Tanzania

Cold Chain Storage for Dairy: Investment Brief

Climate Adaptation Market Opportunities
Agriculture & Food Systems

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GLOBAL CENTER ON ADAPTATION

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GLOBAL CENTER ON ADAPTATION

ABOUT THE GLOBAL CENTER ON ADAPTATION

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

African Union

ABOUT AFRICA ADAPTATION ACCELERATION PROGRAM

GCA is providing technical assistance under the Africa Adaptation Acceleration Program (AAAP), a joint initiative launched by the GCA and the African Development Bank in 2021.

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CONTEXT

This investment brief is part of a regional analysis undertaken by the Global Center on Adaptation, developed in close coordination with partners including CGAP and GCA's downstream financial institution partners under the Africa Adaptation Acceleration Program, in collaboration with the consulting firm Pegasys. The analysis identifies and operationalizes climate adaptation investment opportunities in agriculture and food systems across Tanzania, Kenya, Zambia, and the Democratic Republic of Congo. Building on these results, the present brief aims to provide a decision-support resource for commercial banks, microfinance institutions, and other lenders seeking to assess and integrate climate-related risks and opportunities within their agricultural portfolios.

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

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

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

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INVESTMENT BRIEF: COLD CHAIN STORAGE IN TANZANIA

Executive Summary

Climate change projections for Tanzania indicate a complex intensification of physical hazards. Extreme heat (>35°C) is set to surge along the coast and highlands, while drought conditions will modestly increase water stress in western and southern provinces. Concurrently, extreme rainfall events will strengthen nationwide, exacerbating urban flash floods and river flooding. This places over 100,000 people in key regions—such as Morogoro, Tanga, and Pwani—at risk of severe flood events by 2050.

Tanzania's dairy sector presents a high-urgency, systemic vulnerability. Climate-induced hazards exacerbate credit risk for financial institutions, as extreme heat and flooding threaten supply chain continuity. Despite a widening domestic milk production deficit (projected to increase by 77% over five years) (Tanzania Dairy Board, 2021), the sector faces a paradoxical crisis of devastating post-harvest loss. This crisis is part of a larger national challenge, where approximately 23% of dairy production in the country is lost during the post-harvest handling and processing stages due to lack of preservation infrastructure (FAO, 2022).

This vast quantity of waste occurs simultaneously with domestic demand for milk projected to increase significantly, rising from 3.1 billion litres to 5.5 billion litres by 2030 (Tanzania Dairy Board, 2021). The market is poised for explosive growth but is currently choked by preventable losses.

This paradoxical crisis, where rising demand is met by massive, structural loss, creates extreme price and revenue volatility. This volatility is financially toxic to lenders, as it renders a significant portion of farmer revenue unstable and unpredictable. Furthermore, the problem extends beyond dairy; post-harvest losses in other high-value crops like tomatoes can reach up to 50%, with the lack of cold storage facilities being the leading cause for massive small-scale farmer losses. (Rutta, 2022).

Cold chain infrastructure presents a proven, commercially viable **de-risking technology** that transforms inherently vulnerable smallholder borrowers into resilient, profitable, and ultimately, low-risk producers. By enabling quality preservation, this technology immediately stabilizes the most volatile variable in the farmer's cash flow: the quantity and price of saleable milk. This is achieved through the certainty of immediate grading and reliable off-take by formal processors. When financial institutions finance these systems, they are not engaging in passive climate adaptation; instead, they are actively **restructuring their exposure to climate risk** by financing a hard asset that strengthens income stability. The stability derived from quality premiums and verifiable loss reduction directly improves debt servicing capacity, ensuring higher repayment rates. This has already been proven in pilot programs where small holder income increased by as much as 40%. (EEP Africa, 2023)

Financing **cold chain infrastructure** for milk chilling and preservation is fundamentally a proactive **credit risk mitigation tactic** that unlocks profitable asset finance opportunities, providing predictable, annuity-like returns, and critically, aligns the institution with rapidly expanding global **green finance mandates** and specifically targets the improvement of Green Asset Ratios (GAR) and ESG compliance requirements.

Call to Action for Banks

Immediately pivot lending from passive exposure to proactive credit risk mitigation by financing cold chain infrastructure (such as cold chain cooling facilities) for the dairy sector in Tanzania. This strategic investment transforms the volatile dairy and agriculture sectors into stable, **low-risk asset finance opportunities**, securing higher repayment rates and aligning with essential **green finance and ESG mandates**.

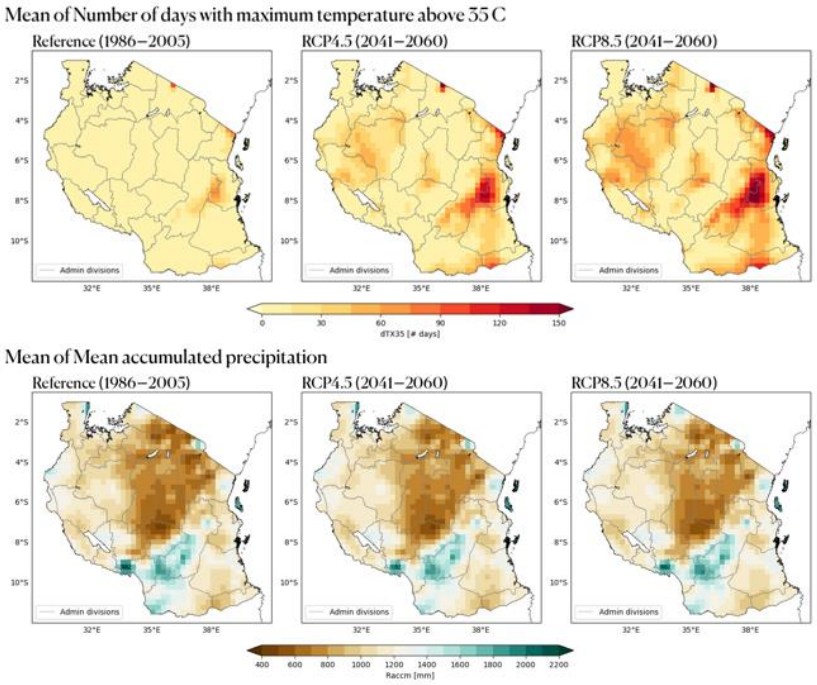
The Adaptation Challenge

Climate Risk as Credit Risk in Tanzania's Dairy Sector

Tanzania's agricultural productivity is fundamentally vulnerable to **climate variability**, which has profound and direct implications for the asset quality and stability of financial institutions' loan books. Climate modelling indicates a concerning trend where rainfall variability is increasing, with the crucial long rains projected to become shorter but more intense, while the dry season is expected to become dramatically drier and longer (Tanzania Agricultural Policy Profile, 2024).

Climate change projections indicate a complex intensification of multiple physical hazards across Tanzania. **Extreme heat** is set to surge, particularly along the coast, central plateau, and northern highlands, bringing very hot days exceeding 35 °C. Concurrently, **drought** hazard is projected to intensify modestly, especially in the western and southern provinces, as elevated temperatures drive high evapotranspiration, offsetting localized rainfall gains and resulting in increased water stress. **Extreme rainfall events** (1-day intensity) will strengthen nationwide, with the largest increases expected along the coast, islands (Pemba, Tanga), and the south-western highlands, significantly increasing urban and flash-flood potential. This rise in rainfall intensity, combined with continued exposure in existing high-risk areas like Morogoro, Tabora, and Pwani, is set to exacerbate **river flooding** (fluvial), notably increasing flood extent in regions like Arusha, Manyara, and Morogoro, putting over 100,000 people in Morogoro, Tanga, and Pwani at risk of 1-in-50-year events by 2050. Finally, **wind gusts** are expected to see a slight intensification, primarily in highland pockets and along Pemba.

Figure 1: Climate hazard projections for Tanzania

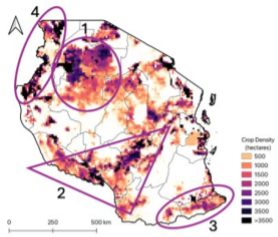


In the dairy sector, climate hazards create a dangerous chain of causation: **extreme heat** stresses herd health increasing feed demand. This, paired with reduced available feed from crop yield necessitates expensive emergency feed purchases, (further eroding farmer margins), and critically lowers milk and crop yield for farmers. In addition to the risk faced by the livestock, **rising temperatures** place pressure on an already underdeveloped cold chain network leading to further losses. Milk yields vary significantly depending on breed and production system in Tanzania. Traditional systems yield about 1 litre per cow per day, while improved systems with crossbreed cows yield between 6 to 12 litres per cow per day. In some high milk-producing regions like Njombe and Kilimanjaro, average yields can reach around 10 to 12 litres per day (ILRI, 2023). The combination of climate factors drives milk yield volatility of **20–40%** (litres

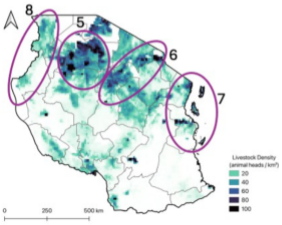
per cow per day) across seasons and years (World Bank Group, 2023). Additionally, dairy productivity drops significantly during heat waves, with heat stress projected to reduce milk yield per cow by 3 to 11% by 2050. This volatility directly undermines the predictable cash flow necessary for loan servicing, converting macro-level climate events into micro-level default risk.

For dairy producers, the vulnerabilities inherent in livestock production systems are driven primarily by the combined effects of droughts of varying magnitudes. This exposure was starkly illustrated during the 2021–2022 droughts when over 92,000 livestock, mainly cattle, sheep, and goats, died in a single semi-arid pastoral district in Northern Tanzania due to a lack of water and pasture (Juma M. , 2022). Excessive rain and subsequent flooding constitute the second most critical cause of vulnerability, causing livestock deaths and significant income loss. Such resource scarcity often incites conflicts between crop cultivators and livestock keepers, especially within catchment areas and crater basins. Further compounding these risks are wildfires, which can destroy grazing land and infrastructure, and landslides that damage water sources and disrupt the supply of manure for fodder crops.

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



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



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

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

Moving up the value chain, dairy manufacturers and processors face a convergence of physical and operational risks. Their facilities, often located in urban and industrial hubs like Dar es Salaam and Tanga, are highly exposed to intensifying fluvial and flash flooding, leading to direct physical damage to factories and warehouses (e.g., USD7.6 million in losses reported in 2018) (Rentschler, 2021). Critically, the perishability of raw milk makes processors acutely vulnerable to business interruption from climate-induced infrastructure failures. Strong storms and floods frequently disrupt power grids and road networks, immediately compromising the cold chain and leading to significant spoilage and inventory loss. Beyond direct damage, manufacturers face chronic operational risks: high ambient temperatures increase cooling and pasteurization energy demands, while drought conditions threaten water supply. Most importantly, firms are affected by supply chain amplification, where severe milk yield volatility at the producer level directly translates into reduced throughput and underutilized capacity at the processing plant, creating systemic business continuity risk.

For lenders exposed to the agricultural sector, specifically those financing smallholder cooperatives, dairy processors, and commercial farms, climate volatility is fundamentally a systemic credit risk problem. Lenders such as the Tanzania Agricultural Development Bank (TADB) often finance the value chain through Agricultural Marketing Co-operative Societies (AMCOS) or direct lending to processors. When heat stress and drought reduce milk volumes, smallholders face income shocks that prevent them from servicing these debts. Consequently, processors face supply shortages that jeopardize their own repayment capacity. While Non-Performing Loans (NPLs) often exceed the national average of 5% and can range between 8–12% for dedicated agricultural portfolios (Tanzania Agricultural Development Bank,

2022), this specific climate-induced NPL drag significantly limits the bank's ability to allocate capital to the sector.

Financing resilient, income-stabilizing assets like cold chain infrastructure is therefore the most strategic defence against future climate induced losses, offering a concrete path to drive down NPL ratios within this key portfolio segment by converting the risk profile from **cyclical** (climate-driven) to **structural** (asset-protected).

Who Is Affected: The Primary Vulnerable Population

Tanzania's dairy sector is dominated by approximately **650,000 smallholder farming households**. These producers typically operate with a low, often illiquid asset base, limited formal market access, and suffer from financial exclusion, with **86%** of milk sold informally (Tanzania Dairy Board, 2021). Their reliance on informal cash sales and local middlemen means they lack the verifiable income data and credit history required by formal lenders. They are highly vulnerable to both climate shocks and post-harvest spoilage due to their reliance on traditional, production systems and limited power access. Their vulnerability is a direct result of being excluded from the quality premiums and reliable collection routes of the formal market.

Furthermore, while women constitute **40–50%** of dairy producers and shoulder the majority of daily labour burdens, they typically control only **20–25%** of productive assets and subsequent income, complicating the targeting of credit and asset ownership strategies (Tanzania Livestock Master Plan, 2017). This gender-based asset gap means a lack of collateral and a reduced voice in investment decisions, perpetuating the vulnerability cycle. The goal of cold chain finance is not just technology deployment, but the strategic transition of these vulnerable but productive smallholders into bankable, resilient clients with traceable, verifiable income and secure asset ownership.

In contrast to the high-risk smallholders, formal financial institutions often rely on established anchor clients—typically Milk Collection Centres (MCCs) or large processors—as their main intermediary borrowers. These anchor clients, characterized by traceable cash flows and substantial collateral, act as reliable, large-scale partners in the financing ecosystem. This structure opens a crucial pathway for intervention: banks can lend directly to the anchor client for the deployment of climate-smart assets, such as solar-powered chilling equipment, which the anchor then strategically places at smallholder feeder farms. This mechanism achieves two goals simultaneously: it de-risks the bank's loan by focusing on a reliable counterparty (the anchor) while providing the essential cold chain infrastructure and market linkage required to formalize and stabilize the smallholders' income, thereby gradually raising their adaptive capacity.

The profound financial vulnerability and lack of adaptive capacity among smallholders thus creates a self-reinforcing financial-climate trap. Because these producers lack the capital (or access to credit) to invest in climate-smart solutions—such as improved fodder, efficient irrigation, or solar-powered chilling—they remain exposed to the intensifying climate risks. The resulting volatility and default risk is then socialized through the entire value chain, ultimately constraining the ability of development banks like TADB to fulfil their mandate. Therefore, intervening in the cold chain to formalize income and enable asset finance is not merely a development goal, but a necessary systemic de-risking strategy for the entire dairy sector.

Technology Variants and Price Points

The financing opportunities are segmented by technology, catering to different points in the value chain and borrower scales:

- **Incumbent solution:** The incumbent cold chain infrastructure in Tanzania is **highly fragmented** and predominantly relies on conventional and, often, **obsolete technologies**, particularly in the **critical first mile** from farm to market. The existing setup for perishable goods, including produce, fish, and dairy, often involves the use of **non-refrigerated transport** and **traditional storage methods** that utilize ambient temperatures. Where modern cold storage facilities exist

(refrigerated warehouses, cold rooms, and refrigerated trucks), they are typically large-scale, centralized, and concentrated near major export hubs like the Dar es Salaam port or larger urban collection points. These centralized facilities rely primarily on grid electricity or diesel generators to power conventional mechanical vapor-compression refrigeration systems. This reliance on conventional power introduces major systemic vulnerabilities to climate change: high and volatile operational costs, susceptibility to frequent power outages. Furthermore, the inherently large scale and e unaffordable capital expenditure requirements of these conventional systems create significant access barriers for the majority of smallholder farmers and local traders. The result of this traditional, power-intensive ecosystem is persistent high post-harvest losses. Addressing these infrastructural and power reliability deficits requires a strategic shift away from centralized, fossil-fuel-dependent models. The high capital expenditure and grid unreliability associated with conventional technologies make them economically infeasible for small-scale operators in remote, off-grid areas. For Tanzania's vast and decentralized agricultural landscape, Solar-Powered Cold Storage Technologies (SPCSTs) emerge as the optimal, resilient solution going forward. SPCSTs, often delivered as modular, mobile, or containerized units, provide reliable, off-grid cooling directly at the farm-gate or local aggregation points.

- Solar-Powered Cold Storage Technologies (SPCSTs): These are robust, off-grid units, often equipped with battery storage to ensure 24/7 cooling despite intermittency, which is critical for consistent quality. They are suitable for cooperative societies or private aggregators, serving 50–150 smallholder families, and are ideal for secured, medium-scale financing. The technologies are highly scalable with design extendable for centralized collection and require minimal daily supervision from the central facility.

  SPCST units ranges from mobile milk cooling systems (500 litre to 1250 litre) to containerized cold rooms (2-10 tons or 8m³–100m³+ capacity). Typical investment costs for a communal cold room range from USD 3,200 to USD 25,000 (~TZS 7.7 million to TZS 60 million). These containerized units are often imported, though local firms provide assembly, installation, and financing services. Key regional providers and distributors with reach in Tanzania include companies like ENdep Limited (a Tanzanian ESCO providing cooling-as-a-service, particularly for fish traders) and East Africa-focused firms like SokoFresh and Techwin Limited (suppliers of solar cold rooms for dairy, produce, and agro-processors).

- Biogas Domestic Milk Chillers (Household): These small-scale chillers offer critical on-farm storage flexibility, allowing farmers to store milk and wait for optimal collection times, dramatically reducing on-farm spoilage. They also offer a powerful co-benefit of fuel generation (cooking gas) from the cow manure, creating a high-value, dual-use proposition highly attractive to individual households for micro-finance. This creates a circular economy benefit at the farm level. Local installation and service for the biogas systems are often provided by partners like Sistema-Agro (SIMA), focusing on high-efficiency digester construction and maintenance.

- Portable/Mobile Cooling Units (Transport): These specialized, battery-powered units are designed to reduce collection losses over traditional methods during the critical 'first mile' (from farm to collection centres) transport phase. They are suitable for SME transport companies or dedicated collection agents who service remote, dispersed farmers. Their rapid cooling capability ensures the quality preserved en route to the main collection centre. SME adoption is often supported by regional tech providers such as Cold Hubs (providing mobile aggregation technology) or local firms installing FreshBox (battery-powered refrigeration kits) in existing motorcycle/truck fleets. This technology presents a direct investment opportunity to finance small-scale SME transport companies or MCCs (Milk Collection Centres) who act as dedicated collection agents, thereby creating a new tier of cold-chain logistics entrepreneurs.

Figure 3 :Comparison of cold chain typologies: solar (left), domestic biogas (centre) and mobile (right) (1 USD = 2,400 TZS)

Competitive Positioning of Solar Against Incumbent Alternatives

Solar Cooling achieves a low operational cost per litre cooled/year of **USD 0.05–USD 0.08**, (~TZS 125 – TZS 200) versus a high and volatile **USD 0.18–USD 0.25** (~TZS 450 – TZS 600) for diesel generation and cooling (EEP Africa, 2023). This stark cost difference translates to a low total cost of ownership (TCO), offering a substantial **68% cost advantage** over diesel's volatility-prone cost structure, which is constantly exposed to global price shocks and logistics headaches in rural areas. This superior, climate-resilient performance is the foundation of the commercial and financial return. Furthermore, solar and biogas systems require significantly less complex, less frequent maintenance and are less susceptible to theft than diesel engines, reducing operational downtime and service costs which further improves loan viability and asset longevity for the lender.

From Value Protection to Value Creation: Income and Yield Gains

The implementation of cold chain technology transforms the financial model from one of **value preservation** (reducing spoilage loss) to one of powerful **value creation**. Cooled milk consistently commands a **10–15% price premium** over non-cooled, often rejected, milk in formal markets, immediately boosting the farmer's top-line revenue (Malque, 2023). Beyond the premium, the consistent access to formal markets allows for economies of scale and better, longer-term contract certainty with processors. This volume and quality guarantee enhances the farmer's bargaining power. Crucially, demonstrated interventions with milk cooling in the Tanga Region have shown a **42% increase** in annual milk yield per cow and a substantial **43% increase** in annual milk income for an average five-cow household (Notenbaert, Radulovich, Omondi, & Seré, 2020).

This stabilized, enhanced income stream directly builds the farmer's financial and livelihood-based adaptive capacity, creating income resilience that allows the household to absorb and recover from external shocks, including those resulting from climate variability and change.

This powerful multiplier effect results from the newly stabilized cash flow enabling crucial investments in higher-quality feed, timely veterinary care, and improved animal husbandry practices. This predictable, significant income stability, generated by the asset itself, becomes the primary, reliable guarantor of loan repayment, rendering traditional land-based collateral less important than the traceable flow of cash.

Figure 4: Competitive Positioning of Cold Chain Infrastructure

Market Opportunity

Structural Ecosystem Inefficiencies

The dairy value chain is plagued by endemic inefficiencies that begin the moment milk leaves the cow, leading to a catastrophic structural loss of value. **The absence of quality-stabilizing cold chain infrastructure necessitates fast, dispersed, and frequent collection trips, driving up effective collection costs (15–25% of the farm-gate price) due to the high volume of unusable milk.** Collection times are unacceptably long (four to eight hours, sometimes longer), leading to rapid microbial growth, acidification, and critical milk quality degradation (Lore, Lwelamira, & Mpiri, 2005).

Crucially, new data from 2021-2022 reveals that milk losses at the household level are significantly variable by season, quantified at **7.8% in the dry season** but peaking at **12.3% in the wet season** (ASRIC, 2024). This difference highlights the acute vulnerability during periods of high milk production. Overall, milk is mainly lost through spillage, spoilage, and contamination, with key determinants of spoilage including the **water used for washing milk utensils** and **storage equipment** (ASRIC, 2023). This results in a loss of **6.5%** of production recorded at the farm level alone (Lore, Lwelamira, & Mpiri, 2005). Under high temperatures rejection rates soar to between **30-40%** of delivered milk due to failed quality tests (e.g., alcohol stability or high somatic cell count). (FAO, 2018)

This high rejection rate makes storage and quality stabilization highly profitable. (FAO, 2018) This system-wide failure represents massive financial waste, restricts processors' ability to scale and meet demand, and forces them to rely on more expensive, long-haul sourcing. Addressing this bottleneck by stabilizing the quality and volume of local supply is the single greatest opportunity for margin improvement across the entire value chain as the immense losses (up to 40% rejection) demonstrate the value that can be captured through cold chain investment.

Financial and Credit Barriers: Structuring Debt for Anchor Institutions

Financial and Credit Barriers The high upfront capital expenditure (CAPEX) barrier is formidable for the smallholder, making individual purchase impossible. **While the individual farmer cannot finance these assets, the value chain's anchor institutions (processors, cooperatives, and formal collection centres) are the optimal borrowers for scaled deployment and distribution to their farmer suppliers.** To put this in context, the cost of a single unit may exceed the value of a smallholder's entire productive livestock herd. Traditional bank lending further exacerbates this by typically requiring a prohibitive cash down payment, locking out the vast majority of smallholders. Furthermore, a critical **tenor mismatch** exists while the cold chain assets themselves boast a robust **15–20-year economic life** short-term working capital or standard agricultural loans operate on short **12–18-month cycles**. This misalignment forces unsustainable high principal repayments that are incompatible with the farmers' irregular, climate-influenced cash flows (Tanzania Agricultural Development Bank, 2022). A single, unseasonable drought can trigger default on a short-term loan, even if the underlying asset is highly profitable in the long term. This structural barrier is further exacerbated by systemic **credit rationing**; the lack of institutional credit models tailored to smallholder cash flows means banks perceive the sector as too risky. The core risk driver is **information asymmetry**: traditional banks struggle to verify a smallholder's true income and monitor the productive use of the loan, forcing them to apply higher, blanket interest rates. Addressing the tenor, collateral, and information gap simultaneously is the key to unlocking this massive, ready-to-scale market.

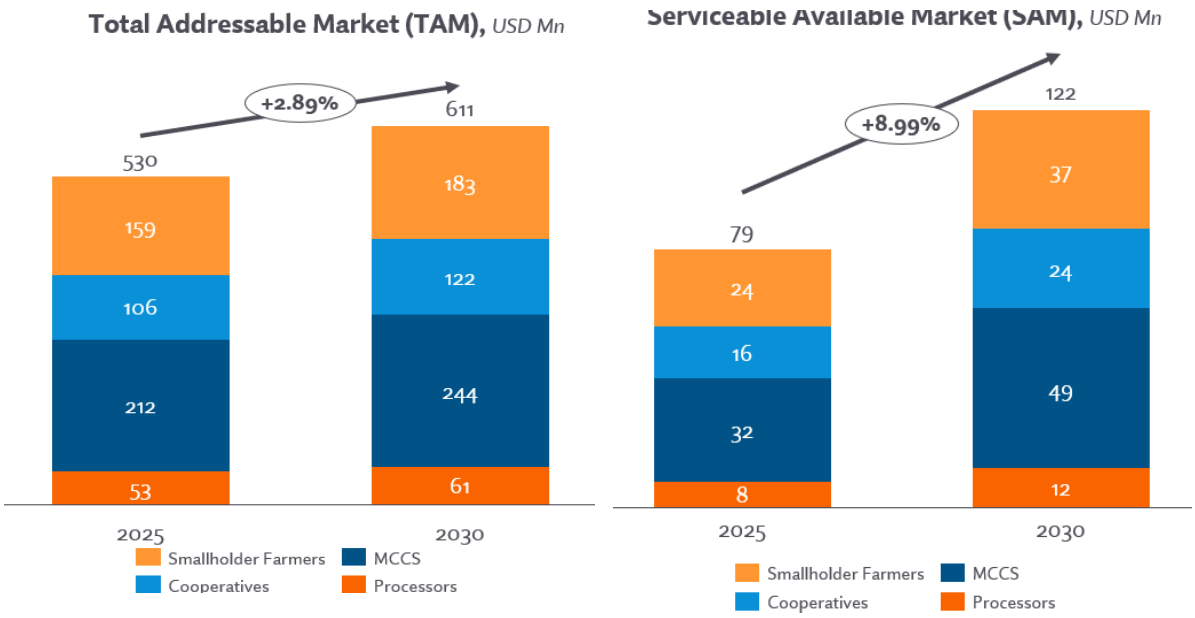
The Investment Opportunity

The total addressable market (TAM) for this investment is conservatively estimated at between **USD 500 million and USD 550 million** over the next five years, reflecting the full scale of the national cold chain deficit required to meet projected demand and eliminate post-harvest losses. The serviceable available

market (SAM) is a concentrated **USD 70 million to USD 80 million**[1], specifically targeting **40,000–60,000** smallholder dairy producers already engaged in formal or semi-formal supply chains in high-potential zones (e.g., Tanga, Mbeya, Arusha). This target group is the most commercially oriented and credit-ready cohort. These producers can be immediately onboarded via aggregator partners, reducing initial outreach and due diligence costs. The Portable/Mobile Cooling Units also represent a distinct, non-household **asset-finance opportunity** targeting the **supply chain enablers** rather than the producer. This investment tier focuses on **SME transport companies** or **dedicated Milk Collection Centres (MCCs)** that service geographically dispersed farmers. The economics are driven by the ability to monetize the 'first-mile' loss reduction. By financing the acquisition of these battery-powered refrigeration kits (e.g., FreshBox), investors enable the SME to charge a **higher, reliable service fee** to aggregators for certified cold-chain transport. This service fee acts as the primary revenue stream for loan repayment. The business model carries **low credit risk** as the SME borrower is directly integrated into the formal supply chain and benefits immediately from reduced spoilage and volume integrity, offering compelling returns on **asset-backed finance** over a typical 3–4-year tenor.

The borrower economics are highly compelling, with solar milk coolers offering a payback period of between **two to three years** and biogas chillers seeing returns within **18 to 24 months**. This rapid recoupment translates to a strong return on investment (ROI) with an internal rate of return (IRR) of **15-40%** (FAO, 2018). Producers gain new, stable income streams through quality premiums, which provide a guaranteed **10–15% price uplift** for consistently cooled milk, reinforcing the repayment capacity of the borrower against market fluctuations (NSO, 2023).

Figure 5: Cold chain infrastructure market size



Segmenting the Opportunity

- **Smallholder Farmers**: The primary **drivers of demand** for **cold chain technology** are the critical need to mitigate post-harvest losses, ensure milk quality for formal market access, and enhance energy access through co-benefit technologies. This segment is best served by microfinance institutions (MFIs) and SACCOS, who are positioned to finance the lower-cost, household-level

[1] Note that the TAM is calculated based on volumes: i.e. revised chiller cycles which is a combination of storage time and utilization. If we change utilization rate to 60% or 70%, the TAM drops to USD 200 million or approx. USD 265 million. The SAM then assumes 15% adoption rate, which then becomes a USD 35 million or USD 52 million.

technology (e.g., typically 50-100 litre capacity units suitable for producers with 2-5 dairy cows) such as Biogas Domestic Milk Chillers and/or small solar chillers. These chillers provide critical on-farm storage flexibility, dramatically reducing spoilage, and, as a key driver of adoption, offer the powerful co-benefit of fuel generation (bio gas) from cow dung. As approximately 86% of milk is sold informally by these producers, who often lack verifiable income data, the recommended financing model is the Cooperative/Group Lending model. This approach, facilitated by MFIs and other lenders, significantly lowers default risk through social collateral and peer monitoring (IFAD, 2011). Aggregate TAM: USD 150-160 million and Aggregate SAM: USD 20-30 million (Pegasys estimates)

- Co-ops/Associations: Cooperative societies and private aggregators are the primary borrowers for the medium-scale Solar Milk Coolers. The main driver of demand is the collective need to establish a centralized point for quality assurance and achieve the minimum volume threshold required for formal, contractual engagement with processors. These associations are the strategic focus of Commercial Banks for medium to large-scale financing. Financing these groups enables the cooling unit to serve 50–150 smallholder families, making it an ideal candidate for secured, medium-scale financing. The loan viability is significantly enhanced by the integration of Pay-As-You-Go (PAYG) technology, which allows the lender to remotely monitor the asset and verify the real-time cash flow from the processor, addressing the problem of information asymmetry. Aggregate TAM: USD 100-110 million and Aggregate SAM: USD 10-20 million (Pegasys estimates)

- Milk Collection Centres (MCCs): MCCs are officially designated, temperature-controlled facilities where milk is tested, aggregated from smallholders, and stored before bulk transport to processors. Ownership varies, encompassing primary cooperative societies, private aggregators, or, less frequently, individual micro-entrepreneurs. The core demand driver for investment in MCC infrastructure is the immediate and quantifiable need to reduce rejection losses due to spoilage, effectively transforming informal milk into formal, quality-verified supply. The Commercial Bank's primary targets for financing MCC equipment are the Cooperative Societies or Private Aggregators that own and operate these centres. Investment here is strategic because it addresses endemic inefficiencies, such as collection times of four to eight hours that lead to rapid quality degradation. The use of cold chain infrastructure at the MCC prevents an additional 15–30% of delivered milk from being rejected by formal processors due to failed quality tests. MCCs are also the logical point for leveraging Portable/Mobile Cooling Units by collection agents to service remote farmers, reducing last-mile transport losses. Aggregate TAM: USD 210-220 million and Aggregate SAM: USD 30-35 million (Pegasys estimates)

- Formal Dairy Processors: Processors are a crucial client segment, as the investment creates a stabilized, high-quality, and predictable volume of milk supply. The key drivers of demand are the need for supply chain resilience and long-term cost stability, mitigating reliance on expensive, long-haul sourcing. This is achieved by financing upstream cold chain assets (e.g., MCC coolers, transport units, or farmer domestic chillers) in the supply network, rather than solely upgrading their primary processing plant equipment. The current systemic failure of the cold chain restricts their ability to scale and forces them to rely on more expensive, long-haul sourcing. By financing this cold chain infrastructure, the bank is stabilizing its borrower base while simultaneously creating a guaranteed, quality-assured supply pipeline for the processors. This enables processors to offer better, longer-term contract certainty and supports the farmer's bargaining power. Consistent local supply also reduces the national reliance on expensive, volatile food imports. Aggregate TAM: USD 50-55 million and Aggregate SAM: USD 7-10 million (Pegasys estimates) In cases where the processor acts as an anchor buyer to its suppliers, two financing models typically emerge: 1) the processor takes the debt onto their balance sheet to fund the

supplier's equipment; or 2) the processor offers a guaranteed offtake agreement, with the supplier taking the loan and the anchor buyer guaranteeing or facilitating repayment via direct deductions from milk payments.

Business Model and Value Proposition for Financial Institutions

Tailoring Products for Commercial Banks and MFIs

Financial institutions must strategically differentiate their cold chain offerings based on client scale and risk tolerance, aligning the product features precisely to the borrower's capacity:

- Commercial Banks: To gain the economies of scale, these larger institutions should strategically focus on medium to large-scale financing targeted at collection centres, cooperative aggregators, and commercial dairy farms. Their core function is two-fold: first, to leverage their scale to access commercial and, where available, Development Financial Institution (DFI) finance. DFI funds are blended with commercial rates to effectively lower the overall interest rate (affordability) and extend repayment periods (tenors), facilitating client uptake. (Note: Detailed discussion of affordability and tenors as market demand drivers is covered in the Market Opportunity section.) Second, and most critically, they must deploy robust Collateral Enhancement strategies. This is achieved by partnering with specialized technology providers to implement integrated Pay-As-You-Go (PAYG) systems embedded directly in the cooling units. These digital platforms allow for the remote monitoring and control of the asset's performance, providing real-time data on uptime, cooling efficiency, and power generation. This directly solves the problem of information asymmetry, transforming the physical equipment into a traceable, bankable asset whose health is directly observable by the lender. Furthermore, the PAYG remote-control feature allows the lender to effectively repossess the function of the cooling unit in case of severe non-payment, creating a powerful non-physical security interest that often surpasses the legal complexity of land-based collateral. The availability of this data allows the bank to move away from relying on static collateral like land titles to relying on verifiable, real-time cash flow from the processor. This de-risked lending methodology is aimed squarely at driving the typically elevated agricultural Non-Performing Loan (NPL) ratio, currently averaging 8-12%, down to a targeted performance of below 5% for this specific, technologically monitored asset class (Tanzania Agricultural Development Bank, 2022).
- Microfinance Institutions (MFIs) and SACCOS: Are best positioned to finance household-level chillers such as small solar-powered or biogas-linked cooling units. Their superior local knowledge and community presence reduce adverse selection and improves client screening efficiency. Their mandated use of the Cooperative/Group Lending model is vital, as it reduces administrative costs, increases outreach to remote areas, and significantly lowers default risk through social collateral and peer monitoring (IFAD, 2011). That said, larger institutions like commercial banks can partner with MFIs/ SACCOS to provide finance for this target group of clients. The group dynamic ensures accountability for loan repayment through peer pressure and shared liability, making these smaller, dual-benefit assets highly viable for micro-credit and expanding financial inclusion to the most remote smallholders while bolstering the MFI's brand reputation within the community.

Leveraging Digital Collection Infrastructure

The successful financing model relies heavily on the integration of robust, secure digital payment rails. Collections should be processed directly via ubiquitous mobile money platforms (e.g., M-Pesa, Tigo Pesa), which are used by over 50% of the rural population in Tanzania (GSMA Intelligence, 2021). The collection process is digitized: milk is collected, volume and quality are digitally logged at the centre via a Point-of-Sale (POS) device, and payment is immediately triggered via mobile money. This digital track record provides the lender with two crucial, auditable data points: verifiable income data (from the processor, confirming sales volumes and quality bonuses) and verifiable repayment history (via the mobile network operator). This integrated system overcomes the traditional hurdle of financial exclusion and reduces the risk of cash diversion by eliminating physical cash handling, creating a robust, auditable financial profile for the previously "unbankable" smallholder. It essentially digitizes the farmer's cash flow, transforming it into a credit score that can be leveraged for future financial products.

Development and Climate Benefits

Enhancing Food Security and Yield Resilience

The reduction of post-harvest loss represents a direct, immediate, and high-impact increase in the national food supply. This improvement in consistent, year-round food availability contributes significantly to SDG 2 (Zero Hunger) by stabilizing milk prices and supply, which in turn improves access to nutrition and reduces malnutrition, particularly in vulnerable demographics and low-income urban areas.

While Tanzania's annual milk consumption of 67.5 litres per capita remains low compared to the global average of 200 litres, addressing losses is key to closing the supply gap and reducing the national reliance on imports, which totalled 5.2 million litres in 2021/22 (ASRIC, 2024). Furthermore, the stable income stream enabled by quality premiums, in combination with access to financial services and input markets, allows farmers to consistently invest in better veterinary supplies, quality livestock genetics (e.g., cross-breeding for heat tolerance), and climate-resilient feed (e.g., establishing drought-resistant fodder or investing in water harvesting solutions for rotational grazing). This strategic, recurring investment directly improves herd health and productivity, ensuring greater yield resilience during external climate shocks like prolonged drought or excessive heat, which is the core goal of agricultural adaptation. Consistent local supply also reduces the national reliance on expensive, volatile food imports.

Gender Empowerment and Inclusive Growth

Women are disproportionately responsible for milk handling, basic processing, and transportation. Women constitute 60–80% of labour in smallholder dairy systems across Africa and South Asia, primarily handling milk collection, basic processing, and transport to markets or collection points. This work often involves carrying 20–30 kg containers over distances of up to 5 km, contributing to severe physical drudgery and time poverty. (FAO, 2018)The implementation of cooling infrastructure at the farm gate or village level saves women an estimated 3–4 hours per day of physically arduous transportation and queuing time (Tanzania Livestock Master Plan, 2017). This saved time is a vital economic resource that can be reallocated to other productive economic activities, such as starting a micro-enterprise, engaging in community leadership, or dedicating more time to children's education and essential care work, creating a human capital dividend.

Crucially, selling cooled milk to formal collection centres results in direct, traceable payments via mobile money to the household's dedicated manager (who is often the woman), significantly increasing her control over income and productive assets and fostering financial independence, directly supporting SDG 5 (Gender Equality). The formal financial record strengthens her position for independent credit access. Selling cooled milk through formal channels ensures traceable mobile money payments, increasing women's control over household income and productive assets. Mobile money adoption is strongly correlated with women's economic empowerment, improving resilience and enabling access to credit; in Sub-Saharan Africa, mobile money accounts grew by 800% between 2012 and 2021, with women among the primary beneficiaries. (GSMA, 2022)

Environmental and Climate Co-Benefits

The adoption of off-grid solar and biogas cold chain solutions directly substitutes the most carbon-intensive methods currently used for cooling and power, creating significant and measurable climate mitigation co-benefits by directly substituting the most carbon-intensive cooling and power methods. Specifically, the solution is primarily a mitigation measure when it replaces existing diesel generators, but it is *a primary adaptation measure when it is the first solution in place, preventing greater milk loss that would otherwise occur* due to the increasingly severe climate shocks.

The transition from traditional diesel generators—which are often inefficient, poorly maintained, and heavy polluters—to a biogas system or solar charging unit eliminates approximately 3,100 kg CO_2e per household annually (IPCC, 2021). This is a substantial reduction achieved by shifting away from volatile

fossil fuels for productive use. Furthermore, the increased farm income and stability fostered by the cold chain allows farmers to invest in higher-quality feed and improved animal husbandry, leading to healthier animals that produce milk with significantly lower carbon intensity.

This is achieved because more efficient, well-fed animals convert feed to milk more effectively, reducing enteric methane emissions from approximately 1.2 kg CO2e to a much more efficient 0.6 kg CO2e per litre (IVL, 2015). This systemic shift aligns directly with Tanzania's Nationally Determined Contributions (NDCs), Tanzania's Development Vision 2025, and the National Renewable Energy Strategy (2024–2034) to scale up renewable energy adoption and increase efficiency in productive sectors, making this investment a concrete contribution to SDG 13 (Climate Action) and aligning the bank's portfolio with global green finance taxonomy.

Implementation and Scaling Pathway

This document details a **phased, four-step approach** to launch and scale an innovative cold chain financing solution (which adapts existing long-term asset finance with integrated PAYG data streams and specialized risk modelling) designed to address critical infrastructure and risk challenges within the agricultural sector, specifically targeting smallholder dairy farmers. By systematically moving from a small-scale, intensively monitored **pilot lending** phase to securing **co-financing guarantees** and ultimately achieving **institutional integration** and **policy alignment**, the framework aims to de-risk adaptation finance, prove the economic viability of long-tenor loans, and establish a permanent, scalable climate-adjusted lending model that leverages real-time asset performance data.

Figure 6: Scaling pathway for cold chain infrastructure in Tanzania

Step 1: Pilot Lending

- **Focus:** Validate repayment and risk pricing via a small-scale, intensively monitored pilot project. Target 1,000–2,000 creditworthy smallholders in a key dairy region (e.g., Southern Highlands: districts: Iringa, Njombe, Mbeya) with strong, verified processor partnerships in place. The success of this pilot hinges on rigorous data collection and the establishment of partnership agreements with PAYG providers and Mobile Network Operators (MNOs).
- **Goal:** Successfully test the 36-60 month loan tenor (addressing the critical mismatch , as cold chain infrastructure typically has a 7-10 year economic life, far exceeding the typical 12-24 month tenor offered for seasonal agricultural asset loans like tractor financing), integrate the PAYG remote monitoring system, and prove the core thesis by achieving a demonstrably low sub-5% Non-Performing Loan (NPL) rate for this specific product (EEP Africa, 2023). This validated data, demonstrating both asset performance and repayment efficiency, is essential for attracting co-financing partners.

Step 2: Aggregation and Co-Financing Focus: Use successful pilot data and the proven sub-5% NPL rate as leverage to secure DFI guarantees or concessional lines of credit (e.g., from the African Development Bank or, leveraging the AfDB's accreditation, potential co-financing from the Green Climate Fund). This step moves from internal validation to external de-risking. The validated data provides the necessary evidence base to satisfy DFI requirements for blended finance.

- **Goal:** Secure a crucial first-loss guarantee (typically 5–10% of the loan book value) to de-risk commercial capital, potentially leveraging sector-specific players like Aceli Africa in addition to DFI guarantees, allowing the bank to leverage its own funds 5-10x and attract significantly larger pools of blended capital for scale and reduced cost of funds. This guarantee shields the bank from initial portfolio volatility, making the proposition attractive to the credit committee.

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

- **Focus:** Transition the cold chain loan product from a temporary pilot project into a core, standardized, and permanent offering within the bank's agricultural lending portfolio, supported

by specialized staff training and branch-level incentives. This institutionalization requires integrating the PAYG data stream into the bank's core IT infrastructure.

- Goal: Develop an internal Climate-Adjusted Risk Model (CARM) that utilizes the asset's performance data (PAYG data on uptime, cooling efficiency, milk volume, and maintenance alerts) as a direct and immediate proxy for borrower health. This shift enables faster, more accurate credit scoring and aims to reduce average credit administration time by 25-40% by relying on real-time data instead of costly, sporadic physical visits.

Step 4: Scale Through Policy and Ecosystem Alignment

- Focus: Secure long-term government support and quality standard enforcement to sustain market demand and competitive advantage for cooled milk. The UN Food Systems Coordination Hub has already flagged a national commitment to improve infrastructure investment by 2030, with an estimated cost of over USD238.5 million USD (UN Food Systems Coordination Hub, 2025). This institutionalization is key to long-term profitability and the sustained quality of the bank's underlying assets.
- Goal: Advocate for policy changes, such as VAT or duty tax breaks on imported solar and biogas cooling components to permanently reduce the CAPEX barrier for all farmers. Crucially, work with the Tanzania Bureau of Standards (TBS) to enforce stricter milk quality standards, thereby sustaining the borrower's quality price premium and guaranteeing demand for the high-quality milk produced through the cold chain. This policy action provides a competitive moat for the bank's client base.

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

A&R Outcome Measurements for Financial Institutions:

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

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

RESOURCES

This brief directly builds on the following technical report:

- GCA (2026), Market Study to Identify and Quantify Adaptation Investment Opportunities in Agriculture and Food Systems: Tanzania, Kenya, Zambia, DR Congo. Developed in cooperation with partners including CGAP, and consulting firm: Pegasys.

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