Tanzania: Rapid Climate Risk Assessment and Adaptation Investment Opportunity Mapping

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.

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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GLOSSARY

Abbreviation and Terms	Description
AATF	African Agricultural Technology Foundation, a non-profit that promotes access and adoption of agricultural technologies to improve productivity and resilience.
AGRA	Alliance for a Green Revolution in Africa, an institution driving agricultural transformation through improved seeds, inputs, markets, and inclusive finance
AMCOS	Agricultural Marketing Cooperative Societies, farmer-owned cooperatives that facilitate collective marketing and access to inputs in Tanzania
ASAL	Arid and Semi-Arid Lands, regions with low rainfall and high variability that are highly vulnerable to drought and pastoral system stresses
ASTGS	Agricultural Sector Transformation and Growth Strategy, Kenya's national plan for agricultural modernization and resilience
Aflasafe	A biological control product developed to reduce aflatoxin contamination by introducing non-toxic strains of *Aspergillus* into crop fields.
Aflatoxin	A toxin produced by *Aspergillus* fungi that contaminates crops such as maize and groundnuts under hot and humid conditions, posing food safety and trade risks
CGIAR	International Maize and Wheat Improvement Center, a CGIAR research center focused on developing climate-resilient maize and wheat varieties.
COMESA	Common Market for Eastern and Southern Africa, a regional economic community supporting trade and integration across member states
CORDEX	Coordinated Regional Downscaling Experiment, a global framework providing high-resolution climate projections
CSA	Climate-Smart Agriculture, an approach that strengthens adaptation, productivity, and mitigation in farming systems
Climate-Smart Agriculture	An integrated approach that increases productivity, enhances climate resilience, and reduces emissions, including practices like conservation agriculture and agroforestry
Cold Chain	A temperature-controlled system for storing and transporting perishables, reducing post-harvest losses and improving food safety
Conservation Agriculture	A soil and water management system based on minimum tillage, crop rotation, and permanent soil cover to build resilience to drought
CTCN	Climate Technology Centre and Network, the operational arm of the UNFCCC Technology Mechanism promoting transfer of climate technologies

DCAS	Digital Climate Advisory Services, platforms delivering climate and agronomic information to farmers via digital channels
Digital Advisory	Mobile and digital platforms providing weather forecasts, market prices, and agronomic advice to farmers
Drought-tolerant Seeds	Improved crop varieties bred to withstand water scarcity and heat stress, ensuring more stable yields under climate change
EbA	Ecosystem-based Adaptation, the use of biodiversity and ecosystem services to help people adapt to the adverse effects of climate change
Early Warning Systems	Tools and platforms that provide timely climate, weather, and hazard information to help farmers anticipate and respond to risks
ENSO	El Niño–Southern Oscillation, a climatic phenomenon that affects rainfall patterns and drought/flood risks in East and Southern Africa
EU	European Union, a political and economic union that also funds climate and agricultural adaptation programs
FAO	Food and Agriculture Organization of the United Nations, leading international efforts to defeat hunger and improve agriculture and food systems
FISP	Farmer Input Support Program, Zambia's subsidy program for seed and fertilizer that supports adoption of improved practices
GCA	Global Center on Adaptation, an international organization accelerating adaptation action and investment worldwide
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit, Germany's international development agency supporting agricultural and climate programs
GSMA	GSM Association, an industry organization representing mobile network operators, often partners in scaling digital advisory services
Hermetic Storage	Sealed storage technologies, such as hermetic bags or silos, that protect grain from pests, moisture, and aflatoxin contamination
ICT	Information and Communication Technology, digital tools and platforms used in agricultural extension and climate services
IFAD	International Fund for Agricultural Development, a UN agency financing rural development and agricultural adaptation programs
IFC	International Finance Corporation, a World Bank Group member that mobilizes private sector investment, including for climate adaptation
IFPRI	International Food Policy Research Institute, a CGIAR center focused on research-based policy solutions for agriculture and food security

IITA	International Institute of Tropical Agriculture, a CGIAR research center focusing on solutions for hunger, poverty, and resource degradation
ILRI	International Livestock Research Institute, a CGIAR center working to improve food security and reduce poverty through livestock research.
IWMI	International Water Management Institute, a CGIAR research center focusing on sustainable water and land management
Pay-as-you-go	A financing model where farmers pay in installments for technologies such as solar irrigation pumps, making them more affordable and accessible
Post-harvest Loss	The reduction in quantity or quality of crops between harvest and consumption, often caused by poor drying, storage, and handling
RCP	Representative Concentration Pathways, greenhouse gas concentration trajectories used in climate modelling and projections
Resilient Fodder	Drought- and flood-tolerant forage varieties that secure feed supply for cattle and livestock under climate stress
Solar Irrigation	Irrigation systems powered by solar energy that reduce dependence on rain and stabilize yields under drought conditions
SPEI	Standardized Precipitation Evapotranspiration Index, a climate index used to assess drought severity and duration
UNFCCC	United Nations Framework Convention on Climate Change, the global treaty framework for climate action and adaptation efforts
Value Addition	Processing activities (e.g., solar drying, milling) that increase the market value of crops while reducing losses and creating new income opportunities
Weather-Index Insurance	Insurance linked to weather indicators (rainfall, temperature) rather than direct crop losses, providing payouts when thresholds are breached
WFP	World Food Programme, the UN agency addressing food security, often implementing post-harvest and resilience initiatives
WMO	World Meteorological Organization, a UN agency providing weather, climate, and water-related services
WWF	World Wide Fund for Nature, an international NGO supporting conservation and ecosystem-based adaptation initiatives
Yield Gap	The difference between potential and actual crop yields, often widened by climate stress, poor inputs, or limited access to technology

EXECUTIVE SUMMARY – ALL COUNTRIES

Agriculture underpins food security, employment, and rural incomes across East and Southern Africa. Yet, it is increasingly exposed to climate change. Rising temperatures, prolonged droughts, more intense rainfall, and shifting pest and disease pressures are already eroding yields, disrupting markets, and straining rural livelihoods. Left unaddressed, these hazards will undermine food systems, financial stability, and long-term development. For GCA, this challenge presents an opportunity: to identify and scale **investable adaptation solutions** that safeguard value chains, reduce systemic risk, and catalyze private capital flows towards resilience.

Across Tanzania, Zambia, Kenya, and the Democratic Republic of Congo (DRC), hazard mapping reveals a common profile of exposure. **Heat extremes and droughts** depress crop yields and livestock productivity; **floods and waterlogging** drive disease outbreaks and post-harvest contamination; while **aflatoxin and pests** pose mounting threats to food safety and trade. These pressures converge most sharply on **staple value chains** such as maize, rice, cassava, potatoes, soybeans, and plantain, alongside **livestock systems** that anchor rural nutrition and incomes. Export crops such as tea and coffee also face growing climate stress. The **gender dimension** is critical: women, who provide the majority of farm labour and dominate post-harvest handling, cassava and plantain processing, poultry, and small-scale trade, face heightened exposure yet have fewer resources to adapt.

From this landscape of need, the analysis distilled a portfolio of **commercially ready solutions**, clustered into five recurring adaptation themes:

- **Storage and Post-Harvest Systems** (hermetic bags, solar dryers, cold chain)
- **Water Management and Irrigation** (solar-powered irrigation, water harvesting)
- **Livestock feed and Health** (climate-resilient fodder, veterinary services)
- **Pest and Disease Management** (aflatoxin biocontrol, disease-resistant varieties)
- **Digital Platforms** (digital climate advisory services, early warning)

These solutions stand out because they directly address climate pressures while offering **proven delivery models, repayment structures, and gender-responsive pathways** that make them bankable.

Country-specific priorities sharpen this picture. In **Tanzania**, top opportunities include aflatoxin biocontrol, resilient fodder, cold chain, hermetic storage, and solar irrigation. In **Zambia**, priorities are drought-tolerant maize and soybean seed, aflatoxin biocontrol, fodder systems, solar drying, and hermetic storage. In **Kenya**, the emphasis is on digital advisory platforms, hermetic storage, fodder systems, solar drying, and solar irrigation, with potatoes and tea adding unique vulnerabilities. In the **DRC**, priorities include biological pest control for aflatoxin, solar drying systems, disease-resistant cassava and plantain varieties, and hermetic storage, solutions critical for safeguarding food security in cassava, maize, and plantain value chains that sustain most households.

Taken together, these findings provide a roadmap for GCA to advance its mandate of catalyzing climate adaptation finance. The identified interventions are tangible, financeable products and services that can be scaled through **banks, MFIs, cooperatives, and agri-business networks**. They present opportunities to crowd in private finance, empower women and smallholders, and convert climate risks into **structured investment opportunities**. By building on these bankable entry points across Tanzania, Zambia, Kenya, and the DRC, GCA can help transform food systems in East Africa, strengthening resilience while unlocking new markets for adaptation finance.

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INTRODUCTION AND BACKGROUND SETTING

Project Context

This report forms part of a multi-phase assignment commissioned by the Global Center on Adaptation (GCA) to identify and scale climate adaptation investment opportunities within agriculture and food systems in Tanzania, Kenya, Zambia, and the Democratic Republic of the Congo (DRC). The overall aim of the program is to generate a robust evidence base, identify a range of viable adaptation solutions, and position private finance to play a catalytic role in strengthening resilience across these countries.

The present report corresponds to Phase 2 of the work, that builds upon the Phase-I Inception. It brings together a spatially explicit climate risk analysis, the identification of priority agri-food value chains, and the mapping of relevant adaptation solutions. This analysis connects hazard exposure with the crops and livestock systems most critical for food security and rural incomes, before matching them to adaptation options that are technically mature, locally relevant, productivity-enhancing, and gender-inclusive. In doing so, it establishes a foundation of "what matters most", the combinations of risks, value chains, and solutions that merit deeper investment consideration.

Insights from this phase directly feed into the remaining deliverables. Phase 3 will quantify the market opportunity size for the shortlisted solutions, map value chains in greater detail, and assess the market structures that will influence uptake. Phase 4 will test their financial and commercial viability, exploring whether they present a compelling business case for smallholder farmers, cooperatives, and agri-SMEs on the one hand, and for commercial banks and MFIs on the other. Finally, Phase 5 will synthesize all evidence, from climate and market analysis through to ROI, into a strategy and set of recommendations that can guide GCA, governments, and financial institutions in scaling private-sector adaptation finance.

By clarifying the risks, exposures, and most promising solution pathways, this report therefore serves as the analytical backbone for the phases that follow, ensuring that market sizing, financial analysis, and strategy development are firmly grounded in climate and agricultural realities.

Study Rationale and Objectives

Agriculture across Tanzania, Kenya, Zambia, and the DRC sits at the very heart of livelihoods, food security, and economic growth. Yet for millions of farmers and agriculture small and medium size enterprises (SMEs), the sector is increasingly shaped not by opportunity alone but by the constraints of a changing climate. Droughts reduce yields and water availability, floods destroy crops and infrastructure, erratic rainfall shortens growing windows, while heat stress and shifting pest and disease dynamics compound the risks. For smallholder farmers, cooperatives, and agribusinesses alike, these shocks translate directly into lost income, heightened food insecurity, and constrained access to finance.

Understanding these risks is not simply a technical exercise; it is about uncovering where climate hazards are most deeply felt by farmers and value chain actors, and how these risks intersect with the realities of production systems. A climate-smart solution that works in one agro-ecological zone may not be relevant in another; an innovation that makes sense for commercial horticulture may not be viable for rainfed maize farmers. This is why a spatially explicit and context-sensitive climate risk assessment is critical. It allows us to see not just the hazards themselves, but how they map onto livelihoods, commodities, and where the biggest vulnerabilities lie.

Climate risks in agriculture are not gender neutral. Women constitute the majority of the agricultural labour force, but they consistently face systemic barriers in access to land, finance, technology, extension services, and markets. These inequities heighten women's vulnerability to climate change impacts and constrain their ability to adopt adaptation strategies (bank, 2023b) (UNDP, 2020).

At the same time, there is no shortage of adaptation solutions in principle: from drought-tolerant crop varieties to digital climate information services, from water-efficient irrigation systems to parametric insurance. What is missing is a clear understanding of which of these solutions are both relevant and scalable in the four countries, and which can credibly attract private sector and development finance. GCA's mandate to catalyse adaptation investment requires that opportunities identified are not only scientifically grounded but also practically investable.

This phase is therefore designed to serve as a bridge between climate risk evidence and adaptation investment opportunity. It anchors adaptation choices in a granular understanding of climate hazards, links these hazards to priority commodities and food systems value chain stages, and then systematically screens a wide universe of adaptation options to highlight those that are most relevant, financially viable, and capable of scaling. In doing so, it ensures that the final set of opportunities is both human-centred, reflecting farmers' realities and system constraints and finance-ready, providing clear pathways for lenders and investors to support adaptation at scale.

The report is designed around four main objectives:

Development of a Rapid Climate Risk Assessment. The first objective is to build a robust yet rapid climate risk assessment that goes beyond generic climate summaries. We examined historical trends, current hazard dynamics, and future projections (using regional datasets under RCP4.5 and RCP8.5) to understand how droughts, floods, heat stress, rainfall variability intersect with food systems. By spatially overlaying these hazards with agro-ecological zones and production systems, the report highlights not just which hazards are increasing, but where their impacts on agriculture and food systems will be most pronounced. This provides the evidence base for linking risks to value chains and identifying priority areas of intervention.

Agricultural Landscape Assessment and Prioritization of Value Chains. A second objective is to anchor the analysis in the national agricultural landscape, recognising that climate risks do not operate in a vacuum. Each country has its own set of strategic crops and livestock commodities that are both central to food security and highly exposed to climate hazards. This task examines the structure of agricultural production systems, identified priority value chains at national level, and considered their role in livelihoods, trade, and food security. By linking these value chains to the mapped climate risks, we could identify where adaptation needs are most urgent, and where interventions have the potential to deliver the greatest resilience benefits across large numbers of farmers and agri-SMEs.

Identification of Adaptation Solutions (Long List Development). Building on the risk and value chain assessments, the third objective is to generate a comprehensive "long list" of potential adaptation solutions. This long list drew from global and regional taxonomies (e.g., CGIAR's Adaptation Atlas, FAO, Tailwind, CTCN, CBRT, AgFunder, and national programs) as well as expert consultations. It spans both technology-based solutions (e.g., irrigation systems, stress-tolerant seeds, post-harvest storage) and service-based or institutional solutions (e.g., climate advisories, insurance, warehouse receipt systems). At this stage, the report emphasises on inclusivity, capturing the widest possible range of interventions that could in principle address identified risks and strengthen resilience across crops, livestock, fisheries, and aquaculture.

Prioritization Framework for Investment-Ready Solutions. Finally, this report applies a structured, multi-criteria assessment framework to screen the long list into a focused shortlist of the most viable opportunities. Building on multi-themes and indicators, the framework assesses solutions against several dimensions:

- Climate hazard alignment and policy support
- Relevance to local production systems and farmer capacity
- Technical maturity, scalability and market demand
- Financial viability and attractiveness to lenders

- Environmental co-benefits and contribution to social inclusion

Through this process and informed by expert interviews and stakeholder consultations, we filtered the universe of options down to those solutions that are not only contextually relevant but also capable of mobilising capital and scaling impact.

Report Structure

This section provides further clarity on how the report is organised. For each country, the report is structured into three core components:

1. National Climate Hazard Mapping

   Establishes the climatological baseline and forward-looking projections, covering major hazards such as extreme temperatures, droughts, and floods. It highlights where these hazards occur across regions and provinces, comparing reference periods (1986–2005) with mid-century projections (2041–2060) under RCP 4.5 and RCP 8.5 scenarios.

2. Agriculture and Food Security Exposure to Climate Hazards

   Maps the intersection between climate risks and agriculture. This section profiles the key agri-food systems, crops, livestock, and fisheries, and identifies major production zones. It highlights which commodities are most exposed to climate hazards, thereby defining the priority agri-food systems that may require adaptation attention. Validates the prioritisation of agri-food systems through triangulation of climate risk findings with literature, policy reviews, and expert interviews. This ensures that priority value chains are aligned with both climate vulnerability evidence and national agricultural strategies.

3. Climate Adaptation Solutions

   Identifies adaptation solution themes and specific interventions relevant to the priority agri-food systems. This section applies a structured prioritisation framework to filter solutions based on technical maturity, commercial viability, policy support, borrower's fit, and potential for impact and gender, resulting in a shortlist of opportunities that can strengthen resilience for smallholder farmers, cooperatives, agri-SMEs and women.

Methodological Considerations

The preparation of this report required the use of multiple analytical approaches to generate the evidence presented. Below is a brief description of the processes and methodologies applied in developing the content of the report.

Climate hazard analysis

A rapid and spatially focused climate hazard assessment was carried out, focusing on agricultural cropland and livestock in the study countries. This approach used historical climate conditions, current hazard dynamics, and future climate projections (RCP4.5 and RCP8.5 for the mid-century) to identify where climate hazards are intensifying and where they overlap with key production areas, providing the grounding for adaptation planning.

- Extreme heat

Acute heat risk was measured by the highest daily temperatures with a 10-year return period. Chronic heat stress was assessed using the average number of days per year above 35°C. This indicator is essential for crop suitability and also important for livestock, highlighting risks of reduced productivity and increased mortality. It can also be used to indicate an increased risk of wildfires in farming areas.

- Drought

Drought was evaluated both through annual average precipitation and the Standardised Precipitation Evapotranspiration Index (SPEI12), helping to identify regions with recurrent or chronic water shortages. This assessment is important for understanding long-term crop and pasture viability and resilience within the food system.

- Extreme precipitation and extreme wind

Extreme rainfall was characterized using the maximum daily total over a 25-year return period, indicating the risk of flash flooding. Wind risk was assessed using the highest daily wind gusts for the same return period. Both measures inform the risk of acute damage to crops, infrastructure and livestock.

- River flooding and population exposure

River flooding was assessed using flood extent and depth data from the European Joint Research Centre (JRC) Floods Maps, which have a 100-metre spatial resolution and cover current baseline conditions. Population density data were overlaid to better estimate community vulnerability and risk to agricultural assets. For future projections, patterns drawn from the World Resources Institute (WRI) Aqueduct Flood Maps multi-model ensemble were used. This approach enables a more complete assessment of vulnerability, accounting for regions where agriculture and settlements overlap.

Baseline climate conditions for the period 1986 to 2005 were mapped using well-established climate reanalysis and satellite-derived gridded observational datasets. Specifically, precipitation was drawn from the CHIRPS dataset, temperature data came from CHIRTS-Daily, and wind and other meteorological variables were sourced from the ERA5 reanalysis product. All at 0.25º resolution. These datasets provide spatially continuous and consistent representations of climate variables across the study countries, enabling robust baseline characterisation. The spatial analysis focused on provincial-level administrative units – such as provinces, counties, or mikoa, depending on the country.

For future climate projections covering the 2041 to 2060 period, a bias-corrected ensemble of 16 regional climate model simulations from the Africa CORDEX initiative was used, at a 0.25º resolution. These projections, under both RCP4.5 and RCP8.5 emissions scenarios, offer spatially detailed and scientifically robust estimates of future climate change signals and associated uncertainties to support risk assessment.

Agricultural exposure assessment

The primary goal of the agricultural exposure assessment was to first understand where the core agricultural activity is concentrated. This foundational step is essential before focusing on particular regions to evaluate the climate impacts on agriculture and livestock.

The analysis principally targeted two key sectors critically important for the food security in the project countries: crop production and livestock rearing. For crops, we mapped the density of cropland measured as hectares of cropland per grid cell. This was derived using the Spatial Production Allocation Model (SPAM) 2017 version 2.1 for Sub-Saharan Africa, developed by IFPRI and CGIAR partners. SPAM offers gridded estimates of crop area, production, and yields at approximately 10 km by 10 km spatial resolution near the Equator. In this study, we employed the physical area layers that estimate the extent of cropland devoted to individual crop types within each grid cell. From over 40 crops available, we focused on a subset of key commodities dominating agricultural production and food security in the Democratic Republic of Congo, Tanzania, Kenya, and Zambia. These crops included maize, cassava, beans, groundnuts (peanuts), rice, sorghum, millet, sweet potatoes, plantains/bananas, and sugarcane. These commodities were aggregated to create exposure layers that are relevant for the climate hazard and impact assessments.

For livestock, we used the Gridded Livestock of the World, version 4 (GLW4, reference year 2020) dataset produced by the FAO. GLW4 provides globally consistent, high-resolution (approximately 10 km) livestock distribution maps expressed as the number of heads per grid cell. These estimates are generated by

downscaling official subnational census statistics with environmental predictors, land cover, and human population density. For this study, livestock species layers for cattle, sheep, goats, pigs, and chickens were aggregated to produce total livestock exposure surfaces.

The crop and livestock distribution maps, combined with a thorough review of the agro-ecological characteristics and socio-cultural contexts of the countries, facilitated the identification of key agricultural hotspot regions. These regions were defined as clusters exhibiting high agricultural productivity, often shaped by distinct agro-ecological conditions as well as local societal factors such as traditional practices and resource limitations. The delineated areas were named based on their geographic features or notable societal attributes. This approach enabled a more natural and relevant classification of agricultural zones than administrative boundaries alone, capturing where production activity is most concentrated and where climate impacts could be most significant.

It is important to note that while the climate hazard assessment was primarily conducted at the provincial level or equivalent administrative divisions, the agricultural exposure analysis often extended across multiple provinces. While administrative units remain useful for aggregating data, the exposure analysis prioritised natural boundaries such as agro-ecological zones and landscape features that better reflect agricultural realities. Even so, key provinces within these cross-boundary regions are frequently linked in the analysis, recognising that agricultural production systems and socio-economic interactions often transcend formal administrative divisions.

Within each identified key area, the main commodities produced were identified. For livestock, this was based on the number of animals, and for crops, on the total production value of each commodity. While cropland area indicates regions of high production extent, production value better reflects the potential economic risk from climate-induced losses. Finally, the key climate hazards were linked to each region and their main commodities, providing an integrated view of climate risk across both crops and livestock.

Prioritisation of food value chain

The prioritisation of food value chains in Kenya, Zambia, Tanzania, and the DRC was undertaken through a semi-structured, multi-criteria process that triangulated quantitative climate-risk evidence with policy relevance and expert judgement[1]. The prioritisation process considered such factors as:

- Climate risk & resilience
- Food security & nutrition
- Economic importance & livelihoods
- Market performance & access
- Supply-side constraints
- Policy & institutional alignment
- Expert validation

Building on the hazard exposure mapping in the key agriculture production regions, a qualitative analysis of potential climate impact to the main commodities within the regions was conducted using a qualitative Impact score (High/Medium/Low) of climate sensitivity and region-specific climate trends (Annex 1: High-Level Climate Impact Analysis). The analysis resulted in the identification of the commodities that

[1] While recognising the importance of fisheries/aquaculture, the scope focused on crop and livestock subsectors due to their primary role in the project countries' food security.

potentially would be most impacted by projected climate trends, and contributed to the prioritisation process.

An explicit consideration of gender inclusion was also applied, recognizing that women play critical roles in agriculture and food systems but face structural barriers to resources, finance, and decision-making. Commodities where women's participation is significant, but where climate risks could further exacerbate gender inequalities, were given higher priority. Screening results were then stress-tested with national experts and CGIAR/GCA specialists.

This process produced a short list of priority crop and livestock value chains to guide the identification of adaptation solutions and investment design.

Identification and prioritization of adaptation solutions

Step 1: Building the Long List of Solutions

The identification process began with a review of **21 global, regional, and national adaptation taxonomies and reports** (e.g., CGIAR's Adaptation Atlas, FAO, Tailwind, CTCN, CBRT, AgFunder, and national programs), complemented by targeted expert consultations. This exercise produced a **long list of adaptation options** spanning a wide spectrum, from climate-smart agricultural (CSA) and best-management practices (e.g., mulching, crop rotation, conservation agriculture), to technology-based products, services, and financial instruments. Drawing on established taxonomies ensured that the pool of solutions was not only broad and representative but also **anchored in credible, widely recognised frameworks**. This provided a common language and consistent classification system, making it easier to compare solutions across geographies and to align them with institutional priorities and funding landscapes.

Each solution was then mapped against the **climate hazards addressed, relevant commodities, and food system stages**, and grouped into one of nine broad categories: Environment-based Adaptation (EbA) and agriculture best-management practices; physical climate risk management and infrastructure, physical climate risk transfer, physical climate smart inputs, improved processes tools, advisory services, data management and operations, decision-support tools, and physical climate risks identification and impact assessment. This comprehensive approach ensured that no relevant solution set was overlooked and that the long list captured the diversity of adaptation options currently being developed and deployed across Africa.

Step 2: Rationale for Focusing on Products and Services over CSA Practices

While Climate-smart agricultural (CSA) practices, such as mulching, intercropping, or conservation agriculture, play an important role in strengthening resilience and enhancing farmers' adaptive capacity. They improve soil health, stabilise yields, and help smallholders cope with climate variability. For this reason, such practices remain central to long-term climate adaptation strategies and should continue to be promoted through public policy, extension systems, and farmer-led initiatives. However, while vital agronomically, these practices do not easily translate into investable opportunities that commercial banks or MFIs can underwrite. Their benefits are real but diffuse, incremental, and highly context-specific, making it difficult to define discrete cash flows or structure them as bankable products.

By contrast, products and services, such as solar irrigation pumps, cold storage, hermetic bags, or climate advisory platforms, are tangible, financeable interventions. They have identifiable costs, measurable impacts on yields or post-harvest losses, and clearer payback profiles that enable lenders to build a risk-return case. Banks and MFIs require solutions that can be standardized and deployed at scale. Products and services lend themselves to this because they can be aggregated (e.g., group lending for irrigation kits), bundled (e.g., insurance with advisory), and replicated across geographies. CSA practices, however, depend heavily on local context, farmer knowledge, and extension capacity, which limits their suitability as a scalable, financeable offering in the short term.

Banks can extend loans for these technologies in ways they cannot for "adopting mulching" or "practicing crop rotation." This creates a more direct business case for financial institutions while still delivering resilience benefits to farmers. For the purposes of this project, where the goal is to prioritise investable adaptation solutions that can unlock private finance, **focusing on products and services provides a more practical pathway** to mobilising capital at scale.

This focus does not imply that CSA practices are unimportant. On the contrary, they remain a critical foundation for sustainable and climate-resilient agriculture and should continue to be advanced through public extension systems, NGO programmes, and farmer-led initiatives. To acknowledge their value, we have collated a set of the most effective CSA practices (Annex 3-6), those that build adaptive capacity and improve yields, productivity, and farm incomes, for GCA's future consideration. For this specific project, however, where the objective is to identify **8–10 bankable adaptation solutions** that can attract private finance, we emphasized on shortlisting the technologies, products, and services that offer a clear investable proposition for financial institutions.

Step 3: Adaptation Solution Prioritization

The refined long list was systematically assessed against the **climate risk profiles and priority value chains** identified in each country, and validated through expert consultations, including inputs from CGIAR centres. A **multi-criteria analysis (MCA)** provided the backbone of this exercise, enabling a structured evaluation of how each solution aligns with country-specific hazards and agri-food systems, and its operational fit for key borrower segments such as smallholder farmers, cooperatives, and agri-SMEs.

Each solution was evaluated against explicit criteria, including **operational fit for key borrower segments** (such as smallholder farmers, cooperatives, and agri-SMEs), **technical maturity and local delivery readiness, potential to increase productivity, institutional and policy alignment, and gender and social inclusion**. Gender responsiveness was built into the framework explicitly: solutions that reduce women's labour burden, expand access to finance or extension, or strengthen women's role in decision-making received higher scores. This reflects evidence that without deliberate gender-responsive design, adaptation interventions risk reinforcing existing inequalities

To ensure rigour, each criterion was assessed using a **weighted scoring system** that reflected the relative importance of each indicator. The process was guided by diagnostic questions and evidence-based benchmarks, which allowed for a **nuanced comparison** of solutions based on both their technical and socio-economic contributions. Solutions with high composite scores were shortlisted for deeper analysis, including market sizing, value chain mapping, and financial viability assessments – that will be delivered in the next phase of the project.

This prioritisation approach ensures that the solutions taken forward are not only **technically sound and contextually relevant**, but also **scalable, inclusive, and institutionally aligned**—providing a strong foundation for GCA and its partners to identify interventions that can attract private finance while addressing urgent climate risks in agriculture.

COUNTRY OVERVIEW: TANZANIA

Country Executive Summary

Agriculture underpins Tanzania's economy and society, contributing nearly **29% of GDP**, driving the majority of exports, and sustaining livelihoods for **three in four Tanzanians**. Yet this foundation is increasingly shaped by intensifying climate hazards. National projections highlight a future marked by more frequent extreme heat, shifting rainfall extremes, localized drought intensification, and stronger wind and storm events. These changes are already beginning to reshape patterns of agricultural risk across the country's key production zones.

National Hazard mapping for Tanzania shows that **extreme heat** will become more pronounced along the coast (Pwani, Tanga), the central plateau (Dodoma, Tabora), and parts of the northern highlands, with the number of very hot days exceeding 35 °C rising significantly. Some zones will face extreme spikes above 41 °C. **Drought hazards** are projected to intensify in the western and southern provinces, with pockets near the Western Rift Valley facing conditions classed as "severely dry" (SPEI < −1.5). Although average rainfall may increase in places such as Dodoma, higher evapotranspiration from rising temperatures will amplify water stress. **Extreme rainfall events** will also grow stronger, particularly in coastal and island regions such as Pemba and Tanga, as well as parts of the south-western highlands. **Wind hazards** are projected to remain concentrated in Pemba and highland pockets in Manyara, Mbeya, Njombe, and Iringa, with slightly stronger gust extremes by mid-century.

The intersection of these hazards with Tanzania's agri-food systems underscores the scale of adaptation need. **Maize and rice**, which are staples of food security, are highly sensitive to both heat and water stress, with risks of reduced yields and crop failures. **Beans and groundnuts** also face medium-to-high vulnerability, while **cassava** is comparatively resilient under drought but prone to damage from flooding and waterlogging. **Banana/plantain** show moderate sensitivity to shifting rainfall patterns. In the livestock sector, **cattle and poultry** are most exposed to hotter conditions and flood-prone zones in the coastal belt and lake regions, whereas goats are relatively more resilient. Together, four value chains, **maize, rice, cassava, and cattle** stand out as both strategically central and highly climate-sensitive, requiring priority attention in the design of adaptation responses.

The **gendered dimensions** of vulnerability are equally important. Women comprise **67% of Tanzania's agricultural workforce** and are heavily involved in labor-intensive production and post-harvest stages, including weeding, harvesting, drying, and storage. Yet their yields are systematically lower than men's, reflecting reduced access to land, inputs, and finance. Climate change compounds these inequities: droughts increase women's unpaid workload for water and fuel collection, while floods often damage the food stores and small-scale processing activities where women predominate. Evidence also points to women's demand for low-cost storage and drying technologies, but adoption remains constrained by affordability and credit barriers.

Taken together, the findings highlight that Tanzania's agriculture is entering a period of heightened climate risk, with staple crops and livestock under growing pressure from heat, drought, and extreme rainfall. The most urgent risks converge around the maize, rice, cassava, and cattle value chains, which are central to national food security and rural livelihoods. Addressing these risks will require adaptation strategies that are not only technically sound and commercially viable but also inclusive of the women who provide the majority of agricultural labour. This report therefore sets the stage for identifying and prioritising concrete adaptation solutions that can help safeguard Tanzania's food systems and rural economy in the decades ahead.

Tanzania's top adaptation opportunities lie in five commercially ready solutions: aflatoxin biocontrol, climate-resilient fodder, cold chain systems, hermetic storage, and solar-powered irrigation. Already piloted and supported by credible partners, these interventions align urgent resilience needs with scalable

financing models, making them strong entry points for mobilizing private investment in the agri-food system.

National Climate Hazard Mapping

Key findings:

Extreme heat. Warming is projected to intensify most along the coast (Pwani, Tanga), the central plateau (Tabora, Dodoma), and parts of the northern highlands, with a surge in very hot days (>35 °C) and some extremes >41 °C.

Drought. Drought hazard is projected to intensify modestly overall (often ΔSPEI > −0.5), with western and southern provinces reaching moderate risk (SPEI < −1) by mid-century under both RCP 4.5 and RCP 8.5; localized zones near the Western Rift Valley may cross severely dry (SPEI < −1.5). Despite rising mean rainfall in places such as Dodoma, higher temperatures/evapotranspiration drive new water-stress pressures.

Wind gusts. By mid-century, wind hazard slightly intensifies: Pemba remains the windiest; highland pockets in Manyara, Mbeya, Njombe, and Iringa see the strongest extremes, often >20 m/s in ~1-in-25-year events. Spatial patterns remain similar to the baseline.

Extreme rainfall (1-day intensity / pluvial flood). 1-day extremes strengthen nationwide, with the largest absolute increases along the coast and islands—notably Pemba and Tanga—and amplification in the south-western highlands due to orographic effects. Interior belts (central plateau, western provinces) also show meaningful increases, raising urban/flash-flood potential.

River flooding (fluvial). Exposure remains highest in Morogoro, Tabora, and Pwani. Flood extent (>0.5 m depth) grows most in Arusha (+108 km²), Manyara (+94 km²), and Morogoro (+75 km²). By 2050, about 131,370 people in Morogoro (~5% of 2.7 M) and ~108,950 in Tanga are projected to be in 1-in-50-year flood zones, with Pwani showing the highest share at risk (>8%), roughly 100,000 people.

Climatology of Tanzania

Tanzania, located in East Africa just south of the Equator, covers both a vast mainland (formerly Tanganyika) and the semi-autonomous islands of Unguja (Zanzibar) and Pemba in the Indian Ocean, with a total of 945500 km^2. It shares borders with Kenya and Uganda to the north, Rwanda, Burundi, and the DRC across Lake Tanganyika to the west, and Zambia, Malawi, and Mozambique to the south. Except the offshore islands and the narrow coastline of Tanzania's mainland (which stretches along the Indian Ocean for about 1424 km), most of the country has an average elevation of 1000 to 2000 m, dominated by broad plains and plateaus punctuated by major relief features: Africa's highest mountain; Mount Kilimanjaro (5895 m) in the north, the East African Rift System (with deep lakes such as Tanganyika and Rukwa), the central plateau (covering more than a third of the country), and highland blocks in the southwest and northeast. Given its numerous lakes (including half of Lake Victoria) and numerous rivers, Tanzania is rich in freshwater: approximately 59000 km^2 consists of inland water.

Climatically, mainland Tanzania can be divided into four broad zones: hot, humid coastal lowlands; the hot and arid central plateau; the high inland mountain and lake region in the north (including Kilimanjaro); and the tropical/temperate highlands of the northeast and southwest. Rainfall is strongly seasonal and shaped by the migration of the Intertropical Convergence Zone: northern and eastern regions typically have two rainy seasons (March–May and October–December), while much of the south and west has a single rainy season (November–April). The coastal and many highland areas, as well as the offshore islands receive heavier precipitation. Temperatures fluctuate little through the year due to Tanzania's equatorial position, with cooler conditions in the uplands and occasional ground frost above 2500 meters.

Figure 1. Regions in Tanzania (mikoa – administrative divisions).

Extreme temperatures

Extreme heat exposure in Tanzania is driven by a mix of coastal warmth, lowland plateau heating, and elevation contrasts.

The most intense hotspots are found along the Indian Ocean seaboard (e.g., Pwani, Tanga, Lindi), where coastal lowlands trap heat and humidity, while another belt of high temperatures extends inland across the central plateau (e.g., Tabora, Katavi, Shinyanga), where open terrain and semi-arid conditions amplify surface heating.

By contrast, extreme temperatures are lowest in the northern and southwestern highlands (e.g., Arusha, Iringa, Njombe), where elevations are around 1500-2500m and rise to Africa's highest peak at Mount Kilimanjaro in the north, producing cooler conditions on average, even though localized extremes can still occur.

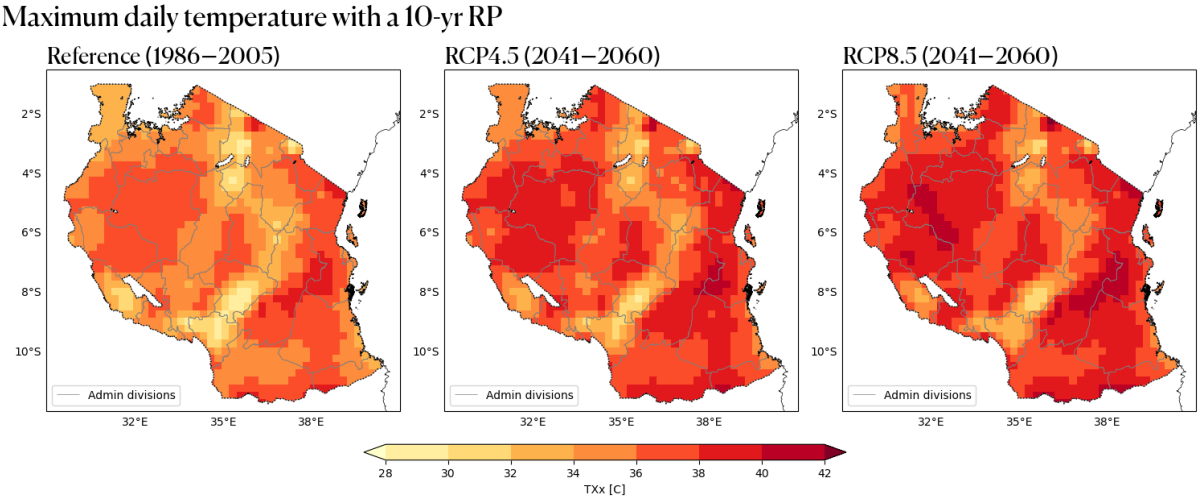

Figure 2. Comparison of the maximum daily temperature with a 10-year return period during the reference period and the projected values for 2041-2060 under RCP4.5 and RCP8.5 scenarios.

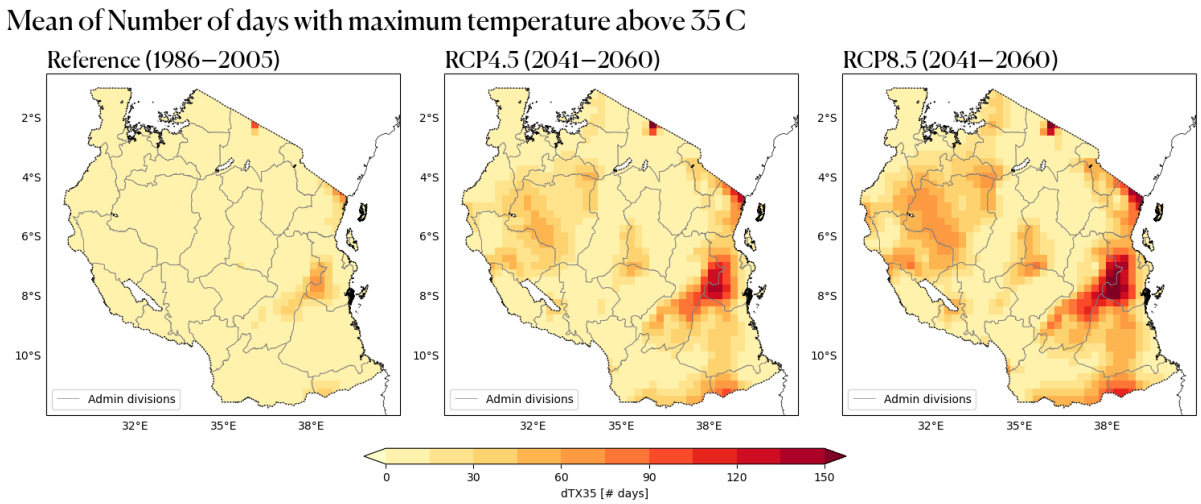

Figure 3. Comparison of the mean annual number of days above 35ºC during the reference period and the projected values for 2041-2060 under RCP4.5 and RCP8.5 scenarios.

REFERENCE PERIOD (1986-2005)

- Extreme heat events occurring once in 10 years show hottest-day temperatures of 36–37°C in coastal and northeastern provinces like Pwani, Tanga or Morogoro, with localized peaks exceeding 39°C, especially in Arusha and Pwani.
- The offshore islands of Unguja and Pemba (Zanzibar) recorded 10-year temperature extremes of 34–35°C, and virtually no days above 35°C, reflecting their consistently milder climate.
- The central plateau (Dodoma, Singida, Tabora) and western zones (Katavi, Shinyanga) had moderate heat extremes, with values for peak events around 34–37°C and an annual number of days above 35°C between 2 and 12.
- The southern and northern highlands (Mbeya, Njombe, Arusha, Kilimanjaro) remained cooler overall, but Arusha showed a localized anomaly with up to 100 days/year above 35°C, likely linked to the Lake Natron basin.

PROJECTION FOR 2041-2060

- Pwani will become a major hotspot, with hottest-day temperatures for an event once in 10 years reaching 39°C and localized extremes reaching 41°C under both climate scenarios. The number of days above 35°C is projected to rise to over 160 days/year under RCP8.5 in the region between Pwani and Morogoro (as shown in Figure 3). Eastern Tanga, though less extreme, will also continue to be a hotspot.
- Tabora will experience a pronounced increase in heat, with 10-year extremes rising to 39°C and localized values of 40°C under RCP8.5. The number of hot days per year will surge from around 4 historically to 44 days on average, with localized areas reaching up to 73 days/year.
- Although Arusha as a region will see few days above 35°C, very localised spots—near Lake Natron—will see the highest number of hot days in Tanzania, climbing to 179 days/year under RCP4.5, 203 days under RCP8.5, and extreme maximum temperatures reaching 42°C.
- The southern highlands (Mbeya, Njombe, Iringa) will experience maximum temperature values of 34–36°C, with localised extremes up to 39°C especially in low-lying areas. Days above 35°C will be up to 46 (RCP4.5) or 64 days/year (RCP8.5) in the area between Iringa and Dodoma (near the Mtera Dam).

- The offshore islands will reach extreme temperatures of 36–37°C for a 10-year return period event, with Pemba showing the largest increase in days above 35°C (from less than 1 day/year to 25-40 days/year under RCP8.5).

In summary, extreme heat will intensify across Tanzania, with coastal regions (notably Pwani and Tanga), the central plateau around Tabora and Dodoma, and parts of the northern highlands as the most affected areas. These regions will see more extreme heat events (some exceeding 41°C) and a surge in very hot days, intensifying stress on communities. Moreover, agriculture will suffer from shorter growing seasons, reduced yields and increased irrigation demand, especially for heat-sensitive crops like maize and beans. Coastal and lowland zones may see declines in livestock health and productivity, while highland regions will face new adaptation challenges due to sustained heat.

Drought

Drought hazard in Tanzania depends on the complex interplay between seasonal rainfall variability, topography, and regional climate zones.

While the coastal belt (e.g., Dar-es-Salaam, Pwani, Tanga), the southwestern highlands (e.g., Njombe, Mbeya, Songwe), and the islands of Zanzibar and Pemba (Unguja and Pemba regions) historically receive abundant rainfall, the central plateau (e.g., Dodoma, Singida, Tabora) and northern arid zones (Arusha, Manyara) experience lower precipitation and are more exposed to prolonged dry spells.

However, climate projections point to a future where both wet and dry regions face increasing drought stress, driven not as much by declining rainfall (trends are positive, indicating a potential increase in annual rainfall) but by rising evapotranspiration due to higher temperatures.

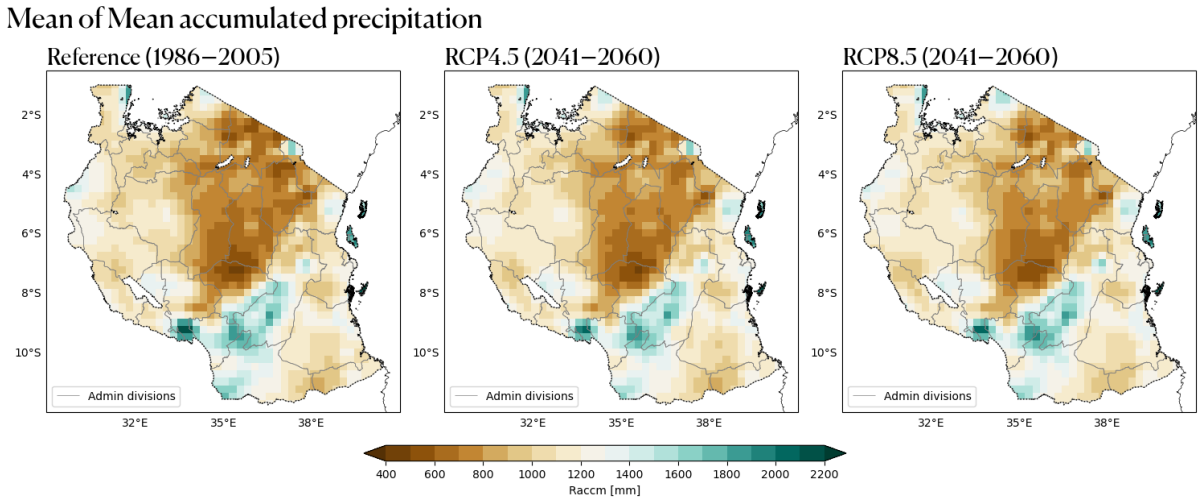

Figure 4. Comparison of the mean annual accumulated precpitation during the reference period and the projected values for 2041-2060 under RCP4.5 and RCP8.5 scenarios.

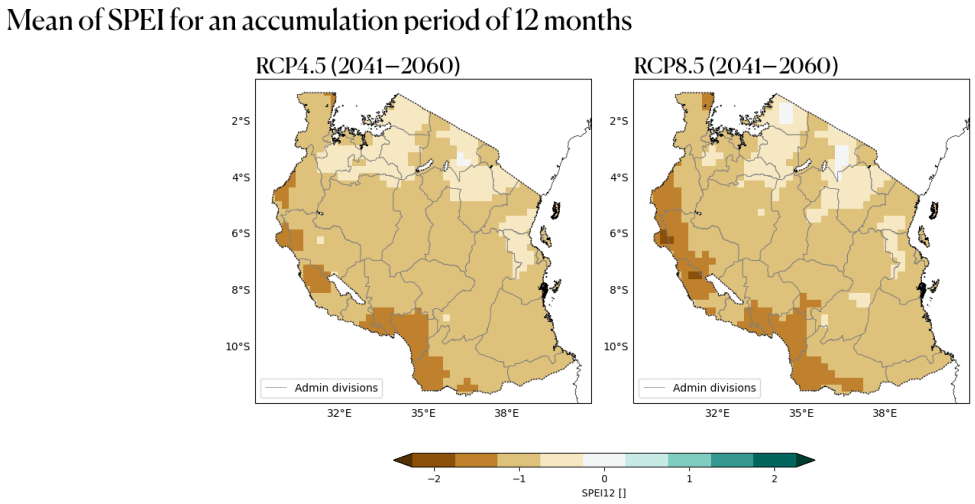

Figure 5. Projected mean of SPEI values (multiscalar drought index) for an accumulation period of 12 months under RCP4.5 and RCP8.5 scenarios for 2041-2060.

REFERENCE PERIOD (1986-2005)

- Precipitation patterns show a marked spatial gradient shaped by elevation and proximity to the coast. The islands and southwestern highlands emerge as the most humid zones, with consistently high levels of accumulated rainfall.
- Kaskazini Unguja (Zanzibar) recorded the highest average annual precipitation (~1774 mm), followed by Kusini Pemba (1772 mm), Kusini Unguja (1752 mm), and Mjini Magharibi (1693 mm), reflecting the tropical maritime climate of Zanzibar.
- Inland highland regions such as Njombe (1428 mm), Ruvuma (1318 mm), and Morogoro (1282 mm) also show high rainfall, supported by orographic uplift and forest cover (as seen in Figure 4).
- In contrast, central plateau provinces like Dodoma (709 mm), Manyara (736 mm), Singida (750 mm), and Arusha (746 mm) are significantly drier, with seasonal rainfall and higher drought exposure.
- Transitional zones such as Tabora (1016 mm) and Shinyanga (928 mm) sit between wetter western regions and the arid central belt, showing moderate rainfall levels.

PROJECTION FOR 2041-2060

- Njombe faces one of the sharpest increases in drought stress. Rainfall drops by over 50 mm (one of the few mioka with decreasing rainfall), and SPEI12 plunges to −1.34 (RCP4.5), signaling a shift toward moderate drought risk in one of the provinces that receives higher precipitation.
- The western rift zone (especially Kigoma and Katavi) emerges as a drought hotspot. SPEI12 values fall to −1.28 and −1.23, with extreme localised drought reaching −1.86, marking some of the most severe conditions nationally under RCP8.5 (as seen in Figure 5).
- Central provinces such as Dodoma and Singida, already dry, remain vulnerable: althouh rainfall seems to increase (742 mm and 798 mm under RCP8.5), SPEI12 drops around −0.9.
- In the Lake Victoria basin, Kagera shows growing water stress despite an increase in rainfall (1239 mm under RCP8.5). However, SPEI12 declines to −1, indicating emerging drought risk.
- Coastal regions (Dar-es-Salaam, Pwani, Lindi) also see slight rainfall increases, but SPEI values worsen around −1.

Future drought hazard in Tanzania is expected to intensify, although with spatial differences and with a relatively smaller degree than neighbouring countries (mostly due to stable or even increasing yearly precipitation). Overall, despite a trend towards more severe drought events, changes are projected to be relatively mild (less than -0.5 units in most cases). Drought risk will emerge particularly across the western and southern provinces, which are projected to reach a moderate risk level (SPEI < -1) by mid-century under both RCP 4.5 and RCP 8.5. In addition, some localised areas near the Western Rift Valley are projected to cross the considered "severely dry" threshold in mean SPEI values (< -1.5). Already arid areas such as Dodoma will remain vulnerable, though experiencing an increase in mean precipitation. Importantly, rainfall stability in some regions suggest that heat and evapotranspiration are driving new drought pressures, even where precipitation rises. Despite the relatively smaller changes of this hazard, drought will remain an increasing risk.

Extreme wind

Wind gust hazard in Tanzania is shaped by coastal exposure, elevation, and local topography.

Coastal and island regions (e.g., Pemba, Unguja, Mtwara) are influenced by maritime winds, while highland and mountainous areas (e.g., Manyara, Mbeya, Njombe, Iringa) experience strong gusts due to orographic effects and funneling along rift escarpments. The central plateau (Dodoma, Singida, Tabora) and western rift zones (Katavi, Rukwa, Kigoma) also record notable gusts. Climate projections indicate a modest but widespread intensification of wind gusts by mid-century, with the spatial pattern largely preserved.

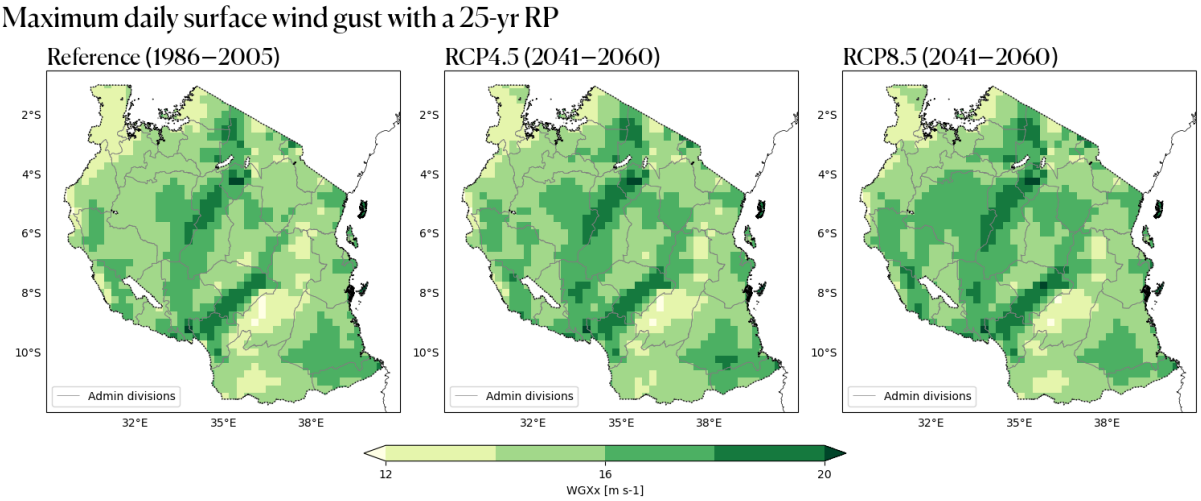

Figure 6. Comparison of the maximum daily surface wind gust with a 25-year return period during the reference period and the projected values for 2041-2060 under RCP4.5 and RCP8.5 scenarios.

REFERENCE PERIOD (1986-2005)

- The highest values for maximum daily surface wind gust for a 25-year return period are observed in the island of Pemba: Kaskazini Pemba (19.47 m/s) and Kusini Pemba (19.42 m/s), with extremes up to 19.87 m/s. Additionally, in Mafia Island (part of Pwani region) wind gusts values reach up to 20.56 m/s.
- Inland highlands such as Mbeya (16.48 m/s), Njombe (16.62 m/s), and Manyara (15.75 m/s) record high values, with Manyara reaching the highest extreme in the dataset (22.68 m/s). Its position along the escarpment of the Eastern Rift Valley contributes to amplify gust intensity, as it clearly shows in Figure 6.
- Coastal mainland areas such as Mtwara (16.60 m/s) and Dar-es-Salaam (16.40 m/s) also register high values due to onshore winds during extreme events (once in 25 years).

- More sheltered inland regions like Kagera (13.54 m/s) and Geita (14.11 m/s) have the lowest means, though localised extremes can still exceed 17 m/s in 25-year return period events.

PROJECTION FOR 2041-2060

- Pemba provinces (Kaskazini and Kusini) remain the highest-risk zones regarding extreme wind gusts for a 25-year return period, with values near 19.4 m/s (RCP 8.5). Their unsheltered maritime exposure keeps wind intensity high.
- In the southwestern highlands, Mbeya, Njombe, and Iringa show certain wind intensification. Values rise to ~17.0 m/s, with high passes and exposed slopes reaching 21–22 m/s under both climate scenarios, driven by orographic funneling.
- Katavi and Rukwa, in the western rift zone, experience some of the (relatively) largest increases (up to 0.7 m/s), with gusts around 16 m/s in localised spots nearing 19 m/s during extreme events.
- Manyara, on the rift flank, climbs to 16.22 m/s, with spots such as the area near Babati peaking around 23 m/s (both under RCP 8.5).

By mid-century, Tanzania's wind gust hazard will intensify slightly, with Pemba remaining the windiest and certain spots in highland areas like Manyara, Mbeya, Njombe, and Iringa seeing the strongest extremes, often above 20 m/s during extreme events (once in 25 years). Though absolute increases are modest and the spatial pattern from the reference period is largely preserved, these regions may face greater risks, alongside lower-risk areas where occasional strong gusts could still cause disruption.

Extreme precipitation

Extreme 1-day rainfall events in Tanzania are influenced by coastal convergence from the Indian Ocean, orographic uplift in the highlands and rift escarpments, and lake-effect storms around its major inland waters. Coastal and island provinces such as Pemba, Unguja, Tanga, and Pwani are exposed to the highest intensities, while upland areas like Mbeya, Njombe, and Kilimanjaro experience enhancement from terrain-driven lifting. Even drier central plateau provinces, including Dodoma and Singida, can see damaging downpours, highlighting that risk is widespread despite differences in average rainfall.

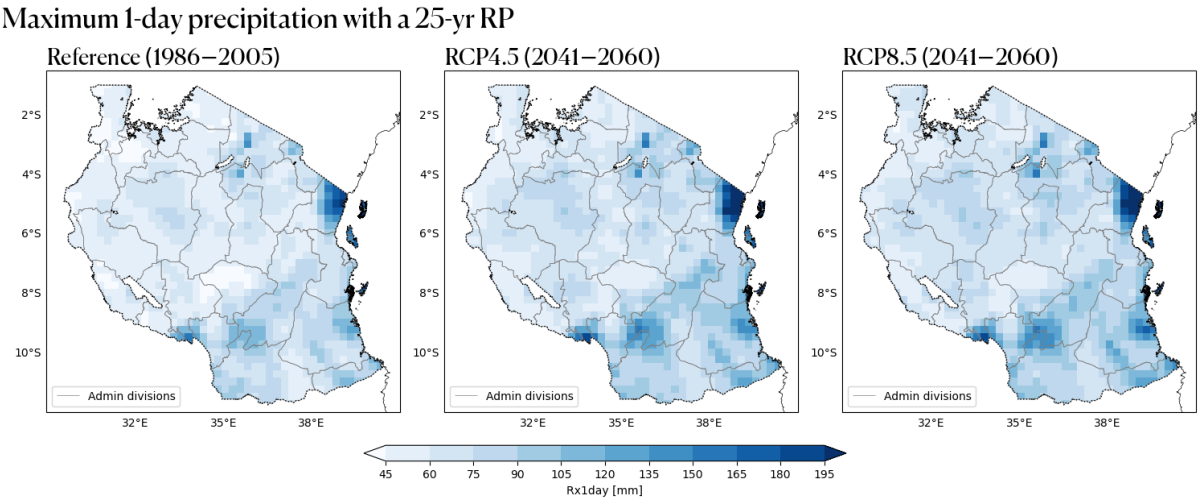

Figure 7. Comparison of the maximum 1-day precipitation with a 25-year return period during the reference period and the projected values for 2041-2060 under RCP4.5 and RCP8.5 scenarios.

REFERENCE PERIOD (1986-2005)

- Kaskazini Pemba (195 mm) and Kusini Pemba (229 mm) record the highest 1-day totals for an extreme event with a 25-year return period, followed by Kaskazini Unguja (152 mm), Kusini Unguja (148 mm), and Mjini Magharibi (130 mm).
- Tanga (especially its eastern half) also stands out at 105 mm, reflecting maritime exposure and coastal convergence (as seen in Figure 7).
- Mbeya (65 mm), Njombe (84 mm), Iringa (61 mm), and Kilimanjaro (74 mm) show elevated localised peaks such as Mbeya's 159 mm and Manyara's 123 mm, linked to orographic lifting along rift flanks.
- Mwanza (57 mm), Kagera (48 mm), Kigoma (50 mm), and Katavi (54 mm) present moderate values, with lake-breeze effects and topographic channeling shaping event intensity.
- Dodoma (61 mm), Singida (57 mm), and Tabora (63 mm) are lower in absolute intensity but still experience damaging localised events.

PROJECTION FOR 2041-2060

- Pemba provinces (Kaskazini and Kusini) continue to hold the national maxima, with Kusini Pemba reaching 288.63 mm (RCP 8.5) — the highest projected 1-day rainfall (once in 25 years) in Tanzania, reinforcing their exceptional flood exposure. Moreover, localised spots in Pemba island rise to 309 mm.
- Tanga shows one of the largest increases, rising from 105 mm (historical period) to ~129 mm (in both climate scenarios), with localised peaks climbing from 195 mm to 262 mm (RCP 4.5), driven by coastal convergence and uplift along the Usambara–Pare ranges.
- Pwani and Dar-es-Salaam see substantial gains, with Pwani's localised peaks rising from 198 mm (historical period) to nearly 239 mm (RCP 8.5), highlighting growing flood risk in low-lying coastal catchments.
- In the southern highlands, Mbeya, Njombe, and Iringa experience persistent orographic enhancement, with Mbeya reaching 193 mm (RCP 4.5) and Njombe exceeding 150 mm (in both climate scenarios) in localised places, despite showing lower values overall.
- Even historically lower-intensity zones like interior provinces (Dodoma, Singida or Tabora) show noticeable increases, with 1-day totals rising to 72–77 mm and localised peaks around 95 mm or 103 mm in the case of Tabora (RCP 8.5), indicating more extreme rainfall during extreme events.

By mid-century, 1-day extreme rainfall associated with 25-year events is projected to intensify across Tanzania, with the largest absolute increases along the coast and islands (especially both Pemba provinces and Tanga, respectively) and amplification in the southwestern highlands due to orographic effects. Interior provinces, including the central plateau and the western belt, also register meaningful increases from the reference period, raising flood potential even where baseline intensities were lower.

River flooding

In Tanzania, there are nine river basins defined by the Water Management Government, and include the major river systems of Pangani, Wami Ruvu, Rufiji (the largest source of renewable water), and Ruvuma, as well as the Lake Nyasa, Lake Tanganyika, Lake Victoria basins, and the Internal Drainage Basin (Figure 8).

Figure 8. Map of principal river basins in Tanzania (in white), together with the main river network in the country.

The Pangani, Wami, Ruvu, Rufiji, and Ruvuma rivers flow eastward. Much of the country's population is located in these basins, especially Dar es Salaam (6 million people) and Dodoma (2 million people). This is also the case in some key agricultural areas, such as the southern and northeastern coastal plains, which are described in Section 0.

In the historical period, the country has been exposed to extreme rainfall, especially due to the influence of El Niño, which has led to episodes of significant flooding. The table below illustrates recent cases, and the driving factor that affected the region.

Table 1: Major recent flood events in Tanzania

Date	Region	Impact
May 2024	Dodoma and Dar es Salaam region	Extreme rainfall causing floods, flash floods and landslides (ECHO, 2024).
April 2024	Rufiji River Basin, the largest river basin in Tanzania and East Africa	Flooding along the Rufiji River devastated the district, damaging more than 28,000 hectares of crops (Conversation, 2024).
October 2023	North-east of the country, Morogoro, Dar es Salaam, and Kilimanjaro	Above-average extreme rainfall during the El Niño event led to widespread flood (FAO, 2024).

Especially for agriculture, the impacts of flooding in Tanzania are important. During the El Niño events of 2023-early 2024, most of the agricultural production was affected, as floods came after almost all agriculture had already been planted (FAO, 2024).

REFERENCE PERIOD (1986-2005)

To evaluate the impact of river flooding at the country level, an analysis is carried out using the flood extent and water depths from the European Joint Research Centre (JRC) Floods Maps, which have a

100m resolution and are available under current baseline conditions. For future projections, the multi-model climate change patterns from WRI's Aqueduct Flood Maps (Ward, 2020) are derived and used.

To impact of river flooding in Tanzania is assessed considering a 50-year return period event.

- The majority of most exposed basin are located in the East part of the Country.
- Based on the flood extent for a 50-year return period event, the regions of Morogoro, Tabora, Pwani and Singida stand as the areas with the largest extension of flooded areas of at least 0.5 meters of water
- Morogoro has flooded extent of 3,771 km^2 representing 5% of the province's area. This region lies in the Rufiji River Basin, the largest in Tanzania
- The regions of Tabora, Pwani and Singida have flooded extent of 3486 km^2, 2642 km^2 and 2231 km^2 respectively

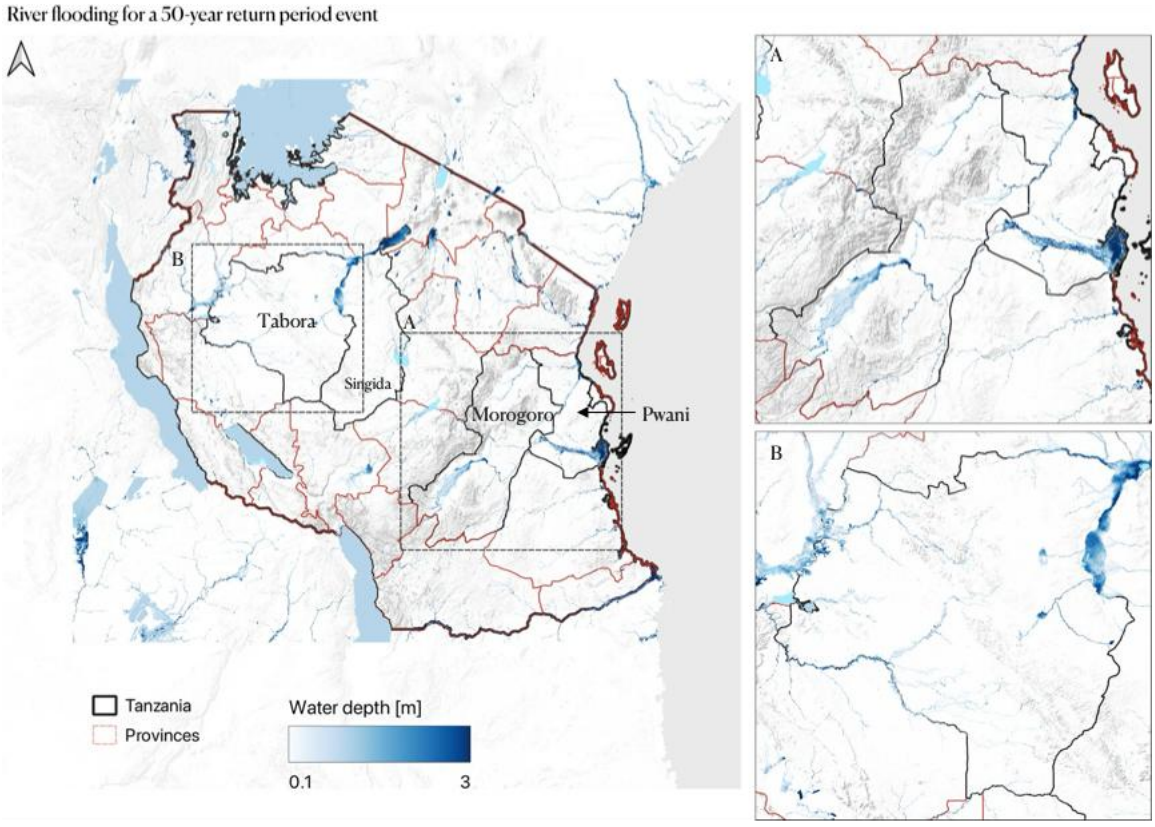

Figure 9. Flood Map for 1 in a 50 year river flooding event for the historical period. The provinces highlighted in (A) and (B) are the ones with the largest exposure (largest area with at least 0.5m of floodwater expected).

PROJECTION FOR 2041-2060

The assess the impacts of river flooding in the future, we obtain the flood mask of at least 0.5m of water associated to a 50-year return period event for 2050 (under an RCP4.5 scenario), and combine this information with the presence of population from a 100-meters gridded dataset (WorldPop & Center for International Earth Science Information Network (CIESIN), 2018). Table presents the most exposed provinces by flooded area, difference between present and future, and linked to population.

- Provinces most exposed to river flooding: Similar to the historical period, Morogoro, Tabora and Pwani will continue to be the most exposed regions in Tanzania.
- Largest increase in total water extent: Comparing the flood extent (>0.5m water depth) of the historical period and 2050 shows that Arusha is the province that will increase the most the

flooded area with +108 km^2, followed by Manyara and Morogo with 94 km^2 and 75 km^2 respectively.

- Future exposed population: Morogoro is the province with the largest amount of population located in flood-prone areas with 131,370 people exposed in regions with a probability to be flooded at least 0.5m of water 1 in a 50-year event. This represents 5% of the total population (2.7M people).
- The province with the second largest population exposed is Tanga, that will have over 108,950 people in risk areas.
- Analysing the provinces with the largest percentage of population at risk, the analysis shows that Pwani will have over 8% of its population in risk areas (with almost 100,000 people affected).

Table 2: Top-10 provinces with the largest population located in flood-prone areas for a 2050 river flooding map. Flood-prone areas are defined as areas with at least 0.5 meter of water. Data for future is provided for 2050 based on the RCP4.5. Red rows represent exposed regions.

Provinces	Context		Flood extent 50-year return period			Population in flood areas *Based on 2050 Flood map*	
	Area *Km2*	Population *M people*	Historic *Km2*	2050 *RCP4.5 Km2*	Difference *Km2*	#	%
Morogoro	71,978	2.7	3,771	3,846	75	131,370	5%
Tanga	28,310	2.5	968	1,001	33	108,950	4%
Pwani	32,642	1.3	2,642	2,648	6	99,257	8%
Tabora	76,544	2.9	3,486	3,414	-72	81,229	3%
Mbeya	38,956	2.1	1,457	1,486	29	78,213	4%
Kagera	26,652	2.8	1,211	1,199	-12	72,590	3%
Mtwara	18,587	1.4	634	667	32	65,981	5%
Singida	49,385	1.7	2,231	2,157	-74	51,943	3%
Kigoma	36,827	2.6	2,179	2,116	-63	51,112	2%
Dar-es-salaam	1,667	6.8	14	12	-2	51,058	1%

Agricultural and Food Security Exposure to Climate Hazards

Key findings:

Agriculture remains central to Tanzania's economy - contributing ~28.7% of GDP, accounting for the bulk of exports, and providing livelihoods for roughly 75% of the population (FAO, he State of Food and Agriculture 2021: Making agrifood systems more resilient to shocks and stresses, 2021). Women represent 67% of Tanzania's agricultural workforce, yet they achieve lower yields than men due to reduced access to land, labour, and inputs (Bank, Tanzania Economic Update: Transforming Agriculture, 2022a). Female farmers are concentrated in weeding, harvesting, and post-harvest processing, while men dominate ploughing, pesticide application, and marketing. Evidence highlights women's preferences for affordable storage and drying solutions, but adoption is limited by high costs and restricted access to finance. Climate change intensifies these constraints, with droughts increasing women's unpaid workload in water and fuel collection and floods damaging food stores managed by women (Bank, Women in Agribusiness in Eastern and Southern Africa: Country Assessment for Tanzania, 2022b).

Climate risks—more very hot days, intense short-duration rainfall/flooding, and localized drought—will hit maize and rice hardest, with beans and groundnuts facing medium–high impacts; cassava is comparatively resilient (but vulnerable to waterlogging), and banana/plantain show moderate sensitivity.

In livestock, cattle and poultry are most exposed in hotter, flood-prone coastal and lake regions, while goats are relatively resilient. Tanzania's food system is anchored by four strategic staples—maize, rice, cassava, and cattle—where targeted adaptation on seed/water management, post-harvest systems, rangeland/veterinary services, and disease control is most urgent; cash crops (coffee, cotton, cashew) remain important for income but have less direct influence on staple affordability. Priority value chains for follow-on adaptation design are Maize, Rice, Cassava, Cattle.

Agriculture sector overview

Agriculture is a vital sector in Tanzania's economy, contributing approximately 28.7% to national GDP (AGRICA, 2021) and accounting for 85% of exports (Jean-Louis Fusillier, 2021). Tanzania remains categorized as a least developed country (LDC), with a real GDP per capita of 1.211 USD (in 2023). A significant portion of Tanzania's population, about 75%, relies on agriculture for employment and livelihoods.

Tanzania holds a significant position in the regional trade of essential staples as a member of the East Africa Community (EAC) and the Southern African Development Community (SADC) (Rweyemamu, Mruma, & Nkanyani, 2024). It typically produces an excess of staple cereals and pulses, exporting substantial amounts of these goods to nearby countries such as Kenya, Malawi, Zambia, Uganda, Rwanda, Burundi, and the Democratic Republic of Congo (Famine Early Warning Systems Network, 2018).

Tanzania's farm landscape is dominated by maize and extensive cattle grazing, with smaller shares in beans, rice, cassava, sunflower, sorghum and bananas. Crop yields are generally below the Eastern Africa average—beans are a bright spot (above average) and sunflower is roughly on par—while cattle meat yields lag regional peers (CCAFS, 2019).

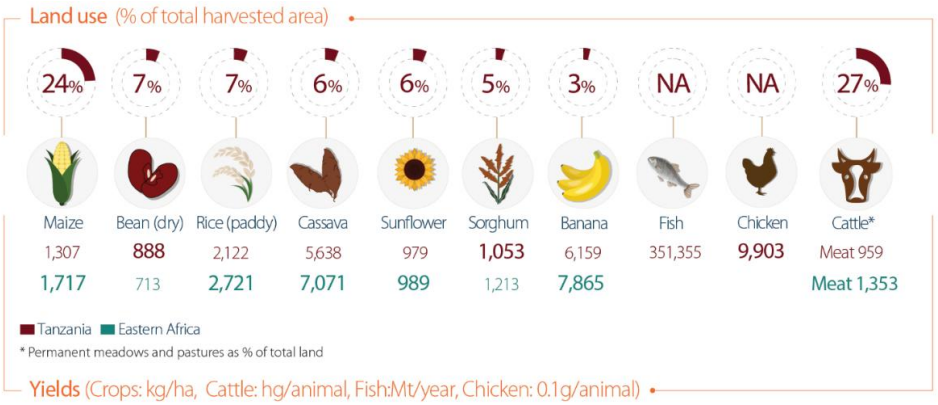

Figure 10. Production systems key for food security in Tanzania.

Climate change is a growing threat to Tanzanian agriculture. Tanzania's agricultural sector experienced a 3.3% growth in value added as a percentage of GDP. This is a slight decline from the 3.7% growth recorded in 2021 (World Bank, 2023). The reduction is attributed to erratic and poorly timed rains in specific areas, leading to droughts and floods, disrupted planting cycles, reduced yields, and exacerbated water scarcity for both crops and livestock. Without sufficient irrigation infrastructure, smallholder farmers are particularly vulnerable. Climate change also increases the prevalence of pests and diseases affecting crops such as maize, rice, and wheat, while extreme weather events—floods, storms—damage farmland, infrastructure, and storage, contributing further to post-harvest losses (Climate Action Network (CAN), 2020).

Crop

The crop subsector is the largest contributor of agriculture's GDP accounting for approximately 70–75% of the sector's value. Cropland covers about 44.6% of the country's total land area, of which 24% is actively cultivated. Despite this potential, irrigation is very limited: only 1.5% of Tanzania's 29.4 million hectares of suitable cropland is irrigated, leaving the vast majority of farming dependent on rainfall and therefore highly vulnerable to droughts and erratic rainfall patterns (Rweyemamu, Mruma, & Nkanyani, 2024).

The agricultural landscape is diverse, but maize remains the dominant staple crop, providing the main source of calories for most households. It is followed in importance by rice, sorghum, millet, pulses, cassava, and bananas. However, yields for these crops remain low compared to regional and global benchmarks, with maize averaging 1,370 kg/ha and rice 2,122 kg/ha (CCAFS, 2019) against a Sub-Saharan African average of around 2,000–2,500 kg/ha for maize and 3,000–4,000 kg/ha for rice. This yield gap highlights the sector's productivity challenges and the urgent need for climate-resilient agricultural practices, improved irrigation, and better access to inputs.

Livestock

In 2022, the livestock sector accounted for 7.4% of GDP and 26.1% of agricultural GDP. Tanzania's livestock population is among the largest in Africa and globally and is expanding rapidly. Its cattle herd accounts for 11% of Africa's total and 1.4% of the global total – the second largest on the continent after Ethiopia. However, recurrent droughts and floods have led to significant livestock mortality. For example, the 2022/23 drought in northern and central Tanzania caused the death of an estimated 62,000 cattle and 100,000 small ruminants due to lack of water and pasture (FAO, 2023). Similarly, the El Niño–related floods of 2023/24 resulted in the loss of about 90,000 head of livestock valued at USD 62 million (FAO, 2024).

The main species reared are cattle, goats, sheep, poultry, and pigs, many of which serve multiple purposes – providing food, draft power, transport, income, and savings, as well as contributing to cultural and traditional practices. Between 2010 and 2022, the total numbers of cattle, goats, sheep, and poultry increased by an average of 83%, with the cattle herd more than doubling over the period (World Bank, 2024). Climate-sensitive diseases also pose a growing challenge and reduce milk yields, meat output, and incomes for pastoral households, further increasing vulnerability to climate change

Production systems cover arid, semi-arid, sub-humid, and humid agro-ecologies. Around 80% of the national herd is raised in agropastoral systems, 14% in pastoral systems, and the remaining 6% on commercial ranches.

Fisheries

The fisheries sector accounts for 1.71% of national GDP in 2022 and growing at 1.5% per year. Tanzania's marine resources include a Territorial Sea of 64,000 sq. km, an Exclusive Economic Zone (EEZ) of 223,000 sq. km., and 1,424 km of coastline along the Indian Ocean. Inland water resources cover about 5,000 sq. km, including major shared lakes: Lake Victoria (with Kenya and Uganda), Lake Tanganyika (with Burundi, DRC, and Zambia), and Lake Nyasa (with Malawi and Mozambique).

The sector supports a per capita fish consumption of 8.5 kg per year. Around 200,000 people (0.35% of the population) are engaged as full-time small-scale fishers, while approximately 4.5 million Tanzanians (6.89%) are indirectly employed in fisheries-related activities. With abundant marine and inland resources, the sector has strong potential to expand (Ministry of Livestock and Fisheries, 2021).

Recent data show climate change is already impacting both marine and freshwater fisheries. In Lake Tanganyika, warming surface waters have reduced fish productivity by an estimated 30% over the past century (A. Cohen, 2016). Along the Indian Ocean, Cyclone Hidaya in May 2024 disrupted marine fishing activities for several weeks, cutting catches in southern Tanzania (FAO, 2024).

Gender considerations in agriculture

Women make up around two-thirds of Tanzania's agricultural (ILO, 2022), particularly in food crops such as maize, cassava, beans, and horticulture, as well as poultry and small livestock. They dominate weeding, harvesting, post-harvest processing, and informal marketing (UN Women, 2023). These subsectors - food crops and post-harvest activities - are also the most exposed to climate risks such as droughts, floods, and heat stress, placing women at the frontline of impacts.

Structural inequities intensify this vulnerability. Only 8% of women report sole land ownership versus 25% of men (World Bank, 2023a). Female-headed households cultivate smaller plots, own fewer livestock, and face limited access to fertiliser, equipment, and labour, contributing to a 20–30% yield gap between men and women (World Bank, 2015). Women also have lower access to irrigation, extension, and climate information, meaning adaptation support often reaches them later.

As a result, climate shocks translate into greater yield losses for women's rainfed plots, higher post-harvest losses in storage and trade, and increased time burdens for water and fuelwood collection during droughts (FAO, 2021). These pressures reduce women's incomes and household food security, given that women's earnings are strongly tied to nutrition and education expenditures.

Without targeted interventions, climate hazards risk widening gender inequalities. Closing these gaps requires scaling women's access to finance, inputs, and extension (particularly via female extension agents), promoting labour- and time-saving technologies, and strengthening women's cooperatives as delivery channels (Government of Tanzania, 2013) (Agenda 10/30, 2020).

Climate impact at key agriculture production zones

Major crop and livestock production areas

Figure 11. Key crop production and livestock areas.

Most agricultural activity in Tanzania is concentrated in four production zones—Lake Victoria Southern Plateau (key crops: rice, maize, groundnuts), Southern Highlands Corridor (maize, beans, groundnuts), Southeastern Coastal Plains (cassava, rice, groundnuts), and the Albertine Highlands (banana, beans, plantain). Livestock production is similarly clustered, with major hotspots overlapping these zones and

extending into the Maasai Steppe Pastoral Corridor and the Northeastern Coastal Plains & Islands, where cattle, chickens, and goats dominate. [2]

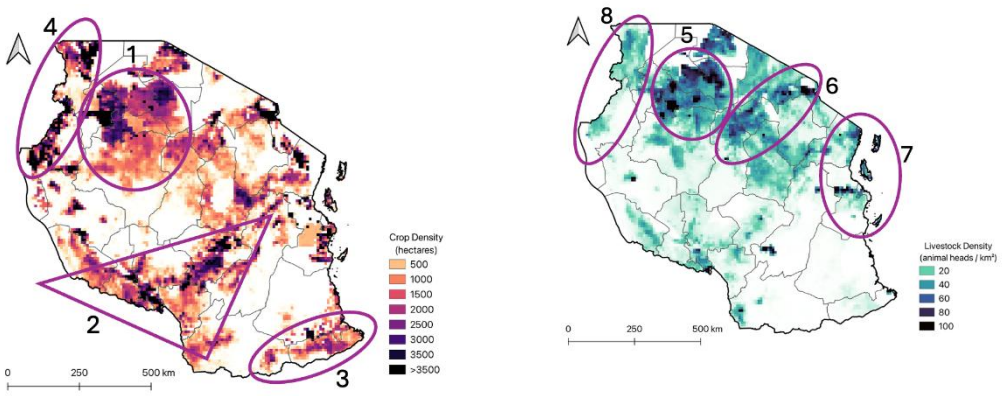

Figure 12. Sketch of the 4 key crop and livestock production areas. While most of the country shows high production, these focus areas aim to set representative areas for study.

Lake Victoria Southern Plateau

South of Lake Victoria, an extensive plateau from Mwanza to Tabora forms one of Tanzania's key agricultural zones. Lying between the Rift Valley shoulders at 1,000–1,400 m, the gently undulating terrain is framed by higher escarpments to the east and west. Weathered upland soils interspersed with fertile black-cotton (mbuga) soils support mixed smallholder agriculture under a unimodal November–May rainy season (700–1,200 mm/year). Farming centres on maize, sorghum, cassava, rice, and livestock systems, with cotton historically giving the area its "cotton belt" identity; settlement and land use are dense. By production value, the leading crop commodities are rice, maize, groundnuts, and cassava.

Covering Mwanza, Shinyanga, Simiyu, and Tabora, the region hosts Tanzania's densest agropastoral systems, where livestock are closely integrated into crop-based livelihoods. Communal grazing and use of crop residues provide feed, sustaining relatively large herds and generating cash from milk, meat, and hides, while animals also serve as household assets for risk management, dowries, and social status.

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[2] The density of crop production is displayed in Figure 11, shown as the physical area of crops (in hectares) derived from the Spatial Production Allocation Model 2017 (SPAM2017) dataset for Sub-Saharan Africa, produced by IFPRI and partners, at a spatial resolution of approximately 10 km × 10 km near the Equator. This spatial dataset provides a national-scale picture of where cropland is most intensively used in Tanzania, reflecting patterns shaped by climate, soils, topography, and proximity to markets. It reveals clear contrasts between zones of concentrated agricultural activity and extensive areas with sparse cultivation, illustrating the interplay of environmental constraints and population density. From this mapping, several distinct zones of high-density production emerge, each embedded within unique geographic and socio-economic landscapes. For ease of reference, these zones have been assigned descriptive names drawn from their location, physiographic characteristics, and spatial patterns evident in the dataset. Alongside these major zones, there are smaller, isolated clusters of cropland commonly associated with peri-urban agriculture around key urban centres, such as Dar es Salaam, Mwanza, and Arusha. Nevertheless, this analysis primarily focuses on the larger regions that form the backbone of Tanzania's agricultural production.

Building on the spatial patterns of cropland density, livestock distribution maps reveal complementary zones of animal production that interact closely with cropping systems, together shaping agricultural livelihoods and ecosystem dynamics critical for integrated climate vulnerability and adaptation assessments. The distribution of livestock across Tanzania is shown in Figure 9, based on the Gridded Livestock of the World (GLW4) dataset for 2020 at 10 km spatial resolution, produced by the FAO and partners. The dataset combines multiple species—cattle, chickens, goats, sheep, and pigs—and expresses density as the number of individual animals (heads) per square kilometre. This mapping highlights marked regional differences, with extensive areas of low livestock presence contrasted by distinct zones of higher density. From this national-scale perspective, four main regions of concentrated livestock production emerge, each shaped by its own environmental conditions, land-use practices, and market access. For ease of reference in the sections that follow, these zones have been assigned descriptive names based on their geographic position and the spatial patterns evident in the dataset.

Seasonal herd movements (transhumance) and vibrant weekly markets link rural producers to urban demand. By herd size (number of animals), the leading livestock species are cattle, chicken, and goats.

Climate impacts to agriculture production in the Lake Victoria Southern Plateau

Extreme heat is projected to intensify, with peaks near 40 °C and the number of hot days >35 °C projected to extend from 1–2 weeks to over 2 months. Extreme precipitation is projected to be a major hazard, with single-day totals ≥100 mm. River flooding is projected to occur mainly on the northeastern and northwestern flanks of Tabora.

The most affected value chains are maize and rice due to prolonged hot spells (>35 °C for weeks–months) that hit pollination, plus very intense rain (≥100 mm/day) causing lodging, flooding and post-harvest drying/aflatoxin risks. Cattle also face heat stress and variable pasture/water. Groundnuts are challenged by heat at flowering and wet curing periods; chicken are vulnerable to heat waves and rain-damaged housin. Goats remain comparatively resilient.

Southern Highlands Corridor

The Southern Highlands, spanning Mbeya, Iringa, and Njombe, extend along the border with Zambia and Malawi before branching inland toward the Udzungwa and Rubeho Mountains. This complex of uplands, volcanic ranges, and high plateaus reaches elevations above 2,500 metres, with fertile volcanic soils and a climate cooler than elsewhere in Tanzania, averaging 15–23 °C. Rainfall is generally high (1,000–2,500 mm per year), delivered in a reliably long or bimodal rainy season. This combination makes the region the country's most productive food system, widely recognised as Tanzania's "breadbasket". It produces surplus maize, beans, potatoes, and wheat alongside high-value crops such as tea, coffee, and horticulture. The integration of favourable agro-ecological conditions with links to domestic and export markets underlies its prominence in national food security. In order of importance by production value in this region, the most important crop commodities are maize, beans, groundnuts and rice.

Climate impacts to agriculture production in the Southern Highlands Corridor

Heat is projected to increase but remain moderated by elevation (lower valleys still reaching the high-30s). SPEI-12 drought conditions are projected to intensify more than anywhere else nationally. Extreme rainfall is projected to be among the country's highest (around 200 mm/day), with winds projected to approach ~22 m/s and river flooding projected to be important in southwestern Morogoro (Rufiji Basin).

All three crop chains are high-impact: maize, beans, and groundnuts are exposed to the country's strongest drought intensification, very heavy rain (~200 mm/day) and occasional high winds (~22 m/s), driving pollination failure, erosion/waterlogging, disease pressure and aflatoxin risk.

Southeastern Coastal Plains

In the southeast, the low-lying plains of Lindi and Mtwara are characterised by warm, humid conditions and flat to gently rolling sandy terrain. Rainfall averages 800–1,200 mm a year, mainly in the December–April rainy season, supporting drought-tolerant crops in a system adapted to variable conditions. The region is internationally recognised as Tanzania's cashew belt, with cashew nuts as a dominant export crop alongside cassava, and other crops. Compared to inland zones, rural settlement density is lower, yet smallholders here contribute significantly to export-oriented production while also maintaining subsistence crops for local food systems.

In order of importance by production value in this region, the most important crop commodities are cassava, rice, groundnuts and maize. Additionally, there's important production of sesame seed and pigeonpea.

Climate impacts to agriculture production in the Southeastern Coastal Plains

Extreme heat is projected to reach >40 °C in localized areas, with >35 °C days projected to exceed 100 days in some locations. Coastal downpours are projected to intensify, with extreme rainfall around 150 mm/day.

Rice is most impacted by localized >40 °C heat around flowering and extreme coastal downpours (~150 mm/day) that cause sterility, lodging and wet-season harvesting constraints. Cassava and groundnuts are generally tolerant to heat but suffer from waterlogging, disease pressure and curing/quality issues during humid spells.

Albertine Highlands

Along Tanzania's north-western margin, the Albertine Highlands—including the Kagera Highlands on the borders with Rwanda and Burundi—form a distinct agricultural region. Elevations range from 1,200 to >2,500 m, with fertile volcanic soils, reliable 1,200–2,000 mm rainfall, and bimodal seasons that enable two cropping cycles per year. This is one of Tanzania's traditional centres for food and commercial production, combining a mosaic of smallholder farms on sloping terrain with historically important estates and expanding intensive small-scale cultivation. By production value, the leading crops are banana, beans, plantain, and cassava, with significant horticulture and coffee also produced.

The Albertine Arc supports a distinctive mix of smallholder and commercial livestock systems. Higher rainfall, fertile soils, and good market access favour diversified enterprises that integrate cattle, goats, and sheep alongside cropping. Traditional grazing persists in rural uplands, while peri-urban and market-oriented valleys increasingly adopt zero-grazing (stall-feeding) and improved-breed programs. The area remains a vital contributor to Tanzania's milk and beef supply chains, with active trade and genetic linkages to neighbouring countries. By herd/flock size (number of animals), the leading livestock species are chicken, cattle, and goats.

Climate impacts to agriculture production in the Albertine Highlands

Extreme heat is projected to remain limited to lower-lying areas, with highlands projected to stay below 38 °C and experience infrequent >35 °C days; storms on steep terrain are projected to elevate local erosion and waterlogging risks.

Impacts are moderate for tree and pulse crops—banana, plantain, beans—as storms and saturated soils reduce bunch size and increase disease on steep slopes. Livestock exposure is lower: cattle vary with pasture/water during rainy-season extremes, while chicken and goats are generally low-impact in the milder highland climate.

Maasai Steppe Pastoral Corridor

A broad diagonal rangeland belt, stretching from north of Singida through west Manyara and southeast Arusha into northern Kilimanjaro, marks the heart of Tanzania's Maasai Steppe. Here, extensive pastoralism dominates: multi-species grazing systems centre on large herds of indigenous cattle, sheep, and goats, moved seasonally across open savannas. The Maasai and Barabaig, among other groups, practice mobile livestock management, adapting to variable rainfall and pasture availability. Water points, seasonal migration routes, and communal grazing underpin both livelihoods and cultural identity. While some areas are seeing sedentarisation or cropping expansion, the corridor remains a major source of Tanzania's red meat and live animal trade, with growing dairy and fattening operations around town peripheries and roadways.

In order of importance by size (number of animals), the most important crop commodities are chicken, cattle, goats and sheep.

Climate impacts to agriculture production in the Maasai Steppe – Pastoral Corridor

Heat is projected to rise, with maxima around 38 °C, while >35 °C days are projected to remain infrequent and localized. Dry conditions are projected to persist (<800 mm/year), and extreme rainfall is projected to remain lower than elsewhere, generally 60–130 mm/day in the north.

No commodity is high-impact, but livestock chains face moderate exposure: cattle and chicken (Medium) are stressed by chronic dryness (<800 mm/yr), heat peaks (~38 °C) and occasional storm damage to basic housing; goats are the least impacted (Low) given their browsing habits and heat tolerance.

Northeastern Coastal Plains and Islands

Along Tanzania's northernmost coastline and across the islands of Unguja and Pemba, livestock densities peak around peri-urban and rural settlements. Here, husbandry mostly focuses on indigenous cattle, goats, and poultry maintained by smallholders, with dairy and commercial poultry growing near towns. Coastal vegetation, salt-tolerant grasses, and tree cover provide grazing and shade, while integration with crop, coconut, and cashew systems remains widespread. Livestock in these areas buffer households against crop failure and supply local markets with fresh milk, poultry, eggs, and beef. Despite modest average herd sizes, the combination of density near markets and adaptability to climatic stresses gives this zone unique resilience and economic importance, particularly on the islands where land is at a premium.

In order of importance by size (number of animals), the most important crop commodities are chicken, goats and cattle.

Climate impacts to agriculture production in the Northeastern Coastal Plains & Islands

Extreme heat is projected to be significant, with north-coast maxima >41 °C and >35 °C days projected to extend beyond 5 months (on islands, from virtually none to >1 month). This region's extreme precipitation is projected to be the most intense nationally, increasing by >20%, with maxima >260 mm/day on the coast and ~300 mm/day on Pemba. Coastal winds are projected to approach ~20 m/s, and river flooding in Tanga is projected to remain important (Pangani River).

The most affected are chicken and cattle because of very long hot seasons (>5 months >35 °C), extreme rain totals (coast >260 mm/day; Pemba ~300 mm/day), strong coastal winds (~20 m/s) and flood disruption (e.g., Pangani). Goats (Medium) cope better with heat but are still exposed to storm/waterlogging-related disease and short-term feed gaps, especially on islands.

Table 3: High-level climate impact analysis (see Annex 1: High-Level Climate Impact Analysis).

Region	Projected climate trends	Food value chains impacted	Impact
Lake Victoria Southern Plateau (livestock and cropland)	**Extreme heat** will become a significant risk with extremes nearing 40ºC and the number of days >35ºC increasing for 1 or 2 weeks to up to over 2 months. **Extreme precipitation** is a major hazard nationwide. This area will reach daily rainfall exceeding 100 mm. **River flooding is** limited to the northeastern and northwestern flanks of Tabora.	Rice - Heat near 40 °C at flowering depresses grain set; very intense rain (≥100 mm/day) causes flash floods, siltation of intakes, and lodging. Humid spells complicate drying and storage.	H
		Maize - Extended hot days (>35 °C for weeks–months) drive pollination failure and yield loss; storms cause lodging; wet spells raise aflatoxin risk post-harvest.	H
		Groundnuts - Heat/drought cut pod set; heavy rain delays drying and raises aflatoxin risk.	M
		Cattle - Heat stress lowers milk and fertility; variable water/pasture; higher disease/vector pressure.	H

		Chicken - Heat waves increase mortality without shade/ventilation; heavy rain damages backyard housing and spoils feed.	M
		Goats - Generally cope with heat/dry periods; main risks are water scarcity and disease after floods.	L
Southern Highlands Corridor	**Extreme heat** will increase, but higher elevation prevents this hazard from becoming extreme. Lower areas will still experience temperatures in the high 30's. **Dry conditions** are prevalent in the central part of the country (areas < 500 mm). Little change expected. **Drought** events (through SPEI12) will intensify here more than anywhere else in the country. **Extreme precipitation** is one of the highest in the country, with extremes expected to fall shy of 200 mm in a day. **Extreme wind** is one of the largest here (nearing 22 m/s in future extremes). **River flooding** will be an important hazard, particularly in southwestern Morogoro (Rufiji River Basin).	Maize - Strongest drought intensification nationally; extreme rain days (~200 mm) trigger erosion, waterlogging, and fungal disease; wind (to ~22 m/s) increases lodging risk.	H
		Beans - Sensitive to drought and heat (>30 °C) at flowering; downpours cause flower drop and disease pressure; drying/storage difficulties.	H
		Groundnut - Drought at flowering/pod fill reduces yields; wet extremes heighten aflatoxin and rotting.	H
Southeastern Coastal Plains	**Extreme heat,** will increase to over 40ºC in localized areas, with coastal areas showing milder values. The number of days >35ºC will overpass 100 days in some areas. **Extreme precipitation**, particularly near the coast, is expected to exceed 150 mm in a day.	Cassava - Tolerant to heat/dryness but vulnerable to waterlogging in coastal downpours; storm damage to roots and cuttings; pest/disease pressure may rise.	M
		Rice - Local heat >40 °C around flowering plus extreme coastal rainfall (≥150 mm/day) lead to sterility, lodging, and disease; difficult harvest/drying windows.	H
		Groundnuts - Heat stress plus humid/rainy spells complicate curing; elevated aflatoxin risk and quality downgrades.	M
Maasai Steppe Pastoral Corridor	**Extreme heat** will increase. Highest temperatures will oscillate around 38ºC in places, but the number of days >35ºC will remain infrequent and limited to surrounding areas of the corridor. **Dry conditions** are prevalent here, with some of the smaller yearly rainfall in the (areas < 800 mm). Little change expected. **Extreme precipitation**, although lower than other parts of the country, is large (> 60 mm) and will reach up to 130 mm in the northernmost part.	Chicken - Heat peaks (~38 °C) and chronic dryness limit water and feed; occasional heavy downpours (up to ~130 mm) can damage simple housing and spike disease after wet spells.	M
		Cattle - Semi-arid conditions (<800 mm/yr) constrain pasture and water; heat stress reduces milk and fertility in dry seasons, though extremes >35 °C are relatively infrequent.	M
		Goats - Well adapted to browsing in drylands and tolerate heat; main risks are prolonged water scarcity and post-storm disease pressure.	L
Northeastern Coastal Plains and Islands	**Extreme heat** is significant in the region and will increase even more, to maxima above 41ºC in the northernmost coast. The number of days >35ºC will increase to over 5 months	Chicken - Strong heat (up to >5 months >35 °C, ~1+ month on islands) drives mortality without ventilation; extreme rain (≥260–300 mm) and coastal winds (~20 m/s) damage coops and raise disease; flood risk in Tanga.	H

	there, with the islands going from virtually no days >35ºC to over a month, in places. **Extreme precipitation** in this region will be the most extreme of the country, with increases of over 20% in the future. Maxima will exceed 260 mm in the coast, and 300 mm in the island of Pemba (Zanzibar). **Extreme wind** will be important in coastal areas and islands (near 20 m/s), yet relatively not the most important hazard. **River flooding** will be an important hazard in Tanga, with a large part of the population exposed to flooding related to the Pangani River.	Cattle - Heat/humidity depress productivity and fertility; extreme rainfall and Pangani-related flooding disrupt grazing and water access; higher tick/biting-fly pressure, occasional salinity/contamination near coast.	H
		Goats - More heat-tolerant than cattle but exposed to storm/wind damage, waterlogging-related disease, and short-term feed shortages during floods and long hot spells—especially on islands.	L
Albertine Highlands (livestock and cropland)	**Extreme heat** will be more limited to lower-lying areas. Highlands will remain below 38ºC with infrequent days >35ºC.	Banana - Cooler highlands lower heat stress, but storms/waterlogging reduce bunch size and can topple plants.	M
		Beans - Generally suitable temperatures; intense rains increase disease and field losses on steep slopes.	M
		Plantain - Needs steady moisture; susceptible to windthrow and waterlogging in valleys.	M
		Chicken - Mild temperatures; basic housing sufficient; occasional storm losses.	L
		Cattle - Lower heat stress than lowlands, but pasture/water vary with rainy-season extremes; slope erosion affects grazing.	M
		Goats - Most resilient; browse-based diet and tolerance to variable conditions.	L

Based on projected climate hazards (more hot days, intense short-duration rainfall and flooding, and localized drought), the most affected food value chains are maize and rice (high sensitivity to heat at flowering, lodging and harvest losses in heavy rain/floods). Beans and groundnuts face medium–high impacts due to drought/heat at flowering and wet-season disease/aflatoxin risks, particularly in the Southern Highlands and Lake Victoria zones. Cassava is relatively resilient but vulnerable to waterlogging in coastal plains; banana/plantain show moderate sensitivity to storms and saturated soils in the Albertine Highlands. For livestock, cattle and poultry are most exposed in hotter, flood-prone coastal and lake regions, while goats remain the most resilient but can experience short-term feed and health pressures during cyclonic storms and floods.

Priority value chains for adaptation planning

Food value chains in Tanzania were prioritised by triangulating quantitative climate-risk evidence with policy relevance and expert judgement. A long list of major crops and livestock was screened against: (i) agriculture-sector development trends and market importance; (ii) alignment with national agriculture and climate-resilience policies; and (iii) climate-hazard and exposure mapping (heat, drought, extreme rainfall/flood, wind). Screening results were calibrated with inputs from national experts and CGIAR/GCA specialists to test feasibility and implementation potential, yielding a short list of priority chains for adaptation design.

In addition to their economic and climate relevance, these value chains are also highly gendered. Women dominate food crop production and post-harvest handling, especially for maize, cassava, beans, and groundnuts, and are heavily engaged in small livestock and poultry rearing. These subsectors are precisely those most climate-exposed, meaning women are disproportionately affected by climate shocks. By contrast, men tend to dominate commercial cattle production, mechanised activities, and access to higher-value markets (UN Women, 2023).

Projected hazards include more hot days, short-duration intense rainfall and flooding, and localised drought. The highest impacts fall on maize and rice—both sensitive to heat at flowering and to lodging and harvest losses under heavy rain/floods. Beans and groundnuts face medium–high impacts from drought/heat at flowering and wet-season disease/aflatoxin risk, most acute in the Southern Highlands and Lake Victoria Southern Plateau. Cassava is comparatively resilient but vulnerable to waterlogging in the Southeastern Coastal Plains. Banana/plantain show moderate sensitivity to storms and saturated soils in the Albertine Highlands. For livestock, cattle and poultry are most exposed in hotter, flood-prone coastal and lake regions, while goats remain the most resilient but can face short-term feed and health pressures during cyclonic storms and floods.

Tanzania's food system is anchored by four strategic staples—maize, rice, cassava, and cattle—that underpin food security and affordability. Maize is the chief staple but highly exposed to rainfall variability and pests, making post-harvest handling a priority. Rice is urban/peri-urban, price-sensitive, and increasingly dependent on irrigation and water management. Cassava supports affordability and drought resilience but needs stronger processing and disease control. Cattle are central for livelihoods and nutrition yet constrained by drought and rangeland degradation, pointing to pastoral value-chain support and veterinary services. By contrast, coffee, cotton, and cashew are primarily cash/export crops; they boost rural incomes but have limited direct influence on staple prices and face distinct climate/market risks (altitude/rainfall shifts for coffee; rainfall dependence and processing/inputs for cotton; pest pressure and quality/processing constraints for cashew).

Drawing on the screening, expert calibration and policy alignment described above, the priority food value chains for Tanzania, to guide follow-on adaptation investment design, are: Maize, Rice, Cassava, and Cattle.

Table 4: Key socio-economic considerations in prioritising food value chains.

Commodity	Food Security Contribution	Affordability	Resilience	Other considerations
Coffee	Non-staple; important cash/export crop for incomes (coffee accounts for 5% of total exports value, averaging USD100M/year) (FAO, WB)	Limited direct impact on staple food costs (NBS FBS)	Altitude & rainfall sensitive; climate risks to arabica/robusta zones (FAO)	Quality, processing & market access central to competitiveness (FAO)
Cotton	Cash crop; household income effects in western zones (FAO)	No direct role in staple food price levels (NBS FBS)	Rainfall variability & pests affect yields (FAO)	Revival hinges on input systems, ginning & contract farming (FAO)
Cashew Nuts	Cash/export crop in coastal regions; supports rural incomes (FAO)	Indirect effects via income; not in staple basket (NBS FBS)	Drought & pest pressure; need for climate-smart husbandry (FAO (price incentives))	Processing and value addition constraints (World Bank)

Maize	Main staple & largest source of cereal calories (approximately 60%) (NBS FBS)	Tanzania offers the most affordable Maize in East Africa (Food Security Monitor)	Rainfall variability & pests constrain yields (FAO)	11.7% post-harvest loss (M. Chegere), Post-harvest handling & storage improvements needed, (FAO)
Rice	Key staple in urban/peri-urban diets; complements maize (21% of caloric supply) (NBS FBS)	Urban food basket sensitive to rice prices (FAO GIEWS)	Irrigation & water management critical under climate change (FAO)	There is an opportunity to upgrade milling quality & seed systems to boost competitiveness (FAO)
Cassava	Major food crop (10% contribution to per capita energy); important in drought years (NBS FBS)	Local availability supports affordability in deficit seasons (FAO GIEWS)	Drought-tolerant; resilient staple for vulnerable households (FAO)	Processing (gari/flour/starch) & disease control are needed to secure production (CMD/CBSD) (FAO)
Cattle	Livelihoods & nutrition (milk/meat) for rural households (WFP CSP)	Feed/maize price linkages pass through to consumers (FAO GIEWS)	Drought & rangeland degradation risks; animal health gaps (LSTP)	Pastoral value chains & veterinary services prioritized at national level (LSTP)

Table 5: Summary of agriculture related priorities in the national policies and strategies.

Nationally Determined Contribution (updated 2021). Agriculture, livestock, and fisheries/coastal–marine are flagged as priority adaptation sectors. The document emphasizes climate-smart agriculture, access to early warning, reduced post-harvest losses, improved storage, and stronger extension. Livestock priorities include climate-smart infrastructure and services, sustainable rangeland and pasture management, water harvesting, and early warning, while fisheries priorities include climate-informed planning, livelihood diversification, monitoring and surveillance, ecosystem rehabilitation, and climate-smart aquaculture.
National Climate Change Response Strategy (2021–2026). Agriculture is prioritized through climate-smart land and water management and efficient water use; aquaculture is advanced via climate-smart technologies and resilient breeds. Livestock systems are to become climate-informed, focusing on infrastructure and services. The strategy centers mainstreaming CSA and climate information into planning, services, and implementation.
Agriculture Climate Resilience Plan (2014–2019). The plan concentrates on the crop sub-sector, highlighting climate risks to staples such as maize and rice and acknowledging roles for wheat and export crops (e.g., cotton, sugarcane, tobacco). Priority options include improved land and water management, accelerated CSA uptake, risk management (including early warning/insurance), and stronger knowledge systems. It also provides indicative cost envelopes for implementation to guide prioritization.
Agricultural Sector Development Strategy II (2015/16–2024/25). The sector is defined across crop, livestock, and fishery, with priorities spanning irrigation and water use, research and extension, inputs and mechanization, value addition, and market access. Export crops, particularly sugar, tea, and tobacco, are recognized for their economic weight, alongside efforts to enhance aquaculture. Adaptation measures are explicit, including drought-tolerant crops/varieties, water-use efficiency (rainwater harvesting, on-farm storage, drip), catchment and soil management, and dissemination of climate and weather information.
Climate-Smart Agriculture Guidelines. Coverage spans crop, livestock, and fishing/aquaculture sub-sectors, offering a practical menu of CSA practices. For crops, the guidance highlights rainwater harvesting, SRI, conservation agriculture, integrated soil fertility management, adapted varieties, and IPM; for livestock, it emphasizes improved/adapted breeds, fodder conservation, pasture management, manure management, and biogas; for aquaculture, it promotes ponds, mariculture, integrated/cage culture, and sustainable fishing. The guidelines are geared to mainstream CSA through district planning and extension, reinforcing national strategy directions.
National Post-Harvest Management Strategy (2019–2029). The strategy focuses on food crops (cereals, legumes, fruits and vegetables, roots and tubers, and edible oil crops) while excluding traditional cash crops and livestock products. Its aim is to reduce post-harvest losses along value chains through awareness and capacity, access to tested technologies, market and financing mechanisms, research and innovation, and standards and compliance. Climate considerations are explicit via an objective to adapt PHM systems to mitigate impacts such as moisture, pests and diseases, and bio-deterioration.

Climate Adaptation Solutions

Key findings:

Tanzania's food systems are increasingly shaped by overlapping climate pressures, heat extremes, droughts, floods, and post-harvest losses, that cut across cereals, roots, and livestock value chains. Maize and rice face sharp yield declines from heat stress and flooding, while cassava, though drought-tolerant, is vulnerable to waterlogging and disease in coastal zones. Livestock systems, particularly cattle and poultry, are constrained by drought-driven feed shortages and flood-driven disease outbreaks. These hazards disrupt production and markets, with gendered impacts as women carry disproportionate burdens in post-harvest handling, poultry rearing, and small-scale processing. The core adaptation needs therefore converge around climate-resilient cereals, flood- and drought-tolerant roots, sustainable livestock feed and health systems, and gender-responsive storage and post-harvest solutions.

In response, Tanzania's adaptation priorities cluster around themes where resilience imperatives align with investable opportunities. Five solutions stand out as both urgent and commercially ready: (1) biological pest control to tackle aflatoxin in maize and groundnuts; (2) climate-resilient fodder varieties to buffer livestock systems against drought; (3) cold chain infrastructure to reduce losses in dairy and perishables; (4) hermetic storage systems to protect cereals and legumes from spoilage and contamination; and (5) solar-powered irrigation to stabilize staple crop yields under drought. These interventions are already piloted in Tanzania, supported by credible institutions, and suited to aggregation or pay-as-you-go financing models. Together, they offer the strongest entry points to mobilize private investment while building climate resilience across Tanzania's agri-food system.

Adaptation Needs, Themes, and Prioritization of Solutions

Adaptation Needs in Kenya's Climate Value Chain

Tanzania's food system sits at the intersection of multiple climate pressures that are already reshaping production landscapes. Heat extremes are expanding in frequency and intensity, with the Lake Victoria Southern Plateau and coastal zones now facing weeks to months each year above 35 °C. These conditions depress pollination in maize and rice, increase mortality in poultry, and push dairy and beef systems into recurrent feed and water stress. Heavy rainfall and flooding compound these challenges—flash floods in Tabora, coastal downpours exceeding 150–200 mm per day, and the Rufiji Basin's flood-prone plains are disrupting harvests, eroding soils, and amplifying disease and aflatoxin risks. Drought, especially in the Southern Highlands and Maasai Steppe, further narrows the window for reliable production. Taken together, these overlapping hazards create a pattern of **adaptation needs** that cut across cereals, roots, and livestock systems: heat tolerance, water management, flood resilience, and stronger post-harvest risk management.

The value chain context sharpens these needs. **Maize,** Tanzania's primary staple, is both the backbone of diets and one of the most climate-exposed crops. Prolonged hot spells threaten yields at flowering, while heavy rains cause lodging and post-harvest contamination. **Rice**, increasingly important in urban and peri-urban diets, is highly sensitive to water extremes: irrigated areas face risks from siltation and flood damage, while heat near flowering undermines grain set. **Cassava** remains the most drought-resilient staple, but its vulnerability to waterlogging and disease in flood-prone coastal zones makes post-harvest and processing interventions critical. **Cattle** underpin both rural nutrition and household incomes, yet they suffer declining fertility and milk productivity during prolonged droughts, with episodic flood-driven outbreaks of disease further destabilizing pastoral systems. Each of these value chains illustrates how climate shocks are no longer isolated events but systemic disruptors of production, aggregation, and market stability.

These pressures also carry a strong **gender dimension**. Women provide the majority of labor in maize, cassava, beans, and post-harvest handling, positioning them at the frontline of aflatoxin risks, storage losses, and labor burdens during flood or drought recovery. They are also deeply engaged in poultry rearing, where housing and feed systems are especially vulnerable to heat and rainfall extremes. By contrast, men dominate large-scale cattle herding and access to higher-value markets, but the resilience of pastoral systems still determines household food security across many regions. This asymmetry in exposure and decision-making capacity reinforces why adaptation planning must address not just climate hazards but also the **social distribution of risk**.

In short, **Tanzania's adaptation needs** converge around four imperatives: climate-resilient cereals (**maize and rice**), reliable drought- and flood-tolerant roots (**cassava**), sustainable and productive livestock systems (**cattle and poultry**), and gender-responsive post-harvest and storage solutions. These are the foundations on which to frame the country's priority adaptation themes and, ultimately, the investable interventions that can unlock private capital for resilience.

Adaptation Themes

Tanzania's adaptation priorities become clearer when the hazard–value chain risks are organized into thematic areas where interventions can both address urgent climate pressures and create investable opportunities. From the long list of possible options, a smaller set of themes emerges as particularly relevant when tested against the dual filter of **adaptation need** (heat, drought, floods, post-harvest risk) and **commercial readiness** (availability of tested products, delivery channels, and financing pathways).

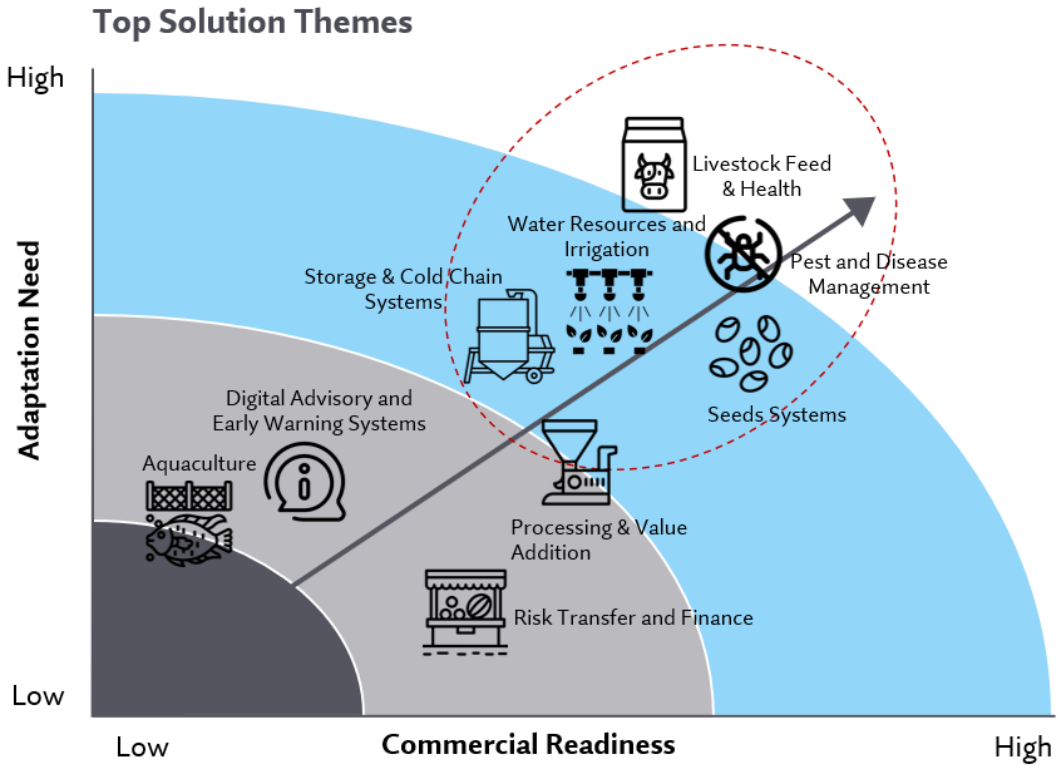

Figure 13. Priority adaptation themes in Tanzania.

Pest and Disease Management

High heat and humidity are fuelling aflatoxin contamination in maize and groundnuts, undermining both food security and market access. Biological pest control solutions—such as Aflasafe biocontrol—offer a scalable and financeable pathway to reduce losses and meet export standards. Women, who are disproportionately responsible for grain drying and storage, bear the brunt of health risks and food

security shocks from aflatoxin; accessible biocontrol solutions can directly reduce their burden while improving household nutrition.

Livestock Feed and Health

Cattle and poultry face mounting pressure from drought-driven feed shortages and disease outbreaks after floods. Climate-resilient fodder varieties (e.g., drought-tolerant Napier grass, Brachiaria) help bridge feed gaps and sustain milk yields, while integrated veterinary services reduce mortality. These interventions are commercially advanced, supported by ILRI and private seed suppliers, and directly relevant for both pastoral systems in the Maasai Steppe and dairy markets in the Southern Highlands. Gender dimensions are significant: women contribute heavily to dairy processing and small livestock care, so access to improved fodder and health services can translate into greater income stability.

Storage and Cold Chain Systems

Post-harvest losses remain stubbornly high, over 10% for maize and even higher in beans and groundnuts, due to poor drying, storage, and handling. Hermetic bags, metallic silos, and decentralized cold chain facilities are proven technologies already piloted in Tanzania with donor and private sector support. Their uptake is especially important for women, who are heavily engaged in post-harvest activities yet face higher barriers to credit. Cold chain systems also provide downstream benefits for dairy and horticulture, enabling smallholders to tap into more stable, higher-value markets.

Water Resources and Irrigation

With drought intensifying in the Southern Highlands and maize/rice zones, smallholder access to reliable irrigation is central to adaptation. Solar-powered pumps, micro-irrigation kits, and water harvesting structures are increasingly available through pay-as-you-go distributors and MFIs. These technologies not only stabilize production but also offer a clearer business case for lenders, as repayment can be tied to improved yields and year-round market supply. Women smallholders, who typically face greater constraints to accessing irrigation, require tailored financing and cooperative-based distribution models to benefit equally.

Processing and Value Addition

Solar drying and small-scale processing create resilience by reducing dependence on narrow harvest windows and extending shelf life of staples like maize and cassava. These solutions are particularly relevant in the Lake Victoria and coastal regions where humid spells complicate drying and storage. Beyond food security, they open up pathways for youth and women's groups to engage in value addition and entrepreneurship.

Other themes were considered but not elevated for immediate prioritization. Seed systems remain critical for long-term resilience but are still largely donor-driven and weakly commercialized. Risk transfer mechanisms such as weather index insurance are promising but face low trust and adoption barriers. Protected cultivation and aquaculture interventions are relevant in niche zones (peri-urban horticulture, coastal fisheries) but do not align as strongly with the four priority staples.

Together, these themes highlight where Tanzania's adaptation needs converge with investable opportunities, pointing toward solutions that not only mitigate climate shocks but can also be scaled commercially, financed through banks and MFIs, and delivered in gender-inclusive ways.

Climate Smart Agriculture Practice vs Products and Service Based Adaptation Solutions

Tanzania has made significant progress in promoting climate-smart agriculture (CSA) practices, which remain central to long-term resilience. Conservation agriculture, integrated soil fertility management, rotational grazing, and water harvesting are widely referenced in national frameworks such as the *Tanzania Climate Smart Agriculture Programme (2015–2025)* and the *National Climate Change Strategy (2021)*. These practices strengthen soils, improve water retention, and diversify production systems

benefits that are especially valuable in drought-prone zones like the Southern Highlands and pastoral corridors. For women, who are overrepresented in maize, cassava, and post-harvest handling, CSA techniques such as mulching or tarpaulin-based drying reduce labour and crop loss burdens, directly improving household food security.

Yet, while these practices are **vital agronomically**, they are not easily structured into investable products that commercial banks or MFIs can finance. For instance, lenders can extend loans for solar irrigation kits or cold chain equipment, but they cannot underwrite "adoption of mulching" or "rotational grazing," even though these improve adaptive capacity. The benefits of CSA are diffuse, incremental, and context-specific, making it difficult to establish predictable cash flows or repayment models, both of which are essential for mobilizing private finance at scale.

By contrast, **product- and service-based solutions** offer a clearer pathway to bridge adaptation needs with commercial readiness. Solar-powered irrigation systems, hermetic storage bags, biological pest control for aflatoxin, or resilient fodder varieties are tangible technologies with defined costs, measurable impacts on yields or post-harvest losses, and repayment profiles that align with borrower and lender requirements. Many are already in Tanzania's markets through pay-as-you-go models, private distributors, or NGO-facilitated pilots. They can also be aggregated (e.g., group loans for irrigation kits), bundled (e.g., climate advisory with insurance), and scaled across regions in ways that CSA practices typically cannot.

For this reason, while this report collates a set of priority CSA practices for GCA's future consideration, its emphasis is on **bankable products and services**. These solutions maintain the resilience-building intent of CSA but package it in ways that attract investment capital, expand delivery through SMEs and cooperatives, and offer gender-responsive entry points for women farmers and pastoralists who often face the steepest barriers to adaptation.

Prioritization of Adaptation Solutions

The prioritization of adaptation solutions for Tanzania combined evidence on climate hazards, value chain vulnerabilities, and solution feasibility with a structured multi-criteria analysis (MCA). Each solution from the long list was evaluated against indicators such as **technical maturity and local delivery readiness, borrower-system fit, productivity and livelihood uplift, gender inclusion, and policy alignment and institutional traction.** Weightings reflected GCA's focus on scalability and impact, with gender responsiveness and productivity uplift carrying the highest emphasis.

This process confirmed that while many interventions show strong agronomic value, only a subset currently demonstrates both **adaptation need and commercial readiness**. In Tanzania's case, the adaptation need is sharpest around:

- **Maize and rice** exposed to recurrent droughts, heat stress, and post-harvest aflatoxin contamination.
- **Cassava**, drought tolerant but highly vulnerable to waterlogging and disease in coastal plains.
- **Cattle systems**, where prolonged droughts, rangeland degradation, and livestock disease constrain milk and meat output, threatening pastoral livelihoods.

When these needs were mapped against the MCA scoring, **five priority solutions emerged** as the most investable entry points for adaptation finance:

1. **Biological pest control (Aflatoxin biocontrol)** – addressing widespread aflatoxin risks in maize through commercial products like *Aflasafe™,* which are already piloted and distributed in East Africa.
2. **Climate-resilient fodder varieties** – improving feed security for cattle under drought stress and degraded grazing lands, with ILRI and seed companies supporting seed commercialization.

3. Cold chain infrastructure – critical for dairy and perishable staples, reducing losses in high-rainfall regions and enabling income diversification through value-added products.
4. Hermetic storage systems – tackling post-harvest losses and aflatoxin contamination in maize, rice, and groundnuts, with strong gender uptake given women's central role in post-harvest handling.
5. Solar-powered irrigation systems – enabling smallholders to buffer against droughts, stabilize rice and maize yields, and expand dry-season cultivation, already supported by pay-as-you-go providers and MFIs.

Other themes, such as seed systems, risk transfer mechanisms, or aquaculture, scored positively but ranked lower due to weaker borrower fit or delivery readiness in Tanzania's current context. For instance, drought-tolerant seeds remain heavily donor-driven with limited private sector scale-up, while weather index insurance continues to face uptake challenges linked to trust and basis risk.

Overall, the prioritization reflects a balance between urgency of adaptation need and the feasibility of commercial delivery. The five selected solutions are already present in Tanzania's markets, backed by credible institutions, and offer clear repayment or aggregation models. This positions them as the strongest candidates for deeper market analysis and investment design in subsequent phases of the project.

Deep Dive on Priority Solutions

1. Aflatoxin Biocontrol (for Maize)

Adaptation Challenge

Aflatoxin contamination is one of the most acute food safety and trade risks in Tanzania. Hot and humid spells during maize flowering and post-harvest storage create ideal conditions for Aspergillus fungi, which produce carcinogenic aflatoxins. Heavy rainfall that delays drying, combined with the use of traditional storage, increases exposure. Outbreaks have been reported in Dodoma, Manyara, and Morogoro, with contamination levels often exceeding international safety thresholds (IITA; FAO). Aflatoxin not only causes chronic health problems, especially stunting and liver cancer, but also leads to rejection in both domestic and export markets. For households relying on maize for more than 60% of caloric intake (NBS Food Balance Sheet), this represents both a public health and livelihood crisis.

Relevance to Value Chains

Maize, Tanzania's dominant staple, is the most vulnerable value chain. Contamination compromises both household consumption and market supply. Rice and groundnuts also face aflatoxin risk, but maize is by far the most significant due to its volume, role in food security, and sensitivity to humid storage conditions. Aflatoxin outbreaks undermine warehouse receipt systems and cooperative marketing, eroding trust and depressing prices. Reducing contamination strengthens food safety, stabilizes farmer incomes, and opens access to institutional buyers such as WFP and school feeding programs that currently screen out unsafe grain.

Technical Maturity & Local Delivery Readiness

Biocontrol products like Aflasafe™ TZ, developed by IITA in partnership with Tanzania's Ministry of Agriculture, are already tested and registered. The technology relies on spreading naturally occurring, non-toxic strains of Aspergillus that outcompete toxin-producing ones. Field trials across Tanzanian maize zones have demonstrated 80–90% reductions in aflatoxin levels (IITA, 2020). Distribution remains uneven, concentrated in donor-supported pilots, but the supply chain is strengthening: IITA has worked with local private firms for manufacturing and farmer groups for dissemination. Extension requirements are relatively light (product applied once per season), which supports scale-up.

Productivity Increase

While biocontrol does not increase yield directly, its benefits are captured in **marketability and reduced losses**. Farmers adopting Aflasafe™ see **maize** lots accepted by higher-value buyers, avoiding 20–40% price penalties for contaminated grain (IFPRI; PACA). Safe maize also reduces the need for repeated sorting and discarding of moulded grain, lowering labour costs. At the macro level, reducing aflatoxin improves trust in maize marketing channels and raises competitiveness in regional trade with Kenya and Rwanda.

Gender Inclusion

Women are heavily involved in **maize drying, sorting, and storage**. They are also the primary household food preparers, and thus bear the brunt of health and labour costs associated with aflatoxin. Introducing biocontrol reduces women's invisible labour in managing contaminated grain and improves household food safety. When delivered through women's savings groups or cooperatives, uptake is higher because women see immediate benefits in both food security and reduced health risks. Embedding female extension agents in dissemination efforts has been shown by IFAD and FAO to significantly improve adoption

Relevance to Borrowers

For smallholders, the product is easy to apply and affordable relative to the income losses it prevents. Cooperatives can bulk-purchase and distribute, lowering costs further. Traders and millers also benefit from higher-quality maize. For financial institutions, the solution fits naturally into input credit packages, since the benefits are measurable and tied to improved market access.

Policy Alignment & Institutional Traction

Aflatoxin control is a stated priority in Tanzania's food safety strategy. The product has backing from IITA, PACA (African Union), and donors like USAID and the Gates Foundation. WFP has shown demand for aflatoxin-free maize in procurement programs, and national food safety regulators have approved the technology. This creates strong institutional traction for scaling.

Why This Solution Stands Out

Aflatoxin biocontrol responds to a high-stakes problem at the intersection of climate risk, public health, and trade. It is proven, locally validated, and aligned with policy priorities. It reduces women's invisible labour, safeguards food for millions, and strengthens access to premium markets. With its simple application and clear cost-benefit profile, it is both impactful and bankable, ready for bundling with cooperative finance and donor de-risking instruments.

2. Climate Resistant Fodder Varieties

Adaptation Challenge

Tanzania's livestock systems face a tightening feed and water constraint. Hotter, longer dry seasons and episodic floods degrade pasture, lengthen trekking distances to water, and trigger disease spikes, depressing milk yields, growth rates and fertility, especially across the Maasai Steppe and drier fringes of the Southern Highlands. Feed typically accounts for the majority of on-farm livestock costs, and scarcity during the dry season forces distress sales or herd losses. Climate-resilient forages (drought/heat-tolerant grasses and legumes) directly address the binding constraint by maintaining biomass and nutritive value under stress, smoothing seasonal troughs in production.

Relevance to Value Chains

Fodder resilience directly underpins Tanzania's priority value chain in cattle, but also supports goats and poultry systems where supplementary feed is critical. Since cattle are a cornerstone of livelihoods, nutrition, and food security in Tanzania, strengthening feed systems links directly to the performance of the dairy and meat subsectors. Better fodder availability reduces dependence on shrinking grazing lands, supports commercialization of dairy, and lowers the cost of production for smallholders and agri-SMEs.

Technical Maturity & Local Delivery Readiness

Climate-resilient fodder varieties (e.g., **drought-tolerant Napier grass, Brachiaria**, and dual-purpose legumes) are already being researched, piloted, and distributed in Tanzania through ILRI, CIAT, and the Tanzania Livestock Research Institute. Some commercial seed companies and cooperatives are beginning to distribute Brachiaria hybrids, supported by extension services and demonstration plots. Delivery channels exist (seed firms, agro-dealers, NGO/dairy hubs, processor-linked outgrower schemes in Tanga, Iringa, Njombe), but bottlenecks remain: limited certified seed, uneven last-mile advice on establishment/harvest, and weak business models for local multipliers. These are surmountable with aggregator-led offtake and targeted working-capital finance.

Productivity Increase

Trials and on-farm demonstrations in the region (ILRI, TALIRI/TARI) consistently show **15–40% increases in milk yield** when improved fodders replace low-quality roughage, alongside better body condition and shorter calving intervals. Drought-tolerant grasses maintain **higher dry-matter yields** through dry spells, supporting **continuous milking** and reducing mortality. In mixed crop–livestock systems of the Southern Highlands, integrating Brachiaria/Napier on field margins and set-aside plots raises annual forage output, enables **silage/hay reserves**, and stabilizes dairy cashflow. For goats in peri-urban and coastal belts, fast-regrowing fodders cut purchase of commercial feeds and reduce time spent foraging.

Gender Inclusion

Women manage much of the day-to-day dairy enterprise, feeding, milking, and small ruminant care, yet face barriers to land, cash, and extension. Climate-resilient fodder can be **planted close to homesteads**, cutting the time women spend collecting feed and water; higher, steadier milk output increases the income streams women typically control. Women's savings groups and dairy cooperatives are effective entry points for distributing fodder seed/cuttings, offering **gender-intentional training** (establishment, harvesting, simple feed budgeting) and bundled micro-loans for small equipment (chaff cutters, silage bags). Programs led by ILRI, Heifer International, SNV and processor-linked hubs in Tanga have demonstrated that **women-centred delivery** accelerates uptake and retention.

Relevance to Borrowers

- **Smallholders (dairy and dual-purpose cattle):** Low ticket sizes for seed/cuttings; clear cash-flow uplift from extra litres/day and extended lactations; simple practices (cut-and-carry, basic silage).
- **Pastoralists (ASALs):** Reseeding of degraded enclosures with Rhodes/buffel; **community fodder banks** near water points; contractual hay purchase for drought buffers.
- **Cooperatives/producer groups:** Bulk procurement of seed/cuttings; group training; shared equipment (chaff cutters/balers); collective marketing of milk/hay.
- **Agri-SMEs:** Seed multiplication enterprises, silage/hay contractors, and last-mile advisory firms—each with investable working-capital/asset-finance needs.
- **For lenders**, repayment links naturally to **milk collection data** (processor statements), cooperative pass-throughs, or forward contracts for hay/silage.

Policy Alignment & Institutional Traction

The **Tanzania Livestock Master Plan** prioritizes feed and animal health as pillars for productivity gains; **ASDP II** and the national **CSA frameworks** emphasize improved forages, rangeland management, and feed conservation. TALIRI/TARI and ILRI provide R&D and technical backstopping; development partners (IFAD, World Bank, SNV, Heifer International) have financed dairy hubs, fodder demos, and advisory. Dairy processors (e.g., Tanga Fresh and Southern Highlands processors) increasingly support **embedded fodder extension** to secure consistent volumes and quality, signalling private-sector pull.

Why This Solution Stands Out

- **Direct hit on a systemic constraint:** Feed scarcity is the primary driver of low and volatile livestock productivity under heat and drought; resilient fodders are the most cost-effective lever to stabilize output.
- **Commercial readiness with clear cash flows:** Tangible inputs (seed/cuttings) and services (silage/hay making) have **repayment anchored in milk receipts**, enabling cooperative/vendor finance and results-based models.
- **Scalable, inclusive delivery:** Works for smallholders and pastoralists; lends itself to **women-centred distribution** via dairy groups and VSLAs; supports youth micro-enterprises in seed multiplication and fodder services.
- **Stackable with complementary investments:** Pairs naturally with **solar irrigation** for small plots, **water points**, and **vet services**, compounding resilience gains.
- **Policy-backed and institutionally supported:** Alignment with national livestock and CSA strategies reduces execution risk and opens doors to blended finance.

Therefore, climate-resilient fodder varieties squarely align **adaptation need** with **commercial readiness** in Tanzania's livestock economy, delivering measurable productivity gains, strong borrower fit, and a practical path for banks and MFIs to finance resilience at scale.

3. Hermetic Storage Systems

Adaptation Challenge

Tanzania's humid harvest periods and increasingly intense rainfall events exacerbate one of the country's most persistent food-system risks: post-harvest losses. Maize, groundnuts, and rice are especially vulnerable, with average maize losses estimated at 10–15% (FAO; World Bank; Chegere, University of Dar es Salaam), often rising higher in wet years. Beyond the quantitative loss, aflatoxin contamination in maize and groundnuts poses severe health and market risks, leading to rejections in formal markets and jeopardising household food security. Because the majority of smallholders store grain at home using traditional sacks or granaries, these losses directly reduce household food availability, undermine nutrition, and cut into incomes, while repeated aflatoxin events, flagged by institutions such as IITA, PACA, and the Tanzania Bureau of Standards, pose both public health risks and barriers to accessing formal markets.

Relevance to Value Chains

Hermetic storage directly responds to the needs of Tanzania's priority value chains. For **maize**, airtight systems block insect infestation and cut off the oxygen needed for fungal growth, reducing both spoilage and aflatoxin formation – safeguarding household reserves and saleable grain. In **rice**, sealed storage helps stabilise quality, especially aroma and milling yield, which is critical for buyers in urban markets and helps millers/aggregators meet buyer specs (WFP Purchase for Progress; FAO). For **groundnuts**, hermetic solutions offer one of the few cost-effective ways to protect quality and reduce aflatoxin risk after curing, enabling smallholders to access premium buyers and processors. By cutting losses and protecting quality in **three core staples**, hermetic storage strengthens food security and price stability while unlocking safer, higher-value markets.

Technical Maturity & Local Delivery Readiness

Hermetic storage is no longer an experimental technology in Tanzania, it is **widely available and locally manufactured**. Multilayer hermetic bags (such as PICS, GrainPro, and AgroZ) are sold through **agro-dealer networks, NGOs, and development programmes**. AgroZ bags, for instance, are produced by A to Z Textile Mills in Arusha, signalling domestic manufacturing capacity. At **the cooperative and SME level**, hermetic cocoons and metallic silos are in use, supported by partners such as WFP and CIMMYT. Training on proper use, drying grain to below 13-13.5% moisture before sealing, is already embedded in extension materials, and NGOs such as WFP, IFAD, and AGRA have built distribution networks across many districts. The **main barriers** remain affordability at harvest time, last-mile distribution to remote areas, and the

presence of counterfeit bags, but these challenges are increasingly addressed through bulk procurement models, vendor-finance schemes, and quality assurance measures by TBS and development partners.

Productivity Increase

Evidence from field trials shows **hermetic storage reduces post-harvest losses** from typical ranges of 10–20% to under 5% when used correctly (CIMMYT; FAO). By eliminating the need for repeated re-drying or fumigation, hermetic systems **lower household labour and pesticide costs**. They also allow farmers to safely delay sales until lean periods, when **price premiums** can reach 10–20% depending on the market cycle (IFC; CIMMYT). Beyond reducing losses, these systems preserve quality, vital for **rice and groundnuts,** helping farmers and traders capture higher market value.

Gender Inclusion

Women play a central role in drying, sorting, and storing household harvests. Hermetic storage reduces their labour burden by cutting out repeated handling and drying, and limits their exposure to toxic chemicals used in fumigation. Because women are also typically responsible for safeguarding household grain reserves, hermetic bags directly strengthen food security under their control. Evidence from IFAD and SNV indicates that adoption is higher when these products are distributed through women's cooperatives, savings groups, or facilitated by female extension agents. In this way, hermetic storage aligns with Tanzania's Climate Change Gender Action Plan and offers an accessible entry point for women to benefit from adaptation finance.

Relevance to Borrowers

For smallholder farmers, hermetic bags represent a relatively low-cost, financeable purchase that delivers quick and visible benefits. Cooperatives and AMCOS can pool procurement to reduce costs and extend storage to members, while larger silos and cocoons provide opportunities to link with warehouse receipt systems and access credit. For traders and millers, hermetic storage reduces shrinkage and quality downgrades, improving throughput and compliance with contract specifications. From a lender's perspective, these are tangible, repeatable assets with clear cash-flow impacts, making them well-suited for microfinance or vendor-financing models.

Policy Alignment & Institutional Traction

Reducing post-harvest losses is embedded in Tanzania's Agricultural Sector Development Programme (ASDP II), and aflatoxin control is prioritized through national action plans and standards developed by TBS and the Tanzania Food and Drugs Authority. Global and regional institutions including FAO, IITA, PACA, and WFP have invested in training, distribution pilots, and quality monitoring systems. Local manufacturing capacity through A to Z Textile Mills further anchors delivery, while donor-funded programs have demonstrated farmer willingness to adopt and pay. These alignments significantly de-risk large-scale uptake.

Why This Solution Stands Out

Hermetic storage directly tackles a climate-amplified bottleneck with measurable, high-impact results. It cuts losses, protects food safety, and boosts farmer incomes across multiple strategic value chains. It is gender-responsive by design, with strong adoption pathways for women. It is commercially proven, locally manufactured, and embedded in national policy priorities. Importantly, it can be financed at multiple scales—from individual households to cooperatives and SMEs, making it an ideal candidate for GCA support and a practical entry point for private capital mobilization.

4. Solar-Powered Irrigation Systems

Adaptation Challenge

Tanzania's agriculture is overwhelmingly rain-fed, with irrigation covering less than 5% of cultivated land (FAO). This dependence makes smallholders highly vulnerable to rainfall variability, which is intensifying under climate change. In the Southern Highlands Corridor, recurrent droughts threaten maize and bean production, with farmers facing frequent mid-season dry spells that cause pollination failure and yield loss. In the Lake Victoria and Coastal Plains, extreme rainfall alternates with dry periods, leaving crops either water-stressed or waterlogged, undermining production stability. Cattle and rice systems are also increasingly at risk: pastoralists face seasonal pasture shortages as dry spells lengthen, while rice farmers in peri-urban areas suffer when floods damage poorly managed canal systems and drought years constrain water flows.

Traditional irrigation systems, often diesel-powered pumps or gravity-fed canals, are costly, unreliable, and contribute to environmental degradation. Farmers are constrained by high fuel costs, weak infrastructure, and unreliable water delivery. The result is a persistent yield gap and seasonal income volatility. Solar-powered irrigation directly addresses these challenges by providing a clean, reliable, and cost-effective way to manage water availability, buffering farmers against both drought stress and rainfall unpredictability.

Relevance to Value Chains

The solution has strong cross-value chain relevance in Tanzania:

- Maize: Solar irrigation can stabilize yields in the drought-prone Southern Highlands and Lake Victoria Basin, where mid-season water shortages cut harvests by up to 30% in bad years (World Bank).
- Rice: Reliable, controlled irrigation supports rice farmers in peri-urban and coastal zones, reducing exposure to both flooding (through better drainage management) and dry-season water stress.
- Cassava: While cassava is drought-tolerant, supplemental irrigation enhances productivity in coastal zones where flooding is often followed by prolonged dry spells, helping maintain root quality and reduce disease pressure.
- Cattle: Solar pumps enable livestock water points in pastoral areas (Maasai Steppe, Lake Victoria), reducing the need for long treks in dry seasons and lowering livestock mortality during droughts.

By spanning food staples and livestock systems, solar-powered irrigation becomes a systemic adaptation enabler rather than a crop-specific fix. Its multi-sector relevance strengthens its commercial case, as aggregation models (e.g., cooperative-owned pumps) can spread costs and reach diverse borrower groups.

Technical Maturity & Local Delivery Readiness

Solar irrigation in Tanzania has moved well beyond the pilot stage and is now at an early commercialization phase. Companies such as SunCulture, Futurepump, and Simusolar are already active in the country, supported by donor-backed programs like SNV's SEFFA initiative and the World Bank's Tanzania Energy Development and Access Expansion Project (TEDAP). These actors have introduced pay-as-you-go and lease-to-own financing models that help smallholders overcome high upfront costs. Distribution networks are beginning to expand beyond Dar es Salaam into Morogoro, Arusha, Mwanza, and the Southern Highlands, with trained agents providing installation and maintenance services. While adoption is still concentrated in higher-value horticulture, the delivery ecosystem for pumps and smallholder-friendly finance is in place and growing. Barriers remain in affordability for the poorest farmers and water governance in fragile watersheds, but overall the technology is proven, replicable, and supported by a functioning delivery chain.

Productivity Increase

The productivity case for solar irrigation in Tanzania is strong and well-documented. In the **Southern Highlands**, **maize** yields can double when reliable irrigation reduces drought losses during critical flowering stages. For **rice systems around Lake Victoria and Morogoro**, controlled irrigation reduces both sterility from heat at flowering and lodging during floods, while also improving milling recovery rates. Cassava, while relatively drought tolerant, benefits from stabilized root development and reduced losses from rot in dry spells. For **livestock systems**, solar-powered water points help sustain cattle weight and milk output in semi-arid regions, reducing fertility losses and dry-season mortality. Income impacts are significant: USAID's **Power Africa** pilots and FAO case studies report **20–80% income gains** depending on crop type and production system. Farmers with irrigation access can also diversify into higher-value horticulture (tomatoes, onions, leafy greens), generating steady cash flows that provide repayment capacity for loans. By reducing vulnerability to rainfall variability and enabling year-round production, solar irrigation creates a **direct pathway to both climate resilience and commercial viability**.

Gender Inclusion

Solar-powered irrigation has **strong gender relevance** in Tanzania because women are disproportionately affected by water stress in agriculture. Women smallholders are heavily engaged in maize, cassava, beans, and horticulture, where they often spend hours fetching water or rely on unreliable rainfall. Access to solar pumps reduces this labor burden, improves timeliness of planting and watering, and supports women's role in post-harvest crop quality (less spoilage from erratic rains). Evidence from **SNV and the World Bank's SE4ALL programs** shows that women-led groups demonstrate higher repayment discipline in PAYG schemes, and that women prefer technologies that reduce time poverty while increasing food security. However, barriers persist: women face limited access to credit, land ownership, and extension services, making gender-intentional delivery models essential. Partnering with **savings groups, cooperatives, and female extension agents** is critical to ensure equitable access.

Relevance to Borrowers

The borrower fit for solar-powered irrigation is **multi-segment**. For **smallholder farmers**, PAYG (Pay-As-You-Go) and microfinance-linked pump schemes provide entry points, especially in maize–bean–groundnut intercropping systems and in peri-urban horticulture. **Medium-scale commercial farmers**, particularly in **rice systems** in Morogoro and along Lake Victoria, have higher capacity to adopt and scale irrigation, making them attractive to banks. **Pastoralists and cattle farmers** in semi-arid regions benefit indirectly, as solar water points sustain herds and reduce losses during prolonged dry seasons. The technology also suits **farmer cooperatives and women's groups**, where shared ownership models lower costs and spread risks. Lenders can underwrite these borrowers because the pumps are tangible assets with repayment flows tied to measurable productivity gains. This direct fit across borrower segments strengthens the case for scaling solar irrigation as a financeable adaptation solution.

Policy Alignment & Institutional Traction

Tanzania's national policy environment provides strong support for irrigation expansion, particularly using renewable energy solutions. The **National Irrigation Commission (NIC)** has prioritized irrigation development in the Southern Highlands, Lake Zone, and Rufiji Basin, targeting smallholder farmers as well as medium-scale producers. The **Agricultural Sector Development Programme II (ASDP II)** explicitly highlights irrigation modernization and water-use efficiency as core adaptation strategies. Development partners such as the **World Bank (Tanzania Sustainable Rural Water Supply Program)**, **IFAD**, and the **African Development Bank (Bagamoyo Solar Irrigation Pilot)** have piloted solar irrigation schemes, demonstrating operational viability and policy traction. Moreover, Tanzania's **National Energy Policy** promotes off-grid solar adoption, creating enabling conditions for bundling irrigation with rural electrification and energy access programs. Together, this institutional momentum indicates strong policy alignment and an ecosystem supportive of scale-up.

Why This Solution Stands Out

Solar-powered irrigation emerges as one of the most strategic adaptation solutions for Tanzania because it sits at the intersection of high adaptation need (climate-stressed maize, rice, and cattle systems) and commercial readiness (asset-backed, PAYG-compatible, and supported by national policy). Unlike CSA practices that diffuse benefits, solar irrigation creates clear repayment streams tied to yield and income gains, making it more attractive to lenders and MFIs. It directly addresses drought and heat risks, while simultaneously reducing women's labor burden and expanding access to year-round production. With strong institutional traction, proven private-sector participation, and increasing affordability of solar technologies, this solution is poised to transition from scattered pilots to scalable, bankable investments. For GCA, it represents a high-impact, high-leverage opportunity to mobilize private finance into climate adaptation.

5. Cold Chain Infrastructure (Milk Chilling and Preservation)

Adaptation Challenge

Tanzania's dairy sector, built on one of Africa's largest cattle herds, suffers heavy post-harvest losses due to lack of reliable cold storage. Milk spoils within 3–5 hours at ambient temperatures above 30 °C, which are increasingly common in the Lake Victoria Plateau, Southern Highlands, and coastal zones. Seasonal floods further delay transport, while humid spells accelerate bacterial growth and souring. In the absence of chilling facilities, processors routinely reject deliveries, and smallholders lose both income and trust in formal markets.

The scale of this challenge is significant. Tanzania produces close to 3.8 billion liters of milk annually (FAO, *Tanzania Dairy Sector Analysis* (2020); Tanzania Dairy Board), yet only 12–15% enters the formal market (International Livestock Research Institute, 2019); of that, an estimated 25–40% is lost (World Bank (2019), (CGIAR, 2014) before reaching processors because of inadequate chilling and transport delays. This translates into hundreds of millions of liters wasted every year, one of the largest post-harvest losses of any food system in the country. The impact falls directly on more than 2 million smallholder households (Tanzania Dairy Board & ILRI (2019)), most of whom keep only 2–5 cows. For these farmers, especially women who are heavily engaged in milking and bulking, spoilage means immediate income loss, wasted labor, and heightened vulnerability during hot spells and rainy seasons. Climate volatility is amplifying these risks, with hotter days and heavier rains turning what was once a seasonal inconvenience into a systemic drain on livelihoods and food security.

Relevance to Value Chains

Cold chain infrastructure is most critical for dairy, though benefits spill into related agri-food systems:

- Milk: Village-level chilling at MCCs reduces spoilage during hot or rainy periods, enabling farmers to sell consistently into processors like Tanga Fresh and ASAS Dairies.
- Cattle Systems: By preserving more of the milk produced, cold storage stabilizes incomes and incentivizes better herd management, indirectly supporting meat and hide systems.
- Women-led Dairy Enterprises: Chilling allows women's groups and cooperatives to pool milk and negotiate better prices, lifting their participation in formal value chains.

The dairy sector's scale, millions of smallholder households keeping 2–5 cows each, makes this an adaptation lever with system-wide reach.

Technical Maturity & Local Delivery Readiness

Milk chillers are not new technology, but their delivery model is changing. Tanzania already has a network of MCCs (Milk Chilling Centres), many equipped with diesel-powered or outdated chillers that are costly and unreliable. Solar-hybrid chillers and modular cold rooms are now commercially available, offered by providers such as Simusolar, PowerGen, and East Africa Dairy Development projects. Lease-to-own and

pay-as-you-go (PAYG) models have begun to spread, reducing the upfront barrier for cooperatives. Technicians are trained in installation and maintenance in dairy hubs like Tanga and Iringa, and processors increasingly support MCCs with equipment upgrades. This ecosystem is still consolidating but demonstrates clear signs of early commercialization, backed by donor and private initiatives.

Productivity Increase

Cold chain infrastructure does not increase yields in the field—it safeguards what is already produced. Evidence from East African pilots shows that chilling milk at MCCs reduces spoilage rates from **25–40% down to under 5%**, representing hundreds of millions of liters saved annually. For farmers, this translates into higher acceptance rates, steadier cash income, and reduced waste of household labor. Processors also benefit: better milk quality improves shelf life of packaged products, increases efficiency in processing plants, and opens up market opportunities for UHT and export. The income impact is significant: studies in Tanzania and Kenya report **20–50% higher earnings** for smallholders linked to chilled MCCs compared to those relying on informal, uncooled marketing channels.

Gender Inclusion

Women are central to Tanzania's dairy economy, responsible for milking, handling, and small-scale sales. They are often the first to suffer income losses when milk spoils or is rejected. Cold chain infrastructure directly reduces this burden, allowing women to market milk more reliably and pool volumes through cooperatives. Moreover, MCCs create jobs in testing, record-keeping, and quality assurance, roles where women's participation is growing. By anchoring cold chain investments in **women-led cooperatives and savings groups**, this solution not only strengthens resilience but also expands women's access to finance and decision-making in the dairy value chain.

Relevance to Borrowers

Cold storage assets are highly financeable. For **cooperatives**, chillers can be leased or financed through group loans, repaid via chilling fees per litre. For **processors**, equipment at MCCs can be supported through off-take agreements, with repayments linked to delivered volumes. **SMEs** running village-level MCCs can access PAYG or asset-backed loans for modular cold rooms. Because milk chilling generates direct and measurable income streams, lenders can underwrite these investments with confidence. Importantly, bundling cold storage with inventory or working-capital finance further improves repayment capacity, making this solution attractive for both microfinance institutions and commercial banks.

Policy Alignment & Institutional Traction

Cold chain infrastructure aligns strongly with Tanzania's agricultural and climate policies. The **Agricultural Sector Development Programme II (ASDP II)** prioritizes dairy modernization, including cold storage at MCCs. The **National Climate Change Strategy** identifies post-harvest loss reduction as a core adaptation pathway. Processors such as Tanga Fresh and ASAS Dairies are already working with cooperatives to expand chilling capacity, often with donor support from IFAD, the World Bank, and the African Development Bank. National energy policies promoting solar off-grid solutions further support the deployment of solar-hybrid chillers in rural zones. This convergence of policy priorities and private-sector demand provides a favorable environment for scale-up.

Why This Solution Stands Out

Cold chain infrastructure for milk chilling is a **high-impact, commercially ready adaptation solution** for Tanzania. It addresses a clearly quantified problem, 25–40% post-harvest losses in milk, affecting millions of smallholder farmers and disproportionately harming women. The solution is **bankable** (asset-based, fee-for-service, cooperative-owned), **scalable** (MCCs already exist nationwide), and **technically mature** (solar-hybrid systems proven in East Africa). Unlike more diffuse climate-smart practices, chilling generates direct revenue streams, making it attractive for lenders and MFIs. It also strengthens resilience across the dairy sector by stabilizing incomes, reducing waste, and enabling processors to expand higher-

value markets. For GCA, investing in cold chain infrastructure represents a clear opportunity to mobilize private finance into a sector that anchors rural livelihoods and national food security, while building adaptive capacity against Tanzania's escalating climate risks.

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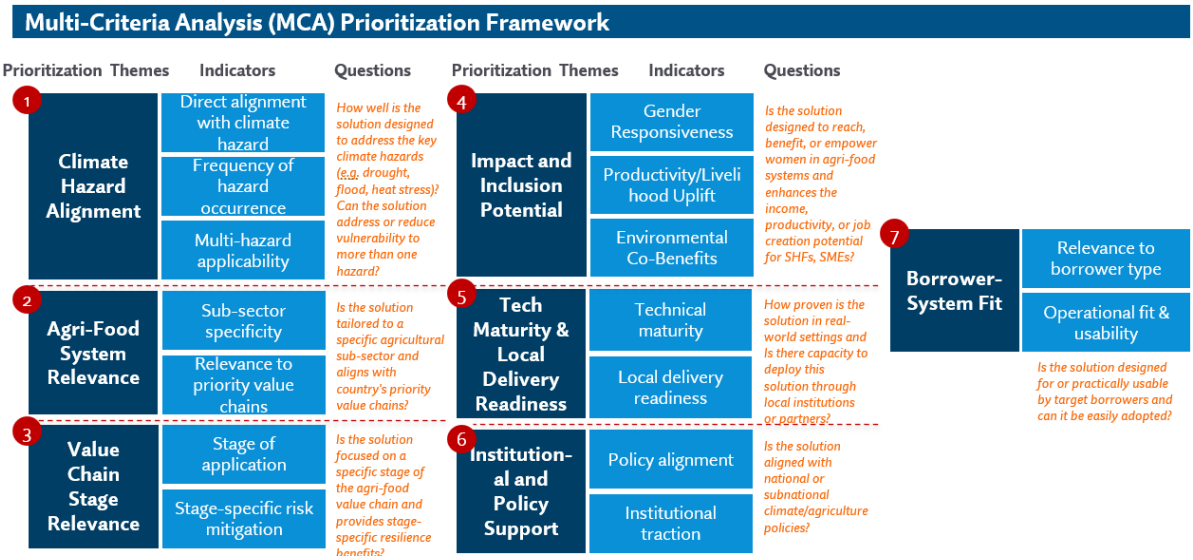
1 ANNEX 1: HIGH-LEVEL CLIMATE IMPACT ANALYSIS

This impact classification is a qualitative framework based on expert judgment, drawing on projected climate hazards, crop and livestock sensitivities, and contextual evidence from policy and scientific literature. It is intended as a comparative guide to prioritise adaptation needs rather than a precise quantitative assessment.

I=Impact	
High impact	Crops or livestock in this category are highly sensitive to projected climate hazards such as extreme heat, drought, flooding, or disease outbreaks. Without significant and targeted adaptation measures, these systems are expected to face **severe and frequent** yield losses, productivity declines, or high mortality rates, potentially undermining their economic or food-security viability. *Example:* Maize under >35ºC for several months in Katanga Plateau (DRC).
Medium impact	Systems in this category are moderately vulnerable to climate hazards. Yields or productivity may decline under hotter or wetter conditions, but **losses are generally manageable** with adaptation. Improvements in crop varieties, farm management, infrastructure, or veterinary services can significantly mitigate risks and preserve viability. *Example:* Groundnuts in Kasai Triangle (DRC) under hotter, wetter conditions.
Low impact	These crops or livestock are relatively resilient to projected hazards, either because of their physiological tolerance (heat, drought, disease) or their flexibility in production systems (browsing habits, low water requirements, vegetative propagation). Climate change impacts are expected to be **minor or only severe under extreme, prolonged events**. In some cases, these systems may even become more competitive compared to vulnerable ones. *Example:* Cassava, or goats in drought-prone zones.

2 ANNEX 2: ADAPTATION SOLUTION PRIORITIZATION METHODOLGY

Methodology for Identifying and Prioritizing Adaptation Solutions using Multi-Criteria Analysis (MCA)



The methodology for identifying and prioritizing adaptation solutions was designed as a **staged, evidence-based process** that systematically reduced a large global solution universe into a **shortlist of the most context-relevant, financeable, and commercially ready interventions** for each country.

Step 1. Comprehensive Long List Development

We began by compiling an initial long list of ~**700 adaptation solutions** from over twenty-one global, regional, and national taxonomies and reports. This broad scan ensured no major classes of interventions were excluded at the outset.

Step 2. Refinement and Screening for Relevance

The initial long list was refined to a more practical inventory through:

- **Deduplication** of overlapping entries (e.g., multiple versions of "solar irrigation pumps"), reducing the list to ~277 solutions.
- **Removal of umbrella terms** (e.g., "mechanized irrigation systems"), keeping only discrete solutions.
- **Exclusion of mitigation-focused solutions** and those too diffuse to be structured as investable products or services (e.g., generic CSA practices like mulching).

This process yielded a refined set of **~70+ discrete, investable adaptation solutions**.

Step 3. First-Pass MCA Filtering: Country Context Alignment

At this stage, we introduced **country-specific filters** to ensure solutions directly aligned with both the **climate hazard profile** and the **priority agri–value chains** of each country. Using the MCA framework's relevance dimensions, solutions that were not clearly addressing priority hazards (heat, drought, floods, pests/disease) or not relevant to the short-listed value chains were removed.

This **first-pass MCA application** narrowed the pool to **~44 solutions** that were both technically plausible and contextually meaningful for in-country application.

Step 4. Second-Pass MCA Scoring: Commercial and Institutional Readiness

The remaining 44 solutions were then scored in detail across the **full MCA framework**, which included:

- **Borrower-System Fit** (e.g., usability by SHFs, SMEs, cooperatives).

- Technical Maturity & Local Delivery Readiness (track record of deployment and presence of delivery partners).
- Impact & Inclusion Potential (productivity uplift and gender responsiveness).
- Institutional & Policy Alignment (fit with national strategies, backing from IFIs or government programs).

Weights were applied to reflect strategic priorities (e.g., gender and productivity received higher emphasis). Scoring was conducted across all four countries simultaneously, given that many solutions are cross-cutting but differ in local readiness and institutional traction.

Step 5. Country-Specific Shortlisting

Finally, the scoring outputs were combined with country-level hazard and value chain assessments to identify the top 5 priority solutions for each country. These shortlists represent the intersection of:

- Adaptation need (hazard and value chain exposure).
- Commercial readiness (bankability and scalability).
- Institutional traction (alignment with policy and delivery ecosystems).

This two-pass MCA approach ensured rigor, efficiency, and strategic focus, filtering first by relevance to climate and agri-food systems, and then by commercial and institutional readiness.

3 ANNEX 3: ADAPTATION IN TANZANIA

The projected climate hazards (more hot days, intense short-duration rainfall and flooding, and localized drought) indicate higher risks for maize and rice due to their sensitivity to heat at flowering, lodging, and harvest losses in heavy rain/floods, while for livestock, cattle and poultry are most exposed in hotter, flood-prone coastal and lake regions. At the same time, goats remain the most resilient but can experience short-term feed and health pressures during cyclonic storms and floods. Considering other key crops, beans and groundnuts face medium–high impacts due to drought/heat at flowering and wet-season disease/aflatoxin risks, particularly in the Southern Highlands and Lake Victoria zones. Cassava is relatively resilient but vulnerable to waterlogging in coastal plains; banana/plantain shows moderate sensitivity to storms and saturated soils in the Albertine Highlands. Solutions need to focus on these particular climate hazards: response to heat stress and temperature control, water management (considering drought potential increasing frequency), as well as flood management, emerge as the key areas of response.

Based on Tanzania's national policy framework, World Bank analysis, and expert assessments, the country has prioritized several key climate adaptation solution areas across its agricultural sectors. Climate-smart ecosystem-based adaptation (EbA) and best management agriculture practices form the foundation, including conservation agriculture, integrated soil fertility management (including sustainable fertilizer provision with potential incentives to move away from chemical fertilizers), and integrated pest management approaches. There is a particular focus on sustainable resource management, including pasture and rangeland management, fodder conservation, manure management and biogas production, and ecosystem rehabilitation, particularly for coastal and marine systems that are impacted by sea-level rises, including improving seaweed farming resilience and addressing saltwater intrusion in Zanzibar. Water management solutions are also a key focus to respond to more erratic rainfall patterns and drought areas, including rainwater harvesting, efficient irrigation systems with particular emphasis on solar and micro-irrigation technologies such as drip irrigation and hand pipes (World Bank Group, 2024), on-farm water storage, catchment management, and water harvesting infrastructure. Crop and livestock improvements focus on developing and deploying drought-tolerant and climate-adapted varieties, improved livestock breeds, and resilient aquaculture species, with experts emphasizing the need for increased investment in research and development to climate-proof seeds and maximize livestock yield potential (World Bank Group, 2024). Infrastructure and technology priorities include improved storage facilities, climate-smart livestock housing, sustainable pond and cage culture systems for aquaculture, post-harvest management technologies to reduce losses from moisture, pests, and diseases, and solar-powered cold chains to reduce dairy wastage (World Bank Group, 2024). Finally, there are references on knowledge and extension services that focus on strengthening these extension systems, farmer capacity building, improved veterinary services, and mainstreaming climate-smart practices through district-level planning.

Beyond Agriculture-focused interventions, the different national policies discuss different systemic initiatives that have spillover effects and impact the agriculture sector, including information and early warning systems that emphasize climate and weather information dissemination, early warning services, and climate-informed planning across all sectors, supported by digital solutions to improve market linkages between aggregators and farmers. These systemic features also consider risk management and finance solutions, including crop and livestock insurance programs, improved market access, financing mechanisms for climate technologies, and comprehensive risk management systems.

Gender and Social Inclusion Considerations: Adoption of these adaptation solutions is shaped by gendered barriers. Women, who dominate maize, cassava, beans, and post-harvest handling, consistently face lower access to land, finance, and extension, and are less likely to adopt irrigation or mechanised equipment. Prior research has indicated that women prefer solutions like hermetic bags, silos, and

tarpaulins, but high upfront costs, limited availability, and sociocultural norms constrain uptake. Embedding gender-responsive delivery - through women's cooperatives, savings groups, and female extension agents - can reduce these barriers and align Tanzania's adaptation planning with its Climate Change Gender Action Plan (2013) and Agenda 10/30, while strengthening overall food system resilience.

These initiatives, alongside Environmental-based Adaptation (EbA) and Agriculture Best Management Practices, are summarized in the image below, from Tanzania's Climate Smart Agriculture Profile (2017):

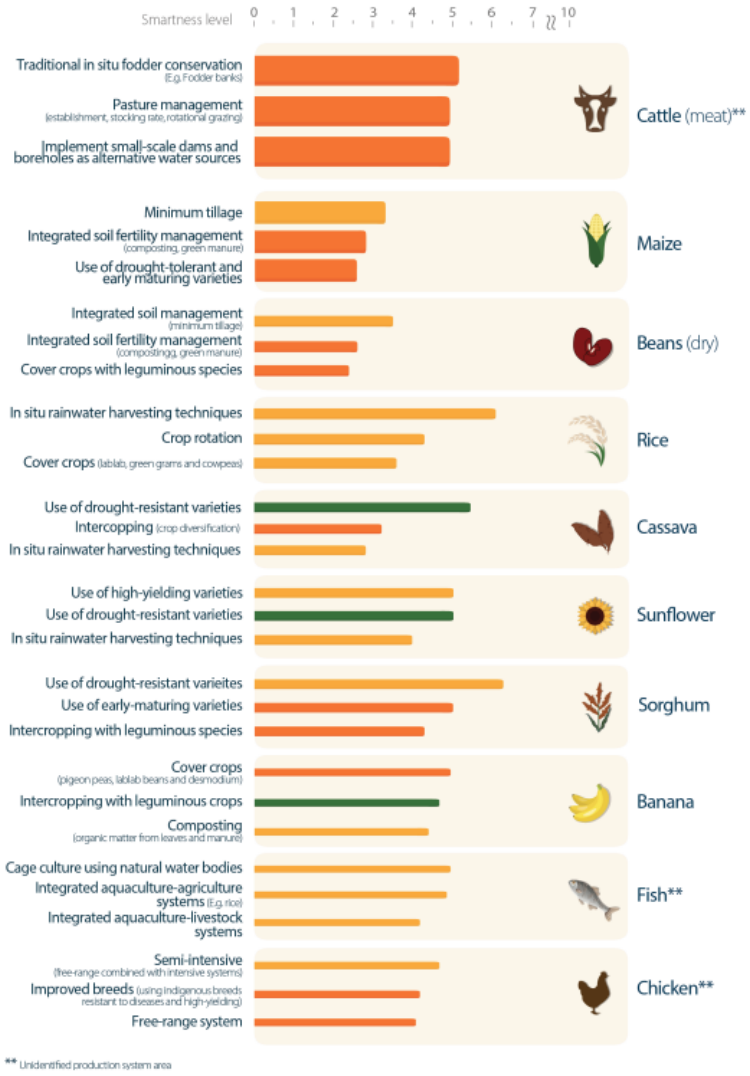


Figure 14. Climate-Smart Agriculture Suggested Solutions for Tanzania Agricultural Sector (CIAT;World Bank, 2017)

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