



Kenya

Digital Climate Advisory Services: Investment Brief

Climate Adaptation Market Opportunities
Agriculture & Food Systems

April 2026



GLOBAL
CENTER ON
ADAPTATION



AUTHORS & ACKNOWLEDGEMENTS

This report was developed by

Global Center on Adaptation:

Florentina Daniela Gheorghe, Senior Adaptation Finance Specialist (project lead), **Julia Eichhorn**, Program Officer Adaptation Finance, **Hans Muzoora**, Senior Adaptation Finance Specialist, **Kimwaga Mhando**, Senior Program Officer Agribusiness and Private Sector Engagement, **Oluwabunmi Ajilore**, Food Security Specialist, **Thu Minh Ta**, Adaptation Finance Specialist, **Abraar Ahmad**, Program Officer Adaptation Finance, **Madison Berry**, Monitoring and Data Analyst, Under the guidance of **Oluyede Ajayi**, Global Lead Food Security and Rural Wellbeing, **Adele Cadario**, Global Lead Adaptation Finance and Infrastructure and Nature-based Solutions, and **Nitin Jain**, Senior Director of Programs.

In close collaboration with:

CGAP: Jamie Barbara Anderson, Senior Financial Sector Specialist.

Consultants and lead authors:

Pegasys Consulting: Rohit Shankar (project lead), **Mogammad Jardien**, **Polly Hodgkins**, Gender Specialist, Under the guidance of **Daniel Seddon-Daines** and **Jane Wilkinson**.

DESCRIPTORS

Sector: Agriculture

Countries: Kenya

Key words: climate adaptation and resilience, market sizing, commercial banks, digital climate advisory services

Contact: climatefinance@gca.org

How to cite this report:

Global Center on Adaptation, Kenya. Investment brief for Digital Climate Advisory Services, 2026. Partnership: CGAP. Consulting firm: Pegasys Consulting. Developed under the AAAP.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the valuable insights and experiences shared by experts from **Equity Bank**, **CRDB Bank**, **CGIAR centres - Alliance Biodiversity International-CIAT**, **International Livestock Research Institute (ILRI)**, **International Water Management Institute (IWMI)**, **International Institute of Tropical Agriculture (IITA)** - , **ACELI Africa**, **FSD Tanzania**, **IDH**, **ISF Advisors**, **One Acre Fund**, **Eastern African Grain Council (EAGC)** **ESOKO**, **YAPU Solutions** whose perspectives informed the development of this report.

ABOUT THE GLOBAL CENTER ON ADAPTATION



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.

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.

In close collaboration with:



Consultants:



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.

CONTENTS

Contents.....	3
INVESTMENT BRIEF: DIGITAL CLIMATE ADVISORY SERVICES IN KENYA	4
Executive Summary	4
The Adaptation Challenge.....	6
Market Opportunity.....	9
Business Model Discussion	12
Value Proposition for Financial Institutions.....	14
Development and Climate Impact Benefits	17
Implementation and Scaling Pathway.....	19
Resources	22

INVESTMENT BRIEF: DIGITAL CLIMATE ADVISORY SERVICES IN KENYA

Executive Summary

Climate risk is now a credit risk in Kenya's agricultural system. The escalating crisis of climate change, including the most severe drought in 40 years (2019-2023), is a direct and material threat to the financial stability of the agricultural sector. Climate-related disasters are costing Kenya an estimated **US\$56.96 million annually**, with periodic drought crises alone accounting for losses equivalent to **8% of Kenya's GDP every five years**. (Government of Kenya, 2017) This exposes financial institutions to severe, unmitigated **systemic credit risk**.

Digital Climate Advisory Services (DCAS) are not merely a climate adaptation measure in agri-food systems, but an essential, cost-effective intervention required for financial portfolio de-risking. DCAS delivers "timely, tailored, and actionable information—from weather forecasts and pest alerts to input recommendations and real time market information." These tools are not merely weather apps; they are integrated "innovation packages" that bundle climate intelligence with agronomic action points and pricing data. This bundling addresses the primary challenge of smallholder farmers: limited access to localized tools that enable risk-informed decision-making.

DCAS reduces climate-induced productivity risks for farmers and post-harvest losses for traders. For agricultural trade portfolios, access to localized climate data allows aggregators to optimize logistics and reduce spoilage. This enables optimal planting, fertilization, irrigation, and harvesting decisions. This effective mitigation of operational risk for the borrower, in turn, directly reduces the financial institution's exposure to climate-driven default risk within its portfolio. **The product fit is straightforward: DCAS can be a subsidized addition to existing financial products and represents a highly cost-efficient way to reduce systemic risk.**

- **Yield and Income Protection:** Farmers utilizing DCAS experience significant productivity gains. Safaricom's DigiFarm has shown a 70% productivity gain and 70% income gain. One Acre Fund's Digital Weather Advisory Services (DWAS) pilot showed a 12–17% yield increase for targeted farmers.
- **Borrower Resilience:** DCAS users demonstrate a Resilience Capacity Index (RCI) more than 3.5 times higher (21.4) compared to non-users (6.15) (Scale for Resilience & YAPU Solutions, 2025).
- **Cost-Effectiveness:** The global benefit-cost ratio (BCR) for DCAS ranges from 1:10 to 1:70 (GCA, 2021). The mean up-front investment cost per small-scale producer is estimated at only US\$16.20 (GCA, 2021).

The market is significant, segmented and anchored in national agricultural priorities. Kenya's economy is deeply dependent on agriculture, which contributes over one-third of the GDP and employs **over 70% of the rural population**. The target user segments are clear: **Smallholder Farmers (SHFs)** (primary focus), **Commercial Farmers & Agribusiness**, and **Co-operatives and Farmer Groups**.

De-risking structures are actionable: The scaling pathway involves leveraging Development Finance Institution (DFI) guarantees or concessional lines of credit to attract larger commercial capital pools. For instance, a DFI might offer a first-loss guarantee on a percentage of the expanded portfolio (**covering both agricultural inputs and DCAS subscriptions**), which significantly reduces the perceived risk for private commercial banks, thereby enabling them to enter the market and accelerate the scale-up of DCAS financing. Furthermore, the government provides a robust institutional environment, formally prioritizing

DCAS within the National Framework for Climate Services (NFCS) and the National Climate Change Action Plan (NCCAP).

Development and Climate Dividends are Material

Scaling DCAS is a potent vehicle for achieving both climate adaptation and significant socio-economic development outcomes, creating **value protection** and generating **value**.

- **Lifting Household Incomes:** Returns to farmers in the form of productivity and income average **30% and 25%**, respectively. (GCA, 2021) Investment in climate services in Kenya is estimated to generate approximately **USUSD281.6 million annually in revenue gains** from smallholder farmers alone. (GCA, 2021)
- **Gender Empowerment:** DCAS reduces information asymmetry, allowing women to gain greater control over household income and assets. **Digital advisory services designed with gender sensitivity strengthen women farmers' climate preparedness.** The Sauti East Africa project, which delivers mobile climate information platforms in Kenya, reported that 57.8% of new women users integrated climate change adaptation strategies into their farming practices, with women representing 49% of all users (16,596 women) across four climate-vulnerable counties. (Sauti East Africa, 2025)
- **Environmental Co-benefits:** DCAS drives enhanced **input efficiency** (less water and fertilizer) and supports Kenya's drive towards low carbon climate-resilient development.

Call to Action for Banks

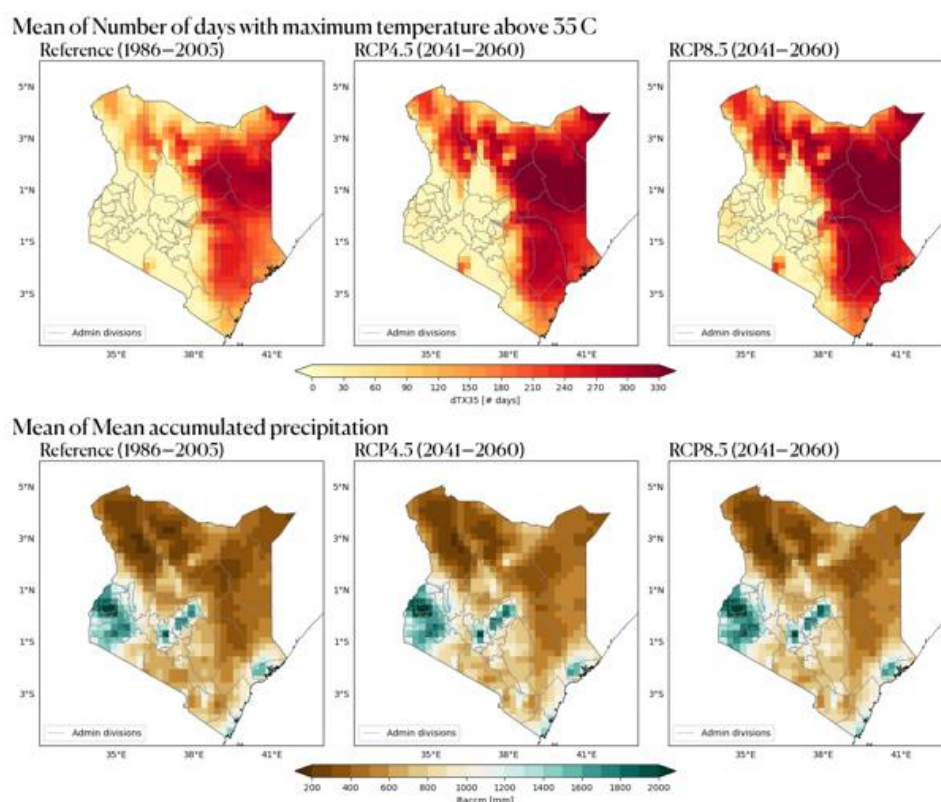
Finance Digital Climate Advisory Services (DCAS) now, recognizing that this is not merely an investment in agriculture, but a **proven strategy for proactive credit risk mitigation and portfolio stabilization**. Climate-driven production volatility creates systemic, cascading default risks across the entire agricultural value chain, from input suppliers to trade finance operations. By integrating DCAS as a mandatory loan requirement, financial institutions immediately stabilize their lending exposure, ensuring more efficient use of financed inputs, securing farmer repayment capacity, and protecting associated commodity flows. **This integration, in turn, effectively 'green tags' the loan portfolio, providing a verifiable mechanism to meet stringent ESG mandates** and unlock significant pools of climate adaptation and concessional finance, ultimately shifting the bank's profile toward a more stable, climate-aligned, and sustainably profitable footing.

The Adaptation Challenge

Kenya's agriculture, which contributes significantly to the national GDP (~21%) and employs a vast portion of its population (~40% of the total population and more than 70% of the rural population) (FTMA, 2022), is confronting an accelerating and urgent climate crisis (IFPRI, 2023). Climate change, characterized by increasingly erratic rainfall, rising average temperatures, and prolonged periods of high humidity, is no longer just an environmental issue; it is a fundamental credit risk that threatens the repayment capacity of the agri-sector.

By 2050, Kenya is projected to face severe, regionally differentiated climate hazards dominated by **extreme heat** and **flooding**. Heat will be most intense in the northeastern arid lowlands (Mandera, Wajir, Isiolo), with peak days reaching 45–47 °C, while the western/central highlands will experience the most significant relative warming (up to +2.4 °C). Concurrently, **drought intensity** is set to strengthen to moderate levels across the coast, highlands, and northwest, driven by rising evaporative demand despite localized rainfall increases, necessitating adaptation in newly drought-prone highland areas. The risk of **riverine and flash floods** is heightening due to intensifying short-duration rainfall, particularly in coastal and eastern counties; major river flooding exposure is projected to concentrate in Tana River, Garissa, and Turkana, with Kilifi (249,172 people) and Tana River (29% of its population) facing the highest population risk. Finally, changes in **wind extremes** are projected to be modest overall, with only minor localized increases in the eastern lowlands.

Figure 1: Climate hazard projections for Kenya



The escalating crisis of climate change in Kenya transcends environmental concern, manifesting as a **direct and material threat to the financial stability** of the nation's agricultural sector. This section defines the scope of the problem by detailing the **current and projected economic losses** attributable to extreme weather events, which fundamentally undermine the solvency of smallholder farmers and expose financial institutions to severe, **systemic credit risk**. It then highlights the critical information gap facing these vulnerable smallholders, establishing the context for why **Digital Climate Advisory Services (DCAS)**

are not merely an adaptation measure, but an essential, cost-effective intervention required for financial portfolio de-risking in agriculture.

Financial Risk and Projected Losses

Kenya is currently facing substantial economic losses from climate-related disasters, losing an estimated **US\$56.96 million annually** to droughts, mudslides, and floods (ICPAC, 2024). These losses create a systemic drag on the national economy and are highly concentrated in the climate-sensitive agricultural sector, where loan defaults are directly correlated with harvest failure.

Furthermore, periodic drought crises alone account for losses equivalent to **8% of Kenya's GDP every five years** (Government of Kenya, 2023). The 2019-2023 drought was the most severe in 40 years, resulting in approximately **4.4 million people** facing high levels of acute food insecurity by February 2023 (Government of Kenya, 2023).

For financial institutions, this projection represents a severe, exposure to systemic portfolio risk. Adaptation finance is therefore a necessity for **value protection**.

The Smallholder Vulnerability and Information Gap

Over **80% of Kenya's population** relies on agriculture, which is predominantly rainfed, highlighting notable exposure to climate shocks (World Bank Group, 2015). Additionally, Kenya's mean annual temperature has increased by **1.0°C since 1960** at an average rate of 0.21°C per decade, with the long-rain season becoming shorter and drier and extreme rainfall events increasing, compounding the need for accurate, localized information and/or advisory (KMD, 2024). Smallholder farmers, who constitute the vast majority of this population, are the most exposed to climate variability and shocks. Their primary challenge is the **limited access to timely, downscaled, and community-specific climate information**, which severely hinders appropriate agricultural planning and decision-making.

Existing national frameworks, such as the **National Climate Change Action Plan (NCCAP) 2023-2027** (Government of Kenya, 2023) and the **National Framework for Climate Services (NFCS) Kenya** (KMD, 2024), recognize the critical need for strengthening climate services. However, a functional gap persists between the availability of raw data and its delivery as actionable, farm-level advice.

The Imperative for Digital Climate Advisory Services (DCAS)

To close this risk and vulnerability gap, investment must be directed toward scaling **Digital Climate Advisory Services (DCAS)**. DCAS tools and platforms integrate localized climate information into agricultural decision-making, offering a scalable, cost-effective solution to build resilience (Ferdinand, et al., 2021). By financing the adoption of these services, financial institutions directly reduce the climate-induced risk to the farmer, thereby de-risking the underlying agricultural loans and safeguarding their portfolio. The deployment of DCAS is, therefore, a core **Credit Risk Solution**.

DCAS strategically mitigates credit risk across the agricultural value chain by providing granular, actionable data tailored to different borrower segments. For **agri-production** entities (farmers and smallholders), DCAS delivers real-time, localized advisories on weather, pest control, and optimal input use, supporting climate-smart decision-making that is proven to increase productivity by an average of 30% and household income by 25% (GCA, 2021) (IFPRI, 2010). This reduction in output volatility and climate-driven losses significantly improves their repayment capacity and overall credit profile. For **agri-input providers** (dealers and suppliers), digital platforms bundled with DCAS services streamline the distribution channel by enabling a B2C model (Farmforce, 2024), facilitating direct engagement with farmers, and often linking credit approvals to input redemption at designated outlets, which lowers the risk of credit diversion and simplifies the supply chain (AFDB, 2019). Finally, for **agri-trade** entities (off-takers and commodity traders), the integration of climate information services (CIS) into their operations provides high-resolution seasonal and sub-seasonal forecasts (CGIAR, 2023). This early warning

capability stabilizes commodity supply, reduces volatility, and allows traders to proactively manage procurement and contract risks, thereby reinforcing the creditworthiness of their overall operation and minimizing systemic supply chain disruptions (SEI, 2021).

Market Opportunity

The investment case for Digital Climate Advisory Services (DCAS) in Kenya is driven by a massive, quantifiable need to protect a climate-vulnerable agricultural sector while unlocking significant economic returns. Kenya's economy remains deeply dependent on agriculture, with the sector employing over 70% of the rural population and contributing over one-fifth of the GDP (Central Bank of Kenya, 2024). This represents a massive addressable market, but one characterized by high risk.

Estimated Market size

The market analysis for digital climate advisory services in Kenya reveals a rapidly accessible and expanding opportunity, with the **Total Addressable Market (TAM) projected at USD 72-76 million in 2025**, growing modestly to USD 77-82 million by 2030. Crucially, the Serviceable Available Market (SAM)—representing the segment immediately accessible to providers—shows robust growth, increasing significantly from **USD 32-36 million in 2025** to USD 45-50 million by 2030. This expansion of the SAM, outpacing the TAM's growth, is a direct reflection of Kenya's strategic environment: its advanced "Silicon Savannah" digital infrastructure and strong government policies are actively converting the theoretical total market into a commercially accessible one, driven by international adaptation financing and the critical need for climate resilience in the agriculture sector.

Three clear key user segments can be found in the market:

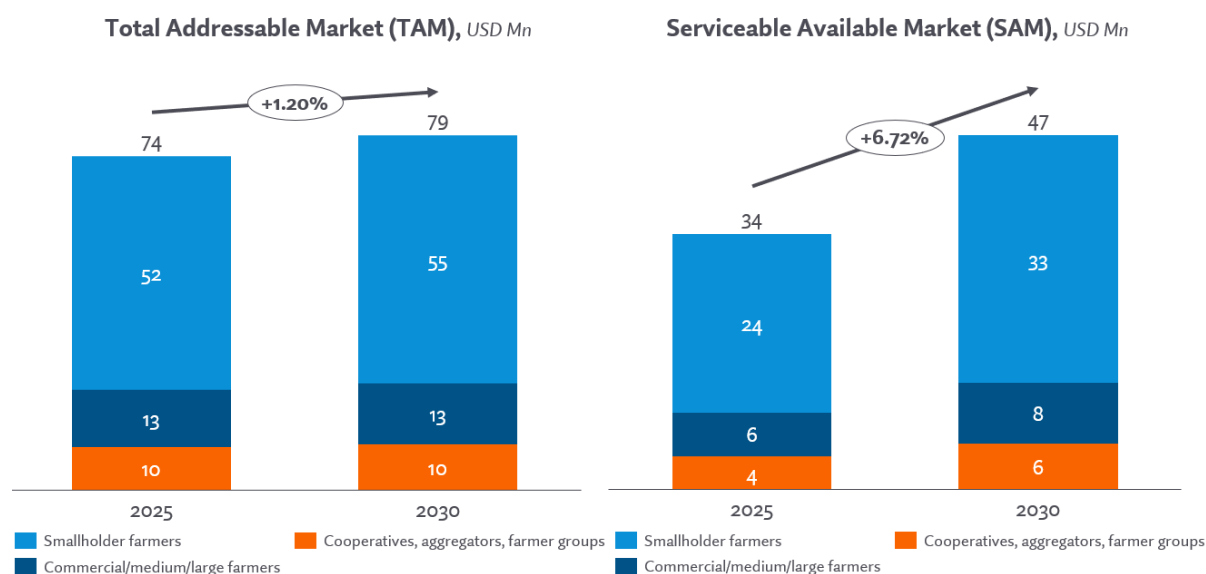
- **Smallholder Farmers (SHFs):** The primary focus, requiring basic, affordable, and timely information delivered through low-cost channels like SMS and USSD to protect staple crops and livestock. Their scale drives the core revenue-gain potential. **Aggregate TAM:** USD 50-55 million and **Aggregate SAM:** USD 22-26 million (Pegasys estimates).
- **Commercial Farmers:** This segment requires high-precision, plot-level data for optimizing logistics, managing high-value inputs, and de-risking financial portfolios. They are key early adopters who can validate the Willingness-to-Pay (WTP) for premium DCAS models (Kamau, Mburu, Mills, & Kirimi, 2024). **Aggregate TAM:** USD 10-15 million and **Aggregate SAM:** USD 4-6 million (Pegasys estimates).
- **Co-operatives and Farmer Groups:** These institutional channels are critical for scaling DCAS, as they serve as aggregation points for effective dissemination, training, and collective bargaining. Leveraging these groups reduces the last-mile cost and improves farmer comprehension of complex advisories. **Aggregate TAM:** USD 8-12 million and **Aggregate SAM:** USD 4-8 million (Pegasys estimates).

Additional Key User Segments:

Agri-Input Providers: This B2B segment uses DCAS to optimize inventory, distribution, and product application timing, thereby enhancing the efficacy of high-value inputs like seeds and fertilizer. This integration shifts DCAS from a pure advisory tool to a sales and risk mitigation enabler for the input value chain.

Agri-Traders/Aggregators: This institutional segment uses localized climate and yield forecasts to optimize logistics, procurement scheduling, storage capacity, and transportation planning for post-harvest activities. Their investment in DCAS reduces supply-chain waste and enhances market stability.

Figure 2: DCAS market size

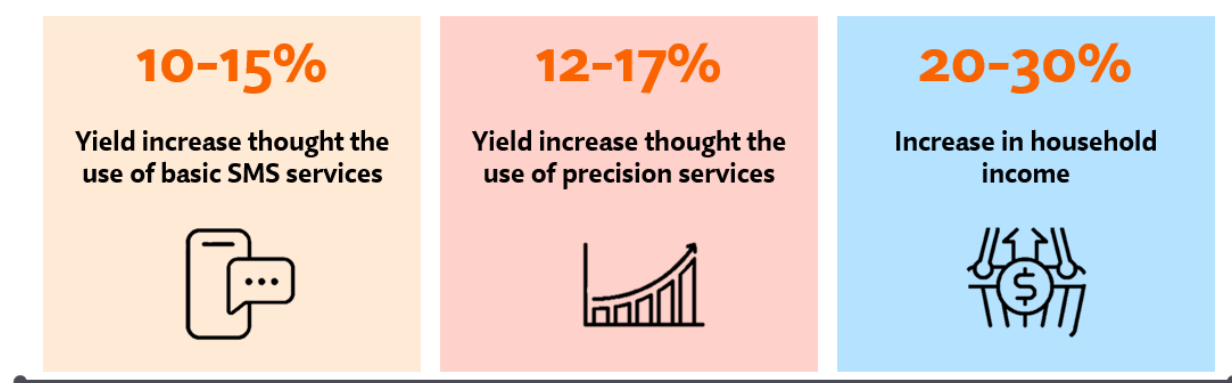


DCAS Service Taxonomy

Digital Climate Advisory Services (DCAS) are a tiered suite of solutions that deliver increasingly granular and actionable information, moving beyond simple weather forecasts to integrated farm management.

- Foundational Services (Weather & Seasonal Forecasts):** These services use high-frequency delivery channels (SMS, USSD, Radio) to provide simple, actionable advice on core farming decisions like when to plant, irrigate, or harvest to avoid imminent risks. **Proven Impact:** SMS advisories alone have been shown to increase yields by **11.5%** in a Kenyan sugar cane trial (Casaburi, Mullainathan, Kremer, & Ramrattan, 2019).
- Integrated Services (Digital Extension):** These solutions use interactive media (e.g., *Shamba Shape Up*) and mobile apps (e.g., DigiFarm, referenced in Mercy Corps AgriFin, 2019) to combine general climate information with specific agronomic advice, such as optimal fertilizer rates and pest/disease warnings. **Proven Impact:** Existing models result in **65%** of farmers reporting positive changes in practice, with **55%** experiencing increased production and a **25%** increase in household income reported in select cases (Vyas, et al., 2024).
- Advanced Services (Precision Agriculture):** This represents the high-value end of the market, leveraging satellite/drone imagery, soil testing, and machine learning to deliver plot-specific, time-sensitive interventions tailored to local microclimates and soil conditions (Mercy Corps AgriFin., 2019). **Proven Impact:** One Acre Fund's Digital Weather Advisory Service (DWAS) pilot resulted in a **12–17% yield increase** for targeted farmers by providing weekly plus daily forecasts (One Acre Fund, 2025).

Figure 3 : DCAS enables tangible uplift through different channels



Market Landscape: Key Players in Kenya's Digital Advisory Ecosystem

The Kenyan market for digital agricultural solutions is highly mature, evidenced by **over 100 digital solutions** on the market, **64 of which are headquartered in Kenya** (Bolwig, Haselip, Strange, Hornum, & Pedersen, 2021). These players possess proven technology stacks and established farmer trust that FIs can immediately leverage.

- Prominent among commercial and development actors is **Safaricom's DigiFarm**, which provides an integrated, mobile-based platform using USSD, SMS, and an app, offering a comprehensive ecosystem of precision agriculture advisory services bundled with input financing and market linkages (Mercy Corps AgriFin., 2019). This platform alone reaches **1.3 million farmers** (Bolwig, Haselip, Strange, Hornum, & Pedersen, 2021)
- On the rigorous impact validation side, **One Acre Fund (Tupande)** runs the Digital Weather Advisory Service (DWAS), which focuses specifically on yield increase for smallholder farmers through direct SMS and field agent delivery, demonstrating high-impact results that are rigorously tested (One Acre Fund, 2025).
- Furthermore, solutions like **iShamba and Shamba Shape Up** use engaging TV (*Edutainment*) and SMS-based platforms to provide broader advisory services, covering livestock productivity, climate adaptation, and crucial financial literacy (Vyas, et al., 2024) (Vyas et al., 2024).
- Finally, the Kenya Agricultural and Livestock Research Organization (**KALRO**) serves as a crucial, government-backed institutional provider, disseminating credible SMS advisories with recommended steps based on current and forecasted weather (Kamau, Mburu, Mills, & Kirimi, 2024).

The challenge is not *proving* the concept but integrating these proven solutions into the loan disbursement and monitoring process, effectively turning **DCAS adoption into a loan requirement** for credit committees.

Business Model Discussion

Prioritizing Public Good Provision

The choice of business model for scaling Digital Climate Advisory Services (**DCAS**) is pivotal to achieving both **impact and financial sustainability**. Analysis of the current market and socioeconomic factors indicates that relying on a direct-to-consumer model is infeasible, positioning the **Business-to-Government (B2G)** approach as the most promising primary pathway to national scale.

Business-to-Government (B2G): The Primary Model

The B2G model involves private sector DCAS providers contracting directly with government entities (e.g., the Kenya Meteorological Department, Ministry of Agriculture, County Governments, or dedicated funds like County Climate Change Funds). This approach is necessary and optimal for several reasons:

- **DCAS as a Public Good:** Climate information is increasingly recognized as a **fundamental human right** and a prerequisite for national food security and disaster risk reduction. Framing it as a public utility justifies the use of public funds, aligning with government policy documents like the **National Framework for Climate Services (NFCS) Kenya** and the **National Climate Change Action Plan (NCCAP) III**.
- **Low Willingness to Pay (WTP):** Direct cost recovery from smallholder farmers is extremely challenging. A WTP study among Kenyan farmers found that approximately **50% of smallholders were unwilling to pay** for digital agricultural tools at any price, suggesting that a fee-for-service model would fail to achieve the required penetration and impact (Kamau, Mburu, Mills, & Kiriimi, 2024).
- **Ensuring Sustainability and Scale:** Current DCAS provision is often **fragmented and unsustainable beyond initial project cycles** (GCA, 2021). A B2G model provides the stable, long-term funding, which is primarily channelled through the World Bank and Multilateral Development Banks (MDBs) via large-scale concessional loans and grants to the Kenyan government. This mechanism is necessary to move DCAS beyond the pilot phase and achieve the required scale to protect the millions of climate-vulnerable households across Kenya (Mercy Corps AgriFin., 2019).

Supplemental Models: B2B and B2B2C

While B2G provides the necessary foundation for ubiquity, complementary models can drive efficiency, enhance service quality, and open diverse revenue streams.

- **Business-to-Business (B2B):** This model focuses on selling the underlying, value-added data or aggregated insights to commercial clients. This is highly relevant to **financial institutions** like commercial banks, as it monetizes the de-risking function of DCAS.
 - **Value Proposition:** DCAS generates high-resolution risk data (e.g., predicted climate stress, localized yield impact estimates) that can be sold to credit providers for **loan underwriting, portfolio risk management, and insurance pricing** (GCA, 2021).
 - **Target Clients:** Agricultural aggregators, input suppliers, large-scale buyers, commodity traders, and commercial banks/MFIs.
- **Business-to-Business-to-Consumer (B2B2C):** This involves integrating DCAS into the product offering of established commercial or development platforms that already have large farmer networks. The service is often bundled or subsidized.
 - **Value Proposition:** Existing platforms (e.g., Safaricom's DigiFarm, One Acre Fund's DWAS pilot) can leverage their established communication channels (e.g., SMS) and farmer trust to deliver the service at a low marginal cost. The cost is either absorbed by the partner or cross-subsidized by their core business (e.g., input finance, mobile money).

Conclusion on Business Model

The scaling strategy for DCAS must be anchored by a **Business-to-Government (B2G) model**, treating climate information as a **public good** to ensure national resilience and overcome the overwhelming evidence of low Willingness-to-Pay (WTP) among smallholder farmers. This focus is strongly supported by the data indicating that **approximately 50% of farmers are unwilling to pay** for digital agricultural tools at any price, necessitating the framing of DCAS as a public good or as a **mandatory, subsidized embedment** within agri-finance loans to ensure high-velocity adoption and portfolio-wide risk reduction. The core economic model must explicitly address two critical constraints to effectiveness: First, despite low provider-side costs (e.g., USD1.00–USD1.75 annual maintenance per producer), **user-borne costs** such as data and airtime pose a significant, recurring barrier to adoption that necessitates subsidy or explicit factoring into the economic calculus. Second, the highest return on investment is achieved when digital services are designed to complement, not replace, traditional in-person extension services, requiring a **hybrid delivery model** that integrates digital information with human interaction for trust-building and interpretation of complex advisories.

Value Proposition for Financial Institutions

Adaptation to Credit Risk Mitigation

By enabling the borrower to make optimal planting, fertilization, irrigation, and harvesting decisions, DCAS directly hedges the FI's portfolio against climate-driven default risk. The global **Cost-Benefit Ratios (CBRs)** for DCAS providers ranges from 1:10 to 1:70 annually (average 1:24), under optimal, best-case deployments. (Ferdinand, et al., 2021). For bankers, the 'Benefit' includes quantifiable gains such as increased farmer income from higher yields, reduced input costs due to precision advice, and, most critically, **avoided portfolio losses** from climate-related defaults. While such high returns are possible, Financial Institutions (FIs) should typically use the empirically proven *yield increase* range (e.g., 12% to 17% in Kenya) as the conservative baseline for their internal modelling. The key investment horizon extends from 2021 to 2030 to effectively build climate resilience for small-scale agricultural producers.

The Investment Case in Kenya

The investment case for DCAS in Kenya is validated by strong empirical evidence demonstrating high efficacy and cost-efficiency:

- **Yield and Income Protection:** Kenyan farmers utilizing DCAS experience significant productivity gains. Safaricom's DigiFarm platform has shown a 70% productivity gain and 70% income gain in Kenya (Ferdinand, et al., 2021). A pilot study for Digital Weather Advisory Services (DWAS) in Kenya, delivering advice via SMS, showed that the optimal 'weekly plus daily' service type resulted in a 12% yield increase compared to the control group, and up to 17% for farmers successfully mitigating drought or flood (One Acre Fund, 2025). **This difference is generally attributed to the service scope; the 12% DWAS result reflects a single, low-tech SMS advisory service, while the 70% DigiFarm result reflects an integrated, comprehensive ecosystem bundling precision advice with input financing and market linkages, leading to a much higher overall impact.** Furthermore, the GEODATICS service in Kenya specifically reported an 82.3% productivity gain (Ferdinand, et al., 2021).
- **Resilience Capacity:** Climate service users in Kenya demonstrated dramatically enhanced resilience capacity, exhibiting a Resilience Capacity Index (RCI) of 21.4 compared to 6.15 for non-users, more than 3.5 times higher (ICPAC, 2024). (The RCI is a standardized, composite metric used to measure a household's capacity to anticipate, cope with, and recover from climate shocks, factoring in elements like assets, savings, and income diversity.) Increased years of service use are correlated with enhanced resilience capacity, suggesting sustained benefits with longer engagement.
- **Cost-Effectiveness and Service Delivery:** The mean up-front investment cost per small-scale producer for DCAS implementation is estimated at USD16.20, with annual maintenance costs of USD1.00–USD1.75 per producer. However, this provider-centric metric isolates operational costs and risks understating the total expenditure required for sustained use. User-borne costs, specifically the recurring expense of data/airtime needed to access the advisories, act as a significant barrier to demand that must be subsidized or explicitly factored into the overall economic model. Crucially, interviews and global best practices confirm that DCAS should complement, not replace, traditional in-person extension services. The most effective models involve the combined use of digital information and human interaction for training, trust-building, and interpretation of complex advisories, a combination that delivers a higher return on investment than either channel alone.

Operationalizing Value through Business Models

The financial value of DCAS is realized only when adoption is mandated or deeply incentivized. With approximately 50% of farmers unwilling to pay for digital agricultural tools at any price (Kamau, Mburu, Mills, & Kirimi, 2024), the model must absorb the cost. This strongly supports the framing of DCAS as a mandatory, subsidized embedment within Agri-finance loans. FIs can leverage existing providers through three primary business models:

1. B2G (Business to Government/Donor, FI is a Beneficiary):

- **FI's Role:** Passive beneficiary. FI partners with providers whose services are already subsidized or paid for by government agencies or international donors (e.g., ICPAC, KMD, or World Bank projects).
- **Provider Example:** Government-backed institutional providers like the Kenya Agricultural and Livestock Research Organization (KALRO) disseminating free SMS advisories.
- **Financial Value:** Zero direct cost for the FI. Value is realized solely through improved portfolio performance stemming from a more resilient borrower base. FI can use DCAS compliance as a soft criterion for lending.

2. B2B Portfolio (FI Pays Provider for Portfolio-Level Support):

- **FI's Role:** Strategic buyer. FI pays a fixed annual fee to a provider for portfolio-level climate intelligence, such as risk monitoring, regional climate alerts, and aggregated data on borrower behaviour (e.g., service usage).
- **Provider Example:** Providers offering advanced risk insights derived from DCAS platform data, similar to the bundled value proposition seen with YAPU in other markets.
- **Financial Value:** Direct cost is incurred, but value is realized through reduced operational expenses, enhanced due diligence, and quantitative risk mitigation (reduced Provisioning for Loan Losses). This allows the FI to adjust capital reserves and pricing models based on verified climate resilience data.

3. B2B Customer Bundle (FI Pays Provider and Bundles DCAS into Agri-Loans):

- **FI's Role:** Active facilitator and cost-absorber. FI pays the provider for DCAS access and makes the service a mandatory, embedded requirement of the Agri-loan, effectively subsidizing the adoption cost.
- **Provider Example:** Commercial actors like Safaricom's DigiFarm or specialized NGOs like One Acre Fund (Tupande) who provide comprehensive, high-impact services.
- **Financial Value:** Highest initial cost for the FI but delivers the highest risk reduction potential by ensuring high-velocity, portfolio-wide adoption. The cost is justified by the proven 70% productivity gains and the subsequent **significant reduction in default risk**, allowing the FI to offer a more competitive product and capture market share.

Enabling Institutional Environment

Kenya's regulatory and governmental commitment provides a robust foundation for scaling DCAS, minimizing policy risk for FIs:

- **National Mandate:** DCAS is formally prioritized within the National Framework for Climate Services (NFCS) (KMD, 2024) and the National Climate Change Action Plan (NCCAP) 2023-2027, confirming government buy-in at the highest levels. The NFCS alone has an implementation cost

of USUSD68.2 million for the 2023-2027 period, showing serious budget allocation (Government of Kenya, 2023).

- **Data Governance:** The established Office of the Data Protection Commissioner (ODPC) and the Personal Data Protection Handbook provide a clear regulatory environment for the secure and ethical use of farmer data, which is essential for precision-based advisories.

Development and Climate Impact Benefits

The deployment of Digital Climate Advisory Services (DCAS) serves as a potent vehicle for achieving both climate adaptation goals and significant socio-economic development outcomes, aligning directly with Kenya's national priorities. The investment creates **value protection** by mitigating climate-driven credit risk and generating **value creation** by driving inclusive growth.

1. Enhancing Food Security and Climate Resilience

DCAS is a direct intervention to stabilize and increase food production, which is highly vulnerable to seasonal climate variability in the region. By delivering timely, localized advice on planting times, fertilizer application, and harvesting, DCAS enables **proactive farm management**. Evidence shows that farmers receiving advice via SMS and DWAS experience statistically significant positive yield impacts, including an observed **11.5% increase in yields** in sugar cane trials (Casaburi, Mullainathan, Kremer, & Ramrattan, 2019) and a **12% yield increase** for those receiving weekly-plus-daily forecasts, which helped to mitigate losses from drought and flood events (One Acre Fund, 2025). Critically, the utilization of climate services is directly linked to **improved household food security** among vulnerable populations long-term users seeing a slight reduction in poor food consumption levels.

2. Lifting Household Incomes and Reducing Poverty

The technology serves as an engine for economic growth at the last mile. By increasing yields and optimizing input use, DCAS directly increases farm revenue, leading to profound socio-economic returns. Returns on investment for farmers in the form of **productivity or income average 30% and 25%**, respectively (Ferdinand, et al., 2021). One study in Kenya reported that **25% of participating farmers experienced a "very much increased" household income** following the adoption of digital advisories (Vyas, et al., 2024).

3. Gender Empowerment and Inclusive Growth

Effective DCAS reduces information asymmetry and empowers typically marginalized groups, particularly **women farmers**, who represent a significant portion of the agricultural labour force. Access to timely and location-specific information reduces the **drudgery** associated with sub-optimal farming practices and weather uncertainty, freeing up valuable time. Notably, **71.6% of those aware** of climate information services in Kenya were women, reflecting their central role in food production (ICPAC, 2023). Increased and stabilized agricultural income—enabled by DCAS—directly translates into **greater control over household income and assets**, fostering inclusive growth. It is essential that the DCAS is implemented with a gender-responsive design and targeting strategy to maximize this benefit.

Gender Empowerment and Inclusive Growth

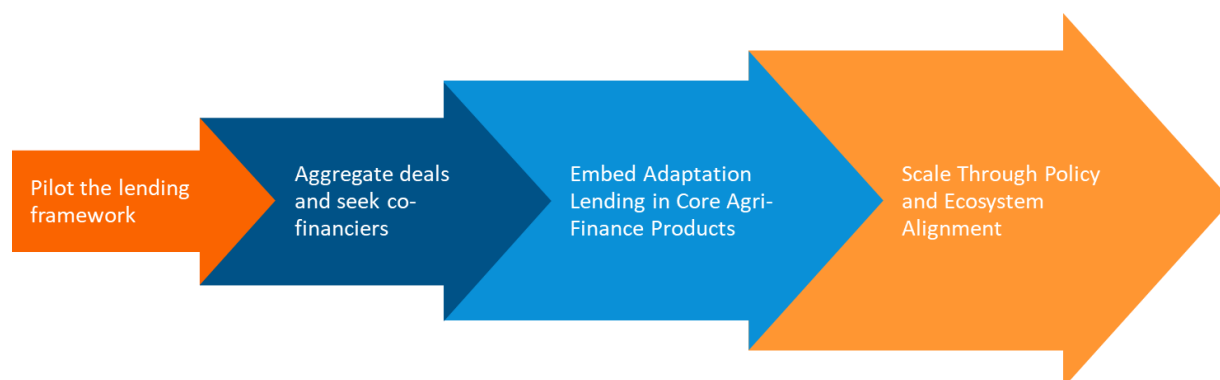
Digital Climate Advisory Services (DCAS) are a proven tool for advancing gender equity and inclusive growth by empowering women farmers. By reducing information asymmetry and optimizing farming practices, DCAS reduces drudgery and frees valuable time for women; significantly, **71.6% of those aware of climate information services in Kenya are women** (ICPAC, 2023). The impact on agency and income is tangible: a mobile-based DCAS initiative showed a **20% increase in women's average monthly farming income** (from KES 10,286 to KES 12,338) and significant gains in confidence and agency in decision-making (Sauti East Africa, 2025). This increased financial control directly contributes to greater participation in household and financial decisions, correlating with a **14% higher likelihood of involvement** in various decision domains and influence over productive assets (Amir-ud-Din, 2024) (CIMMYT, 2019). To maximize these benefits and foster inclusive growth, DCAS implementation requires **explicit gender-responsive design**, including co-creation and targeted delivery channels (Alliance Bioversity CIAT, 2024) (Alliance Bioversity CIAT, 2024). Addressing systemic barriers like language, literacy, and participation gaps is essential for equitable access and fully realized impact (Nganga, Grossi, & Wanjau, 2025).

4. Environmental and Climate Co-Benefits

The use of DCAS drives **Sustainable Development Goals (SDGs)** and supports Kenya's Nationally Determined Contributions (NDCs) by facilitating smarter resource management. The advisories lead to enhanced **input efficiency** (Ferdinand, et al., 2021), meaning farmers apply less water and fertilizer when not needed, reducing waste and environmental runoff. When paired with resilient technologies like **micro-drip irrigation**, DCAS ensures that scarce water resources are used at the most optimal time, maximizing efficiency. Moreover, by reducing the loss of crops to drought or flood, DCAS stabilizes the agricultural landscape, preventing the unplanned clearing of new land or the increased use of energy-intensive mitigation measures, supporting the national drive towards **low carbon climate-resilient development**.

Implementation and Scaling Pathway

Addressing the escalating volatility of climate risk is paramount for securing the future of smallholder agriculture and the stability of agri-finance portfolios in Kenya. This strategy outlines a rigorous, four-step Implementation and Scaling Pathway designed to fully integrate Digital Climate Advisory Services (DCAS) into core agricultural lending products. Critically, this integration links favourable credit terms directly to a farmer's demonstrable adoption of climate-resilient practices, creating a powerful, profitable incentive for both the borrower and the bank. This phased approach moves systematically from initial validation to nationwide institutionalization, ensuring climate resilience becomes a fundamental, profitable input for credit decision-making at national scale.



Step 1: Pilot Lending

- **Focus:** The initial validation of repayment and risk pricing will be conducted through a small-scale, deeply scrutinized pilot project, **selectively targeting either a high-value cash crop or a geographically constrained, high-risk region**. The choice of DCAS delivery model (e.g., direct-to-producer bundled with the loan versus portfolio-level risk aggregation) should **prioritize the FI's subsector exposure**; institutions with high crop production exposure should focus on direct DCAS to producers to maximize data fidelity and underwriting control. **Critical to this phase is the rigorous monitoring of on-farm metrics, including yield data, input cost efficiencies, and detailed farmer usage logs of the DCAS advisories**. The quantitative usage data collected here is the baseline metric for later assessing compliance, adaptation uptake, and the development of the dynamic pricing model in Step 3. Furthermore, the delivery mechanism must prioritize hyper-localized, ward-level advisories, presented in the farmer's preferred vernacular, aligning with key effectiveness lessons learned from the Kenya Climate Smart Agriculture Project (KCSAP) evaluations (Tegemeo Institute, 2023).
- **Goal:** The key objective is to empirically confirm that DCAS recipients demonstrate statistically significant improvements, specifically lower default rates and measurably higher net profitability, relative to a non-DCAS control group. Success provides the essential internal data foundation needed to develop a robust underwriting framework and quantify the "DCAS premium" for risk-pricing models.

Step 2: Aggregation and Co-Financing

- **Focus:** Following successful validation, the primary focus shifts to structuring external capital support by **leveraging sophisticated financial instruments, notably Development Finance Institution (DFI) guarantees or highly concessional lines of credit**. These instruments, often structured as first-loss protection or portfolio guarantees, are essential for mitigating early-stage scaling risks associated with the DCAS-enhanced portfolio. **It is crucial to position the DCAS as**

an integrated *enhancement* to existing credit products, not a standalone new loan; this framing minimizes the need for entirely separate guarantees or novel product registrations, allowing the FI to focus the guarantee on the additional climate-risk exposure the enhancement addresses.

- **Goal:** The strategic goal is to effectively **de-risk the expanded DCAS portfolio** sufficiently to attract larger, more conventional commercial capital pools and institutional investors. This funding mechanism allows the participating Financial Institution (FI) to dramatically scale the product offering while protecting its core balance sheet from excessive exposure to novel climate-related risks.

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

- **Focus:** This pivotal step centres on **developing and fully integrating sophisticated internal risk models** that dynamically price the cost of credit. This pricing mechanism must be directly responsive to the farmer's measured adoption, compliance, and usage patterns of the delivered climate intelligence (e.g., lower interest rates for consistent adherence to adaptive schedules). Achieving this requires mandatory, bi-directional, and **seamless integration** between the FI's core lending management system and the DCAS provider's data platform, ensuring real-time data flow for monitoring and pricing adjustments.
- **Goal:** The ultimate goal here is to **transition the DCAS-embedded loan product** permanently from a temporary "innovation project" into a core, standard offering within the FI's agri-finance portfolio. This institutionalizes climate intelligence as a fundamental input for credit decisioning, directly linking favourable credit terms to demonstrable climate-resilient farming practices.

Step 4: Scale Through Policy and Ecosystem Alignment

- **Focus:** The final stage emphasizes **systemic alignment and regulatory support** to enable scaling across all target geographies. This requires securing robust government buy-in by strategically aligning the DCAS initiative with existing national frameworks, specifically the National Climate Change Action Plan (NCCAP) and the National Financial Inclusion Strategy (NFCS). Furthermore, it is critical to enforce rigorous quality and data standards for all DCAS providers to maintain the fidelity and impact of the climate intelligence being deployed nationally.
- **Goal:** The objective is to **achieve full national scaling** and ensure DCAS is fully institutionalized as a standard, reliable component of resilient agri-finance in Kenya. A core mechanism will be the establishment of targeted Public-Private Partnerships (PPPs) to contract proven private DCAS leaders (such as aWhere or Safaricom DigiFarm) to deliver services with subsidized pricing for smallholders. This approach strategically leverages existing successful structures like the KCSAP, which has already demonstrated reach by benefiting approximately 522,000 households, guaranteeing a path toward widespread, impactful adoption (Government of Kenya, 2023).

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 reports:

- 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.

Relevant bibliography and selected resources used for these technical reports include:

- (2024). ACELI. Profitability of Agricultural SME Lending in East Africa.
- ACTS. (2023). *Market-Analysis. Trends in Solar Dryers' Uptake and Dried Food Markets Development in Kenya*. African Center for Technology Studies.
- ADAS. (2020). *How greenhouse gas emissions relate to crop yields and inputs*.
- AFDB. (2019). *De-risking Agricultural Finance for Smallholder Farmers*.
- Africa Business Communities. (2025). *Rural Kenya farmers triple incomes drying fruits and vegetables in sun*.
- AGRA. (2020). *Economic Assessment of Government Incentives Required for the Promotion of Wide-Scale Utilization of Hermetic Storage Solutions*.
- AGRA. (2020). *Economic Assessment of Government Incentives required for the Promotion of Wide-Scale Utilization and Local Manufacture of Hermetic Storage Technologies*.
- AGRA, A. P.-H. (2021). AGRA. *Post-Harvest Losses and Grain Market Systems in East Africa*.
- AgriFin. (2020). *Policy Brief: Achieving Food Security in Kenya through Smart Solar Irrigation*. Mercy Corps.
- Akoko, P., Degroote, H., Gathungu, E., & Ricker-Gilbert, J. (2021). *Technical and economic analysis of small-scale maize dryers in Kenya*. ICAE.
- Alliance Bioversity CIAT. (2024). *ECREA Project Report on Gender-Responsive Climate Services*.
- Amir-ud-Din. (2024). *Asset Ownership and Women's Empowerment in Developing Countries*. ResearchGate.
- APHLIS. (2021). *Maize Data*. Retrieved from <https://www.aphlis.net/en/data/tables/overview/CD/maize/2021>
- APHLIS. (2021). *Tables dry-weight-losses*. Retrieved from APHLIS: <https://www.aphlis.net/en/data/tables/dry-weight-losses/CD/all-crops/2022?metric=prc&utm>
- Bolwig, S., Haselip, J. A., Strange, L., Hornum, S. T., & Pedersen, M. B. (2021). *Digital solutions for agricultural value chains in Kenya: the role of private-sector actors*. UNEP DTU Partnership.
- BORA GROUP. (2025). *Benefits of hermetic storage bags to smallholder farmers*. Retrieved from BORA GROUP: <https://www.boraagrica.co.tz/2025/07/02/benefits-of-hermetic-storage-bags-to-smallholder-farmers/>
- Burney, J., Woltering, L., Burke, M., Naylor, R., & Pasternak, D. (2010). *Solar-powered drip irrigation enhances food security in the Sudano-Sahel*. *Proceedings of the National Academy of Sciences*, 1848-1853.
- Casaburi, L., Mullainathan, S., Kremer, M., & Ramrattan, R. (2019). *Harnessing ICT to Increase Agricultural Production: Evidence From Kenya*.
- Central Bank of Kenya. (2024). *Agriculture Sector Survey – November 2024*. Central Bank of Kenya, Monetary Policy Department.
- CGIAR. (2023). Retrieved from <https://cgspace.cgiar.org/server/api/core/bitstreams/6d4a5d59-ac0c-48fb-9ddb-252cf74e0926/content>
- CIMMYT. (2019). *Intra-Household Decision-Making in Kenya*.
- CLASP. (2023). *Solar-Powered Irrigation Systems Challenges & Opportunities in Kenya*. Clasp.
- Climate Policy Initiative. (2024). *Landscape of Climate Finance in Africa 2024: Trends, Barriers and Opportunities*.
- CRDB. (2025, October).
- Daily Nation. (2020). *Horticulture farmers reap big from export crops after forming co-operatives*.
- EEP Africa. (2023). *EEP Africa annual report 2023*.
- Efficiency for Access and 60 Decibels. (2021). *Uses & Impacts of Solar Water Pumps: Insights from Kenya, Rwanda, Senegal, Tanzania, Uganda, Zambia*.

- EnDev. (2021). *Empowered women: How solar drying unlocks income for women smallholder farmers in Kenya*. Energising Development.
- Energypedia . (2022). *Solar Drying for Farmer-Clusters and Cooperatives* .
- FAO. (1999). *Economics of irrigation*, FAO Land and Water Discussion Papers, Food and Agriculture Organization of the United Nations.
- FAO. (2018). *Gender and Dairy Value Chains in Africa*. Food and Agriculture Organization of the United Nations.
- FAO. (2022). *Post-Harvest Losses and Food Safety in East Africa: Policy and Practice Brief*. Rome: Food and Agriculture Organization.
- FAO. (2022). *The State of Food and Agriculture 2022: Post-Harvest Losses*.
- FAO. (2024). *Kenya Postharvest Management Strategy*.
- FAO. (2024). *The State of Food and Agriculture 2024 - value driven transformation of agrifood systems*. Rome.
- Farmforce. (2024). *How Digital Farmer Services Empower Smallholders and Bridge the Gap with Industry Stakeholders*.
- Ferdinand, T., Illick-Frank, E., Postema, L., Stephenson, J., Rose, A., Petrovic, D., . . . Rumbaitis del Rio, C. (2021). *A Blueprint for Digital Climate-Informed Advisory Services: Building the Resilience of 300 Million Small-Scale Producers by 2030*. Global Commission on Adaptation.
- FSD Kenya . (2022). *Agriculture & Processing Landscape Report: Kenya*.
- FTMA. (2022). *Farm to Market Alliance: Making markets work better for smallholder farmers; Dec 2022*.
- GCA. (n.d.). Retrieved from GCA: <https://gca.org/video/mainstreaming-adaptation-aligned-investment-gca-and-afdb-support-tadb-under-the-aaap/>
- GCA. (2021). *A Blueprint for Digital Climate-Informed Advisory Services: Building the Resilience of 300 Million Small-Scale Producers by 2030*. Global Commission on Adaptation.
- GCA. (2021). *Investment Blueprint for Digital Climate Advisory Services in Kenya*.
- GCA. (2021). *State and Trends in Adaptation Report 2021*.
- GOGILA. (2023). *Gogla PURE Roadmap Report Kenya*.
- Gorjian, S., Hosseingholilou, B., & Jathar, L. (2021). Recent Advancements in Technical Design and Thermal Performance Enhancement of Solar Greenhouse Dryers. *Sustainability*.
- Government of Kenya. (2017). *Government of Kenya*. Nairobi: Ministry of Agriculture, Livestock and Fisheries.
- Government of Kenya. (2023). *National Climate Change Action Plan (NCCAP) III 2023-2027*. Ministry of Environment, Climate Change and Forestry.
- GSMA. (2022). *Mobile Money State of the Industry Report*.
- GSMA Intelligence. (2021). *Mobile money in Sub-Saharan Africa: Advancing financial inclusion*.
- HCD. (2024). *Horticultural Crops Directorate Annual Report*.
- Houssou, C. A. (2020). *Determinants of Post-Harvest Loss and Farmers' Adoption of Solar Dryer Technology in the Maize Value Chain in Nigeria*. African Development Bank Group.
- ICPAC. (2023). *Climate Information Services Awareness in Kenya*.
- ICPAC. (2023). *The Socio-Economic Value of Climate Services: Evidence from Kenya and Uganda. Policy Brief*.
- ICPAC. (2024). *Kenya Anticipatory Action Roadmap 2024 - 2029*. Nairobi: IGAD Climate Prediction and Applications Centre.
- IFPRI. (2010). *Innovations in rural and agricultural finance: Credit Risk Management in Financing Agriculture*.
- IFPRI. (2023). *From Climate Risk to Resilience: Unpacking the Economic Impacts of Climate Change in Kenya*.
- IFPRI. (2025). *Financial and environmental outlook of groundwater-solar irrigation in sub-Saharan Africa*. IFPRI Africa.
- International Finance Corporation. (2023). *Blended Finance for Climate Action in Agriculture*.
- International Renewable Energy Agency. (2016). *Solar pumping for irrigation: Improving livelihoods and sustainability*.
- IPCC. (2021). *Climate change 2021: The physical science basis. Contribution of Working Group I to the sixth assessment report*.
- ISF Advisors & Hystra . (2024). *Scaling Irrigation for Small-scale Producers: the Role of Private Sector Solutions*.

- ITA. (2024). ITA. Retrieved from International Trade Administration: <https://www.trade.gov/country-commercial-guides/democratic-republic-congo-agriculture>
- IWMI & Efficiency for Access Coalition. (2021). *Sustainable expansion of groundwater-based solar water pumping for smallholder farmers in Sub-Saharan Africa*.
- Juma, W., Lwambok, J., & Ochieng, A. (2022). Economic returns of solar drying technology adoption in rural Western Kenya. *African Journal of Agricultural Economics and Rural Development*.
- Kamau, M., Mburu, J., Mills, B., & Kirimi, L. (2024). *Willingness to Pay for Agro-Weather Messages Among Kenyan Farmers*. The Feed the Future Innovation Lab for Markets, Risk & Resilience.
- Kenya Ministry of Agriculture. (2019). *Agriculture Sector Transformation and Growth Strategy 2019-2029*.
- KERE. (2022). *Kenya Renewable Energy Association Market Outlook*.
- Kilelu, C., Kalele, D., Omolo, I., & Ogutu, F. (2023). *Assessing Capabilities and Skills for Delivery of Quality Solar Drying Technologies in the Kenyan Market*.
- Kilelu, C., Kalele, D., Omolo, I., & Ogutu, F. (2023). *Assessing Capacity and Skills for Quality, Low-cost Solar Drying Technologies in Kenya's Market*. African Centre for Technology Studies, Kenya Industrial Research and Development Institute and United Nations Environment Programme.
- Kilelu, C., Omolo, I., & Okemwa, J. (2023). *Opportunities and Challenges for Enhancing the Quality of Solar Drying Technology and Agri-enterprise in Kenya - A Policy Dialogue*.
- KMD. (2024). *State of the Climate Kenya 2023*.
- KNBS. (2024). *National Agriculture Production Report*. Kenya National Bureau of Statistics.
- Linturi, M. (2024). *Post-harvest losses cost Kenya Sh72 billion annually*. Office of the Cabinet Secretary for Agriculture, Kenya.
- Manyika, M. (2021). *Feasibility Study on a Solar Tent Dryer for Fish and Agricultural Products in Tanzania*.
- Mercy Corps AgriFin. (2019). *CASE STUDY: Digital Precision Agriculture Advisory Services in Kenya*.
- Ministry of Agriculture (MoA). (2024). *Comprehensive Agriculture Transformation Support Program (CATSP) (Second National Agriculture Investment Plan 2024-2033)*. GRZ.
- Minot, N. (2014). *Volatility and Resilience in African Food Markets*, Paper presented at the Fourth CAADP Biennial Review Conference.
- National Post-Harvest Losses Management Strategy, Kenya. (2020). *Post-harvest Losses Management Strategy for the IGAD Region*. Nairobi: Ministry of Agriculture, Kenya.
- Nganga, K., Grossi, A., & Wanjau, A. (2025). *Advancing Gender Equity in Digital Agro-Advisory*.
- Njoroge, A., Baoua, I., & Baributsa, D. (2021). Postharvest Management Practices of Grains in the Eastern Region of Kenya. *Journal of Agricultural Science*, 98-105.
- Notenbaert, A., Radulovich, R., Omondi, P., & Seré, C. (2020). *Climate-smart dairy farming in Tanga region: An impact assessment*.
- Ntwali, J., Keller, A., Kasambula, J., & Smith, R. (2021). Progressive Review of Solar Drying Studies of Agricultural Produce in East and Southern Africa: Technology Performance, Economics and Adoption Barriers. *Renewable Energy Reviews*, 111-198.
- Ntwali, J., Schock, S., Romuli, S., Chege, C. G., Banadda, N., Aseru, G., & Müller, J. (2021). *Performance Evaluation of an Inflatable Solar Dryer for Maize and the Effect on Product Quality Compared with Direct Sun Drying*. Applied Sciences.
- One Acre Fund. (2025). *Digital Weather Advisory Service (DWAS) Survey Report*.
- PABRA. (2022). *Farmer Cooperatives transforming smallholder livelihood in Kenya*. Alliance of Bioversity and CIAT.
- Phali, L., Mudhara, M., Ferrer, S., & Makombe, G. (2022). Evaluation of water-user performance in smallholder irrigation schemes in KwaZulu-Natal Province, South Africa: A stochastic meta-frontier analysis. *Frontiers in Sustainable Food Systems*.
- PICS. (2024). PICS. Retrieved from https://ag.purdue.edu/departments/entm/extension/pics-network/_media/pics-newsletter-fall-2024.pdf
- *Playbook of Solutions*. (2013, January 01). Retrieved from World Economic Forum: <https://initiatives.weforum.org/playbook-of-solutions/case-study-details/pay-as-you-save/aJYTG0000000lcr4AE>
- Purdue. (2020). *The PICS Commercialization Experience in Sub-Saharan Africa*. Purdue Improved Crop Storage Project (PICS3).
- Purdue PICS and AGRA. (2020).

- Rhoda, A. N., & Simate, I. N. (2016). *Greenhouse Solar Drying and Thin Layer Drying of Fresh Kapenta*. International Journal of Scientific & Engineering Research.
- Romuli, S., Schock, S., Nagle, M., Chege, C., & Müller, J. (2019). Technical Performance of an Inflatable Solar Dryer for Drying Amaranth Leaves in Kenya. . *Applied Sciences*.
- Sauti East Africa. (2025). *Empowering Women Farmers Through Climate Information Services: Impact and Lessons from Mobile-Based Adaptation Tools for Women Farmers in Kenya*.
- Scale for Resilience & YAPU Solutions. (2025). *Scaling Resilience Finance: Annual Report*.
- SEI. (2021). *Climate change, trade, and global food security*.
- Simate, I. N., Mukwangole, M., & Mukanema, M. (2025). *Natural Convection Solar Tunnel Dryer for Maize: Design Process, CFD Simulation, Drying, Exergy and Economic Performance*. Modern Applied Science.
- Sunculture. (2025). *Sunculture*. Retrieved from <https://sunculture.io/>
- SwitchON Foundation. (2024). *Diesel to Solar - A Viability Assessment on Just Energy Transition for Sustainable Irrigation in India*.
- TAREA. (2020). *Policy Brief: Smallholder Farmers Solar Irrigation - Getting Rid of Petrol Generators for Irrigation*.
- Tegemeo Institute. (2023). *Impact of Digital Agro-Weather Advisories*.
- UN Food Systems Coordination Hub. (2025). *Updated National Pathway and Costed Action Plan*. UN.
- Vyas, S., Burra, D., Kiprop, C., Kirwa, L., Rottmann, S., & Ramirez-Villegas, J. (2024). *Impact of Shamba Shape Up and iShamba on Livestock and Climate Resilience*. CGIAR Initiative on Livestock and Climate.
- Wanzala, J., & Wamalwa, F. (2023). *The Effect of Utilization of Cassava Solar Drying Technology on Small - Scale Cassava Farmers Incomes' in Teso-South Sub-County of Busia County, Kenya*. . International Journal of Research and Innovation in Social Scie.
- Wellspring. (2023). *Opportunities and drivers for SME agribusinesses to reduce food loss in Africa and Asia*. CASA.
- World Bank. (2017). *Agriculture in Africa: Telling Myths from Facts*. Retrieved from World Bank Group: <https://www.worldbank.org/en/programs/africa-myths-and-facts>
- World Bank. (2021). *Post-Harvest Loss Reduction in East Africa: Economic Assessment and Financing Framework*. Washington DC: World Bank Group.
- World Bank Group. (2015). *Increasing Agricultural Production and resilience through Improved Agro-meteorological Services*. Agriculture Global Practice Technical Assistance Paper.
- WWF. (2022). *Measuring and Mitigating GHGs: Maize*.



GLOBAL
CENTER ON
ADAPTATION

ANTOINE PLATEKADE 1006
3072 ME ROTTERDAM
THE NETHERLANDS
+31(0)88-088-6800
WWW.GCA.ORG