Kenya: 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

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.

CONTENTS

Glossary **3**

Executive Summary **6**

Contents **7**

List of Tables **8**

List of Figures **8**

Introduction and Background Setting **9**

Project Context 9

Study Rationale and Objectives 9

Report Structure 11

Methodological Considerations 11

Country Overview: Kenya **16**

Country Executive Summary 16

National Climate Hazard Mapping 17

Climatology of Kenya 17

Agricultural and Food Security Exposure to Climate Hazards 26

Agriculture production exposed to climate change 27

Climate impact at key agriculture production zones 29

Priority Value Chains 33

Climate Adaptation Solutions 35

Adaptation Needs, Themes, and Prioritization of Solutions 36

Deep Dive on Priority Solutions 40

Bibliography **48**

1 Annex 1: High-Level Climate Impact Analysis **56**

2 Annex 2: Adaptation Solution Prioritization Methodolgy **57**

3 Annex 5: Adaptation In Kenya **59**

LIST OF TABLES

Table 1: Key recent flooding events in Kenya. 24
Table 2: Top-10 counties with the largest number of 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. 26
Table 3: Climate trends and impacted value chains in Kenya. 31
Table 4: Key socio-economic considerations in prioritising food value chains 34
Table 5: Summary of agriculture related priorities in the national policies and strategies. 35
Table 6: Key Investments under the Climate Smart Agriculture Investment Plan for Kenya (Jalango D, 2023). 60

LIST OF FIGURES

Figure 1. Counties in Kenya (administrative divisions since 2013). 18
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. 18
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. 19
Figure 4. Comparison of the mean annual accumulated precipitation during the reference period and the projected values for 2041-2060 under RCP4.5 and RCP8.5 scenarios. 20
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. 20
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. 21
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. 23
Figure 8. Map of principal river basins in Kenya (in white), together with the main river network in the country. 24
Figure 9. Flood Map for 1 in a 50-year river flooding event for the historical period. The zoomed area on the right includes the two counties with the largest exposure (largest area with at least 0.5m of floodwater expected). 26
Figure 10. Major crop and livestock production areas, with indication of key commodities 29
Figure 11. Priority adaptation themes in Kenya. 37
Figure 12. Climate-Smart Agriculture Prioritized for Kenyan Key Value Chains profile (World Bank; CIAT, 2015). 59

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: KENYA

Country Executive Summary

Agriculture anchors Kenya's economy and rural livelihoods, providing about **20% of GDP directly** and supporting the majority of rural households through food and employment. Yet the sector is highly climate-sensitive, with most farming rain-fed and smallholder-driven. Projections point to a future of intensified climate stress, marked by extreme heat in the arid lowlands, recurrent droughts, heavier short-duration rainfall, and heightened flood risk along rivers and coasts. These shifts are already altering risk patterns across Kenya's most productive agricultural regions.

Hazard mapping shows that the **northeastern lowlands** (Mandera, Wajir, Isiolo) will see the harshest extremes, with peak daily temperatures reaching 45–47 °C and the majority of days above 35 °C. Turkana, Marsabit, and the coastal belt will also experience prolonged heat waves, while the central and western highlands warm the most in relative terms. **Droughts** remain a chronic hazard, with even rainfall-increasing zones facing higher evaporative demand and water stress. **Intense rainfall events** are projected to rise, particularly along the coast and in eastern counties, intensifying flash-flood and landslide risks. By mid-century, flood exposure will be concentrated in Tana River, Garissa, and Turkana, with hundreds of thousands of people exposed in Kilifi, Mombasa, and Garissa. Wind extremes are projected to shift only modestly.

The intersection of these hazards with Kenya's food systems reveals urgent vulnerabilities. **Maize**, the national staple, is highly exposed to recurrent drought, heat stress at flowering, and storm-related damage, alongside high post-harvest losses. **Cattle productivity** is undermined by heat, water scarcity, and flood-related disease, particularly in pastoral belts. **Potatoes** are increasingly important but face drought, late blight, and weak storage systems. **Tea**, concentrated in the highlands, is sensitive to shifts in temperature and rainfall, threatening a key export earner. National strategies consistently highlight the need for climate-smart seeds, water management, agroecological practices, risk transfer mechanisms, and post-harvest loss reduction. Taken together, **maize, potatoes, and cattle** emerge as Kenya's highest-priority value chains for adaptation investment.

The gender lens adds another layer of urgency. Women contribute **around 75% of farm labour**, particularly in **tea, dairy, potatoes, and beans**, all highly climate-sensitive. Droughts increase women's unpaid workloads in water and fuelwood collection, while floods disrupt local markets and petty trade, where women predominate. These shocks deepen existing gaps in access to land, finance, and extension services, reinforcing productivity losses. Addressing climate risks in Kenya's agriculture will therefore require adaptation strategies that not only strengthen value chain resilience but also expand opportunities for the women who sustain much of the sector.

Climate stress is intensifying in Kenya's agriculture, with the heaviest risks falling on maize, potatoes, and cattle, alongside critical export crops such as tea. Responding effectively will demand adaptation measures that are technically robust, commercially viable, and gender-responsive, to safeguard food security, rural livelihoods, and Kenya's broader economic stability.

Kenya's priority adaptation opportunities include five commercially scalable solutions: digital advisory platforms, hermetic storage, climate-resilient fodder, solar drying, and solar-powered irrigation. Already piloted and backed by strong institutions, these interventions address urgent risks in maize, potatoes, and livestock, while offering clear business models through cooperatives, agro-dealers, and pay-as-you-go finance. They represent the strongest entry points to attract private capital and build resilience across Kenya's food system.

National Climate Hazard Mapping

Key findings:

- **Extreme heat.** Kenya will get markedly hotter, with the northeastern arid lowlands (Mandera, Wajir, Isiolo) seeing the most severe conditions—hottest days 45–47 °C and most days > 35 °C. Turkana, Marsabit and the coast also face prolonged extreme heat (local peaks 41–44 °C), while the western/central highlands warm the most in relative terms (up to +2.4 °C) but still record few very-hot days except in some low valleys.
- **Drought.** Drought remains a major hazard despite projected rainfall increases in parts of the eastern lowlands (up to +20%), as annual totals stay low (< 800 mm; driest areas < 500 mm) and evaporative demand rises. Intensity strengthens to moderate (SPEI −1.5 to −1) across the coast, highlands, and northwest, underscoring adaptation needs in both chronically dry zones and newly drought-prone highland areas.
- **Wind extremes.** Wind hazard changes are modest overall. Localised increases of ~+3–4% are projected in the eastern lowlands (south Isiolo, north Tana River, Garissa) and northwest Turkana, but typical extremes remain < 22 m/s; the western/central highlands and coast are largely stable or slightly lower than the baseline.
- **Extreme precipitation (1-day).** Short-duration intense rainfall intensifies and remains widely disruptive, with the strongest increases in coastal and eastern counties—heightening flash-flood and riverine risks. Even where mean changes are modest (e.g., the highlands), localised extremes will continue to trigger landslides and flood damage.
- **River flooding.** Flood exposure concentrates in Tana River (2,829 km²), Garissa (2,739 km²) and Turkana (2,093 km²) by 2050 (RCP4.5, ≥ 0.5 m depth, 1-in-50-year event). The largest area increases occur in Wajir (+859 km²), Garissa (+847), Isiolo (+639), Turkana (+583) and Tana River (+344); population exposure is highest by share in Tana River (29%, 115,155 people) and by count in Kilifi (249,172, 16%), with Mombasa (126,722, 10%) and Garissa (119,421, 8%) also exceeding 100,000 exposed.

Climatology of Kenya

Kenya, located in East Africa and crossed by the Equator, covers 580,367 km² and extends from the low-lying Indian Ocean coast in the southeast to high mountain ranges and the Rift Valley interior. It shares borders with Ethiopia and South Sudan to the north, Uganda to the west, Tanzania to the south, and Somalia to the east, while also fronting the Indian Ocean. Much of the country lies on elevated plateaus between 900 and 1,800 m. Within this framework, Kenya is divided into the Lake Victoria basin, the Rift Valley and associated highlands, the eastern plateau forelands, the semiarid and arid areas of the north and south, and the coast. Major relief features include Mount Kenya (5,199 m), Africa's second-highest peak; volcanic highlands such as Mount Elgon, the Rift lakes (Turkana, Naivasha, Nakuru, Bogoria, Baringo, Magadi), the Mau Escarpment, and the Aberdare Range. Lake Victoria, the world's second-largest freshwater lake and the largest in Africa, forms part of the western border.

Climatically, Kenya is shaped by seasonal large-scale pressure systems of the western Indian Ocean and other adjacent landmasses. From December to March, prevailing winds bring generally dry conditions, with only local rains. The main rainy season follows from late March to May, while June to August is drier, with southwest and southeast winds dominating north and south of the Equator respectively. Regional contrasts are sharp: the Lake Victoria basin is the wettest and most agriculturally productive; the Rift Valley has dry valley floors but wetter, temperate highlands where agriculture can thrive (e.g., Mau Escarpment); the eastern plateau experiences unreliable rainfall; the northern and northeastern lowlands

are the hottest and driest regions; and finally the coastal strip remains hot, humid, and relatively wet year-round, with the southern coast being the most reliable for agriculture.

Figure 1. Counties in Kenya (administrative divisions since 2013).

Extreme temperatures

Extreme heat exposure in Kenya is shaped by contrasts between arid lowlands, semi-arid rangelands, coastal zones, and the elevated highlands of the Rift Valley. The northeastern and northern lowlands experience persistently high temperatures due to flat terrain, low elevation, and arid conditions. Coastal areas are also warm, influenced by proximity to the Indian Ocean, while western and central highlands remain relatively cool because of their higher elevations. These spatial differences define the baseline pattern of heat exposure across the country.

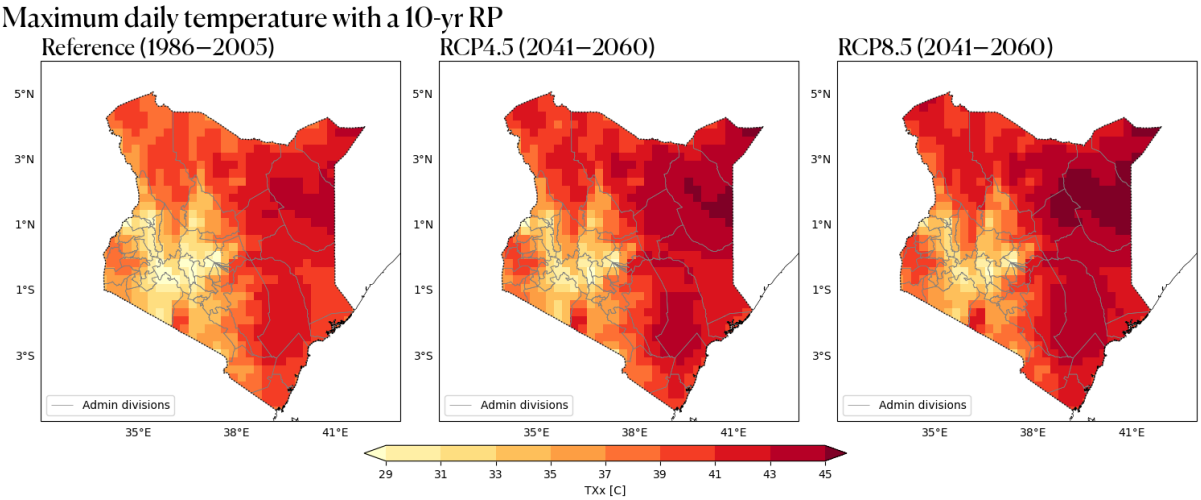


Figure 2. Comparison of the maximum daily temperature with a 10-year return period during the reference period and the projected values for 2041-2060 under RCP4.5 and RCP8.5 scenarios.

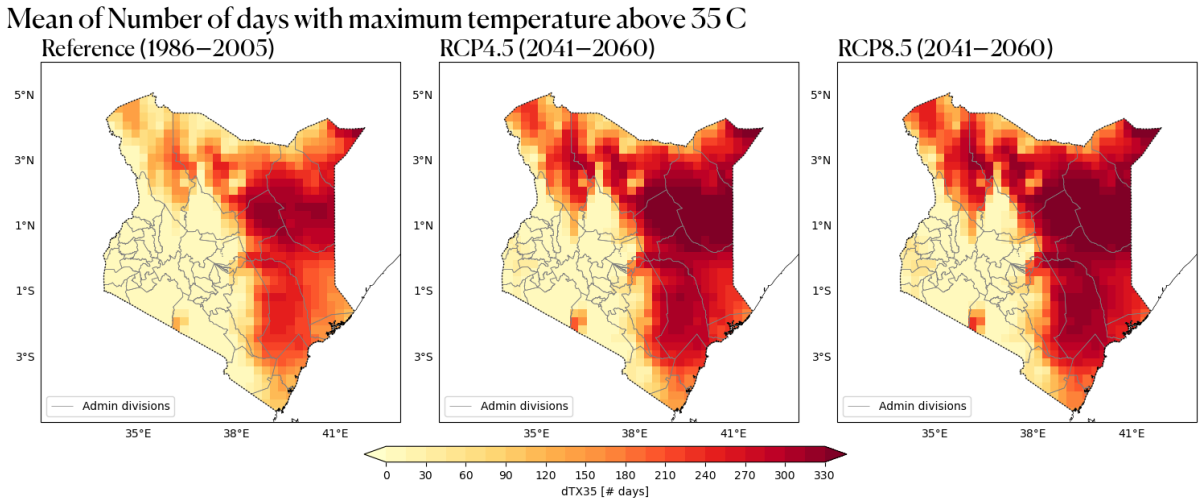


Figure 3. Comparison of the mean annual number of days above 35ºC during the reference period and the projected values for 2041-2060 under RCP4.5 and RCP8.5 scenarios.

REFERENCE PERIOD (1986-2005)

- Extreme heat events occurring once in 10 years (Figure 2) show hottest-day temperatures of 43–45°C in the arid lowlands of northeastern Kenya (counties of Mandera, Isiolo and Wajir), with county averages exceeding 40°C in all three counties.
- Lowland counties in the north (Turkana, Marsabit) and the southeast (Garissa, Tana River, and coastal counties), also experience very hot temperatures, with localised peaks of 40-42°C and slightly cooler temperatures in the coast.
- The number of days above 35°C (Figure 3) exceed 300 days in great parts of eastern and northern Kenya, with coastal regions also seeing over 120 days and over 200 in interior parts of the lowlands.
- The elevated highlands of the Rift Valley in the west (Western and Central Highlands) have, in contrast, much lower extreme temperatures. The number of days above 35°C is virtually 0 in most of this region (except for some low-lying valleys).

PROJECTION FOR 2041-2060

- The increase of temperatures will be widespread, with the largest increase in the cooler highlands (+2.4°C). However, the number of days above 35°C will remain virtually zero on higher ground, and only emerging in some valleys and the west side of the Rift Valley.
- The increase of over 2°C in the hottest parts of the country will lead to temperature extremes easily reaching 45°C and even surpassing 47°C in some places like Mandera.
- These regions could see years where most days exceed 35°C, except for 2 to 3 weeks in a year.
- Coastal counties will typically see 41-43°C (RCP4.5) to 41-44°C (RCP8.5) and at least half year above 35°C (RCP4.5) with potentially up to 300 days in localised parts and RCP8.5.

In summary, extreme heat will intensify across Kenya, with the northeastern arid lowlands (Mandera, Wajir, Isiolo) projected to see the most severe conditions, where hottest-day temperatures could exceed 45–47°C and most days of the year surpass 35°C. Northern counties (Turkana, Marsabit) and coastal regions will also face substantial increases, with local peaks reaching 41–44°C and prolonged periods of extreme heat. In contrast, the western and central highlands will experience the largest temperature rise (up to +2.4°C), but the number of very hot days will remain minimal, except in some low-lying valleys.

These projected changes will heighten risks for human health, agriculture, and water resources, especially in the hottest lowlands, while emerging heat in highland areas poses new adaptation challenges.

Drought

Drought exposure in Kenya reflects sharp contrasts in rainfall distribution between arid lowlands and wetter highlands. The arid and semi-arid lands (ASALs) of the north and east are chronically dry, with short, unreliable rainy seasons and low yearly totals. By contrast, the western and central highlands receive some of the country's highest rainfall, while the coastal belt also records substantial accumulations due to its proximity to the Indian Ocean. These differences define the baseline risk of drought across Kenya, where rainfall variability is as critical as total rainfall.

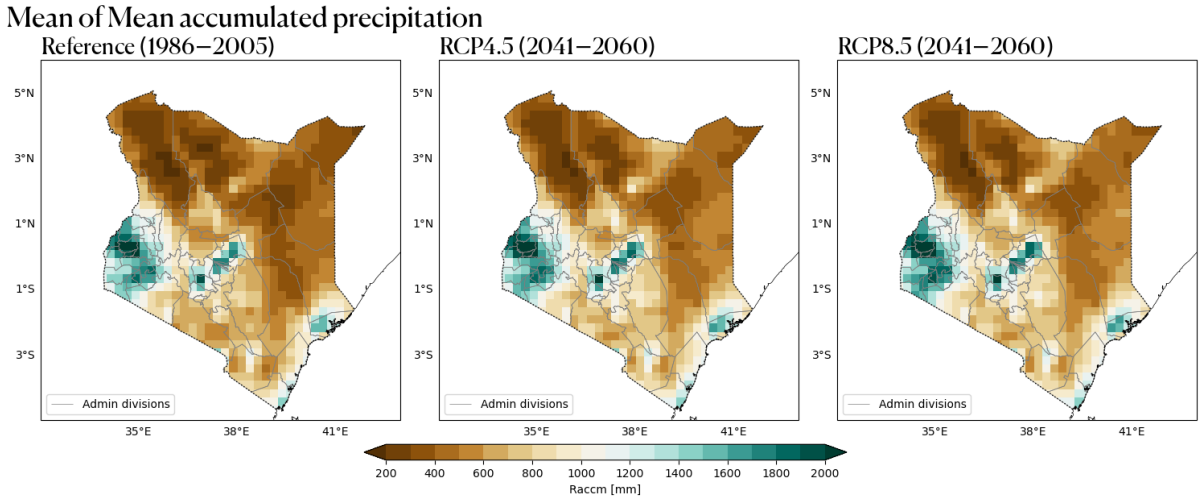


Figure 4. Comparison of the mean annual accumulated precipitation during the reference period and the projected values for 2041-2060 under RCP4.5 and RCP8.5 scenarios.

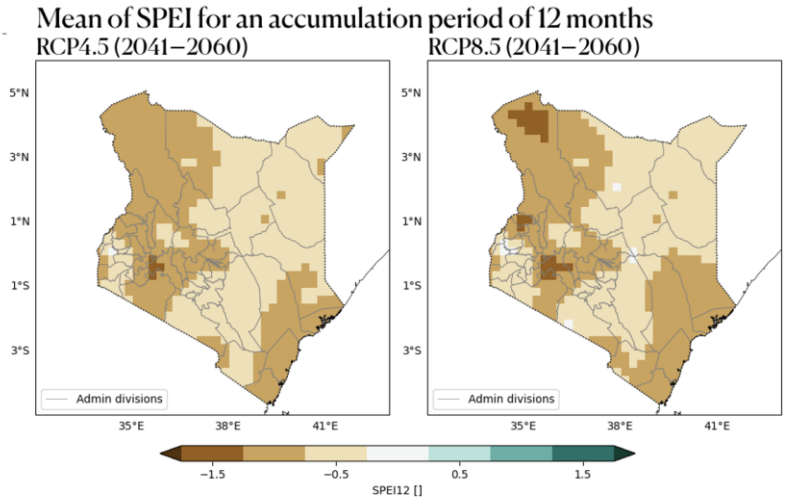


Figure 5. Projected mean of SPEI values (multiscalar drought index) for an accumulation period of 12 months under RCP4.5 and RCP8.5 scenarios for 2041-2060.

REFERENCE PERIOD (1986-2005)

- Kenya's arid and semi-arid landas (ASALs) in the east and north of the country have short rainy seasons with low and highly variable yearly rainfall. Yearly accumulations are typically below 600 mm with localised areas in the north (Turkana, Marsabit) with less than 200 mm (Figure 4).

- In contrast, the Western and Central Highlands see high yearly accumulations well above 1000 mm (with some county averages like Vihiga surpassing 2000 mm).
- Coastal regions also experience high amounts of yearly rainfall. County averages typically see from 889 mm (Kilifi) or more (Kwale: 1003 mm, Lamu: 1121 mm, Mombassa: 1266 mm).

PROJECTION FOR 2041-2060

- Yearly precipitation is expected to remain relatively stable in the western part of the country and the coastal regions, with either small or inconclusive changes.
- The eastern lowlands are expected to see an increase in yearly rainfall accumulation, with an increase of up to 20% in interior parts of Mandera, Wajir, Isiolo and eastern Marsabit. Yearly accumulations will still remain below 800 mm and below 500 mm in the drier parts.
- Drought events (as shown by the SPEI12 indicator, Figure 5) appear to intensify in severity in coastal regions, the highlands and the northwest. However, typical drought conditions will remain within the moderate drought range (SPEI of -1.5 to -1 units).

In summary, drought conditions will persist as a major climate hazard for Kenya, despite projected increases in rainfall in parts of the eastern lowlands (up to +20%). Even with this rise, annual totals will remain low (below 800 mm, and in the driest areas below 500 mm), sustaining high water stress. Meanwhile, drought events are projected to intensify in coastal regions, the highlands, and the northwest, with severity typically within the moderate range (SPEI -1.5 to -1). The contrast between persistently dry lowlands and wetter but more drought-prone highlands underscores the need for adaptation in both chronically arid zones and regions facing heightened drought intensity.

Extreme wind

Wind exposure in Kenya is strongly shaped by topography and proximity to the coast. Eastern lowlands and coastal regions experience consistently high wind intensities, while the northwest (Turkana, Marsabit) is also exposed to strong winds linked to open terrain and channeling effects. Localized topographic features, such as the slopes of Mount Kenya and the Rift Valley escarpments, produce additional wind extremes. By contrast, flatter sections of the Rift Valley record comparatively lower speeds, highlighting the role of landscape in shaping wind variability across the country.

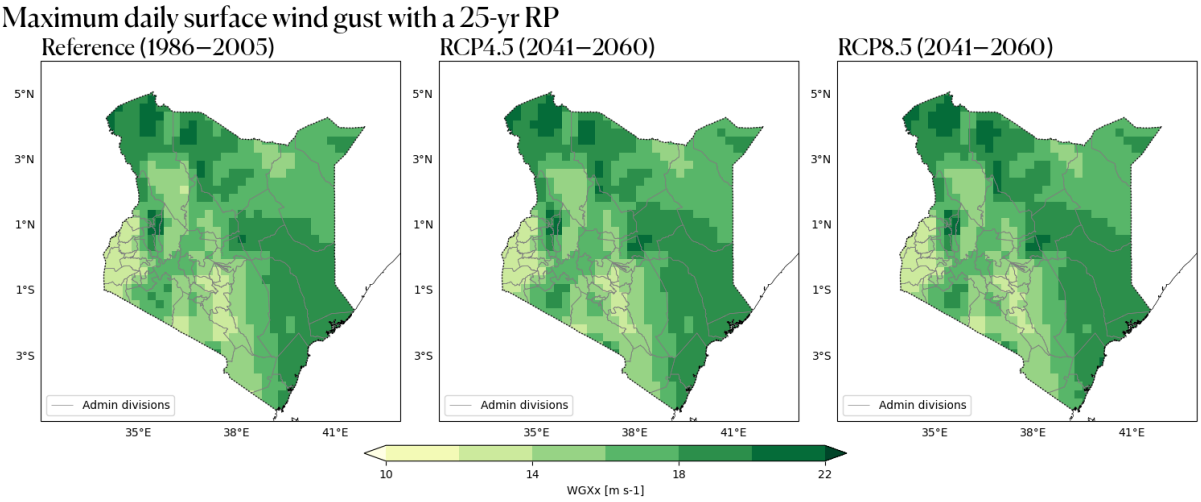


Figure 6. Comparison of the maximum daily surface wind gust with a 25-year return period during the reference period and the projected values for 2041-2060 under RCP4.5 and RCP8.5 scenarios.

REFERENCE PERIOD (1986-2005)

- Extreme wind intensities (Figure 6) vary across the country, with high intensities in coastal and lowland areas in the east (around 20 m/s).
- Northwestern counties (Turkana, northwest Marsabit) and localised areas of the Western Highlands (linked to the topography, like Mount Kenya or the escarpments of the Rift Valley) show the highest extremes (up to 21.8 m/s in the eastern slope of Mount Kenya).
- Flatter areas of the Rift Valley show relatively lower wind speed, between 12 to 16 m/s.

PROJECTION FOR 2041-2060

- Change in extreme wind remains low or uncertain for RCP4.5, with only a significant increase in wind speed (+4%) around Lake Natron, at the border with Tanzania.
- In the worse case scenario (RCP8.5), an increase in wind speed is projected in the lowlands in the east (south Isiolo, and north Tana River and Garissa) and the northwest (Turkana). However these increases rarely surpass a 3%, remaining below 22 m/s.
- The Western and Central Highlands, along with coastal areas, display only minor signals of change, in some cases even reductions.

In summary, extreme wind conditions are not projected to change dramatically in Kenya. Under RCP4.5, changes remain limited, with only localized increases of around +4% near Lake Natron. Even under RCP8.5, projected increases in the eastern lowlands (south Isiolo, north Tana River, Garissa) and northwest Turkana remain modest, typically below +3% and with wind speeds staying under 22 m/s. The Western and Central Highlands, and coastal regions, show little or even negative change. Overall, wind extremes will remain largely stable, with only marginal intensification in already wind-exposed lowland areas.

Extreme precipitation

Extreme precipitation in Kenya is widespread, with marked contrasts between coastal areas, highlands, and interior lowlands. The coastal counties are especially exposed, with intense single-day rainfall events regularly exceeding those in the rest of the country. The western and central highlands also experience high extremes, shaped by complex topography and elevation-driven rainfall variability. Even the northern and eastern lowlands, though generally drier, are prone to heavy downpours that contribute to flash flood risk. Only a few flatter inland regions show relatively lower extremes, though localised heavy rainfall can still occur.

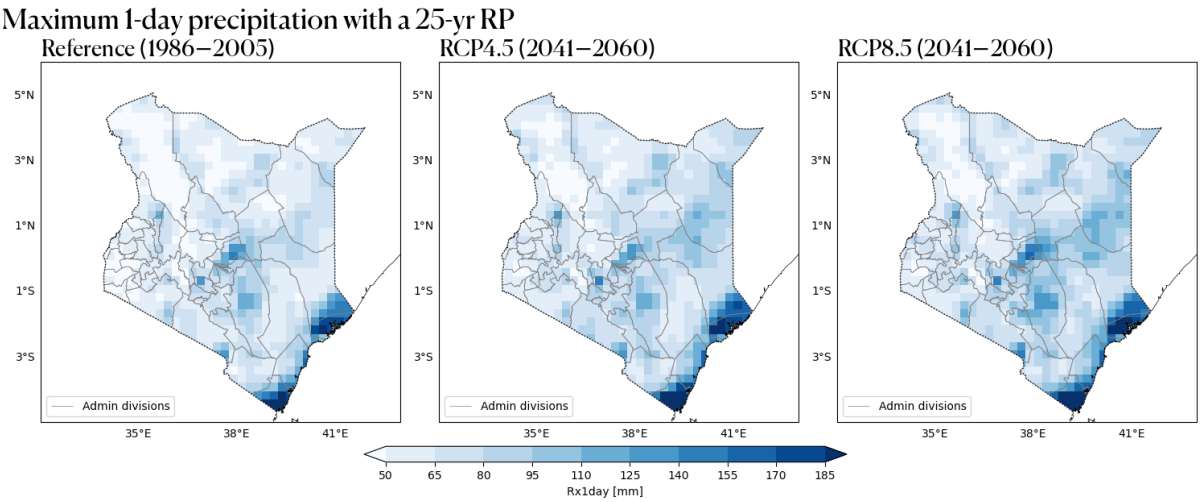


Figure 7. Comparison of the maximum 1-day precipitation with a 25-year return period during the reference period and the projected values for 2041-2060 under RCP4.5 and RCP8.5 scenarios.

REFERENCE PERIOD (1986-2005)

- Extreme precipitation (Figure 7) shows extreme values in coastal areas. Particularly in the counties of Kwale and Lamu with localised maxima of around 200 mm in a day, but also in Mombassa (180 mm), Kilifi (156 mm) and Tana River (136 mm).
- The Highlands show spatial variability that is potentially linked to the topography, with many localised areas showing extremes well over 100 mm in a day. Particularly the Central Highlands show localised areas of up to 143 mm (Meru and Tharaka-Nithi).
- Other parts of the country still show high extreme precipitation values, with many counties in the eastern and northern lowlands exceeding 75 mm in a day.
- The smallest values are found in flat areas not far from Lake Victoria (Kisii and Homa Bay). Yet localised values still reach more than 50 mm in a day.

PROJECTION FOR 2041-2060

- Areas in the centre of the country show stability, with small and/or uncertain changes.
- The eastern lowlands will experience the largest increase in extreme precipiation, reaching a +40% (RCP8.5) is some areas of Wajir and Garissa, reaching maxima of 123 mm and 193 mm respectively.
- Coastal areas will remain the most affected areas, with localised maxima between 150 mm and 308 mm (similar changes for both scenarios).

In summary, extreme precipitation will remain one of Kenya's most disruptive climate hazards. Coastal and eastern regions are projected to face the greatest intensification, heightening the risk of flash floods and riverine flooding in areas already vulnerable to water-related disasters. Even where projected changes are modest, such as in the highlands, localised extremes will continue to trigger landslides and flood damage. This means Kenya's future challenge is not only the rising intensity of rainfall in some regions, but also the widespread nature of flood risk across the country.

River flooding

In Kenya, there are five main river basins defined by the Water Resources Authority (WRA), including the Rift Valley, Ewaso Ng'iro North, Tana, Athi and Lake Victoria (North and South) basins. These basins

encompass major rivers such as the Tana, Athi-Galana-Sabaki, and Ewaso Ng'iro, as well as the catchments draining into Lake Victoria (Error! Reference source not found.).

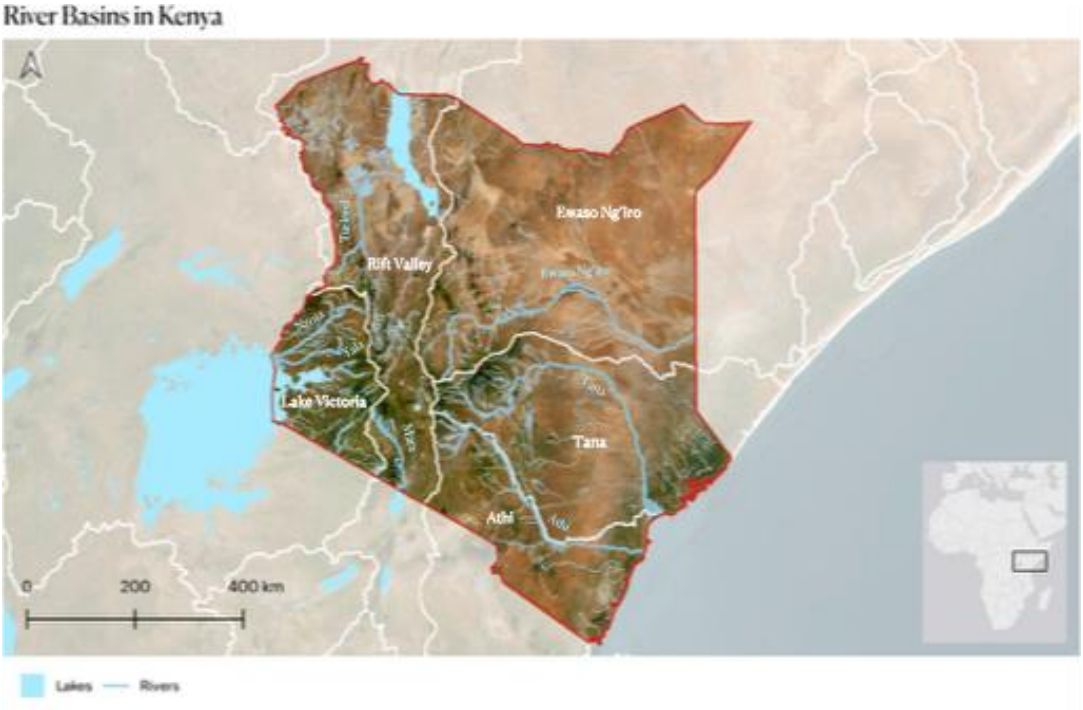


Figure 8. Map of principal river basins in Kenya (in white), together with the main river network in the country.

The Tana and Athi rivers flow southeastward into the Indian Ocean, supporting large populations in and around Nairobi (Nairobi county), Thika (Kiambu county), Garissa (Garissa county), and Mombasa (Mombasa county), while the Ewaso Ng'iro North Basin (the largest, covering 36% of the country) is more sparsely populated but crucial for pastoral livelihoods. The Lake Victoria North and South basins, covering western Kenya, host densely populated towns such as Kisumu (Kisumu county), Eldoret (Uasin Gishu county), and Kakamega (Kakamega county), and are key areas for agriculture due to fertile soils and high rainfall. The Rift Valley Basin stretches north–south along the country, hosting many lakes and rangelands.

Historically, Kenya has been exposed to extreme rainfall linked to El Niño events, which often result in severe riverine flooding, flash floods, and landslides. The table below illustrates recent flood events and their impacts.

Table 1: Key recent flooding events in Kenya.

Date	Region	Impact
Mar – May 2025	Tana River, Isiolo, Homa Bay, Turkana, Nairobi, Kisumu, Wajir, Mandera, Marsabit, Samburu, Kwale, Migori, Garissa, Taita-Taveta (multiple basins)	Long-rains flooding displaced over 18,000 people and affected more than 73,000 people. At least 23 deaths were reported. Widespread destruction of homes, roads, farmland, and livestock occurred, while cholera and visceral leishmaniasis outbreaks spread (Delegation of the European Union to Kenya, 2025).
Mar – May 2024	Nairobi, Machakos, Garissa, Tana River, Kisumu, Homa Bay, Busia, Migori, Isiolo, Mandera, Nakuru, Kajiado, Kiambu, Narok, West Pokot, Nyeri, Siaya, Kirinyaga, Turkana and Baringo (multiple basins, but mainly Athi and Tana basins, as Nairobi and Garissa were the most affected)	Extreme rainfall caused flash floods and riverine flooding, displacing almost 280,000 people and causing 291 deaths. Moreover, 67 roads were damaged, and there was a loss of 11,311 livestock and 47,578 acres of croplands (Reliefweb, 2024).

November 2023	Mandera, Wajir, Garissa, Tana River, Marsabit, Samburu (Tana and Ewaso Ng'iro basins)	El Niño heavy rains caused 136,025 people (27,205 households) displaced, with widespread destruction of homes, infrastructure, and livelihoods. Flash floods compounded vulnerabilities from previous droughts (Reliefweb, 2023).

Thus, for Kenya, flooding has serious implications for agriculture and livelihoods. Both in 2024 and 2025, the March to May rainy season has been well above the normal seasonal average for this time of year, disrupting cropping seasons: floods destroyed multiple crop fields after planting, while also affecting pastoral communities by drowning livestock and degrading grazing areas.

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 are derived and used.

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

- The majority of the most exposed counties are located in the eastern half of Kenya and the northwest, mainly in the arid and semi-arid (ASAL) regions.
- Based on flood extent for a 50-year return period event, the counties with the largest flooded areas are Tana River, Garissa, Turkana, Isiolo, Kilifi, Kajiado, and Wajir.
- Tana River has a flooded extent of 2,485 km² (6% of the county's area), located in the Tana Basin, representing the largest flood-affected area among all counties.
- Garissa and Turkana follow with flooded extents of 1,892 km² and 1,510 km², respectively. Isiolo and Kilifi have 963 km² and 673 km² flooded, while Kajiado and Wajir cover 903 km² and 619 km², spanning the Ewaso Ng'iro and Athi Basins.
- Other counties with notable flood exposure include Lamu (235 km²), Mandera (237 km²), Siaya (150 km²), Busia (129 km², 7% of its area), and Kisumu (120 km²).

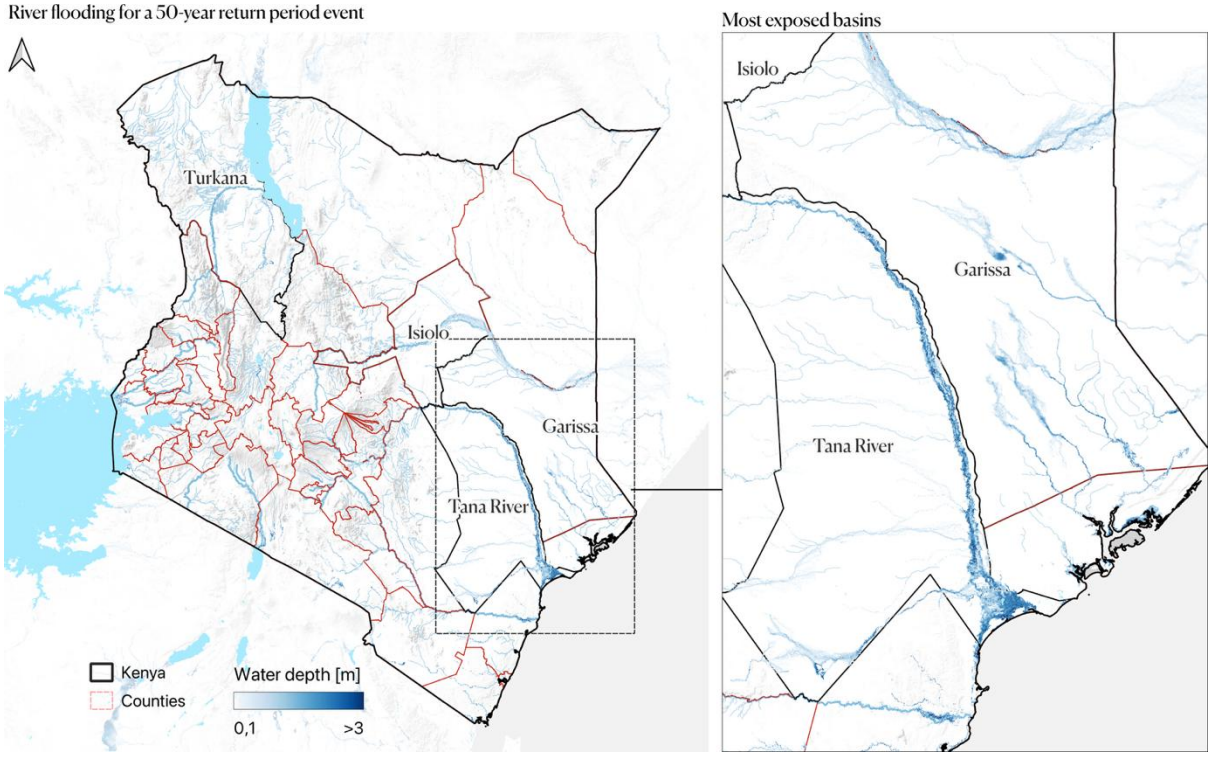


Figure 9. Flood Map for 1 in a 50-year river flooding event for the historical period. The zoomed area on the right includes the two counties with the largest exposure (largest area with at least 0.5m of floodwater expected).

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 (Worldpophub, 2025).

Table presents the most exposed provinces by flooded area, difference between present and future, and linked to population.

- **Counties most exposed to river flooding:** Similar to the historical period, Tana River, Garissa, and Turkana will continue to be the most exposed regions in Kenya, with future flood extents of 2,829 km², 2,739 km², and 2,093 km² respectively.
- **Largest increase in total water extent:** Comparing the flood extent (>0.5 m water depth) of the historical period and 2050 shows that **Wajir** will increase the most with +859 km², followed by Garissa (+847 km²), **Isiolo** (+639 km²), **Turkana** (+583 km²), and **Tana River** (+344 km²).
- **Future exposed population**: The **Tana River County** is the region with the largest share of population located in flood-prone areas in a 2050 scenario; around 29% of its population (115,155 people) will be exposed to flood-prone regions under a 1 in a 50 year event.
- If we take into account the county with the **largest population at risk**, **Kilifi** county**,** located in the Kenyan coast, has 249,172 people in areas prone to flood risk (16% of its total population).
- Overall, two more counties, **Garissa** and **Mombasa** surpass the 100,000 people with high exposure to riverine flooding, with Mombasa having 126,722 people (10% of the county's population) and Garissa having 119,421 people exposed (8% of the county's population).

Table 2: Top-10 counties with the largest number of 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.

Counties	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*	#	%
Kilifi	12,723	1.5	673	746	73	249,172	16%
Mombasa	236	1.3	16	18	2	126,722	10%
Garissa	43,900	1.6	1,892	2,739	847	119,421	8%
Tana River	39,492	0.4	2,485	2,829	344	115,155	29%
Turkana	70,878	1.2	1,510	2,093	583	67,652	6%
Mandera	26,249	2.7	237	372	135	66,346	2%
Kwale	8,365	0.9	248	277	29	56,992	7%
Busia	1,824	1.0	129	130	1	49,285	5%
Wajir	57,118	1.7	619	1,478	859	40,946	2%
Kisumu	2,683	1.2	120	119	-1	38,323	3%

Agricultural and Food Security Exposure to Climate Hazards

Key findings:

Kenya's agriculture spans ~28 million ha, contributes ~20% of GDP directly (with large indirect linkages), and underpins most rural livelihoods; it is highly rain-fed and smallholder-dominated, making it acutely climate-sensitive. Women provide ~75% of agricultural labour—especially in tea, dairy, potatoes, and beans—yet face lower access to land, finance, inputs, storage and cold-chain services. Floods disrupt the petty trade where women predominate, and droughts raise unpaid workloads for water and fuelwood collection, widening productivity gaps and heightening the need for affordable finance, storage, and climate-smart services.

Projected hazards—more very hot days, short-duration intense rainfall/flooding, and recurrent drought—play out differently across the Highlands Food Corridor, Coastal Agro-Pastoral Belt, and Northeastern Pastoral Belt. Maize faces recurrent drought, heat stress at flowering, storm-related lodging and high post-harvest losses; cattle productivity is constrained by heat, rangeland degradation, water scarcity and flood-related disease; potatoes are rising in importance but remain vulnerable to late blight and storage/cold-chain gaps; and tea in the highlands is sensitive to temperature and rainfall shifts and requires targeted adaptation.

National strategies consistently prioritise climate-smart seed and water management, agroecological practices (soil and water conservation, agroforestry, IPM), risk management (early warning, insurance, rangeland and watershed rehabilitation), and post-harvest loss reduction. Priority value chains for follow-on adaptation investment design: Maize, Potatoes, and Cattle.

Agriculture production exposed to climate change

Kenya has a vast agricultural land base, with 28 million hectares designated for farming, which represents over 48% of the country's total land area (Statistica, 2024). As of 2022, Kenya's population was approximately 56.5 million, with 27.9% living in urban centres. The agricultural sector remains a cornerstone of Kenya's economy, contributing directly to 20% to the GDP in 2022 (Central Bank of Kenya, 2023), with other estimates indicating that the economic impact of the sector both directly and indirectly account for about 52% of the GDP if indirect linkages are taken into account (Republic of Kenya, 2015) . It employs over 40% of the overall population and more than 70% of the rural population (Farm to Market Alliance, 2022), although some indicate that the percentage of agriculture-related employment can add to as much as 60% of the total (formal and informal) employment in the country ((Republic of Kenya, 2015). The sector is crucial for Kenya's export economy, generating 65% of export earnings, and supports over 80% of the population through employment, income, and food security (FAO Kenya, n.d.)

The sector is highly vulnerable to climate change, given the predominance of small-scale subsistence cultivation (approximately 80% of farming) (Farm to Market Alliance, 2022) and the extremely high reliance on rainfed irrigation, which represents 98% of agriculture (Republic of Kenya, 2015). Agriculture is very sensitive to shifts in temperature and rainfall; changes in the timing or volume of precipitation have a substantial impact on production (Republic of Kenya, 2015). Production of the main staple food crops – maize, wheat and rice – has typically been below Kenya's consumption requirements, thus contributing to food insecurity (Republic of Kenya, 2015).

Crop

The crops sub-sector is a cornerstone of Kenya's economy, contributing a large share of agricultural GDP and supporting millions of rural households with food, income, and jobs. In 2019, Kenya produced 10.5 million tons of food crops, yet pests, diseases, and weeds caused losses exceeding 30%, and domestic supply still failed to meet demand—necessitating large imports. Maize, grown on 90% of farms, is the principal staple, while beans and potatoes are the most important legume and tuber crops. To ease pressure on maize supply, improve nutrition, and boost employment, the government is promoting crop diversification and its Flour Blending Initiative, which mixes maize and wheat with sorghum, millet, cassava, and sweet potatoes (Agriculture and Food Authority , 2025).

Livestock

The livestock sector is a vital component of Kenya's agricultural economy, contributing significantly to food security, rural livelihoods, and national GDP. It accounts for about 10% of total GDP, supporting approximately 50% of the agricultural labour force. The sector is diverse, encompassing cattle, sheep, goats, camels, pigs, and poultry, as well as emerging enterprises in rabbits, bees, and fish farming. Cattle production dominates, with both dairy and beef contributing to household incomes and national trade. Livestock plays a particularly critical role in the arid and semi-arid lands (ASALs), where it is the primary source of income and nutrition. Challenges include recurrent droughts, animal diseases, limited access to quality feeds and breeding stock, poor infrastructure, and weak market linkages. Opportunities exist in expanding value addition, improving animal health services, and strengthening market access, especially through investment in processing, cold chains, and regional trade (CGIAR, 2023).

Fisheries and aquaculture

Kenya's fisheries resources are found in inland freshwater bodies and the Indian Ocean's Exclusive Economic Zone (EEZ), with inland fisheries managed by ecosystem and marine fisheries by gear, species, and location. The sector contributes about 0.5% of national GDP and 2% of export earnings, employing over 60,000 fishers directly and about 1.2 million people along the value chain.

Inland fisheries, dominated by Lake Victoria (80% of national fish production), produce major species such as omena, Nile perch, and tilapia. Other important sources include Lakes Turkana, Naivasha, and Baringo, as well as rivers and dams. Production is largely artisanal, with environmental degradation, invasive species, illegal fishing, and nutrient runoff contributing to stock decline.

Marine fisheries cover 230,000 km² of territorial waters and EEZ, with production of about 24,709 mt worth KES 4.6 billion from small-scale craft, trawlers, purse seiners, and longliners. Some nearshore species are overfished, while offshore resources (150,000–300,000 mt potential) remain underexploited.

Opportunities exist in expanding marine and Lake Turkana fisheries, reducing post-harvest loss, improving processing and value addition, and investing in handling infrastructure. Fisheries are recognised under Kenya's Vision 2030, SDGs, and Blue Economy agenda as a growth area for food security, poverty reduction, and economic development (Kenya Marine and Fisheries Research Institute, 2020).

Gender considerations in agriculture

Women provide about 75% of labour in Kenya's agriculture (UN Women, 2023), especially in beans, potatoes, tea, and dairy, as well as post-harvest processing and household food security. Despite this central role, they own less than 2% of land (UNDP, 2020) and have limited decision-making power over sales and income from cash crops.

Women's productivity is constrained by unequal access to land, fertiliser, credit, and extension services. Women are more involved in labour-intensive tasks such as harvesting and threshing, while men dominate mechanisation and marketing. Limited access to finance is a key barrier, with microloans often carrying high interest rates of 10–12% per month.

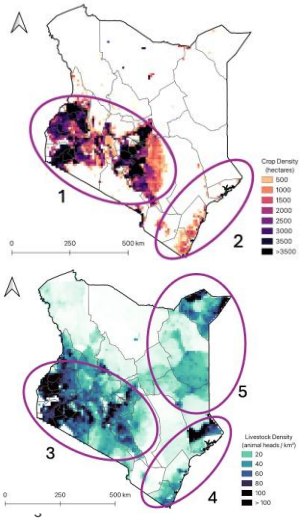
Climate change exacerbates these inequalities: droughts increase women's unpaid workload in water and fuel collection, while floods disrupt local markets where women dominate petty trade. Women are also less likely to receive early warnings and climate information, reducing their ability to adapt in time.

Gender-responsive adaptation in Kenya should focus on affordable post-harvest technologies, women-to-women extension, and targeted financial products. Strengthening cooperatives and producer groups can improve women's access to markets and resources, consistent with Kenya's Climate Change Act (2023) (Government of Kenya, 2023) and Climate-Smart Agriculture Strategy (2017–2026) (Government of Kenya, 2017).

Climate impact at key agriculture production zones

Major crop and livestock production areas.[2]

Kenya's agriculture is concentrated in three broad production zones. The Highlands Food Corridor (western and central highlands) is the main food basket, dominated by rain-fed maize, beans, potatoes, alongside tea and significant dairy/livestock. The Coastal Agro-Pastoral Belt supports mixed cropping and livestock—cassava, rice, bananas and tree crops such as cashew—linked to humid coastal conditions and peri-urban markets. The Northeastern Pastoral Belt is primarily livestock-based—cattle, goats, sheep—with sparse, drought-tolerant cropping, reflecting its hot, arid climate and mobile pastoral systems.



1. **Highlands Food Corridor** – *Maize, beans, banana*
2. **Coastal Agro-Pastoral Belt** – *Banana, maize, cassava*

3. **Highlands Food Corridor** – *Chicken, cattle, goats*
4. **Coastal Agro-Pastoral Belt** – *Goats, sheep, chicken*
5. **Northeastern Pastoral Belt** – *Goats, sheep, cattle*

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

Source: IFPRI -CGIAR, Spacial Production Allocation Model, Lobelia Analysis

Figure 10. Major crop and livestock production areas, with indication of key commodities

This section synthesises climate risks across these zones. The Highlands are projected to warm the most overall yet remain generally below very-hot thresholds (>35 °C); risks are driven by wet extremes and intermittent drought, giving medium impacts on maize, beans, banana and medium risks for cattle/chicken (disease, pasture/housing), while goats remain low. The Coastal Belt is projected to face the strongest heat and heaviest downpours, yielding high impacts on maize (heat sterility, lodging, aflatoxin) and on cattle/chicken (heat stress, flood and vector pressure); cassava, banana, goats, sheep are medium due to waterlogging and storm-related disease. The Northeastern Pastoral Belt remains the

[2] The density of crop production was displayed in Figure 10, 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, reflecting patterns shaped by climate, soils, topography, and proximity to markets. The mapping 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 overview, 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 datasets. While smaller clusters of peri-urban agriculture exist near major cities such as Nairobi and Kisumu, this analysis focuses primarily on the larger cropping regions that constitute Kenya's agricultural backbone.

Building on the spatial patterns of cropland density, livestock distribution maps reveal complementary zones of animal production. Some interact closely with cropping systems, while other pastoral regions emerge in areas with little crop production. The distribution of livestock across Kenya was shown in **Error! Reference source not found.**, 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. From this national-scale perspective, three 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.

hottest and driest, with episodic Tana River flooding: cattle are high impact (heat/water scarcity, post-flood disease), sheep medium, and goats low (most resilient).

Highlands Food Corridor

The broad belt of high agricultural activity across Kenya's western, central and eastern highlands—including counties such as Bungoma, Busia, Kakamega, Vihiga, Migori, Uasin Gishu, Nakuru, Nyandarua, Murang'a, Kiambu, Machakos, Meru, Embu, and Makueni—is defined by elevated terrain, fertile soils and bimodal high rainfall, supporting dense rural populations engaged in both subsistence and commercial farming. Western highlands tend to feature smaller, densely populated farms, while the central/eastern highlands—especially around Nairobi and Mount Kenya—are more commercially integrated with larger market linkages and greater diversification. Despite these differences, agro-ecological conditions and farming systems are sufficiently similar to treat the area as one major region with sub-regional distinctions. By production value, the leading crops are maize, beans, banana and sugarcane.

This corridor overlaps the country's most intensive mixed crop–livestock systems, with dairy and beef cattle, goats, sheep and poultry integrated into smallholder farms across counties such as Bungoma, Uasin Gishu, Nakuru, Murang'a, Kiambu, Meru, and others. Favourable terrain, reliable rainfall, fertile soils and strong market links to major cities underpin commercialisation and year-round supply chains. Livestock is central to household livelihoods—complementing crops, stabilising income, and supporting food security—making this region the core of Kenya's smallholder livestock sector and its most commercialised production systems. By herd/flock size, the leading livestock commodities are chicken, cattle and goats.

Climate impacts to agriculture production in the Albertine Highlands

The region is projected to warm the most nationally (up to +2.4 °C), but extreme heat is not projected to be the dominant hazard, with virtually no days >35 °C. Drought events are projected to occur at moderate–severe levels even though mean annual rainfall remains relatively stable. Extreme precipitation is projected to remain a key hazard, with strong spatial variability and >100 mm single-day events in places. Extreme wind is projected to stay localised (topography-driven) with little change.

Wet extremes and intermittent drought are the main pressures. Maize (IE: *Medium*) experiences yield losses from waterlogging, erosion and wet-season diseases, with drying remaining a recurring constraint. Beans (M) are sensitive to cool, wet disease pressure and short droughts at flowering. Banana (M) is affected by storm damage and saturated soils on slopes. Cattle and chicken (both M) face rain-related housing/pasture stress and disease spikes, while goats (Low) are comparatively tolerant; terrain, rather than climate, is often the limiting factor.

Coastal Agro-Pastoral Belt

The coastal provinces of Kwale, Mombasa, and Kilifi form a distinct agricultural zone shaped by low altitude, a warm–humid oceanic climate, and proximity to the Indian Ocean. The zone extends north along the coast, though crop productivity is highest in the south. Rainfall is more variable and soils are predominantly sandy, so cultivation clusters around river valleys and peri-urban areas rather than being uniformly spread. While less intensively farmed and less densely populated than the highlands, this area supplies important food and cash crops to coastal communities and urban markets; by production value, the leading crops are banana, maize, and cassava.

Widening to the adjacent northern coast and inland fringe—including southern Garissa—the coastal band functions as an agro-pastoral region. Crop cultivation remains densest in the southern segment, whereas livestock activity concentrates toward the northern coast and interior countryside. Systems here combine smallholder cropping with extensive livestock rearing—notably cattle, goats, sheep, and camels—and adapt to seasonal rainfall variability through pastoral mobility that accesses grazing along the coast and

into the semi-arid interior. This mix bridges humid coastal agriculture with semi-arid pastoral livelihoods; by herd/flock size, the leading livestock commodities are goats, sheep, and chicken.

Climate impacts to agriculture production in the Coastal Agro-Pastoral Belt

Extreme heat is projected to be a major issue, with maxima >40 °C, temperature increases of +3–4 °C, and well over 200 days >35 °C in some areas. Dry conditions are projected to rise to moderate levels, while average annual rainfall stays relatively high. Extreme rainfall is projected to be the highest nationally, with localised cloudbursts up to ~200 mm/day and very wet coastal maxima exceeding ~390 mm. Coastal winds are projected to remain around ~20 m/s with little change, and river flooding is projected to remain important, especially along the northern coast and in Mombasa.

This zone combines the strongest heat with the country's heaviest downpours. Maize (H) is the most impacted—heat at flowering causes sterility and cloudbursts lead to lodging and higher aflatoxin risk. Cattle and chicken (both H) are stressed by long hot seasons, storm/flood damage, water shortages and elevated vector-borne disease. Cassava (M) is generally resilient but vulnerable to waterlogging and storm damage; banana (M) suffers windthrow and humidity-driven disease, and goats/sheep (both M) cope better with heat yet face parasites, hoof/respiratory issues and feed disruption after wet spells.

Northeastern Pastoral Belt

This zone encompasses northeastern Kenya, including Mandera, Wajir, northern Garissa, Isiolo, and surrounding arid and semi-arid counties. It is Kenya's most extensive pastoral area, dominated by livestock rearing systems that rely on mobility, communal grazing lands, and sparse water sources. Key species are camels, goats, sheep, and cattle adapted to arid conditions. The belt functions as a vital hub for livestock trade and cross-border pastoralism, linking Kenya to neighbouring Somalia and Ethiopia. Despite harsh environmental conditions, pastoral livelihoods persist as culturally and economically central to the region's inhabitants. In order of importance by size (number of animals), the most important livestock commodities are goats, sheep and cattle.

Climate impacts to agriculture production in the Coastal Agro-Pastoral Belt

This is the country's hottest zone, with 43–45 °C peaks projected to persist and increase by ~+2 °C, bringing more years with frequent days >35 °C. Baseline aridity is projected to continue (<600 mm/yr, locally <200 mm), though annual totals may improve slightly. While less intense than in other regions, extreme rainfall is projected to increase (up to ~40% under high-emissions scenarios), with local maxima >75 mm/day and near 200 mm in some events. Winds are projected to approach ~22 m/s, and river flooding is projected to remain a major risk along the Tana River system (notably Garissa and Isiolo).

The hottest, driest region with episodic Tana River flooding chiefly impacts livestock. Cattle (H) face severe heat and water scarcity that depress milk and fertility, with disease outbreaks after floods. Sheep (M) are sensitive to heat and feed gaps and to hoof/respiratory disease in wet episodes. Goats (L) are the most resilient due to browse-based diets and heat tolerance, though prolonged drought or post-flood disease can still reduce productivity.

Table 3: Climate trends and impacted value chains in Kenya.

Region	Projected climate trends	Food value chains impacted	I
Highlands Food Corridor (livestock and cropland)	While **extreme heat** is not the most significant hazard (virtually no days >35°C), the increase of extreme temperatures in this region will be the largest in the country (up to +2.4 °C). **Dry conditions** in this area remain relatively safe (in annual rainfall), but future drought events will typically reach moderate severity.	Maize - Limited heat stress but vulnerable to waterlogging/erosion and fungal disease in heavy rains; intermittent dry spells may reduce yields; post-harvest drying is a recurring issue.	M
		Potatoes – Limited heat stress but vulnerable to water stress, particularly on drought; extreme precipitation can lead to	M

	Extreme precipitation is a major hazard nationwide. This area, however, shows significant spatial variability, with extremes >100 mm. **Extreme wind** remains very localised and linked to the topography. Little future change is expected.	waterlogging damage and disease pressure;post-harvest drying is a recurring issue and higher temperatures need accelerated sprouting with shortened storage duration.	
		Beans - Sensitive to wet, cool disease pressure and to short droughts during flowering.	M
		Banana - Generally suitable temperatures; risks from storm damage and saturated soils	L
		Chicken - Mild climate; main risks are rain-related housing damage and disease spikes in wet periods.	L
		Cattle - Moderate droughts affect pasture and water; humid seasons elevate tick-borne disease	M
		Goats - Good tolerance to moderate drought and terrain; limited heat stress.	L
Coastal Agro-Pastoral Belt (livestock and cropland)	**Extreme heat** is an important hazards with maxima over 40ºC. Projection show a considerable increase to 43-44ºC and well over 200 days >35ºC. **Dry conditions** (as drought events) will increase to moderate levels, while the average yearly rainfall will remain stable and with relatively high values. **Extreme precipitation** is highest in this region, with localised extremes of up to 200 mm. Conditions will worsen in the future with maxima surpassing 300 mm. **Extreme wind** is consistent through this region with maxima at around 20 m/s. Little change is expected in the future. **River flooding** will be an important hazard, particularly in the northern coast and Mombassa.	Banana - Susceptible to windthrow and waterlogging; heat and humidity intensify foliar diseases, reducing bunch size and quality.	H
		Maize - Heat at flowering and prolonged hot spells cause sterility; cloudbursts drive lodging and harvest losses; high humidity increases aflatoxin risk.	H
		Cassava - Heat- and drought-tolerant, but waterlogging and storm damage raise rot/disease risks	M
		Goats - Heat tolerance, but floods/wet spells lead to parasites and feed disruption.	M
		Sheep - Less heat-tolerant than goats; foot problems and infections rise in humid/flooded conditions.	M
		Chicken - Long hot season increases mortality without cooling; storms damage housing; wet spells raise disease and feed spoilage.	H
Northeastern Pastoral Belt	**Extreme heat** in this region is the most extreme in the country (43-45ºC), with a projected increase of up to +2ºC and future years with most days surpassing 35ºC. **Dry conditions** in terms of annual rainfall are historically the most severe in the country (< 600 mm, with places showing <200 mm). However,	Goats - Most resilient in arid rangelands (browse diet, heat tolerance), though prolonged drought and post-flood disease can still cut productivity.	L
		Sheep - Sensitive to heat and feed gaps; hoof and respiratory diseases increase after wet spikes.	M

	annual rainfall is expected to improve in the future. While **extreme precipitation** is smaller than the other regions, maxima still exceed 75 mm in most places. This hazard is expected to increase by up to 40% (RCP8.5) and localized maxima may reach nearly 200 mm. **Extreme wind** is larger in the south of this region at 20 m/s. Future conditions may push maxima to just under 22 m/s. **River flooding** is an important risk (particularly in Tana River, Garissa and Isiolo, with increasing risk expected in the future.	Cattle - Severe heat and water scarcity depress milk and fertility; long trekking distances to water; disease outbreaks after episodic floods.	H

Priority Value Chains

Food value chains 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.

Projected hazards include more hot days, short-duration intense rainfall and flooding, and recurrent drought, with regional contrasts between the Highlands, Coastal belt, and Northeastern pastoral zones. The most affected value chains are maize and cattle: maize faces recurrent drought, heat stress at flowering, storm-related lodging and high post-harvest losses—compounded by Fall Armyworm—while cattle productivity is constrained by heat stress, rangeland degradation, water scarcity, and disease outbreaks during and after floods. Potatoes are increasingly important for urban diets but are vulnerable to late blight, wet-season losses, and cold-chain gaps. Tea—concentrated in highland zones—remains highly sensitive to temperature and rainfall shifts affecting quality and yields, requiring targeted climate adaptation to remain competitive. Complementary chains—bananas and beans—add dietary diversity and resilience but need stronger disease surveillance and seed systems.

Kenya's food system is anchored by four priority value chains, **maize, tea, potatoes, and cattle**, that together balance food security, affordability, resilience, and export earnings. Maize remains the dominant staple and requires improved post-harvest management and climate-smart agronomy to reduce losses and manage pests. Tea underpins rural incomes and export revenues but needs adaptation (shade, varieties, water management) and value-addition to sustain competitiveness. Potatoes have become a key staple in urban diets, yet price volatility, disease pressure, and storage constraints point to investments in certified seed systems, warehousing, and blight control. Cattle are indispensable for pastoral livelihoods and national nutrition; productivity is limited by drought, grazing pressure, and animal-health risks, highlighting stronger veterinary services, water points, and rangeland management. By contrast, sugar cane and cut flowers play important economic roles but have limited direct food-security impact; bananas and beans support diet quality and resilience, while needing better seed and disease management.

Kenya's priority value chains - tea, cattle, maize, and potatoes - are strongly gendered. Women dominate labour in tea and dairy but have limited control over income, while their work in beans and potatoes is undervalued despite its food security importance. Gender-responsive planning should ensure women's

access to finance, extension, and post-harvest technologies. This aligns with Kenya's Climate Change Act (amended 2023) (Government of Kenya, 2023) and Climate-Smart Agriculture Strategy (2017–2026) (Government of Kenya, 2017), both of which mandate gender integration.

Across Kenya's recent strategies—the Second NDC (2031–2035), National Agricultural Mechanization Policy (2024), Postharvest Management Strategy (2024–2028), National Agroecology Strategy (2024–2033), NDMA Strategic Plan (2023–2027), MECCF Strategic Plan (2023–2027), NCCAP III (2023–2027), and the CSA Strategy (2017–2026)—there is clear convergence on crops, livestock, and fisheries/aquaculture as priority arenas for adaptation. Core solution families recur: climate-smart agriculture (resilient seeds, water-efficient irrigation), agroecological practices (soil/water conservation, agroforestry, IPM), and risk management (early warning/anticipatory action, insurance, rangeland and watershed rehabilitation). On value chains, maize is specifically targeted for post-harvest loss reduction, while tea, coffee, and edible oils are prioritised for financed transition under the agroecology strategy—collectively pushing a consistent agenda to reduce losses, de-risk rain-fed systems, and build resilience and productivity at national and county levels.

Drawing on the screening, expert calibration, and policy alignment described above, the priority food value chains for follow-on adaptation investment design in Kenya are Maize, Potatoes, and Cattle.

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

Commodity	Food Security Contribution	Affordability	Resilience	Other considerations
Tea	Non-staple; Kenya's top agricultural export (16.6% of total exports) — income for smallholders (World Bank)	Minimal direct effect on staple food basket/prices (KNBS FBS)	High climate sensitivity (temperature & rainfall shifts in tea-growing highlands) (World Bank Climate)	Export standards & market access critical; value addition opportunities (World Bank)
Cut Flowers	Non-food export; important foreign exchange earner supporting rural employment ($817M in 2023) (World Bank, OEC)	No direct role in staple food affordability (KNBS FBS)	High water use; Lake Naivasha nutrient/pollution concerns; climate risks (UNEP)	Needed compliance with phytosanitary standards; logistics & cold-chain key (World Bank)
Maize	Primary staple; prices elevated in 2025 on tight availability — 2025 long-rains were up to ~40% above the long-term average in key 'maize basket' counties (FAO GIEWS)	Maize meal central to household food basket; price spikes reduce access Maize prices rose ~17 in key markets; in marginal areas ~30% higher YoY in April 2025 (FAO GIEWS)	Drought & Fall Armyworm risks to yields (FAO FAW); (World Bank Climate)	Post-harvest loss an issue, but reduction prioritized nationally (Kenya Postharvest Strategy)
Sugar Cane	Limited direct contribution to calorie security (non-staple) (KNBS FBS)	Indirect via sugar prices; not core to staple basket (KNBS FBS)	Water/heat stress exposure in lowlands (World Bank Climate)	Milling efficiency & outgrower schemes affect competitiveness (WB)
Bananas	Commonly consumed (28kg/capita in 2018); complements maize in diets (KNBS FBS)	Prices vary seasonally with supply (FAO GIEWS)	Pest/disease risks incl. Fusarium TR4 threat; climate variability (FAO TR4)	Post-harvest handling & disease surveillance constraints (FAO TR4)
Potatoes	Second most important food crop after maize (25kg/capita in 2022); key urban staple (Kenya Potato Strategy)	Some price volatility but more stability that other crops linked to more stable	Late blight & climate risks constrain yields (FAO Newsroom)	Seed quality & storage investments have been prioritisied to reduce losses (Kenya Postharvest Strategy)

		production (FAO Newsroom)		
Cattle	Animal-source foods & incomes; critical in ASALs (World Bank Climate)	Feed & maize price linkages affect meat/dairy prices (FAO GIEWS)	High drought and disease vulnerability; need rangeland mgmt (World Bank Climate)	Animal health services & market access constraints (World Bank)
Beans	Key protein staple with maize in diets (16kg/capita in 2018) (KNBS FBS)	Prices influenced by seasonal supply; important for affordability (FAO GIEWS)	Improves soils via nitrogen fixation; drought-tolerant varieties exist (World Bank Climate)	Yields remain low (often <1 t/ha compared to a potential of 2–3 t/ha) (CGIAR)

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

Kenya's Agricultural Sector Transformation and Growth Strategy (2019-2029). The strategy describes nine chore anchor initiatives that the Kenyan government put in place to transform the country's agricultural sector and make it a regional powerhouse. Among these initiatives, the strategies focuses on increasing small-scale farmer, pastoralist and fisherfolk incomes through stimulating farmer-facing SMEs activity, and focus farming households access to different inputs; increase agricultural output and value addition through establishing large-scale agro-processing hubs, scale sustainable water supply from already existing irrigation infrastructure, and boost household food resilience through the restructuring of the Strategic Food Reserve's operations and focus on community-driven interventions in arid and semi-arid lands. These initiatives will be further strengthened through a series of enabling activities, such as capacity building activities within the government and youth-led and digitally enabled extension programs, strengthen research and innovation and the best use of data for agricultural decisions, alongside closer monitoring of the impacts of climate to agricultural production, and crisis management for pests, diseases and global price shocks.
Kenya's Second Nationally Determined Contribution (2031–2035). The NDC positions adaptation across climate-sensitive sectors and links energy sector reforms to enabling climate-smart agriculture and resilience in vulnerable sectors. It underscores agriculture's macroeconomic role while framing adaptation as a whole-of-government, whole-of-society effort with stronger tracking of results.
National Agricultural Mechanization Policy (March 2024). The policy targets mechanization along agricultural value chains across crops, livestock, and fisheries/aquaculture, with interventions to expand access, quality assurance, research, training, and services. It explicitly connects mechanization to climate-smart agriculture and backs measures for drought and flood adaptation/mitigation, anchoring resilience in land and water management and appropriate technologies.
Kenya Postharvest Management Strategy for Food Loss and Waste Reduction (2024–2028). The strategy pivots to reducing losses along priority chains (using maize as a worked example), with diagnostics at critical loss points and solution sets across micro/meso/macro levels. The emphasis is coordinated, multi-actor implementation that improves food availability and incomes by cutting losses rather than expanding production.
National Agroecology Strategy for Food System Transformation (2024–2033). Agroecology is adopted as the pathway for resilient, sustainable production across crops, livestock, and fisheries. The strategy signals priority value chains (e.g., tea, coffee, edible oils) for resourced transition and promotes practice bundles—soil and water conservation, agroforestry, regenerative/organic methods, and IPM—under national–county coordination.
NDMA Strategic Plan (2023–2027). The plan's goal is enhanced drought resilience and climate change adaptation, via early warning/early action, preparedness, response and recovery, and institution-building, especially in ASALs. For agri-food systems, it focuses on risk reduction, anticipatory action, and faster recovery to protect livelihoods.
Ministry of Environment, Climate Change & Forestry Strategic Plan (2023–2027). The plan establishes agroforestry and commercial forestry development as a key result area and outlines climate change adaptation and mitigation functions - coordination of national climate action and reporting, awareness/capacity building for local climate action, enabling access to implementation resources, and strengthening meteorological services.

Climate Adaptation Solutions

Key findings:

Kenya's food system faces acute climate risks as hotter and longer dry spells, flash floods, and shifting pest and disease pressures disrupt its most strategic value chains. Maize, the national staple, is increasingly exposed to heat stress, drought, and aflatoxin contamination, while potatoes suffer from waterlogging, disease outbreaks, and storage challenges. Tea, the country's top export earner, is squeezed by changing rainfall and temperature thresholds, directly affecting smallholder incomes and foreign exchange. Livestock systems, particularly cattle, face fertility decline, feed shortages, and disease outbreaks under worsening drought–flood cycles. These pressures hit women hardest, as they dominate post-harvest handling, small-scale dairy, and poultry production, sectors where climate risks are most severe. The adaptation agenda is therefore centered on protecting cereals, stabilizing livestock systems, safeguarding post-harvest stages, and ensuring women's participation in resilience-building solutions.

From these needs, five priority solutions stand out as both urgent and commercially scalable: (1) digital information platforms delivering weather, pest, and market advisories; (2) hermetic storage systems to cut post-harvest losses and aflatoxin risks; (3) climate-resilient fodder varieties to stabilize cattle productivity; (4) solar drying systems to extend shelf life of potatoes and horticulture while creating women-led enterprise opportunities; and (5) solar-powered irrigation to buffer maize and potato systems against drought. These solutions are already piloted in Kenya, supported by strong institutions and private distributors, and designed for delivery through cooperatives, agro-dealers, and pay-as-you-go financing. Together, they align adaptation imperatives with investable opportunities, offering clear entry points to mobilize private finance while enhancing resilience across Kenya's most critical value chains.

Adaptation Needs, Themes, and Prioritization of Solutions

Adaptation Needs in Kenya's Climate Value Chain

Kenya's agricultural system sits at the intersection of high climate exposure and critical food security dependencies. The hazard analysis showed a country marked by rising extremes: hotter and longer dry spells in the ASALs, flash floods and waterlogging in highland and coastal counties, and new disease and pest pressures triggered by climate variability. On their own, these hazards paint a challenging picture; but when layered onto Kenya's food system, they define an acute **adaptation need**, the areas where climate risks directly undermine the productivity, stability, and viability of the crops and livestock that matter most for food security, livelihoods, and exports.

This adaptation need is most visible in Kenya's **priority value chains**. Maize, the national staple, faces mounting risks from heat stress at flowering, drought-driven yield losses, and aflatoxin contamination after heavy rains. Potatoes, critical for urban diets, are increasingly vulnerable to post-harvest losses and disease outbreaks tied to shifting rainfall and warmer storage conditions. Tea, the leading export earner, is squeezed by changing rainfall and temperature thresholds in its highland zones, with direct implications for smallholder incomes and foreign exchange. Cattle, which underpin rural nutrition and pastoral livelihoods, are at risk from heat-induced fertility decline, prolonged water scarcity, and heightened disease incidence during floods. Together, these vulnerabilities define where adaptation is not just desirable but urgent.

Recognizing this adaptation need is a critical first step, but not the full story. For GCA and its partners, prioritizing solutions also requires assessing **commercial readiness**, whether interventions are tangible, financeable, and capable of being deployed at scale through existing borrower systems and financial institutions. The next sections therefore build on this dual lens. First, we outline the broader adaptation themes that capture Kenya's resilience priorities, and then we filter these through a commercial readiness lens to highlight the specific products and services that stand out as investable, scalable opportunities.

Adaptation Themes for Kenya

Translating Kenya's adaptation needs into practical solutions requires focusing on the areas where interventions can make the greatest difference. From the long list of potential options, a smaller set of themes emerges as most relevant once considered against the country's hazard profile, its priority value chains, and the objective of identifying solutions that banks and MFIs can realistically finance.

The priority hazards, **extreme heat, drought, intense rainfall, and flooding**, intersect most severely with **maize, potatoes, and cattle**. For maize, the urgent needs are protecting yields from heat stress at flowering, reducing aflatoxin contamination under hot and humid conditions, and cutting post-harvest losses from excess moisture. In the potato sector, the pressures are waterlogging, blight and other disease risks, and the lack of cost-effective storage to stabilize supply in urban markets. For cattle, prolonged droughts and water scarcity reduce milk yields and fertility, while episodic floods accelerate disease outbreaks and degrade grazing lands. These climate pressures point to thematic areas such as storage and post-harvest systems, livestock feed and health interventions, irrigation and water management, and digital advisory platforms that can help farmers adapt in tangible and financeable ways. They also reveal important **gender dimensions**, since women farmers and workers are often concentrated in post-harvest handling, small-scale dairy, and poultry production — the very parts of the system where climate risk is acute.

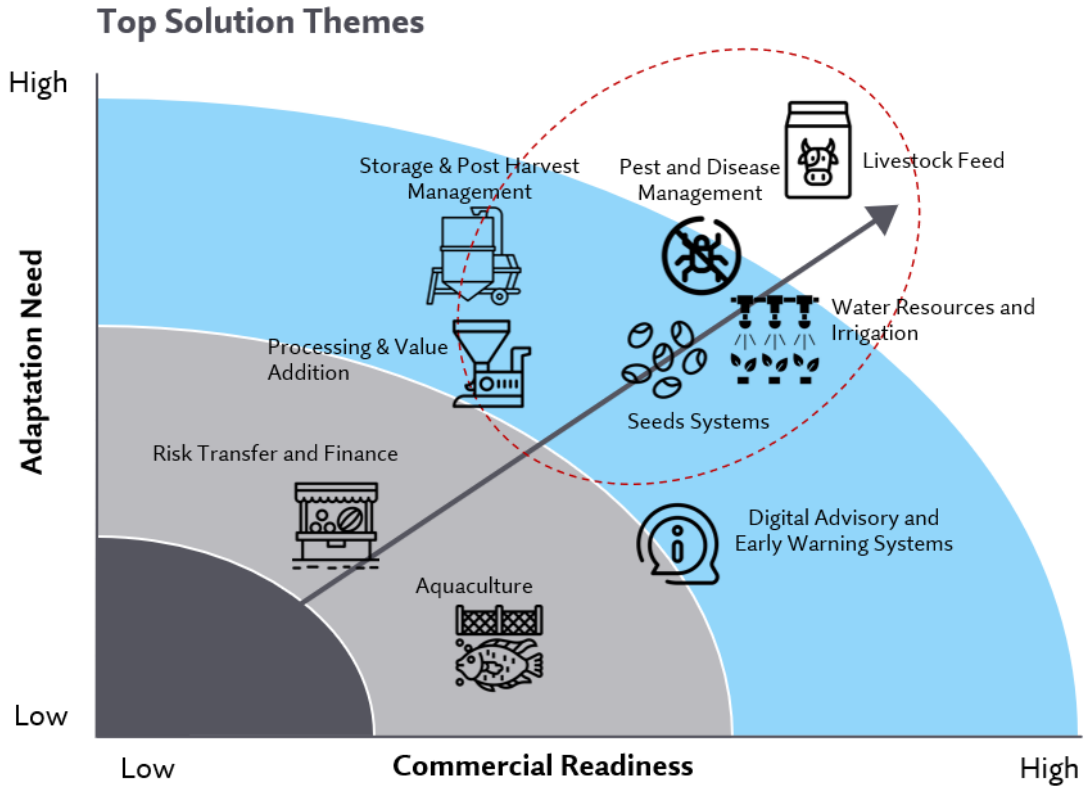


Figure 11. Priority adaptation themes in Kenya.

At the same time, adaptation priorities must also be understood through a commercial lens. Many interventions show strong agronomic benefits but do not easily translate into investable opportunities. Kenya's adaptation pathway therefore hinges on identifying themes where **adaptation need and commercial readiness overlap**, and where the design of solutions can explicitly address women's roles, labour burdens, and access gaps. Out of the broader pool of solution categories, five themes stand out as the most urgent for Kenya today:

- **Digital Advisory and Early Warning Systems:** With farmers operating across diverse agro-ecological zones, timely and location-specific weather, pest, and market information is indispensable. Platforms such as DigiFarm, One Acre Fund's digital extension, and ILRI's herd

health tools are already in use. These services can be scaled in ways that deliberately include women, for example through voice-based services or delivery via women's cooperatives, overcoming literacy and access barriers.

- Storage and Post-Harvest Management: Hermetic storage and solar drying systems directly target high post-harvest losses in maize and potato chains, where aflatoxin contamination and wet-season spoilage are costly. Since women perform much of the drying, sorting, and small-scale storage, these technologies are particularly empowering when made affordable, reducing food losses and labour time. Kenya's Postharvest Strategy backs these technologies, and commercial models already show willingness to pay.
- Water Resources and Irrigation: Solar-powered irrigation and small-scale water harvesting are central to managing drought for maize and potatoes and sustaining cattle in ASALs. Kenya has seen growth in pay-as-you-go irrigation kits and MFI-linked finance, though women still face barriers to uptake due to limited collateral. Targeting women's groups for access can make this theme both more inclusive and more impactful.
- Livestock Feed: Improved fodder systems and resilient forage varieties bridge feed gaps in dry spells, raising dairy yields and pastoral resilience. These solutions also reduce women's workload, as they are often responsible for fetching feed and water for small herds. ILRI and seed companies have already demonstrated commercial feasibility in Kenya.
- Processing and Value Addition: Solar dryers and small-scale processing expand incomes and stabilize supplies in potato and maize value chains. These solutions also create opportunities for women, who are heavily engaged in informal food processing and petty trade but often excluded from larger value-addition investments. Supporting affordable, small-scale processing technologies can expand women's participation and income.

Other themes were considered but not elevated at this stage for Kenya. Seed systems, for example, are vital for resilience but remain largely donor-driven with weak private delivery capacity. Risk transfer mechanisms such as weather index insurance remain strategically important but face persistent barriers to scale due to trust gaps and basis risk. Protected cultivation solutions, like hydroponics or shade nets, are growing but remain niche, concentrated among higher-income producers. These areas remain relevant for Kenya's long-term resilience, but the immediate priority lies with themes that combine adaptation need, commercial readiness, and gender-responsive impact.

Climate Smart Agriculture Practice vs Products and Service Based Adaptation Solutions

Climate-smart agriculture (CSA) practices have long formed the backbone of resilience strategies in Kenya. Techniques such as conservation tillage in the highland maize, potato systems, intercropping beans with maize in semi-arid zones, and agroforestry practices along the Coastal Belt help stabilize yields, improve soil fertility, and reduce vulnerability to rainfall variability. Kenya's CSA Investment Plan (World Bank & CIAT, 2015) and more recent policy strategies highlight these approaches as essential to smallholder adaptation. For example, integrated soil fertility management and water harvesting are already being promoted through county-level agricultural programs, while NGOs and extension services support adoption of improved pasture management in arid rangelands. These interventions are proven agronomically and remain indispensable for long-term climate resilience.

Yet despite their importance, CSA practices face a critical limitation in this project's context: they do not generate clear, financeable entry points for banks or MFIs. Their benefits, higher yields, better soil health, improved resilience, are real but diffuse, highly context-specific, and incremental. A farmer's decision to mulch or rotate crops rarely creates a discrete investment case that a bank can underwrite, unlike the purchase of a solar irrigation kit, hermetic storage bag, or digital advisory subscription. This makes it difficult for lenders to structure loans or design financial products directly around CSA adoption, even though the practices themselves remain central to climate adaptation.

Gender dimensions reinforce this distinction. Women farmers in Kenya are often the first to adopt CSA practices, such as tarpaulin drying, mulching, or water harvesting, because they reduce labour burdens and secure household food. Yet women face systemic barriers to finance: limited land rights, restricted collateral, and high credit costs. CSA adoption alone does not bridge these constraints. By contrast, gender-inclusive products and services, like affordable hermetic bags, pay-as-you-go solar irrigation, or bundled climate insurance, create clearer business cases while directly addressing women's needs. These solutions can be scaled through women's cooperatives or savings groups, combining financial inclusion with resilience.

For this reason, while we acknowledge and have collated the most effective CSA explored in Annex 5 Kenya for GCA's future consideration, the present report focuses on products and services with a clearer investable proposition. These are tangible, financeable solutions that can be scaled through banks and MFIs, while still complementing and reinforcing CSA practices on the ground. In this way, CSA remains the foundation of resilience, but technologies, products, and services provide the commercial entry points needed to mobilize private finance at scale while reinforcing adaptive practices already in use by Kenya's smallholders.

Prioritization of Adaptation Solutions

With Kenya's adaptation needs and thematic priorities established, the next step was to identify specific product- and service-based solutions that are both responsive to the country's climate risks and investable from a financial institution's perspective. From the long list of over 50 candidate solutions, we applied a multi-criteria assessment (MCA) that evaluated each option against a set of dimensions: technical maturity and delivery readiness, borrower fit (smallholder farmers, cooperatives, agri-SMEs, and women), gender responsiveness, productivity and livelihood impact, and alignment with national policy and institutional priorities. This scoring process was supported by expert validation and grounded in Kenya's hazard–value chain context, ensuring that the solutions most relevant to maize, potatoes, cattle, and tea rose to the top.

The analysis revealed that not all interventions with strong agronomic benefits could be translated into bankable opportunities. Solutions like conservation tillage or agroforestry remain vital for long-term resilience but do not generate discrete, financeable cashflows that banks can underwrite. By contrast, tangible products and services with clear payback horizons—such as storage infrastructure, irrigation technologies, or digital platforms—demonstrated the strongest potential to deliver resilience benefits at scale while also attracting private finance. In this way, the prioritization balanced *adaptation need* with *commercial readiness*, aligning GCA's mandate of mobilizing capital through banks and MFIs with Kenya's most pressing food system vulnerabilities.

Through this process, five solutions emerged as priority candidates for Kenya:

- Digital Information Platforms: offers climate, pest, and market advisory tailored to smallholders and pastoralists, with proven uptake through platforms like DigiFarm.
- Hermetic Storage Systems: critical for reducing maize and potato post-harvest losses and minimizing aflatoxin contamination, already commercialized via private distributors.
- Climate-Resilient Fodder Varieties: bridges feed gaps during prolonged droughts to stabilize cattle productivity and rural incomes, supported by ILRI-led seed initiatives.
- Solar Drying Systems: extends shelf life and reducing waste in perishable crops such as potatoes and horticulture, while creating opportunities for women-led microenterprises.
- Solar-Powered Irrigation Systems: mitigates drought and heat stress in maize and potato systems, with demonstrated uptake through pay-as-you-go financing models.

Together, these five solutions represent the intersection of Kenya's most urgent climate risks, the vulnerabilities of its priority value chains, and the requirements of financial institutions seeking investable opportunities. They are not exhaustive of all possible interventions, but they capture where Kenya's

adaptation need and commercial readiness most strongly converge. The following section explores each solution in greater depth, outlining its relevance, evidence of commercialization, gender lens, and areas for further testing in subsequent project phases.

Deep Dive on Priority Solutions

1. Digital Climate Advisory Services

Adaptation Challenge

Kenyan farmers face high exposure to climate variability: recurrent droughts in ASALs, flash floods in highland and coastal areas, and unpredictable rainfall patterns that disrupt planting and harvesting calendars. Limited access to timely, localized, and actionable climate information leaves smallholders unable to anticipate hazards or adjust practices, exacerbating yield losses. For instance, delayed planting decisions due to late rainfall forecasts have contributed to maize yield reductions of up to **20–30% in drought years** (FAO, 2022). Post-harvest losses are similarly worsened when farmers lack real-time guidance on drying and storage during wet spells.

Relevance to Value Chains

DCAS directly addresses climate risks in Kenya's priority value chains:

- **Maize**: seasonal planting advice, aflatoxin risk alerts during humid conditions, market price advisories.
- **Potatoes**: weather-based disease early warnings (late blight) and harvest timing.
- **Cattle**: drought/flood early warnings for pasture and water availability; herd health alerts.
- **Tea**: rainfall variability forecasts to optimize irrigation and reduce quality losses. This cross-cutting relevance makes DCAS a high-leverage adaptation solution spanning both crop and livestock systems.

Technical Maturity & Local Delivery Readiness

Kenya is one of Africa's most advanced markets for DCAS. Platforms such as **DigiFarm (Safaricom)**, **One Acre Fund's digital extension services**, and ILRI's **AfriScout grazing maps** have reached **over 3 million smallholders combined** (World Bank, 2023). Mobile penetration is relatively high (65% smartphone access; 90% GSM coverage), and M-Pesa integration supports scalable payment systems. However, localized accuracy of weather data and extension capacity remain bottlenecks. Partnerships with **KMD (Kenya Meteorological Department)**, CGIAR centers, and private agri-tech start-ups are improving downscaled forecasts and integration with insurance and input supply.

Productivity Increase

Evidence shows that DCAS can raise yields and incomes by **15–25%** when bundled with inputs or finance (GSMA AgriTech, 2021). For maize and potato farmers, tailored planting calendars and pest advisories reduce crop failures and optimize input use. In livestock, early drought warnings support timely destocking and restocking, mitigating income shocks. By reducing losses and stabilizing output, DCAS contribute directly to national food security and smoother supply chains.

Gender Inclusion

Women farmers, who represent ~**75% of Kenya's agricultural labor**, face systemic barriers to extension services (only ~20% of women access public extension agents). DCAS can close this gap by providing direct-to-phone access to weather forecasts, market prices, and agronomic tips. Evidence from **GSMA (2022)** shows that women in Kenya are 10–15% less likely than men to own smartphones, but community-based models (shared phones, women's groups, USSD delivery) improve inclusion. Gender-

intentional design (e.g., using audio/vernacular languages, integrating women's savings groups) enhances uptake. Solutions like **FarmDrive** and **Digital Green** have specifically targeted women with bundled advisory finance services.

Relevance to Borrowers

For **smallholder farmers**, DCAS reduce risk and uncertainty in decision-making. For **cooperatives and agri-SMEs**, they provide aggregated market intelligence and disease alerts that improve collective storage, marketing, and procurement strategies. For **women**, DCAS lower information barriers and allow participation without needing physical extension visits. From a lender's perspective, digital platforms also generate data trails on farmer behavior, which improve credit scoring and de-risk agricultural lending.

Policy Alignment & Institutional Traction

Digital agriculture is explicitly prioritized in Kenya's **Agricultural Sector Transformation and Growth Strategy (2019–2029)** and the **Climate Smart Agriculture Strategy (2017–2026)**. The government has partnered with FAO and WFP on digital early warning systems, while IFAD, World Bank, and USAID have supported scaling of ICT-enabled advisory. Kenya is also part of the **Digital Agriculture Innovation Hubs (FAO/EU)**. Institutional traction is therefore strong, with growing public–private ecosystems around DCAS.

Why This Solution Stands Out

DCAS rank highly because they cut across multiple hazards and value chains, are already commercially viable, and carry strong gender and borrower inclusion potential. They align with national policy, enjoy institutional traction, and have demonstrable productivity gains. Critically, they generate a **clear business case**: banks and MFIs can underwrite bundled services (advisory + insurance + input credit), while cooperatives can aggregate demand. This positions DCAS as one of the most commercially ready adaptation solutions for Kenya.

2. Hermetic Storage Systems

Adaptation Challenge

Post-harvest losses are a major vulnerability in Kenya's food system, particularly for maize and beans, where up to **30–40% of production is lost annually** due to pests, mold, and moisture (FAO, 2021). Rising climate hazards, heavy rains during harvest, prolonged humidity, and more frequent aflatoxin outbreaks, exacerbate these losses. Aflatoxin contamination alone is estimated to cost Kenya over **$150 million annually** in lost trade and health costs (World Bank, 2019). Without effective storage, even good harvests fail to translate into secure food supplies or stable incomes.

Relevance to Value Chains

Hermetic storage solutions (e.g., hermetic bags, metal silos) are particularly relevant to:

- **Maize**: protects against aflatoxin and pest damage, critical for household food security and national reserves.
- **Potatoes**: reduces sprouting and rot during humid storage periods, though complementary technologies (e.g., cold storage) are also needed.
- **Beans**: maintains seed and grain quality, especially under erratic rainfall patterns.
- **Cattle (indirect)**: improves grain storage stabilizes feed availability and lowers price volatility for maize-based livestock feed.

Technical Maturity & Local Delivery Readiness

Hermetic storage is one of the most **mature and widely commercialized adaptation technologies** in Kenya. Products such as **PICS bags, AgroZ hermetic bags, and metal silos** are distributed through agri-

input dealers, cooperatives, and NGOs. The World Food Programme, CIMMYT, and One Acre Fund have scaled hermetic storage to hundreds of thousands of households. Kenya's Postharvest Loss Reduction Strategy (2019) explicitly promotes hermetic storage adoption. However, adoption remains uneven due to upfront costs (KES 250–300 per bag) and uneven last-mile distribution.

Productivity Increase

Evidence shows hermetic storage reduces post-harvest losses from 20-30% to below 5%, effectively raising usable yields by as much as a quarter (World Bank/IFC, 2019). For maize, this means not only more stable household food supply but also safer grain, free of aflatoxin contamination. Farmers using hermetic storage can delay sales to periods of higher market prices, boosting incomes by 10-20%. For cooperatives and SMEs, reduced losses lower unit costs and improve margins, enhancing value-chain efficiency.

Gender Inclusion

Women play a central role in post-harvest handling, particularly drying, sorting, and storage of maize and beans. Yet they face constraints in access to capital and training to purchase or adopt new storage solutions. Hermetic bags are particularly well-suited to women's needs: they are low-maintenance, small-scale, and usable at household level without specialized infrastructure. Studies (CIMMYT, 2021) show that women farmers report higher satisfaction with hermetic bags compared to conventional pesticides, which are costly, health-damaging, and harder to apply. Targeted delivery through women's cooperatives, savings groups, and microfinance channels further enhances gender-inclusive adoption.

Relevance to Borrowers

For smallholder farmers, hermetic bags provide a low-cost, immediate solution to reduce food insecurity and protect income. For cooperatives and aggregators, hermetic storage stabilizes bulk supply, improves bargaining power, and ensures compliance with food safety standards. For agri-SMEs, investing in larger-scale hermetic silos enhances quality assurance in grain processing and marketing. Financial institutions can underwrite loans for bulk purchases by cooperatives or SMEs, making this solution highly compatible with GCA's bankability objectives.

Policy Alignment & Institutional Traction

Kenya's Postharvest Loss Reduction Strategy and the Kenya Cereal Enhancement Programme prioritize hermetic storage as a core intervention. FAO, CIMMYT, USAID, and AGRA have piloted or scaled hermetic storage distribution models. Private firms like A to Z Textile Mills (AgroZ bags) and Bell Industries (metal silos) ensure ongoing commercialization. Institutional traction is thus strong, with proven delivery channels, donor support, and private sector participation.

Why This Solution Stands Out

Hermetic storage directly addresses Kenya's dual challenge of food safety (aflatoxin) and food security (post-harvest loss). It is technically mature, commercially viable, and gender-inclusive, with strong policy backing and private sector delivery. Critically, it offers a clear business case for financing: cooperatives and SMEs can aggregate demand, banks can extend group loans for bulk purchases, and smallholders can repay through savings from reduced losses. This positions hermetic storage as one of the most bankable adaptation solutions in Kenya's agricultural context.

3. Climate-Resilient Fodder Varieties

Adaptation Challenge

Feed scarcity is one of the greatest constraints on livestock productivity in Kenya, especially in the Arid and Semi-Arid Lands (ASALs) where cattle and goats dominate livelihoods. Prolonged droughts degrade rangelands and reduce fodder availability, while episodic floods spread livestock diseases and further damage pasture. Heat stress lowers feed conversion efficiency, milk yields, and fertility. As a result, feed

costs account for up to **60–70% of total livestock production costs** (ILRI, 2022). Climate change is intensifying this crisis, with recurrent droughts driving widespread cattle mortality in counties like Turkana, Garissa, and Isiolo.

Relevance to Value Chains

- **Cattle (dairy & beef):** Productivity is directly tied to consistent fodder supply. Climate-resilient varieties of Napier grass, Brachiaria, and sorghum-sudan hybrids can withstand drought, heat, and disease pressures such as Napier stunt.
- **Goats and sheep:** More tolerant of drought than cattle, but still require reliable fodder, especially during dry seasons when natural browse is depleted.
- **Maize linkages:** Stable feed availability reduces pressure on maize as an alternative feed source, indirectly stabilizing food security.

Technical Maturity & Local Delivery Readiness

This is a **mature but under-scaled solution in Kenya**. ILRI, KALRO, and private seed companies (e.g., **Simlaw Seeds, Advanta**) have piloted and released improved fodder varieties like **Brachiaria cv. Mulato II** and drought-tolerant Napier clones. Farmer cooperatives and NGOs such as **SNV's Kenya Market-led Dairy Programme** have promoted adoption, often bundled with extension support. However, delivery systems remain fragmented: seed multiplication is limited, and many pastoralists lack access to quality planting material.

Productivity Increase

Adoption of improved fodder varieties can boost **milk yields by 15–40%**, depending on management (ILRI trials). Drought-tolerant forages maintain higher biomass production under stress, reducing seasonal feed gaps and cutting livestock mortality. Better feed also improves animal fertility and weight gain, strengthening both dairy incomes and beef supply. The potential to stabilize productivity across dry seasons makes this a transformative adaptation option.

Gender Inclusion

Women are central to Kenya's dairy sector, responsible for **70–80% of day-to-day herd management, milking, and feeding** (FAO, 2021). Feed scarcity disproportionately affects them, as it increases time spent searching for forage and reduces milk available for household nutrition and sale. Climate-resilient fodder reduces women's workload while improving household nutrition and income. Women's dairy cooperatives and savings groups have shown strong uptake of improved fodder, particularly when linked with training and microfinance. Designing delivery models through such women's groups increases both equity and adoption.

Relevance to Borrowers

- **Smallholder farmers:** Gain reliable feed and higher milk yields, translating into better incomes and food security.
- **Cooperatives and dairy groups:** Can bulk-buy and distribute fodder seed, reducing costs and facilitating group lending.
- **Agri-SMEs:** Opportunities to engage in seed multiplication, distribution, and silage-making services.

  Financial institutions can underwrite loans for fodder establishment (e.g., group financing for seed purchase, silage choppers), since payback is clear in increased milk sales.

Policy Alignment & Institutional Traction

Kenya's **Agricultural Sector Transformation and Growth Strategy (ASTGS, 2019–2029)** prioritizes livestock feed systems as a pillar of dairy and beef modernization. ILRI and KALRO provide strong R&D backing, while donor-funded programs (USAID Feed the Future, SNV) have tested commercialization models. However, scaling requires stronger private sector investment in seed production and tighter integration with dairy value chains.

Why This Solution Stands Out

Climate-resilient fodder varieties directly address one of Kenya's most acute adaptation needs: reliable livestock feed under conditions of drought and heat stress. They are technically proven, deliver tangible productivity gains, and disproportionately benefit women who manage feeding and milking. Importantly, they provide a **bankable pathway** for cooperatives and SMEs to expand feed businesses and for lenders to finance inputs tied to predictable returns in milk and beef markets. With strong policy recognition and research support, the main challenge is not proving viability but **scaling delivery systems**, which makes this an excellent candidate for GCA's support.

4. Solar Drying Systems

Adaptation Challenge

Kenya's wetter harvest windows and humid spells increase grain and tuber moisture, driving mould growth, aflatoxin risk, and fast quality downgrades, especially in maize and potatoes. In maize, keeping grain at or below **~13.5% moisture** is critical for safe long-term storage; yet farmers often lack reliable drying options when rains persist, which raises contamination risk. Field experiments in Kenya show that better post-harvest practices (e.g., drying sheets) **cut aflatoxin by ~53%**, underscoring how drying is a first-order adaptation lever. During major outbreaks, **15–50%** of sampled maize exceeded national limits evidence of the scale of the hazard when drying fails.

Relevance to Value Chains

- **Maize:** Rapid, uniform drying lowers aflatoxin formation after wet harvests; improves storability and price realization.
- **Potatoes:** Controlled dehydration (for chips, flakes) and assisted curing/drying reduce storage rot and sprouting; Kenya studies report **double-digit post-harvest losses** without improved handling.
- **Horticulture (mango, avocado, vegetables):** Drying salvages seconds/grade-outs during gluts and wet spells, opening shelf-stable value-added markets. Pilot programs in Kenya have demonstrated viable dried-produce micro-value chains.

Technical Maturity & Local Delivery Readiness

Kenya has an active ecosystem around solar dryers, from **low-cost tent/cabinet units** to modular, food-safe dehydrators. Market and design reviews document **local fabrication capacity** (e.g., Suncatcher-type units) alongside research on greenhouse-type dryers; Kenya has featured in regional technology assessments. Recent programs (SNV SEFFA) co-developed dryers with **Dedan Kimathi University**, installed units at micro-factories, and trained farmer groups; another initiative supplied **8,000 Dehytray®** units for household dehydration to extend shelf life without grid power. Policy briefs also flag skills and QA bottlenecks to wide-scale uptake, gaps that targeted investment can close.

Productivity Increase

By enabling safe moisture reduction during wet harvests, solar dryers curb quantitative and quality losses (less mould/mycotoxin downgrading, fewer discards), stabilizing volumes and prices. Kenya potato studies report sizeable post-harvest losses along the chain; drying into shelf-stable products captures otherwise lost value, while in maize the ability to reach safe moisture **prevents aflatoxin-driven write-offs** and health-related market rejections. SNV business cases show that dried-produce micro-enterprises can be financially positive for smallholders when reliable offtake is in place.

Gender Inclusion

Women dominate post-harvest handling and petty trade in many Kenyan counties. Solar dryers **reduce time and drudgery** in sun-drying, lower smoke exposure versus biomass methods, and create **women-led micro-processing** opportunities (chips, dried veg/fruit). Programs in Kenya that placed dryers with **women's groups** documented job creation and higher net incomes when linked to contract buyers; tech-demo campaigns have prioritized women's participation and skills.

Relevance to Borrowers

- **Smallholders / women's groups:** Community or cooperative ownership with fee-for-use; household-scale trays for micro-enterprises
- **Co-ops / SMEs / aggregators:** Dryer clusters at collection points ("micro-factories") paired with grading and packaging; strengthens quality assurance and offtake reliability.
- **Lenders:** Financeable tangible assets with service contracts; revenue from drying fees or value-added margins supports repayment. Demonstration campaigns and technical standards reduce perceived technology risk.

Policy Alignment & Institutional Traction

Kenya's **Post-Harvest Management Strategy** explicitly promotes loss-reduction technologies (including improved drying) as part of national food-loss and safety objectives. Productive-use-of-energy (PUE) policy roadmaps also highlight off-grid solar appliances that enable rural enterprises, an umbrella under which solar dryers fit naturally. Government partnerships with FAO/WFP on early warning and post-harvest management complement these efforts.

Why This Solution Stands Out

Solar drying directly tackles a **climate-sensitive failure point**—safe moisture reduction during wet, humid harvest conditions, across maize, potatoes, and horticulture. Kenya already has pilots, fabricators, training partners, and offtake models; women's groups are proven adopters; and there is **clear asset-finance potential** for co-ops and SMEs. With strong policy backing on post-harvest loss reduction and PUE, solar dryers present a bankable, inclusive pathway to convert climate risk into resilient, value-added income streams.

5. Drought-Tolerant Varieties for Maize and Soybeans

Adaptation Challenge

Zambia's food system is acutely exposed to climate extremes, and few areas highlight this vulnerability more sharply than maize and soybeans. **Maize, which provides ~60% of Zambia's calorie intake (FAO), is highly sensitive to both drought and heat**, with flowering failure and grain sterility becoming frequent during spells of >35°C, and projections showing future highs of 40–43°C. Yield reductions of 20–30% have been recorded in drought years, and heavy rainfall events further threaten waterlogging and aflatoxin contamination. **Soybeans, Zambia's fastest-growing oilseed crop, face parallel risks**: heat stress at flowering, reduced nitrogen fixation in drought conditions, and pod abortion when exposed to waterlogging or heavy storms. Together, these crops represent both the nutritional foundation (maize) and an emerging driver of income diversification and agro-industry (soybeans), but both are dangerously exposed under current seed systems.

Relevance to Value Chains

For **maize**, drought-tolerant varieties are not just desirable but essential to national food security. In a context where over 80% of rural households grow maize (World Bank), stabilizing yields in hotter, drier years directly translates to reduced import dependence, lower household food expenditure, and more predictable supply for millers. For **soybeans**, the case lies in value chain growth: Zambia has emerged as a net exporter of soybean products, with crushing plants supplying poultry feed and edible oil. Demand is rising in both domestic and regional markets. Adoption of drought-tolerant soybean seed would help

secure consistent raw material flows, reducing risks of factory underutilization and stabilizing farmer incomes. Both crops, therefore, sit at the heart of Zambia's adaptation and economic resilience agenda.

Technical Maturity & Local Delivery Readiness

Drought-tolerant maize varieties are already **commercially available** through local seed companies such as SeedCo, Zamseed, and Pannar, often developed in partnership with CGIAR centers like CIMMYT. Some varieties, such as **SeedCo's SC 403 and SC 627**, have been tested widely in Zambia's Central and Eastern Provinces, showing yield stability under stress conditions. The government's **Farmer Input Support Program (FISP)** has actively promoted climate-smart maize seed distribution, although delivery quality and targeting remain uneven. For soybeans, drought-tolerant lines are newer, often introduced by IITA and partners under donor-backed trials. Local multipliers are emerging but adoption rates are lower than for maize, pointing to a medium level of maturity but strong growth potential. Crucially, **agro-dealer networks across Zambia are dense and well-established**, making seed distribution one of the most advanced delivery channels for any adaptation solution.

Productivity Increase

Evidence suggests drought-tolerant maize varieties can deliver **yield stability gains of 20–30% in drought years** compared to conventional varieties (CIMMYT, FAO). While absolute yields are not always higher in normal years, the reduction in downside risk is transformative for food security. For soybeans, adoption of improved varieties can **increase yields from 0.8–1.2 t/ha to 1.5–2.0 t/ha**, particularly under moderate drought conditions. Beyond yield, improved varieties can shorten growth cycles, allowing farmers to adapt planting windows around shifting rainfall patterns. The productivity uplift extends downstream: millers and processors benefit from steadier supplies, while households see reduced price spikes in lean years.

Gender Inclusion

The gender dynamics of these crops differ, but both underscore the importance of equity in seed systems. **Women are heavily engaged in maize production and post-harvest handling**; ensuring their access to drought-tolerant maize varieties can directly reduce household food insecurity. Yet women often face barriers such as smaller landholdings, limited credit, and weaker links to agro-dealer networks. For **soybeans**, cultivation has historically been more male-dominated, reflecting its cash-crop orientation. However, women are increasingly entering soybean production through cooperative schemes and poultry-linked feed markets. Embedding **gender-responsive seed access mechanisms**, such as women-focused agro-dealer franchises, group-based purchasing, and bundling with training, would be critical to achieving inclusive adoption.

Relevance to Borrowers

The borrower fit for drought-tolerant seeds is particularly strong:

- **Smallholder farmers** (who dominate maize production) benefit directly from more resilient yields and reduced food insecurity.
- **Medium-scale commercial farmers**, particularly in soybeans, see gains in income stability and market access.
- **Agri-SMEs** (seed companies, agro-dealers, millers) are natural intermediaries in distribution and scaling.
- **Cooperatives and farmer groups** can serve as aggregation hubs for seed access, lowering transaction costs.

  This breadth of borrower relevance positions drought-tolerant seed systems as one of the most investable solution types.

Policy Alignment & Institutional Traction

Zambia's National Agriculture Policy (NAP), Climate-Smart Agriculture Investment Plan, and Nationally Determined Contributions (NDCs) all explicitly emphasize the role of improved seed systems, particularly drought-tolerant maize. The FISP program, despite its inefficiencies, demonstrates the government's willingness to invest heavily in seed distribution. For soybeans, institutional traction is building under regional trade and agro-industry policies, including SADC commitments to oilseed self-sufficiency. International actors like USAID's Feed the Future, AGRA, and IITA continue to channel significant resources into seed research, multiplication, and dissemination in Zambia. This alignment makes drought-tolerant seeds not only technically relevant but also policy-prioritized.

Why This Solution Stands Out

Drought-tolerant varieties for maize and soybeans bring together high adaptation need, proven technical maturity, strong borrower fit, and deep policy traction. Unlike many other adaptation solutions, seed adoption integrates seamlessly into existing farming practices, requires relatively modest upfront investment, and delivers benefits directly at farm level while cascading through entire value chains. The dual focus on maize (food security staple) and soybeans (income and industrial crop) strengthens the business case by diversifying impact pathways. When scaled, these varieties could stabilize national grain supplies, strengthen resilience of rural livelihoods, and reduce the volatility of Zambia's agri-industrial base. For GCA and partner institutions, this solution represents one of the clearest bridges between resilience outcomes and bankable investment opportunities.

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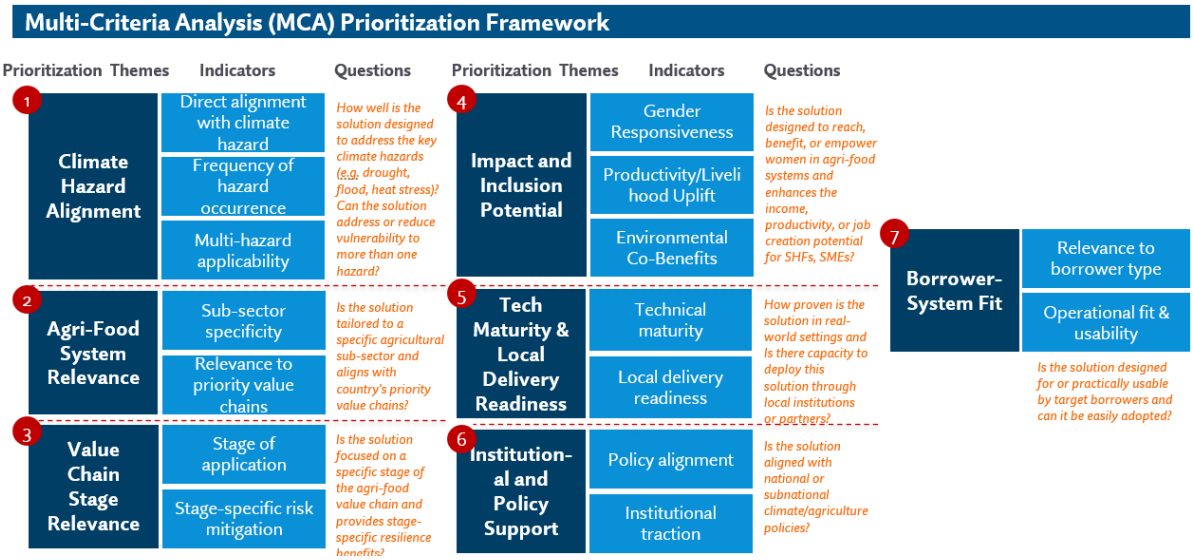
1 ANNEX 1: HIGH-LEVEL CLIMATE IMPACT ANALYSIS

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.
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 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 5: ADAPTATION IN KENYA

Based on projected climate hazards (extreme heat reaching 43-45°C with over 200 days >35°C, intense precipitation up to 300mm, and moderate drought conditions), the most affected food value chains are maize and poultry in the Coastal Agro-Pastoral Belt (high sensitivity to heat stress during flowering and mortality from prolonged hot seasons, plus lodging and housing damage from extreme rainfall). Cattle in the Northeastern Pastoral Belt experience severe impacts due to extreme heat, which depresses milk production and fertility, combined with water scarcity and long trekking distances to water sources. In the Highlands Food Corridor, potatoes face medium-high impacts from the largest temperature increases in the country (+2.4°C), which accelerate sprouting and reduce storage life, while extreme precipitation events (>100mm) create critical post-harvest challenges including waterlogging damage, increased disease pressure, and severe difficulties in drying and storage operations. 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 intense precipitation, which emerge as the key areas of response.

Considering National Policies and a detailed revision of the literature developed to explore Climate-Smart Agriculture in Kenya (particulatly the World Bank designed national profile (World Bank; CIAT, 2015) on the topic and the Climate-Smart Agriculture Investment Plan (Jalango D, 2023)), Kenya's agricultural sector is adopting both traditional and improved climate-smart technologies to build resilience against climate challenges. Farmers are implementing agroforestry, conservation tillage, drought-tolerant crop varieties, water harvesting, and integrated soil fertility management, alongside newer innovations like improved pasture management, and water-efficient irrigation techniques (World Bank; CIAT, 2015). The country benefits from well-developed cold chain logistics for exports, but faces opportunities to expand domestic cold storage and bulk grain-handling facilities to reduce post-harvest losses (World Bank, IFC, 2019). Processing potential exists in fruit purees, processed vegetables, nuts, potatoes, fish, meat, and dairy, though firms face challenges securing sufficient quality raw materials for capital-intensive investments (World Bank, IFC, 2019).The different more traditional CSA techniques currently being deployed in Kenya, albeit with low penetration, are presented in the figure below.

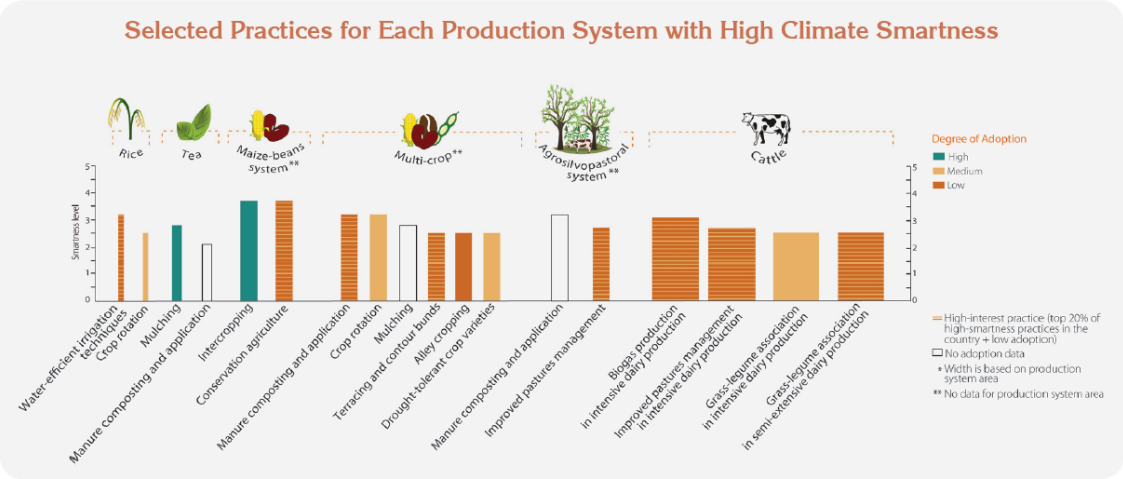


Figure 12. Climate-Smart Agriculture Prioritized for Kenyan Key Value Chains profile (World Bank; CIAT, 2015).

Strategic investments in water infrastructure, irrigation expansion, bulk grain-handling facilities, and technology deployment could dramatically increase the agricultural productivity profile (World Bank; CIAT, 2015) (World Bank, IFC, 2019). Kenya's Agricultural Sector Transformation and Growth Strategy (2019-2029) aims to modernize agriculture through better equipment and inputs, expanded irrigation, improved livestock genetics and feed systems, and sustainable mechanization to address declining labor

productivity from higher temperatures (Ministry of Agriculture and Livestock Development, 2024). Continued investment in **biotechnology, genetics for drought-resistant varieties**, and climate-smart agriculture practices, combined with addressing economic water scarcity through **improved storage and conveyance infrastructure**, could help Kenya achieve food self-sufficiency while reducing environmental impacts and building resilience against climate shocks (World Bank, 2023).The combination of these different adaptation solutions is also presented in greater detail in the Climate-Smart Agriculture Investment Plan, with key initiatives targeting smallholder farmers, women, and youth. These projects include climate-smart aquaculture and fisheries systems, improved dairy livestock operations, digital advisory services, water harvesting and storage systems, integrated agro-industrial parks, dryland cereal and pulse value chain development, integrated soil fertility management, and coastal mangrove restoration (these are presented in more detail in the table below) (Jalango D, 2023). The investments aim to transform subsistence farming into commercial-oriented value chains, reduce post-harvest losses, improve market access, enhance dietary diversity, and build resilience against climate shocks while reducing greenhouse gas emissions and supporting sustainable agricultural development across diverse agro-ecological zones (Jalango D, 2023).

Table 6: Key Investments under the Climate Smart Agriculture Investment Plan for Kenya (Jalango D, 2023).

Project Name	Project Objectives	Key Beneficiaries	Value Chains/Commodities	Scenario without Investment	Scenario with Investment
Climate-Smart Aquaculture and Fisheries	To improve farm-level productivity, diversify livelihoods and income, and enhance nutrition and food security in the country	Small and medium-scale farmers and fishers, including women and youth	Fish, rice, poultry, vegetables	Poor production and management practices in aquaculture. Vulnerability of smallholder farmers to climate change	Improved farm productivity, enhanced dietary diversity, and increased resilience of smallholders from the concurrent production of rice, fish, poultry, and/or vegetables
Climate-Smart Dairy Livestock Systems	To improve the dairy sector productivity, enhance the resilience of smallholder dairy farmers, and contribute towards the reduction of GHG emissions in the dairy livestock sector	Small and medium-scale dairy farmers and other dairy value chain actors	Dairy livestock	Poor dairy breeds with inadequate feeding resources produce low yields and intensify GHG emissions Smallholder farmers rear improved dairy breeds contributing to genetic gains and production	Enhanced value addition, storage, and marketing of dairy products leading to improved incomes and food and nutritional security outcomes

				efficiency.	
Digital Knowledge and Advisory Services	To support information and content dissemination, financial services, and access to markets for smallholder farmers	Smallholder farmers, including women and youth	Tea, fish, dairy and horticultural products, e.g., mango, avocado, banana, and vegetables	Smallholder farmers face challenges accessing markets and rely on outdated technologies and management practices to improve productivity. Glaring yield gaps in value chains Smallholder farmers adopt CSA practices, technologies, and finance that improves and sustains their productivity.	Improved access to decision support tools allows them to anticipate, respond to and recover from climate events.
Sustainable Water Harvesting, Storage, and Utilization Systems	To improve agricultural productivity, support the diversification of crops and diets, and increase the resilience of farming to climate change hazards such as droughts.	Smallholder and medium-scale farmers, particularly women and youth living in the Arid and Semi-Arid Land	Tomatoes, kales, onions, Indigenous vegetables, e.g., Amaranthus, African nightshade, spider plant, cowpeas, and jute mallow	Human-human and human-wildlife conflicts from water resource competition. Increased vulnerability to climate risks. Low crop and livestock yield	Increased crop and livestock productivity, improved incomes and livelihood. Reduced water-related risks, including floods and drought
Integrated agro-industrial parks (IAIPs) for CSA development	To reduce fragmentation in agri-value chains, maximize economies of scale and enable value addition, increasing	Small-scale farmers, including women and youth and other value chain actors, especially agricultural small and medium	Tea, fish, dairy and horticultural products	Underdeveloped agro-industry, low levels of value addition, persistent post-harvest losses, and food import dependency	Smallholder farmers with improved access to organized markets. Reduced postharvest

	productivity, incomes, and competitiveness.	enterprises (SMEs)			losses, increased value addition, and developed local agro-based small and medium enterprises. Increased incomes and secured livelihoods for smallholder farmers, value chain actors, and developed rural areas.
Dryland Cereal and Pulse Value Chain Development	Promote the development of climatesmart value chains in dryland agro-ecologies for increased resilience, improved biodiversity and productivity, and enhanced food and nutrition security among vulnerable population	Smallholder farmers and agribusinesses along the cereal and pulses value chains	Cereals: Sorghum and millet Pulses: Green grams	Increased vulnerability to impacts of climate change. Low dietary diversity, land degradation in dryland counties	Dryland production systems transition from subsistence to commercial-oriented value chains. Population in dryland counties diversify their agro-based activities and diets, enhancing agricultural productivity, incomes, and nutrition.
Integrated Soil Fertility Management (ISFM)	Upscale the adoption and implementation of best agronomic practices and technologies to enhance the soil structure and fertility,	Smallholder farmers and other value chain actors, including input manufacturers and service providers	Green gram and beans	Degraded soils, low yields, and increased vulnerability to climate change effects	Increased agricultural productivity, enhanced soil conservation, improved soil carbon stock through sequestration, and reduction in soil GHGs

	sustain crop yields, improve farm incomes and build ecological sustainability				due to higher crop uptake of nitrogen fertilizers
Mangrove and Coral Reef Restoration and Conservation	To scale up the restoration of degraded mangrove and coral ecosystems, and improve on their management for climate mitigation, conserve biodiversity, improve water quality, and build resilience in coastal communities	Fisher folk and communities in the coastal region		Increased vulnerability of marine and coastal communities to climate change impacts.	Enhance biodiversity of marine ecosystems. Protect infrastructure and the lives of coastal communities from erosion, flooding, cyclones, and storms. Removal of GHG gases from the atmosphere through mangrove carbon sinks.

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