repayment periods range from 6 months to 3 years (Logan, 2024; Beyond the Grid Fund for Africa, 2023). For dairy and matooke sectors, this includes:

- Automated credit scoring, using mobile money transaction histories and agricultural extension data.
- Asset guarantees. If the appliance stops working while being used properly, the cost will be covered by a guarantee. The length of the guarantee is different for each product, but will always cover the appliance for at least the length of the loan.
- Bundled training, which ensures that farmers can effectively operate financed equipment.

Technologies like solar irrigation pumps or cold storage units require high upfront costs that far exceed the budgets of most smallholders and agri-SMEs.

Finally, risk mitigation instruments - like institutionally strengthening cooperatives, insurance and credit guarantees - remain narrow in scope. As a result, donor-funded RBF programs still play a critical role in de-risking early pilots and shaping viable business models (Beyond the Grid Fund for Africa, 2023). The following section translates these financing lessons into cross-cutting recommendations, showing how tailored models can be sequenced to drive adoption at scale.

7. Conclusion and Cross-Cutting Recommendations

Across dairy, matooke, maize and teff, the analysis shows that DRE does not just support agricultural modernization, but is foundational to its competitiveness, resilience, and structural transformation. Despite differences in crop and market dynamics, all 4 value chains face a common set of constraints: post-harvest losses that erode value, rainfed reliance and low mechanization that cap productivity, high processing costs from diesel dependence and fragmented infrastructure, and weak market integration due to poor transport, limited cooperative capacity, uneven access to information and - crucial for the development of the sector - insufficient financing.

Along the chain, DRE addresses these challenges in different ways. At the farm level, small-scale technologies like solar irrigation, mechanized threshers and lighting deliver rapid paybacks and unlock productivity gains. At the post-harvest stage, cold storage, dryers, and hermetic containment reduce losses while improving bargaining power. In processing, solar mills and mini-grids cut costs, improve reliability, and create a platform for value addition and rural employment. At the market interface, electrified transport and digital tools lower transaction costs and connect farmers to higher-value buyers.

Taken together, these interventions highlight the importance of sequencing — quick-win technologies build confidence, mid-scale investments consolidate resilience, and capital-intensive systems unlock long-term transformation. Section 7.1 compares value chain opportunities through this sequencing lens. And it includes a feasibility–impact scorecard that identifies which interventions are most ready to scale today.

7.1 Comparative Cross-Value Chain Opportunities

While specific technologies differ, the 4 value chains studied fall into 3 categories of investment: *Quick wins,* which deliver immediate loss reduction and productivity gains; *resilience builders,* which stabilize production and extend market access; and *transformational systems,* which lay the foundation for structural change but require greater institutional coordination and patient capital. In the Appendix, Tables 19-21 categorize the DRE interventions by their investment profile.

So *within* each value chain, sequencing interventions from quick wins (lower cost technologies) to larger infrastructure projects creates a clear pathway for the sector to grow, through scale and increased value addition. However, policymakers, companies, donors, or financiers might be interested in a ranking of interventions *between* value chains. For instance, if the country's Ministry of Agriculture has a limited budget that could fund a specific intervention, how would that intervention be chosen? This dual framing — sequencing plus prioritization — allows decision-makers to see not only when interventions will help, but also which represent the strongest bets for scale and impact.

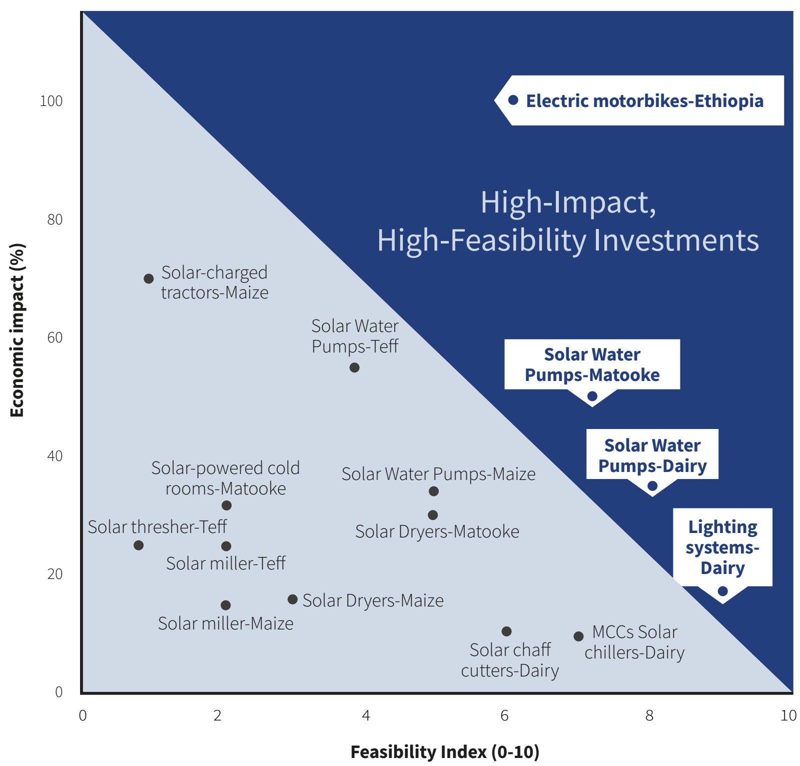
BEYOND SEQUENCING: A SCORECARD FOR PRIORITIZATION

To rank or prioritize interventions, we assume that the best DRE interventions are those that jointly maximize economic impact and feasibility. In other words, they should create real additional value for their stakeholders, but should also be implementable in the short to medium term.

Feasibility is measured by the Feasibility Index, which is determined by ranking each DRE solution across 5 dimensions: policy readiness, awareness, implementation autonomy, finance availability, and popularity of the technology. Economic Impact, on the other hand, represents the increase in annual profit generated by the use of the technology after the payback period — typically under three years. Figure 5 plots each solution on the scorecard, with the Feasibility Index on the x-axis and Economic Impact on the y-axis.

7. Conclusion and Cross-Cutting Recommendations

FIGURE 5: A FRAMEWORK FOR DRE PRIORITIZATION



Note: Figure developed by Power for All based on primary and secondary research.

PRIORITY INTERVENTIONS IDENTIFIED

The scorecard highlights 3 interventions that combine strong feasibility with significant economic returns:

» **Electric motorbikes in Ethiopia:** Positioned as the single highest-impact intervention, they generate the largest income gains for users (+100% yearly profit potential), while benefitting from supportive national policies on electric vehicles. The main challenge is awareness and infrastructure, but the economic case is compelling.

» **Lighting systems for dairy in Uganda:** This is the most feasible intervention, with strong policy support, high awareness, and immediate productivity gains (+18% yearly profit). They represent an accessible entry point that builds user confidence and unlocks demand for additional PUE technologies.

» **Solar water pumps in Uganda:** Offering balanced feasibility and economic impact (+33–50% yearly profit), these stabilize production and reduce rainfall dependence, making them a reliable "resilience builder" which, with targeted financing, is ready to scale.

Integrating Sequencing and Prioritization
Taken together, the tables and scorecard provide a two-layered framework:

1. Sequencing highlights the natural progression from quick wins to transformational systems.
2. Prioritization identifies the best bets within those categories, spotlighting technologies that are both economically compelling and institutionally feasible.

This combined perspective reinforces the importance of phased investment: begin with proven quick wins that deliver immediate benefits and farmer confidence, scale mid-range technologies that consolidate resilience, then prepare enabling conditions for transformational systems that anchor long-term competitiveness.

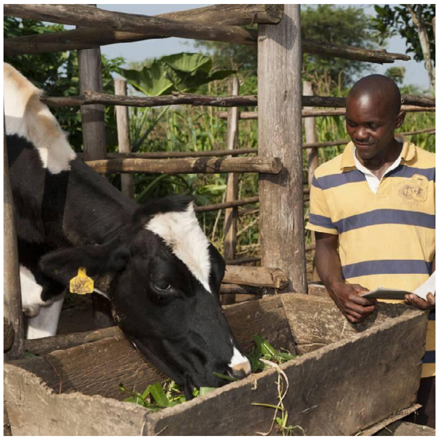
7.2 Cross-Cutting Policy and Investment Recommendations

Specific technologies differ by crop — chillers for dairy, irrigation for matooke, dryers for maize, mechanization for teff. But their ability to scale depends on a common set of enabling conditions. As Section 6 highlighted, unlocking finance, building strong institutions, sequencing interventions, embedding digital tools, and aligning policies are the levers that determine whether DRE remains a patchwork of pilots or becomes a driver of agricultural transformation.

FINANCE: MATCHING CAPITAL TO THE VALUE CHAIN STAGES

Seasonal cash flows make upfront investment unworkable for most farmers and cooperatives. Expanding blended finance through concessional loans, donor guarantees, carbon credits, and climate adaptation funds can de-risk private lending. Delivery models must align with value chain stages: PAYGo repayment for pumps and lighting at the farm level; cooperative leasing schemes for shellers, threshers, and dryers at post-harvest level; and long-tenor, blended vehicles

7. Conclusion and Cross-Cutting Recommendations



Why sequencing matters: quick-win DRE technologies build confidence, mid-scale investments consolidate resilience, and capital-intensive systems unlock long-term transformation.

for mini-grids, milling hubs, and transport fleets at the processing and market stages. Medium- to long-term financial incentives could include:

ETHIOPIA

» Mainstream NAFA risk-sharing: Use Ethiopia's National Agriculture Finance Agency (NAFA) to guarantee loans above USD $5,000 for cooperative-level DRE investments, targeting maize aggregation centers and teff processing hubs in major production areas.

» Integrate FAST digital lending: Deploy the Financial Access and Stability for Transformation (FAST) digital ID system, to provide automated credit scoring for DRE equipment. This eliminates the traditional collateral requirements that exclude most smallholder farmers from formal credit.

» Develop weather-indexed insurance: Create specialized insurance products for solar irrigation systems that protect against both equipment failure and weather variations. These are essential for Ethiopia's agriculture sector, where almost all production currently relies on rainfall.

UGANDA

» Activate processor co-financing: Formalize partnerships between Pearl Dairy, Brookside Uganda, and Jesa Dairy to co-finance solar infrastructure for feeder MCCs, leveraging their established farmer payment systems as loan guarantees.

» Pioneer dairy cluster mini-grids using blended finance from UECCC, World Bank, and private developers. Target areas with processing capacity above 100,000 liters per day, to ensure anchor load viability.

» Link financing to export competitiveness: Create a financing facility to expand Uganda's dairy export market. Focus on cold chain infrastructure that meets East African Community and international standards.

GOVERNANCE AND INSTITUTIONAL STRENGTHENING: ENSURING ASSET RELIABILITY

Energy hardware is only as effective as the institutions that manage it. Weak cooperative governance has undermined the adoption of both chillers in Uganda and storage facilities in Ethiopia. Investments must be paired with governance training, digital inventory systems, and technician networks that extend from farm tools to community milling hubs. Embedding gender inclusion in these structures is critical: women perform the bulk of dairy and matooke labor, but are underrepresented in decision-making. Prioritizing women in training, leadership, and service provision not only reduces drudgery but ensures that benefits are more equitably distributed.

DIGITAL INTEGRATION: ENERGY AS THE BACKBONE OF CONNECTED AGRICULTURE

Reliable energy can unlock digital transformation at every stage. On-farm, mobile-enabled PAYGo platforms allow irrigation and mechanization services to match seasonal incomes. Post-harvest, IoT sensors ensure quality control in milk chillers and matooke cold rooms. At the processing and market levels, DRE-powered hubs support digital platforms that provide transparent pricing, contract enforcement, and access to regional buyers. To further reduce risk for lenders and strengthen supply chains, digital finance should allow farmers to repay loans through milk deliveries, maize sales, or teff aggregation.

7. Conclusion and Cross-Cutting Recommendations

POLICY COORDINATION: ALIGNING ENERGY AND AGRICULTURE AGENDAS

Finally, scaling solutions requires policy alignment. Too often, energy and agriculture ministries operate in silos, treating PUE as peripheral rather than central to transformation. Embedding DRE targets into agricultural strategies, like Uganda's dairy roadmap or Ethiopia's teff and maize programs, would make energy mainstream in sector planning. Extension services should include energy literacy alongside agronomy. And regional trade agreements can convert quality gains from DRE (like gluten-free teff and cold-chain dairy) into export competitiveness.

7.3 Pathways to Transformation

The comparative analysis of dairy, matooke, maize, and teff shows that DRE is not just a technological upgrade, but the foundation for agricultural transformation. At the farm level, it stabilizes yields and reduces drudgery; in post-harvest handling, it preserves value and strengthens bargaining power; in processing, it lowers costs and creates platforms for diversification; and at the market level, it powers transport, digital connectivity, and integration into higher-value trade.

But technologies alone won't deliver transformation. Their impact depends on the enabling ecosystem of finance, governance, sequencing, digital integration, and policy coordination. When aligned, these systemic supports allow quick-win tools to build confidence, mid-tier investments to stabilize production, and large-scale systems to anchor long-term competitiveness.

Taken together, the evidence shows that DRE provides a viable pathway from subsistence farming to resilient, market-oriented agriculture. With deliberate investment and policy alignment, Uganda and Ethiopia can move beyond fragmented interventions toward structural change — unlocking productivity, food security, and export competitiveness in ways that are both economically and environmentally sustainable.

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Notes

1. Introduction

1. Unless otherwise specified, all currency conversions in this report use official exchange rates published by the Commercial Bank of Ethiopia (USD 1 = 134.45 ETB, accessed July 30, 2025) and the Uganda Bureau of Statistics (USD 1 = 3,676 UGX, accessed July 30, 2025).
2. For more detail, refer to the online Appendix.

2. Powering Uganda's Dairy Value Chain

3. Energy poverty is the lack of adequate, affordable, and reliable access to modern energy.
4. Since each testing kit costs USD $27.20.
5. Calculated by Power for All based on export and GDP data (DDA, 2023; Makerere University, 2024; ITA, 2023).
6. Uganda's milk shed structure is concentrated in the Western and Central regions, where smallholder farmers produce 95% of the country's milk supply (DDA, 2023).
7. Power for All analysis based on data gathered from Expert Interviews.
8. All solar dryers referred to are electric solar dryers.
9. The latter is particularly value-additive, since women perform most of the farmgate tasks (Expert Interviews).

3. Powering Uganda's Matooke Value Chain

10. See the Appendix for concrete examples, such as Basiima Leonarda's 1-acre farm and William Busingye's medium farm.
11. Notes:
    • Under suitable conditions, shifting from rainfed to irrigated systems can increase matooke yields by 50–100%. The table uses conservative stabilization benefits for dry-season risk management.
    • Cold rooms are typically installed at cooperative/trading centers. Even a few extra days of shelf life can prevent panic-selling and allow bulk sales. Evidence from comparable perishables shows up to 30% spoilage reduction with simple cooling (FAO, 2019). Grid independence is material, given that rural electricity access is ~42% in 2023 (ESMAP, 2025). Ethiopia's FRI-EL expansion underscores the role of postharvest infrastructure in export growth. This aligns with Lee (2023) on public investment in postharvest tech, adding a clean-energy lens.
    • Without irrigation, farmers can lose up to half their output in the dry season due to water scarcity. Studies show that irrigated systems can increase yields by 50–100% under the right conditions.
12. See the Instollar website.

4. Powering Ethiopia's Maize Value Chain

13. Especially from exposure to aflatoxins, which are produced by certain molds that contaminate crops and can produce liver damage among other health problems.
14. While this digital integration in agriculture has not yet proliferated in Ethiopia, there are regional success examples such as Kenya's DigiFarm platform.
15. See the ESEDA website.
16. See more from the Ministry of Agriculture, Ministry of Water and Energy and the Agricultural Transformation Institute.
17. See more from CGIAR and IDFC.

5. Powering Ethiopia's Teff Value Chain

18. The CIMMYT-GIZ Program is an example of mechanization rental schemes and service provider models in Ethiopia, particularly for line sowing equipment and threshers. See more.
19. See the SAA website.
20. See more from Ture Teff.
21. For example, in Farmer Producer Organizations (FPOs) member farmers pool demand and the organization negotiates bulk purchases, group loans, and buys/leases technology for members. See more here.