ANNEX 2

Kenya

Maize and Beans
Version 4

2024

RE-GAIN: Scaling Solutions for Food Loss in Africa

CONTENTS

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ACRONYMS

APHLIS	African Post-Harvest Loss Information System

ARAF	Acumen Resilient Agriculture Fund
ARCAFIM	Africa Rural Climate Adaptation Finance Mechanism
ASAL	Arid and Semi-Arid areas
ASDS	Agricultural Sector Development Strategy
ASTGS	Agricultural Sector Transformation and Growth Strategy
BAU	Business as Usual
CAADP	Comprehensive Africa Agriculture Development Programme
CCA	Climate Change Adaptation
CGIAR	Consultative Group on International Agricultural Research
CIAT	Centro Internacional de Agricultura Tropical (International Centre for Tropical Agriculture)
CMIP	Coupled Model Intercomparison Project
CSA	Climate Smart Agriculture
EARF	Energy Access Relief Facility
EU	European Union
FAO	Food and Agriculture Organisation of the United Nations
FL-RS	Food Loss Reduction Solutions
GCF	Green Climate Fund
GDP	Gross Domestic Product
GFDRR	Global Facility for Disaster Reduction and Recovery
GHG	Greenhouse Gas
GVA	Gross Value Added
HILDA+	Historic Land Dynamics Assessment
ICRF	Infrastructure Climate Resilient Fund
IFAD	International Fund for Agricultural Development
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Inter Tropical Convergence Zone
KCSAIF	Kenya’s Climate Smart Agriculture Implementation Framework
KCSAS	Kenya Climate Smart Agriculture Strategy
KIPPRA	Kenya Institute for Public Policy Research and Analysis
KNBS	Kenya National Bureau of Statistics
KSIF	Kenya Strategic Investment Framework
LEAF	Leveraging Energy Access Finance
LGB	Larger Grain Borer
LUCF	Land-Use Change and Forestry
LULUCF	Land Use, Land-use Change and Forestry
MSME	Micro, Small, and Medium Enterprises
MTP	Medium-Term Plans
NAP	National Adaptation Plan
NASEP	National Agricultural Sector Extension Policy
NCCAP	National Climate Change Action Plan
NCPD	National Council for Population and Development
NDA	National Designated Authority
NDC	Nationally Determined Contributions

NEMA	National Environment Management Agency
PES	Payment for Ecosystem Services
SDG	Sustainable Development Goals
SLM	Sustainable Land Management
SME	Small and Medium Enterprises
SNC	Second National Communication
SnCF Global	Global Subnational Climate Fund
SRMI	Sustainable Renewables Risk Mitigation Initiative
SSA	Sub-Saharan Africa
SSP	Shared Socioeconomic Pathway
TA	Technical Assistance
TAAT	Technologies for African Agricultural Transformation
TWENDE	Towards Ending Drought Emergencies
UGEAP	Universal Green Energy Access Programme
UNFCCC	United Nations Framework Convention on Climate Change
USDA	United States Department of Agriculture

Executive Summary

Africa's food insecurity challenge has been exacerbated by climate change, with the FAO estimating that post-harvest losses in agriculture contribute to between 30% and 50% of the continent's total food loss (FAO, 2011). Post-harvest food loss, which refers to the reduction in quantity and quality of crops once harvested, occurs during various stages including handling, storage, processing, and transportation. The impacts of these losses include reduced food availability, economic losses for farmers, and increased food insecurity. Climate change exacerbates these issues with rising temperatures, erratic rainfall, and extreme weather events contributing to increased spoilage, pest infestations, and mould growth, further intensifying global food losses. In Kenya, maize and beans, two key crops, are significantly affected, with post-harvest losses reaching up to 36% for maize (De Groote, Muteti, & Bruce, 2023) and 12% for beans (USAID, 2015). These losses impact food security and economic stability in Kenya. The country's frequent droughts and intense floods exacerbate these food losses, jeopardizing the livelihoods of over 40% of the population (Farm to Market Alliance, 2022) and threatening the nation's food supply where these crops are critical.

Given the threat of climate change and the significance of agriculture to the economy, the management of post-harvest food losses within Kenya's agricultural activities and growing seasons, specifically maize and beans crop production, is necessary to ensure socio-economic stability. Agriculture is a cornerstone of Kenya’s economy, supporting livelihoods and contributing approximately 25.4% to the GDP (Republic of Kenya, 2015) and employing approximately 40% of the workforce (Farm to Market Alliance, 2022). Smallholder farmers, who manage around 80% of the agricultural land, primarily cultivate maize and beans, among other crops. Maize is a staple crop integral to Kenya's diet, largely used for making ugali and other food products. Beans are a critical crop for Kenya, used for various food products including githeri, and are vital for reducing import dependency and ensuring food security. The country’s agricultural activities are concentrated in the high-potential areas of western, central, and Rift Valley regions, with distinct growing seasons: the long rains season from March to May, the short rains season from October to December, and the dry season from January to February. Consideration of climate change impacts and associated mitigation and adaptation measures on crop production, processing, and subsequent food loss is therefore necessary to ensure socio-economic stability (Duku, et al., 2023).

National policies and programmatic interventions are comprehensive and set a strong foundation to mitigate and adapt to climate change, however, require intensified efforts manage food loss and support food security. Key policies include the Climate Risk Management Framework (2016), the National Climate Change Action Plan (NCCAP) (2018-2022), and the National Adaptation Plan (NAP) (2015-2030). These policies predominantly target enhancing agricultural productivity, promoting climate-smart agricultural practices, and increasing resilience to climate impacts. For instance, the NCCAP focuses on improving food and nutrition security by increasing agricultural productivity while minimizing carbon emissions (Republic of Kenya, 2023). Other programs have been initiated, such as the TWENDE programme and the Acumen Resilient Agriculture Fund (ARAF) under the Green Climate Fund (GCF). However, despite these robust frameworks, gaps remain in effectively addressing post-harvest losses due to inadequate infrastructure, insufficient funding, and limited access to advanced technologies. This underscored the need for Kenya to deepen efforts through climate resilience practices to manage post-harvest food losses.

Gaining a comprehensive understanding of the climate risks impacting Kenya's agricultural sector is crucial for identifying suitable climate adaptation measures. Kenya faces significant climate risks, including increased temperatures, erratic rainfall, and more frequent droughts and floods. These risks predominantly affect the arid and semi-arid regions, with northern and eastern areas being particularly vulnerable. The impacts of these climate risks include reduced crop yields, increased pest infestations, and soil erosion, leading to heightened food insecurity. Historically, Kenya has experienced a 1.0°C rise in mean annual temperature from 1960 to 2005, and rainfall patterns have become increasingly variable, with northern regions becoming wetter and southern regions drier (Republic of Kenya, 2015). Projections indicate that by 2040, temperatures will continue to rise, with an estimated increase of up to 2.3°C. The number of hot days exceeding 35°C is expected to double, while extreme weather events such as intense rainfall and prolonged droughts will become more frequent. These changes highlight the pressing need for robust climate adaptation and mitigation strategies in Kenya (The World Bank, n.d.).

The prevalence of these climate risks necessitates the application of adaptation measures to ensure the minimization of post-harvest food losses. For maize, increased temperatures and erratic rainfall lead to inconsistent yields and higher post-harvest losses. This is evident with the rising temperatures and changing precipitation patterns, particularly from 1960 to 2020. These climatic changes have led to substantial yield reductions, with an observed total yield loss of 12.8% from 2020 to 2021 (Mutiso & Kimtai, 2023). By 2040, the suitability for maize production is expected to decrease by 17% under the high-emission scenario and by 12% under the medium-emission scenario due to rising temperatures and changing precipitation patterns (The World Bank, n.d.). Additionally, post-harvest losses are exacerbated by inadequate drying and pest infestations. The losses will negatively affect national food security, lower yields will result in reduced income for farmers, increased prices due to the imbalance of supply and demand and will require an increased dependence on imports. Managing adaptation measures to stabilize maize yield and reduce post-harvest losses due to drought and variable rainfall is therefore critical for the value chain.

Like maize, beans face significant challenges due to climate change, with increased temperatures and erratic rainfall reducing yields and increasing losses during storage and processing. For example, heavy rainfall in western Kenya has driven the spread of pests and diseases such as pod borers and blight, significantly damaging bean crops. Bean yields are projected to decrease by up to 50% under high-emission scenarios by 2050 due to climate change impacts such as increased drought exposure and temperature variability (King, 2023). The implication of these climate impacts on beans includes reduced national production, increased dependence on imports, and greater food insecurity for the population. Implementing effective climate adaptation measures for the cultivation and processing of beans is essential to counteract the adverse effects of increased temperatures and erratic rainfall on production.

Like adaptation, mitigation efforts are needed to minimize the negative effects of climate change on Kenya's agricultural sector. Only 20% of the land is suitable for high and medium agricultural potential, with over 50% classified as arid and primarily supporting extensive livestock production. The country is facing increasing pressure on its agricultural land due to rapid urbanization and the expansion of real estate, leading to the conversion of agricultural land into urban uses such as residential and commercial development. This trend threatens the sustainability of Kenya's agricultural sector and exacerbates land use challenges (KIPPRA, 2023).

Kenya's GHG inventory projects a substantial increase in emissions by 2030 under business-as-usual (BAU) scenarios. Emissions from agricultural sources, including crop and livestock production, are expected to rise to 39 $MtCO_2e$ by 2030. In the land use change and forestry (LUCF) sector, emissions are projected to increase significantly, reaching 22 $MtCO_2e$ by 2030. Mitigation of these emissions is critical in the response to climate change (NEMA, 2015).

Of Kenya's emissions contributions, food losses account for a significant proportion of emissions, particularly in the maize and beans value chains. The emissions associated with food loss across the agricultural value chains considered by the RE-GAIN Programme for Kenya could amount to 596,023 tCO_2e for maize and 6,440 tCO_2e for beans, based on smallholder production values (Porter, Reay, higgins, & Bomberg, 2016). Without intervention, emissions related to post-harvest losses on smallholder farms in Kenya are expected to increase by around 21%. For Kenya, this could amount to 722,128 tCO_2e for maize and 7,795 tCO_2e for beans by 2032 (Porter, Reay, higgins, & Bomberg, 2016). Therefore, it is crucial to minimize post-harvest food losses to reduce emissions and support climate change mitigation efforts.

Significant post-harvest losses contributing to agricultural emissions in Kenya occur primarily during the storage and drying processes for maize and beans, and these losses are exacerbated by climate change. On-farm post-harvest losses in the maize value chain are estimated at 14.2% and are primarily due to inadequate drying practices, pest infestations, and poor storage conditions (APHLIS, n.d.). For beans, on-farm post-harvest losses of approximately 12% are largely attributed to inefficient harvesting techniques and improper storage, leading to significant pest damage (USAID, 2015). Additionally, non-climate factors such as insufficient infrastructure, limited access to appropriate storage facilities, and poor market linkages further contribute to food losses in Kenya. Increased temperatures and erratic rainfall due to climate change intensify these already substantial post-harvest losses of maize and beans, where temperatures accelerate spoilage and promote pest infestations, while erratic rainfall disrupts the drying process and causes mould growth. Therefore, addressing climate change and enhancing post-harvest food loss management through effective mitigation and adaptation strategies is imperative to secure Kenya's food supply and support the agricultural sector's resilience.

With this in mind, an evaluation of proposed physical Food Loss-Reduction Solutions (FL-RS) was conducted to identify those with the highest potential to reduce post-harvest food losses and protect harvests against growing impacts from climate hazards. The analysis started on exploring which physical solutions could support mitigate the impacts of the exacerbating climate risks. From this initial analysis, stakeholder engagements in all seven countries provided critical nuances, including advantages, disadvantages, and barriers to use, particularly for smallholder farmers. The assessment facilitated the development of a shortlist of seven relevant physical FL-RS solutions tailored to meet specific country needs, guiding the final selection of solutions to be supported and disseminated by the RE-GAIN programme. Prioritization factors included environmental impact, farmers' awareness, frequency of use, potential to reduce food losses, availability, and scalability for job creation. Affordable solutions such as solar-powered small-scale mechanized solutions are prioritized. Combining hermetic storage solutions with moisture meters is crucial for preventing spoilage and aflatoxin development, particularly in maize and beans. The final shortlist of prioritized solutions for each country considers synergies and increased potential impact on food loss reduction. Communal use solutions include mechanical multi-crop threshers and shellers, moisture meters, and communal storage structures, while individual use solutions include tarpaulins, metal and plastic silos, hermetic bags, and biological storage protectants and control agents. Partnerships with agricultural service providers are recommended for implementing high-cost solutions, and awareness of proper use is essential for effectiveness.

The proposed physical solutions will be complemented by a suite of non-physical solutions, utilising extension services such as awareness-raising and capacity-building activities to create an understanding of the importance of reducing food losses and the competencies to properly implement the FL-RS solutions and generate demand. Access to physical solutions in itself is not enough to strengthen smallholder farmer's resilience to climate – there is a need to build knowledge within the communities as one of the key barriers to adoption of these solutions. Several extension activities are planned, including raising awareness among smallholder farmers about critical issues such as food losses, moisture content, aflatoxin contamination, pests, and proper storage methods, as well as environmental and safety aspects. Farmers will also learn about accessing finance, farm business management, climate change impacts, and crosscutting themes such as gender and youth. Training and capacity building will be organized through the network of village-based advisors (VBAs), leveraging AGRA's expertise and previous activities in this area, while also working in training lead farmers to become VBAs to ensure sustainability of the programme and broad knowledge dissemination. The training will cover various aspects of the agricultural process, including harvesting timing, use of weather forecast data, harvesting methods, operation and maintenance of machinery, and the proper use and maintenance of FL-RS such as moisture meters, drying methods, hermetic bags, and silos. For traders and processors, the focus will be on transport logistics, packaging, adherence to quality standards, and value addition through whole grain processing and marketing strategies to enhance profitability and sustainability.

Critical to this is the development of innovative financing mechanisms, as there is a challenge with in both the supply and demand of FL-RS due to limited access to finance. The RE-GAIN Programme is strategically designed to reduce the cost and risk associated with the adoption and implementation of food-loss reduction solutions (FL-RS) by smallholder farmers and agricultural MSMEs across its target countries. The proposed financing mechanisms are tailored to the needs of smallholder farmers to improve both access and affordability by relieving farmers of the need to securitize loans, mitigating the burden of high interest rates, and facilitating access to necessary capital. The programme employs a multifaceted approach, combining catalytic grants and financial models to make FL-RS more affordable and accessible. For smallholder farmers, the programme introduces catalytic disbursements to lower the cost of essential technologies like hermetic bags, drying sheets, and storage solutions. These grants are strategically deposited in escrow accounts, ensuring that funds are released only upon successful distribution of FL-RS to farmers, thereby enhancing production and driving demand. For agricultural MSMEs, the programme facilitates the development and pilot testing of financial products tailored specifically for the purchase of FL-RS. These solutions include de-risking mechanisms and shared-risk models that encourage investment in more expensive FL-RS, such as threshers, moisture meters, and communal storage structures. The catalytic grants provided to MSMEs not only enhance their access to finance but also help build their credit track records, improve their bankability, and reduce the cost of loans. This approach strengthens the business case for FL-RS service provision, thereby expanding the market and making these solutions more widely available.

To ensure the positive effects created by the RE-GAIN are sustainable, the programme will support the revision of policies to enable FL-RS investments, including tax exemptions, certification and standards for FL-RS quality, and promote successful FL-RS business models for scaling up and replication. Active involvement and support from government organizations, both central and local, will be crucial. The programme will align with other projects and programmes to leverage synergies, utilize existing laws and policies on food loss reduction, MSME promotion, and smallholder support, and ensure effective and efficient programme management, including rigorous monitoring and incorporating lessons learned. Effective stakeholder engagement is essential and will involve raising awareness, providing programme information, and ensuring inclusivity for women, youth, minority groups, and all value chain actors. A grievance mechanism will also be put in place. Additionally, ensuring the availability of quality FL-RS and access to finance is vital to support long-term continuation.

This feasibility study showcases how climate change is likely to exacerbate food losses, and addressing post-harvest food losses in Kenya's maize and beans value chains is critical to enhancing food security, economic stability, and climate resilience in the country. The RE-GAIN Programme's comprehensive approach, combining physical and non-physical solutions with innovative financing mechanisms and policy support, is designed to mitigate climate impacts, reduce food losses, and provide extensive support to smallholder farmers. By prioritizing scalable, affordable technologies and strengthening community knowledge and access to finance, the programme aims to build sustainable agricultural practices that not only protect harvests but also contribute to the long-term socio-economic stability of Kenya. Successful implementation will require continued stakeholder collaboration, government support, and a focus on inclusivity to ensure that the benefits reach all segments of the agricultural sector.

1 Introduction

1.1 PROGRAMME BACKGROUND

A great deal of attention has been paid in recent decades to the impacts of climate change on crop production, i.e., on growing risks to agricultural productivity. Scholarly investigations and public and private research have invested heavily in identifying and – where feasible – quantifying the ramifications of climate change on crop yields, yield stability over seasons, and in exploring plausible management options for the emerging challenges (CGIAR, 2023). As governments and societies look at how to minimize the risks of climate change, the impact of these changes on food production is increasing, fuelling concerns about food security and livelihoods for current and future generations.

Food security, however, is affected not only by changes in crop production but by changes occurring throughout the crop value chain, including during post-harvest phases (Akoth, 2020)**.** It is therefore crucial to examine the impacts of climate change on a crop's value chain, including production, aggregation, storage, transportation, processing, and distribution. Each stage comprises several sub-processes, and climate change may plausibly affect many or all of the sub-processes too.

With the lion's share of research and resources for resilience interventions in the agricultural sector having been focused on production, the RE-GAIN project is an effort to give dedicated focus to harvest and post-harvest stages of the value chain – specifically, harvesting, post-harvesting handling and storage, processing, transportation, and logistics. As summarized in Table 1-1, the International Fund for Agricultural Development (IFAD) report highlights a range of climate change concerns in the post-production stages of value chains and potential adaptation interventions that could increase resilience against such climate change concerns (IFAD, 2015).

Table 1-1 - Illustrative climate change risks and climate change risk management interventions in post-production value chain processes (adapted from IFAD, 2015)

Value Chain Components	Climate Risk Issues	Risk Management Interventions
Post-harvest management	Rising losses in harvest volume; declining safety, market quality and nutritional value due to increasing temperatures, humidity, pests and diseases.	Improve knowledge sharing on harvesting techniques to reduce losses. incentivize waste reduction measures and value addition for by-products; provide renewable energy sources to cover changing requirements for cooling, drying, milling, and threshing.
Siting of processing facilities	Extreme climate events (such as, floods, heatwaves, and storms) may damage processing facilities; shifting climatic conditions may render some sites redundant or increase transportation costs. It could create sustainable environment to pests and diseases, affecting both product quality and its suitability for consumption	Use hazard exposure and crop suitability maps to inform the siting of processing facilities; retrofit processing facilities with protective features; insure processing facilities against extreme climate events.
Energy in processing	High dependence on local bioenergy (wood, charcoal, dung, crop residues) has trade-offs with better soil management; rising temperatures require more energy for cooling.	Provide renewable energy sources (such as solar photovoltaic panels for cooling/drying/milling/heating, wind, biogas); equip processing facilities with energy-saving appliances (e.g., solar lighting, solar charging, efficient cook stoves); adopt pollution control measures.
Water in processing	Declining and more irregular water supplies; growing competition with other domestic or industrial users.	Re-site facilities closer to more suitable water sources; increase water storage and distribution capacity (water harvesting, communal ponds, groundwater recharge); introduce demand-side

Value Chain Components	Climate Risk Issues	Risk Management Interventions
		water efficiency measures; support conflict resolution for different water users (e.g., water user groups).
Packaging materials and methods	Rising temperatures and humidity may increase or decrease post-harvest losses and waste, as well as impact food safety, particularly if current packaging materials are impacted by high temperatures leading to produce damage or poor quality.	Design suitable packaging materials in parallel with waste and storage management strategies.
Processing infrastructure	Buildings and roads are exposed to higher peak rainfall, winds, and heat stress.	Introduce protective features and reinforcements into the design of critical infrastructure to handle run-off and higher temperatures; improve ventilation in buildings; harvest surplus water and energy from rooftops and appliances; use early warning systems.
Transport hubs and routes	Routes may become seasonally or permanently impassable (or open up); extreme events will disrupt logistics.	Re-site hubs; develop contingency plans for road, rail, water, and air transport; co-design value addition, storage, and transport components to avoid high-risk transport routes and seasons; upgrade docks, jetties, roads, and railways.
Refrigeration and cold chains	Temperature rises increase requirements for and costs of refrigeration; rising energy requirements increase greenhouse gas emissions.	Conduct cost-benefit analyses of dependency on refrigerated cold chains to assess best routes; introduce renewable energy sources for cooling and ventilation; optimize storage and transport management.
Just-in-time logistics	Extreme climate events (floods, storms, heatwaves) can make it impossible to comply with "just-in time" requirements.	Develop contingency plans for climate shocks and extreme events; create contingency storage opportunities; link into regional markets to avoid over-dependence on high-value export markets.
Demand from retail and consumers	Shifts in quantity and quality requirements and seasonality with climatic trends; disruptions in demand with climate variability, hence higher price fluctuations.	Assess market risks and opportunities before value chain implementation, including likely climatic impacts on high-value markets; strengthen and diversify storage to buffer price fluctuations; diversify into "off- season" crops.
Commodity labelling and certification	Increased consumer awareness as climate change may create new markets for sustainably produced and processed commodities with a low carbon footprint.	Explore opportunities for sustainable procurement, green labelling, and certification.

AGRA is a continental institution working in 15 African countries addressing food systems focussing on smallholder farmers' production, marketing and nutrition. In the countries where AGRA operates, which are highly diverse in terms of climate, soils, crop choices and institutional capacity, neither all of these climate-related concerns may be applicable, nor all of these potential interventions possible. **Even within the range of what may be applicable, this programme is likely to look at a subset of risks that may be viable to address, and – given resource constraints – only a limited number of high-priority resilience interventions may be feasible to design and deploy.** RE-GAIN is an effort to identify the most salient risks, select the most impactful solutions, and implement the priority interventions through a well-structured, strategic, multi-country programme.

1.2 BRIEF PROGRAMME DESCRIPTION

There is a clear gap in knowledge, data and interventions designed to target the impacts of climate change at the harvest and post-harvest stages of the value chain, despite the mounting evidence of the ramifications on food loss and the impact this has on land use changes and associated climate change mitigation. The majority of the current programmes designed to tackle climate-induced food loss focus on the pre-harvest stages of the value chain.

To address the pressing need for broader implementation of solutions aimed at reducing climate-related harvest and post-harvest food loss, the proposed programme is designed to raise awareness and build capacity to promote the adoption of Food Loss Reduction Solutions (FL-RS). It will do this by creating institutional capacity, facilitating the uptake of FL-RS by end users and service providers, increasing options of solutions' availability, and enabling practical application through policy interventions. This will include enhanced financial access for farmers and Micro, Small, and Medium Enterprises (MSMEs), empowering them to invest in climate-friendly FL-RS and incentivising vendors, manufacturers, and suppliers of climate-adapted FL-RS, fostering a robust market ecosystem.

A key focus is on strengthening the capabilities of countries to develop climate-resilient post-harvest infrastructure, both through providing physical solutions alongside capacity building along the value chains. This includes investing in strategic frameworks and implementation plans, including a regulated quality-based pricing system and tax exemptions on imports, for reducing food loss. By enhancing access to markets, the programme will encourage farmers to adopt FL-RS products and services, thereby boosting their climate and economic resilience.

1.2.1 Target Countries Overview

During the 2023–2027 period, AGRA plans to target 28 million farmers across 15 Sub-Saharan African countries, 40% of which will be women. The RE-GAIN Programme focuses on AGRA's activities in seven target countries, as shown in Figure 1-1 below. The RE-GAIN Programme is designed to combat food loss during the post-harvest stages and to boost climate resilience by fostering awareness and by building capacity for the adoption of Food Loss Reduction solutions (FL-RS). The programme aims to transfer these solutions to end users and service providers for practical application while facilitating financial access to farmers and Micro, Small, and Medium Enterprises (MSMEs) to invest in climate-resilient FL-RS. The programme plans to incentivize vendors, manufacturers, and suppliers to adopt these solutions and enhance the capacity of countries to develop climate-resilient post-harvest food handling infrastructure.

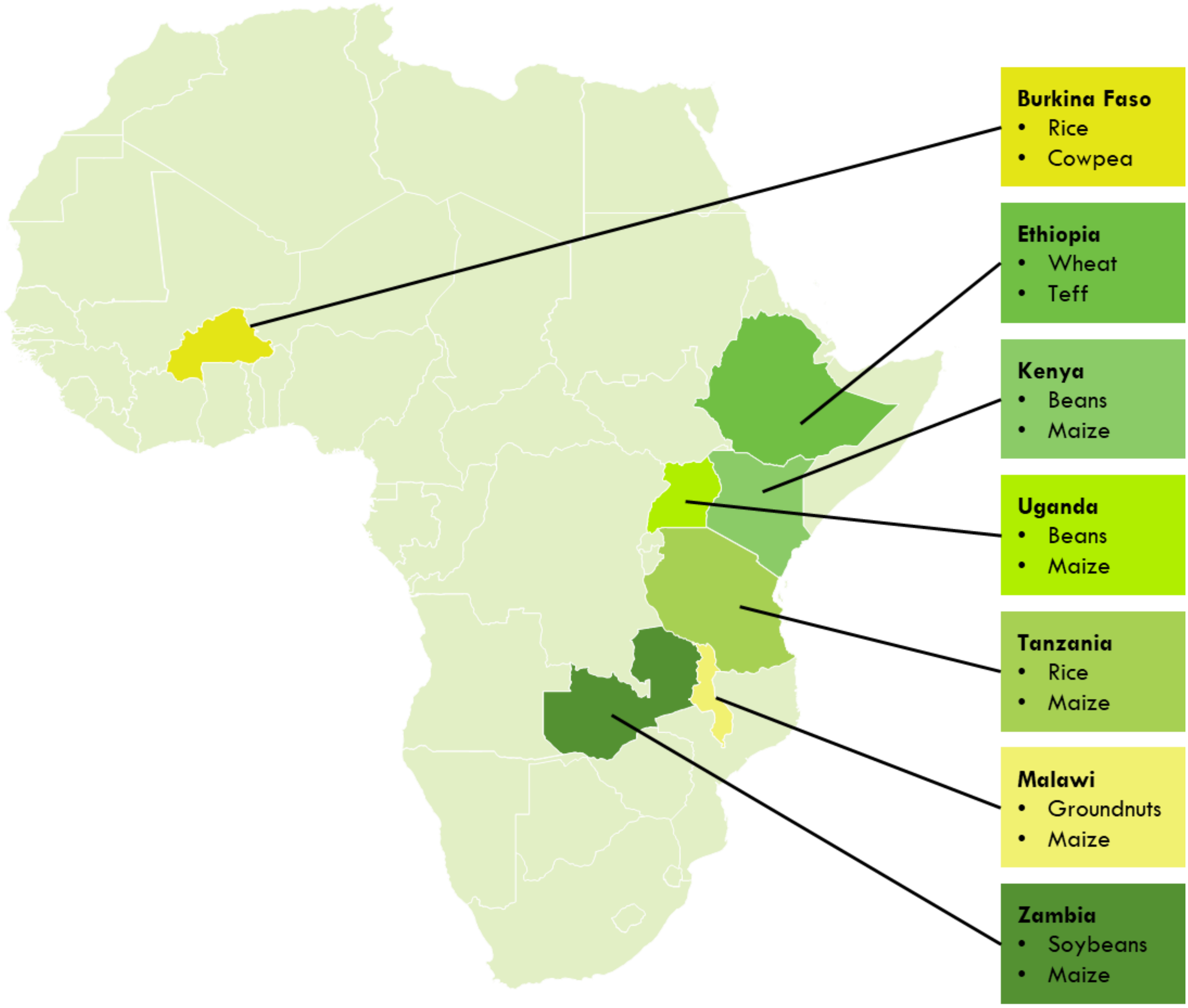


Figure 1-1 Focus Geographies for AGRA (2023-2027)

1.2.2 Crop selection

Key crops were identified by major stakeholders in the respective countries and expert assessments, supported by AGRA and the National Designated Authority (NDA) of each target country. Two major crops per target country were selected, based on area coverage, importance for food security and income, and climate vulnerability, to ensure that sufficient resources would be available for the crafting and execution of targeted solutions. Selected crops are representative of the agricultural dynamics of each country and aligned with the specific needs and strategic agricultural goals of the nation. In addition, these crops hold substantial importance to the country's food security and/or experience particularly high rates of loss within the value chain. Finally, these crops are produced in large parts of the respective countries by a significant number of smallholder farmers. The key crops, therefore, reflect the agronomic and economic realities of each country and provide opportunities for targeted enhancement of food security and sustainable agricultural practices. Additionally, the improved management of these crops is also expected to significantly reduction of GHG emissions contributing to the NDC targets of the countries involved. Figure 1-2 highlights the key crops selected for each of the countries within the programme.

1.2.3 Harvesting and Post Harvesting Definition

For the RE-GAIN programme, the key value chain stages considered are shown in Figure 1-2.

Figure 1-2 Strategic value chain stages included in the RE-GAIN Programme

The harvesting process within this RE-GAIN Programme proposal is defined as the interval between the culmination of agricultural production, marked by the crop reaching its maturity, and the initiation of post-harvest treatment. This process encompasses the identification of the optimal harvesting time and is further delineated into four distinct stages:

1. Removal of contaminated seeds, heads or cobs of matured crops at harvest
2. Reaping, which involves cutting, pulling, or gathering the mature crops.
3. Threshing, the process of separating the grain from the rest of the plant.
4. Cleaning, such as winnowing, to remove chaff and other impurities.
5. Hauling, which entails the transportation of the harvested produce to storage or processing facilities.

The post-harvest handling and storage stage commences once the crop exits the field and is typically conducted on the farm[1]. This stage encompasses several key operations, including:

1. Threshing, which can be performed manually or with mechanical threshing machines.
2. Drying, utilizing cribs, tarpaulins, and similar methods.
3. Cleaning and sorting, such as through winnowing, to remove impurities.
4. On-farm storage, which includes the use of granaries, hermetic bags, ordinary bags, stacks, metal silos, and plastic silos.
5. In some instances, primary processing activities, such as grinding, hulling, pounding, milling, drying, and sieving, are also conducted during this stage.

The processing, transportation, and logistics stage involves farmers selling their harvested crops either directly to traders, who collect the produce from the farm, or to collection centres and processors. These market participants then undertake the tasks of product accumulation, initial processing, quality control, grading, packaging, and transportation to wholesale buyers.

[1] In this instance, a field is where the crops are grown, and a farm consists of the whole small holding including the small aggregation site.

1.3 REASONING FOR REQUESTED FUNDING

Africa's food insecurity challenge has been exacerbated by climate change. Sub-Saharan Africa stands at a crossroads with an unprecedented opportunity for food systems transformation, driven by the demands of a rapidly growing population of 1.5 billion and the pressures of a changing climate (World Bank, 2023) (Worldometer, n.d.). The continent faces significant development challenges including food insecurity, resource degradation, poverty, gender inequality, and social exclusion. The vicious cycle of poverty and environmental degradation in Africa is evident in low crop productivity, deforestation, land degradation, conflict, migration, and vulnerability to climate shocks, which perpetuate persistent food insecurity and poverty. The effects of climate change are expected to be severe in Africa, where the capacity to adapt and respond to a changing climate is weak.

The impacts of climate change have increased over the past decades in Africa, manifesting in more frequent, intense, and prolonged extreme weather events, such as floods, droughts, heatwaves, locust outbreaks, desertification, and sandstorms. These extreme weather events have resulted in increased temperatures and humidity, shifts in precipitation patterns, water stress, and soil erosion. Most African countries already face recurrent droughts that affect growing seasons, often leading to short growing periods reducing the viability of farming in marginal agricultural areas. Projected reductions in crop yields in some countries could reach as much as 50% by 2030, and crop net revenues may fall by up to 90% by 2100, with smallholder farmers being the most affected (IPCC, 2018).

Therefore, the RE-GAIN programme aims to enhance the climate resilience and adaptive capacity of smallholders by promoting the widespread adoption of FL-RS in seven African countries. According to the World Bank estimates, a one percent reduction in post-harvest losses in Sub-Saharan Africa could lead to economic gains of $40 million each year, and most of the benefits would go directly to smallholder farmers (World Bank, 2011). Moreover, food loss and waste are the result of an extremely inefficient use of resources and account for about 3.3 gigatonnes of greenhouse gas emissions globally (FAO, 2013). Large amounts of water and fertilizer also go into the production of food that never reaches human mouths. Recovering the food that is lost during harvest and post-harvest handling some can help close that calorie gap in Africa while strengthening livelihoods and improving food security— without imposing any additional environmental cost. Therefore, facilitated by the Green Climate Fund (GCF) investment, RE-GAIN will roll out a suite of physical interventions alongside capacity building and enhanced financial and market access. Not only will this benefit the respective countries as whole, but it also has the potential to benefit the region and the wider planet.

1.4 PROGRAMME GOAL STATEMENT

IF the capacity of the target countries and communities to respond to climate-triggered food losses is strengthened through improved and inclusive access to financing, promotion of context-specific and gender-responsive innovations to reduce food losses, and better enabling conditions for public and private investments, **THEN** smallholder farmers will have enhanced food security and livelihood resilience, **BECAUSE** the widespread use of food loss-reduction technologies will reduce food loss and reduce the carbon footprint of food systems, while increasing household income and building the resilience of smallholder farmers, MSMEs and rural communities to climate shocks.

1.5 PURPOSE AND STRUCTURE OF THE REPORT

The purpose of this report is to provide an assessment of the climate hazards and vulnerabilities affecting each country and the distinct challenges they pose for the selected crops, and to propose a set of solutions designed to address these concerns. The analysis considers the country contexts, alongside the appropriateness of the solutions from an environmental, social, and financial perspective.

The report begins with an overview of the country context, covering key land use trends and the regulatory landscape. This is followed by an in-depth climate analysis covering adaptation and mitigation measures, before looking at the potential solutions and proposed prioritisation, as well as the current state of the market for these solutions. Each of these country-specific reports concludes indicating the connection between the current climate risks and potential areas for mitigation activities within the selected value chain and the proposed solutions indicated. These in-depth country analyses are then summarized in Annex 2 Summary Feasibility Study which highlights the overarching narrative of the RE-GAIN Programme.

2 Country Context

2.1 SITUATION ASSESSMENT

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 Gross Domestic Product (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.)

Smallholder farmers are the backbone of Kenyan agriculture, with around 7.5 million smallholders producing 80% of the country's total agricultural output (Farm to Market Alliance, 2022). These farmers typically manage plots between 1 to 5 acres (less than 2 hectares), and predominantly rely on rainfed agriculture, making them particularly vulnerable to drought and erratic weather patterns exacerbated by climate change (Farm to Market Alliance, 2022).

According to the 2024 Economic Survey prepared by the Kenya National Bureau of Statistics (KNBS), the agricultural sector rebounded robustly in 2023, reversing the downturn since 2021 (KNBS, 2024). It achieved a notable growth rate of 7.0% in 2023, with the sector's real Gross Value Added (GVA) rising by 6.5%, compared to a 1.5% contraction in 2022 (KNBS, 2024). This resurgence was fuelled by favourable weather, expansion in cultivated areas driven by anticipated higher crop prices, and proactive government measures such as the fertilizer subsidy programme (KNBS, 2024). Key food crops like maize, beans, and potatoes saw substantial increases in production in 2022, demonstrating the sector's resilience and adaptability to changing conditions (KNBS, 2024).

The crops sub-sector plays a pivotal role in achieving the Sustainable Development Goals (SDGs) of reducing poverty and hunger. It aligns with Kenya's Vision 2030 and the Agriculture Sector Transformation and Growth Strategy (2019-2029), which emphasize enhancing agricultural productivity and sustainability (Food Crops Directorate, 2024).

Kenya's agricultural landscape is shaped by a complex interplay of climate, hydrology, and terrain, which determine the suitability of different regions for specific agricultural practices. Climate change poses significant challenges, potentially altering the suitability of areas for various crops, thereby shifting land-use patterns and impacting food security. Additionally, evolving market dynamics are influencing land use, with a notable trend towards cash crops, sometimes at the expense of traditional perennial cropland (Kenya Land Alliance) .

In conclusion, while Kenya's agricultural sector is a critical driver of economic stability and growth, it faces ongoing challenges from climate variability, market fluctuations, low value-add, limited financing, and land-use pressures. Strategic interventions and adaptive practices are essential to sustain and enhance the sector's contribution to Kenya's economy and food security.

2.2 TRENDS IN LAND USE CHANGE

Population growth, settlement-driven land fragmentation, and traditional land tenure practices are significantly impacting land use, land cover changes, and climate change in Kenya, ultimately affecting food production. Kenya's total area is 580 367 square kilometres, which includes 11 227 square kilometres of inland water bodies such as Lake Victoria and Lake Turkana (Index Mundi, 2021). However, only about 20% of this land is suitable for high and medium agricultural potential, characterized by adequate and reliable rainfall for arable farming (KIPPRA, 2023).

Kenya’s land cover comprises various types including forests, savannahs, grasslands, wetlands, fresh and saline water bodies, and deserts (Kenya Land Alliance, 2021). Common land uses encompass agriculture, pastoralism, water catchments, nature reserves, urban and rural settlements, industry, mining, transport, communications, tourism, and recreation. Additionally, land is used for cultural sites, fishing, forestry, and energy production (Kenya Land Alliance, 2021).

Approximately 2.4% of Kenya's land cover consists of indigenous and exotic forests (Kenya Land Alliance, 2021). About 12% of the country benefits from high rainfall, supporting the cultivation of tea, coffee, pyrethrum, horticultural products, floriculture, and food crops like maize, wheat, potatoes, and pulses, along with dairy farming (Kenya Land Alliance, 2021). Semi-arid areas, making up about 32% of the total land, have moderate rainfall, supporting mixed crop and livestock farming. Recently, irrigated flower farming has become prominent alongside agropastoralism (Kenya Land Alliance, 2021). Over half of the land is arid, characterized by very low and erratic rainfall, and is mainly used for extensive livestock production under nomadic systems (Kenya Land Alliance, 2021).

Small farm holdings, averaging 1.2 hectares and primarily located in high-potential areas, constitute 98% of farms and cover 46% of the farmed land (KIPPRA, 2023). Medium farms, ranging from 10 to 60 hectares (average 20 hectares), represent 1.9% of holdings and occupy 15% of farmed land (KIPPRA, 2023). Large farms, averaging 77.8 hectares, account for only 0.1% of farm holdings but span 39% of the farmed area (KIPPRA, 2023). Per capita arable land has decreased from 0.42 hectares in 1961 to 0.11 hectares in 2020 and continues to shrink (KIPPRA, 2023).

In addition, rapid urbanization and the connected increase of real estate projects are putting pressure on agricultural land (KIPPRA, 2023). The percentage of the population living in urban areas grew from 23.9% to 28.5% between 2011 and 2021 (KIPPRA, 2023) and in 2023 the urban population growth was 3.7% (World Bank, 2023). Devolution has resulted in the growth of towns even in formerly rural areas creating a demand for residential houses for commercial use (KIPPRA, 2023). This has led to increased pressure on agricultural land, resulting in its conversion to urban uses such as residential, commercial, and industrial.

The size of landholdings is inversely related to population density, leading to smaller farms over time. In densely populated areas, like Kiambu County, smallholder farm sizes are decreasing, and future small-scale farming may become unfeasible (NCPD, 2018). Increasing family sizes and population growth have led to land fragmentation as land is divided among family members, resulting in progressively smaller farms (NCPD, 2018). In many Kenyan communities, it is customary for children to inherit land from their parents, and this tradition has been upheld across generations. However, this has led to the subdivision of land, resulting in smaller land holdings as families continue to adhere to this cultural practice. The traditional practice of land inheritance has perpetuated this subdivision, reducing available land sizes over time. This trend negatively impacts agricultural production, food security, and social welfare, limiting investments in land improvement, especially in Arid and Semi-Arid Lands (ASALs), and contributing to land degradation and out-migration (NCPD, 2018).

Farming on steep slopes using poor agricultural practices heightens the risk of landslides and soil erosion. As the population increases, the pressure on land may drive more people to encroach on forest reserves and cultivate on unstable slopes.

Further, rapid population growth has degraded land and the environment, in addition to other key challenges that lead to continuous expansion of land use change across the country. Climate change has altered the timing and duration of growing seasons due to warmer temperatures, affecting crop yields. Decreased rainfall and high temperatures have rendered some areas less suitable for certain crops. Additionally, climate change has reduced the availability of arable and grazing land, impacting food production quality and quantity due to the emergence of invasive weeds, pests, and diseases (NCPD, 2018). Increased land demand has intensified human activities, leading to land use changes that challenge local adaptation to climate change (NCPD, 2018).

These issues were integral to the development of the National Land Policy (2009) and the National Land Use Policy (2017). These strategic documents provide frameworks for the sustainable and optimal use of land resources at various levels. Specifically, the National Land Policy aims to curb uncontrolled land subdivision by implementing cluster settlements, though these have yet to be realized.

2.3 NATIONAL AND SECTORAL POLICY LANDSCAPE

A series of Kenyan policies address both the future growth trajectory for the country and its actions towards climate change, as well as initiatives for growth and resilience in the country's agricultural sector. This section outlines the key national and sectoral policies that are relevant to the RE-GAIN Programme.

In Kenya, a key long-term development framework is *Kenya Vision 2030*, which aims to elevate Kenya to a "newly industrializing, middle-income country offering a high quality of life to all its citizens by 2030" (Government of the Republic of Kenya, 2007). Agriculture is highlighted as a vital sector for achieving an annual economic growth target of 10%. Vision 2030 seeks to transition the agricultural sector from its current state of smallholder farming and subsistence operations, characterized by low productivity and minimal value addition, into "an innovative, commercially oriented, internationally competitive, and modern agricultural sector." The implementation of Vision 2030 is guided by successive 5-year Medium-Term Plans (MTPs), which outline policy, program, and intervention priorities.

The ***Bottom-Up Economic Agenda for Inclusive Growth (BETA) Plan*** aims to channel Ksh. 250 billion to the agricultural sector between 2023 and 2027 (Government Delivery Services, 2024). The BETA plans to use modern risk management tools, including crop and livestock insurance and market instruments like forward contracts, to ensure farming profitability and stable income. Efforts will focus on elevating two million poor farmers from food deficit to surplus producers through financial and agricultural extension support. The BETA is targeting productivity enhancements for key food value chains, such as maize, dairy, and beef, and decreasing dependence on basic food imports by 30%. Additionally, underperforming export crops will be revitalised, and emerging crops like coffee and cashew nuts will be expanded, alongside improvements to the tea value chain.

Kenya's *Nationally Determined Contribution (NDC)* for 2020-2030 aims to reduce the nation's GHG emissions by 30% (equivalent to 42.9 $MtCO_2e$) by 2030 compared to the Business as Usual (BAU) scenario, which predicts emissions of 143 $MtCO_2e$ (Ministry of Environment and Forestry, Office of the Cabinet Secretary, 2020). The NDC outlines that 21% of the mitigation costs will be borne by the national government, while the remaining 79% will be covered by international support through financial schemes, technology transfers, and capacity-building initiatives. It highlights the existing gaps in data collection and analysis necessary for accurate GHG emissions estimation, especially within the agricultural sector. The NDC provides a broad list of priority mitigation measures across different sectors, including the promotion of climate-smart agriculture (CSA) through carbon payment for ecosystem services (PES). For adaptation, Kenya aims to enhance resilience to climate change by integrating adaptation measures into its Medium-Term Plans (MTPs) and implementing specific adaptation actions to achieve the goals of Vision 2030. The estimated financial requirement for these mitigation and adaptation actions up to 2030 is over USD 40 billion.

Kenya's third ***National Climate Change Action Plan (NCCAP)*** **for the period 2023-2027** builds on the foundation laid by the previous NCCAPs and provides a framework for Kenya to deliver on its climate change commitments (Government of Kenya, 2023). The NCCAP highlights the threat that climate change poses to Kenya's economy as the impacts climate change on GDP are estimated to between 3% and 5% per year and could increase to between 6.5% and 8.5% of GDP per year between 2021 and 2025 if climate change action is not prioritised. The NCCAP prioritises adaptation to reduce the impact of extreme weather events especially for vulnerable groups and notes that adaptation actions that can also contribute to reducing Kenya's greenhouse gas (GHG) emissions will be considered. Food and nutrition security are a key focus of the NCCAP and is listed as a priority climate action area with the objective of "increas(ing) food and nutrition security by enhancing productivity and resilience of the agricultural sector in as low-carbon manner as possible" (Government of Kenya, 2023). The NCCAP aims to have 2 million farmers that have adopted climate-smart post-harvest technologies, such as cold storage facilities that utilise green energy and solar crop dryers. We have also been informed that Kenya is in the process of developing a national post-harvest strategy.

Agriculture is also a central focus of Kenya's *National Adaptation Plan (NAP)* for 2015-2030 (Ministry of Environment and Natural Resources, 2015). The NAP envisions improved climate resilience to support the realization of Vision 2030, aiming for robust economic growth, resilient ecosystems, and sustainable livelihoods for Kenyans. This plan is rooted in the Constitution of Kenya and aligns with the Climate Change Act of May 2016. It emphasizes the promotion and implementation of climate-smart agriculture (CSA) practices throughout the agricultural value chain to enhance efficiency and reduce food losses by utilizing advanced technologies for greater productivity.

Additionally, the *Kenya Climate Smart Agriculture Strategy (KCSAS)* for 2017-2026 aims to foster a sustainable agricultural sector that is both climate-resilient and low in carbon emissions, ensuring food security and contributing to national development goals (Ministry of Agriculture, Livestock and Fisheries, 2017). The strategy's mission is to promote agricultural practices that boost productivity, improve resilience to climate impacts, and reduce GHG emissions. The Specific Objectives are: (i) to enhance adaptive capacity and resilience of farmers to the adverse impacts of climate change; (ii) to develop mechanisms that minimize GHG emissions from agricultural production systems; (iii) to improve coordination and collaboration among institutions and stakeholders in CSA; and (iv) to address cross-cutting issues that adversely impact or enhance CSA (Ministry of Agriculture, Livestock and Fisheries, 2017). In the crops sub-sector, this strategy identifies the following strategic issues:

- **Vulnerabilities due to changes in temperature regimes and precipitation patterns.** Variations in temperature and rainfall patterns have led to changes in agroecological zones, thereby altering the geographical suitability for different crops and causing shifts in cropping seasons. These changes have resulted in lower crop yields per unit area, higher post-harvest losses, and increased costs of production. Additionally, these climate shifts have escalated the prevalence of pests and diseases in crops and have led to the emergence of new pest and disease threats. According to crop simulation models, rising temperatures due to climate change are the primary factor driving decreases in crop yields (Luedeling, 2011). Crops such as soybeans, which are highly sensitive to increasing temperatures, are likely to experience significant yield reductions. Other crops, including cotton, maize, and dry beans, may also struggle to adapt to future climate conditions.
- **Vulnerabilities due to extreme weather events.** Climate change has intensified the frequency and severity of extreme weather events such as droughts, floods, strong winds, hailstorms, and frosts. Droughts can cause substantial losses in crop production, reducing yields or leading to complete crop failures due to water stress, which hampers nutrient

absorption from the soil and essential physiological processes. Flooding creates waterlogged soil conditions, which impede the roots' ability to respire aerobically and absorb nutrients, resulting in plant stress that reduces yields or causes total crop failure. Strong winds can cause physical damage to crops through breakage, lodging, or injury, and can accelerate evapotranspiration, leading to further stress and reduced yields.

- **Emissions from other sources in agricultural production systems.** Poor agricultural practices contribute significantly to greenhouse gas emissions. These practices include improper tillage methods, burning of crop residues, deforestation on farmlands, and incorrect fertilizer use. Additionally, emissions are produced from agricultural machinery, post-harvest activities, and agro-processing and residue management.

Two of the key strategies included in this document are:

- Provision of accurate, timely, and reliable climate/weather information to inform decisions of actors on crops, livestock, and fisheries value chains. This entails "improvement, modernization, and maintenance of weather infrastructure; integration of scientific and indigenous technical knowledge and technical skills enhancement in weather data analysis; and packaging, dissemination, and use of early warning weather information" (Ministry of Agriculture, Livestock and Fisheries, 2017).
- **Enhance productivity and profitability of agricultural enterprises.** This involves "the promotion and use of improved technologies and post-harvest approaches, such as improved storage and distribution of agricultural products and improved market access" (Ministry of Agriculture, Livestock and Fisheries, 2017).

Kenya's Agricultural Sector Transformation and Growth Strategy (ASTGS) (2019-2029) is built on the principle that ensuring food security hinges upon fostering a dynamic, commercially viable, and contemporary agricultural sector (Ministry of Agriculture, Livestock, Fisheries and Irrigation, 2019). This approach aims to support Kenya's economic growth in a sustainable manner, aligning with national priorities, commitments under the Malabo Declaration of the Comprehensive Africa Agriculture Development Programme (CAADP), and the Sustainable Development Goals (SDGs). The ASTGS prioritizes three anchors to drive the 10-year transformation, with specific targets set for the first five years: Anchor 1: increase small-scale farmer, pastoralist and fisherfolk incomes; Anchor 2: increase agricultural output and value add; and Anchor 3: increase household food resilience (Ministry of Agriculture, Livestock, Fisheries and Irrigation, 2019). Among key specific targets are to:

- Develop and enable 1 000 farmer-facing Small and Medium Enterprises (SME) to provide more farmers with better access to affordable and appropriate inputs, irrigation equipment, improved post-harvest handling and aggregation, and access to markets.
- Ensure minimum participation of 33% women and 30% youth in SMEs benefitting from this programme.
- Integrate mandatory extension services to explain what fertilizer to use based on soil needs, with compulsory lime vouchers for farmers with acidic soils, and proper post-harvest handling of produce where the risk of aflatoxin is high.

Kenya Climate Smart Agriculture Implementation Framework (KCSAIF) for 2018 to 2027 has been designed to guide innovative and transformative initiatives to tackle challenges posed by climate change. Its vision is to enhance agricultural productivity while sustainably strengthening the resilience of national agricultural systems (Ministry of Agriculture, Livestock, Fisheries and Irrigation, 2018). The framework aims to offer diverse options for implementing the KCSAS. The overall goal of the framework is "to achieve a long-term national low-carbon climate-resilient development pathway, whilst realizing the development goals of Kenya Vision 2030" (Republic of Kenya, 2018).

The framework sets 4 strategic objectives: (1) to develop a sustainable system for achieving coordinated and cooperative governance of climate resilience and low carbon growth in the agricultural sector; (2) to mainstream CSA to support the transformation of Kenya's agricultural sector into an innovative, commercially oriented, competitive and modern industry that contributes to poverty reduction and improved food security; (3) to reduce vulnerability of agriculture systems by cushioning them against the impacts of climate change and reduce GHG emissions where possible; and (4) to strengthen communication systems on CSA extension and agro-weather issues (Republic of Kenya, 2018).

One of the sub-components of KCSAIF, Sub-component 2.5: Food and feed storage and distribution, aims to tackle multiple challenges, including significant post-harvest losses throughout value chains, insufficient capacity for preservation and storage, food safety concerns stemming from inadequate post-harvest handling and storage technologies, deficient storage expertise, and marketing infrastructure gaps. This sub-component aims to achieve four objectives namely: (i) reduction of post-harvest losses along agricultural value chains; (ii) enhancing private sector annual storage capacity for agricultural products; (iii) enhancing communities and household capacity to store agricultural produce; and (iv) expanding the strategic food reserve to include all appropriate agricultural products and establish strategic feed/grazing reserves (Republic of Kenya, 2018). This sub-component encompasses diverse initiatives aimed at enhancing post-harvest management and food safety. These include investing in suitable storage facilities and technologies, educating stakeholders, and disseminating up-to-date market information. It also involves establishing rural marketing centres, exploring and integrating traditional food preservation techniques, and implementing policies to diversify food production. Additional measures include conducting surveys to assess storage capabilities and deficiencies, fortifying warehouse systems, renovating storage infrastructure, fostering connections with service providers, strengthening farmers' pest management skills, supporting surplus storage solutions, and promoting safe chemical usage during storage.

Kenya's Climate Risk Management Framework (2016) outlines the government's strategy to align climate change and disaster risk policies (Ministry of Environment, Climate Change and Forestry, 2016). The framework identifies ten priority areas where climate change and disaster risks intersect, presenting opportunities for governmental intervention. The objective is to synchronize programs and initiatives, establish effective coordination mechanisms, and develop a supportive policy and legal framework for integrated climate risk management. Key actions include capacity building at national and county levels, assessing local exposure and vulnerability to disasters, engaging vulnerable communities with a focus on gender and marginalized groups, and mobilizing financial resources. Additionally, the framework includes integrating climate risk management into sectoral programs, implementing pilot projects, enhancing research and knowledge dissemination, and fostering platforms for sharing lessons and best practices.

Kenya's National Policy on Climate Finance (2016) conducts an analysis of climate finance, identifies opportunities for climate finance within Kenya, outlines strategic interventions to achieve policy goals, and details governance structures and financial requirements (Republic of Kenya, 2016). It assesses the current legal and policy landscape for climate financing, encompassing both domestic and international sources, and explores the potential impact of climate finance across key economic sectors. The policy articulates government interventions, including the establishment of a national Climate Change Fund, identification and tracking of climate finance sources, enhancement of Kenya's carbon trading system, and exploration of green bonds as potential avenues for financing climate initiatives.

The primary objective of Kenya's *Agricultural Sector Development Strategy (ASDS) (2010-2020)* is to attain an annual growth rate of 7% for the agricultural sector (Republic of Kenya, 2010). In addition to securing food and nutrition for the entire population of Kenya, there is a significant focus on transitioning from subsistence farming to production that is oriented towards the market. To achieve the vision of "an innovative, commercially oriented and modern agricultural sector", a strong focus is required across five strategic thrusts: (i) increasing productivity and promoting commercialisation and competitiveness of agricultural commodities; (ii) promoting private sector participation in all aspects of agricultural development; (iii) developing and managing the water and land resources, forestry, and wildlife in a sustainable manner; (iv) reforming agricultural service, credit, regulatory, processing, and manufacturing institutions for efficiency and effectiveness; and (v) increasing market access and trade through development of cooperatives and agribusiness.

Regarding post-harvest losses and their mitigation, the ASDS highlights the absence of adequate post-harvest services as a limiting factor in enhancing agricultural sector productivity. It also recognizes that various crop pests and diseases continue to diminish potential yields both before and after harvest. Insufficient storage facilities and improper handling contribute to losses amounting to as much as 40%. Pathogens and aflatoxins, key post-harvest challenges, have had severe consequences, including fatalities, in some regions of the country. According to the ASDS, controlling pests and diseases remains a significant challenge for many farmers, particularly those operating on a small or medium scale, largely due to the high costs of pesticides and control equipment.

As two major challenges for the agricultural sector and successful management of post-harvest losses, the ASDS identifies: a) Limited capital and access to affordable credit. The formal banking sector perceives farming as a high-risk activity, resulting in minimal attention and support. While several microfinance institutions operate in this space, they often raise the cost of credit, serve only a limited number of smallholder farmers, and offer short-term financing solutions. There is emerging development in the formal banking system to establish credit facilities tailored specifically for small-scale farming needs. b) Pre- and post-harvest crop losses occasioned by pests and diseases, and lack of proper handling and storage facilities. Smallholder farmers struggle to manage pests and diseases primarily because of insufficient access to information.

Kenya's National Agriculture Investment Plan (NAIP) (2019-2024) is the five-year strategic investment blueprint linked to the country's 10-year ASTGS (Ministry of Agriculture, Livestock, Fisheries and Irrigation, 2019). Both frameworks are built on the premise that achieving comprehensive food and nutrition security hinges on fostering a dynamic, commercial, modern, and inclusive agricultural sector that promotes sustainable economic growth within the framework of devolution. The NAIP aims to expedite Kenya's agricultural modernization, aligning with the Big Four Presidential Agenda, CAADP, the SDGs, and Kenya's Medium-Term Plan III.

Kenya Strategic Investment Framework (KSIF) for sustainable land management (SLM) (2017-2027) aims to establish a national strategic planning framework to guide intersectoral coordination, prioritize integrated approaches, and foster cost-effective investments and budgetary support for SLM (Ministry of Environment and Natural resources, 2016). Its primary objective is to enhance, sustain, and safeguard Kenya's natural capital productivity through improved investments, sectoral coordination, and scaling up of SLM interventions. Environmentally, it aims to restore Kenya's natural capital assets by addressing the causes of land degradation, mitigating its adverse impacts, promoting long-term ecosystem sustainability, enhancing climate resilience, and improving environmental health.

The Kenya National Spatial Plan (2015-2045) envisions land use that optimizes productivity, sustainability, efficiency, and equity (Ministry of Lands and Physical Planning, Department of Physical Planning, 2015). It underscores the importance of regulating the subdivision of agricultural land, particularly in the context of urbanization.

In 2022, under the ***African Landscape Restoration Initiative***, the Government of Kenya initiated the planting of 15 billion trees by 2032. This initiative aims at reducing greenhouse emissions, stopping and reversing deforestation, and restoring 5.1 million hectares of deforested and degraded landscapes.

Other relevant policy documents and strategies related to the agriculture sector and climate change mitigation include:

- ***Capacity building Strategy for Agriculture Sector (2016-2021):*** This strategy is aimed at enhancing the skills, knowledge, and competencies of staff and stakeholders in the agriculture sector (Ministry of Agriculture, Livestock and Fisheries, 2017). It outlines the institutional prerequisites necessary for delivering services efficiently and effectively. The strategy envisions support from the government and other stakeholders for capacity development at both individual and organizational levels, alongside creating a conducive environment (systems) for all actors throughout the agricultural value chain.

- ***Kenya Agricultural Sector Extension Policy (2023):*** The policy is designed to boost agricultural productivity, enhance food security, and improve farmer livelihoods through sustainable and efficient extension services (Ministry of Agriculture and Livestock Development, 2023). It aims to develop both human resources and infrastructure, improve knowledge management, and strengthen connections between research, extension services, and farmers. The policy highlights the importance of social inclusivity, targeting support for women, youth, and persons with disabilities, and promotes the adoption of climate-smart agricultural practices. Implementation will involve collaboration between national and county governments, supported by a framework for coordination, capacity building, and financial and technical assistance from development partners and the private sector.
- ***Strategic Plan for Ministry of Agriculture, Livestock, Fisheries, and Cooperatives (2018-2022):*** This plan outlines the key strategic goals, priorities, and approaches to be followed for achieving measurable outcomes (Ministry of Agrilture, Livestock, Fisheries and Cooperatives, State Department for Livestock, 2018). It includes eight strategic goals for the period covered: 1) create an enabling environment for agricultural development; 2) increase productivity and outputs in agriculture sector; 3) enhance food and nutrition security; 4) enhance investment in the blue economy; 5) improve market access and trade; 6) strengthen institutional capacity; 7) increase youth, women, and vulnerable groups participation in agricultural value chains; and 8) enhance leadership and integrity in the Ministry. These objectives seek to evolve the predominantly smallholder agriculture sector into modern, market-driven agribusinesses while ensuring complete food and nutrition security in Kenya.
- ***National Agribusiness Strategy (2012):*** It aims to steer the agricultural sector's development and transformation toward a competitive alignment with market demands and commercialization (Government of Kenya, Agricultural Sector Coordination Unit, 2012). The strategy has the following four objectives: (i) to remove barriers and create incentives for the private sector to invest in agribusiness and related business opportunities; (ii) to invest public resources more strategically to trigger growth in agribusiness; (iii) to make agribusiness systems more competitive, easily adaptable, and fleet-footed in order to deal with dynamic markets and the opportunities they bring; and (iv) to encourage institutional frameworks that enable all actors to utilize market opportunities.
- ***Kenya's Agricultural Marketing Strategy (2023 – 2032)*** aims to transform the agricultural sector into a dynamic, productive, and efficient industry that competes effectively both domestically and internationally (Ministry of Agriculture and Livestock Development, 2023). It seeks to achieve tangible and measurable outcomes, including enhanced market access and improved returns for farmers, affordable prices for consumers, lucrative returns for all market participants, increased exports of Kenyan agricultural products, and a favourable trade balance. The strategy aims to streamline trade processes, facilitating the transition of small-scale farmers from subsistence to commercial farming, while enhancing the competitiveness of Kenya's agricultural produce across all segments of the market chain.

2.4 LEGAL AND REGULATORY LANDSCAPE

Beyond policy, legal and regulatory resources also indicate Kenya's commitment to climate action, as outlined below.

Kenya's Climate Change Act (2016) establishes a robust legal framework to address climate change challenges in Kenya (Republic of Kenya, 2016). This pivotal document guides the country's climate change policy, serving as the foundation for initiatives like the National Climate Change Action Plan. The main objectives are to:

- "Mainstream climate change responses into development planning, decision making and implementation;
- Build resilience and enhance adaptive capacity to the impacts of climate change;
- Formulate programmes and plans to enhance the resilience and adaptive capacity of human and ecological systems to the impacts of climate change;
- Mainstream and reinforce climate change disaster risk reduction into strategies and actions of public and private entities;
- Mainstream intergenerational and gender equity in all aspects of climate change responses;
- Provide incentives and obligations for private sector contribution in achieving low carbon climate resilient development;
- Promote low carbon technologies, improve efficiency and reduce emissions intensity by facilitating approaches and uptake of technologies that support low carbon, and climate resilient development;
- Facilitate capacity development for public participation in climate change responses through awareness creation, consultation, representation and access to information;
- Mobilize and transparently manage public and other financial resources for climate change response;
- Provide mechanisms for, and facilitate climate change research and development, training and capacity building;
- Mainstream the principle of sustainable development into the planning for and decision making on climate change response; and
- Integrate climate change into the exercise of power and functions of all levels of governance, and to enhance cooperative climate change governance between the national government and county governments" (Republic of Kenya, 2023).

2.5 GCF COUNTRY PROGRAMME DETAILS

2.5.1 Planned, current, and past climate change-related projects

In Kenya the GCF is implementing 19 projects (

Table 2-1), with a total GCF financing of USD 292.7 million. To date, five country level readiness activities have been approved with a total approved readiness support budget of USD 4.5 million and USD 3.7 million disbursed.

Table 2-1 - GCF Portfolio in Kenya

Project code	Focus	Geographical scope	Project title
FP223	Cross-cutting	Latin America and the Caribbean, Africa, Asia-Pacific (19 countries)	Project GAIA ("GAIA")
FP220	Adaptation	Africa (Kenya, Tanzania, Rwanda, Uganda)	Africa Rural Climate Adaptation Finance Mechanism (ARCAFIM) for East Africa region
FP210	Cross-cutting	Africa (Cote d'Ivoire, Kenya, Rwanda, Zambia, Democratic Republic of the Congo, Nigeria, Uganda)	KawiSafi II

FP205	Adaptation	Africa (19 countries)	Infrastructure Climate Resilient Fund (ICRF)
FP190	Cross-cutting	Latin America and the Caribbean, Africa, Asia-Pacific (19 countries)	Climate Investor Two
FP177	Cross-cutting	Latin America and the Caribbean, Africa, Asia-Pacific, Eastern Europe (9 countries)	Cooling Facility
FP175	Adaptation	Kenya	Enhancing community resilience and water security in the Upper Athi River Catchment Area, Kenya
FP168	Mitigation	Africa (Ethiopia, Guinea, Nigeria, Ghana, Kenya, Tunisia)	Leveraging Energy Access Finance (LEAF) Framework
FP163	Mitigation	Africa, Asia-Pacific (7 countries)	Sustainable Renewables Risk Mitigation Initiative (SRMI) Facility
FP152	Mitigation	Latin America and the Caribbean, Africa, Asia-Pacific, Eastern Europe (42 countries)	Global Subnational Climate Fund (SnCF Global) – Equity
FP151	Mitigation	Eastern Europe, Latin America and the Caribbean, Africa, Asia-Pacific (42 countries)	Global Subnational Climate Fund (SnCF Global) – Technical Assistance (TA) Facility
FP148	Mitigation	Africa (9 countries)	Participation in Energy Access Relief Facility ("EARF")
FP113	Adaptation	Kenya	TWENDE: Towards Ending Drought Emergencies: Ecosystem Based Adaptation in Kenya's Arid and Semi-Arid Rangelands
FP103	Mitigation	Africa (Kenya, Senegal)	Promotion of Climate-Friendly Cooking: Kenya and Senegal
FP099	Mitigation	Africa, Latin America and the Caribbean, Asia-Pacific (19 countries)	Climate Investor One
FP095	Cross-cutting	Africa, Latin America and the Caribbean, Asia-Pacific (17 countries)	Transforming Financial Systems for Climate
FP078	Adaptation	Africa (Ghana, Nigeria, Kenya, Uganda)	Acumen Resilient Agriculture Fund (ARAF)
FP027	Mitigation	Africa (Benin, Kenya, Nigeria, Uganda, Ethiopia, Namibia, Tanzania)	Universal Green Energy Access Programme (UGEAP)
FP005	Cross-cutting	Kenya, Rwanda	KawiSafi Ventures Fund

Of specific importance for the agricultural sector in Kenya are the following projects: FP220 “Africa Rural Climate Adaptation Finance Mechanism (ARCAFIM) for East Africa region”, FP113 “TWENDE: Towards Ending Drought Emergencies: Ecosystem Based Adaptation in Kenya’s Arid and Semi-Arid Rangelands”, FP095 “Transforming Financial Systems for Climate”, and FP078 “Acumen Resilient Agriculture Fund (ARAF)”. These projects are discussed in more detail below.

FP220: ARCAFIM (GCF, 2023)

In East Africa, climate models forecast ongoing rises in average temperatures and more frequent and intense heavy rainfall events, creating substantial challenges for farmers as they face worsening conditions for crop and livestock production. Despite the growing need for more sustainable agricultural practices, progress has been slow in Kenya, Uganda, Tanzania, and Rwanda due to a lack of access to funding for Climate Change Adaptation (CCA) investments. There is a pressing need for private sector financing in CCA to drive long-term, market-oriented change.

The ARCAFIM programme aims to establish a practical and widely adaptable financing model to attract private sector investments for rural CCA initiatives among East African MSMEs and smallholders involved in food systems. These MSMEs and smallholders have the potential to drive sustainable, market-responsive changes over the long term. The programme facilitates climate adaptation by bringing in both international and local financing, including contributions from regional commercial banks and local financial institutions. This model can serve as a proof-of-concept for replication in other regions, offering significant potential to enhance private sector financing for rural CCA projects on a larger scale.

FP113: TWENDE (GCF, 2019)

Climate change is expected to cause greater fluctuations in rainfall and temperature, raising the likelihood of more frequent and severe droughts and other extreme weather events in Kenya's arid and semi-arid regions. This project, running from 2019 to 2025, focuses on eleven counties within two major climate zones, which have devolved powers under Kenya's new constitution. Strengthening capacity and institutions to better implement devolution is crucial for boosting climate resilience in these areas. The project aims to enhance the adaptive abilities of communities and local institutions through evidence-based landscape planning by improving access to climate data and information, and by helping community-based cottage industries gain better access to markets and financial services.

FP095: Transforming Financial Systems for Climate (GCF, 2018a)

In these Africa and Latin America, the private sector still views sustainable energy and climate resilience as costly and complicated, largely because the environmental benefits of more resilient investments and practices are not widely recognized. To achieve critical mass and enhance the commercial feasibility of climate-related projects, it is necessary to illustrate the advantages of investing in these areas. This programme primarily aims to expand climate finance in the targeted countries, redirect financial flows, and strengthen the capacity of local partners in climate-related fields. It plans to accomplish this by offering loans through local partner financial institutions to borrowers involved in sustainable energy, energy efficiency, housing, agriculture, forestry, and water and waste management. Additionally, the programme will feature a technical support component. The anticipated programme duration is 20 years.

FP078: ARAF (GCF, 2018b)

Agriculture is a key industry in the target nations, where up to 80% of farmland is operated by smallholder farmers who are particularly susceptible to climate change effects. Enhancing climate resilience is essential for ensuring sustainable growth in agricultural productivity and income for these farmers over the long term. ARAF aims to bolster climate resilience to secure enduring, sustainable gains in agricultural productivity and farmer incomes. It plans to transform the investment model for climate change adaptation in Africa from reliance on grants to a focus on long-term capital investments, thus enabling smallholder farmers to tackle climate change more efficiently and effectively. The initiative will support innovative private social entrepreneurs in MSMEs by offering aggregation services, digital platforms, and novel financial solutions for smallholder farmers. This project is projected to last for 12 years.

2.5.2 Other relevant projects (on food losses)

Beyond current GCF funding related to agriculture, several initiatives have been implemented in Kenya to address post-harvest food losses in the past decade, focusing on improving food security and reducing waste. Some relevant programmes are listed below:

1. ***FAO and Rockefeller Foundation Partnership (2016-2019)*** (FAO, 2019)***:*** This initiative aimed to strengthen food value chains and improve markets and infrastructure. The project supported the implementation of post-harvest loss reduction mechanisms in Kenya, focusing on staple crops. Activities included forming a national post-harvest technical working group, conducting loss assessment studies, and training stakeholders. The project contributed to the development of a national post-harvest strategy and policy briefs for Kenya by focusing on proper drying, storage, and handling techniques, formed a national post-harvest technical working group, conducted loss assessment studies, and trained over 100 stakeholders and technical staff in post-harvest management.
2. ***YieldWise Programme*** (The Rockefller Foundation, n.d.)***:*** Launched by The Rockefeller Foundation, this programme targeted smallholder farmers in Kenya, Tanzania, and Nigeria. The initiative focused on reducing post-harvest losses through modern technologies such as cooling chambers and improved storage solutions like airtight bags. These

measures helped farmers extend the shelf-life of their produce, and enhance market value, resulting in significant financial gains for the farmers.

3. ***Kenya On-Farm Storage Challenge Project*** (AgResults, n.d.)***:*** The project was conducted between 2014 and 2018 and was a $12 million initiative that utilized a Pay-for-Results prize competition to incentivize private sector participants to create, market, and sell on-farm storage (OFS) solutions to smallholder farmers. This project distributed 1 390 777 improved storage devices, creating 413 265 metric tonnes of improved storage capacity. As a result, there was a 250% increase in sales of on-farm storage products, significantly reducing post-harvest losses of grains and enhancing food security and farmer incomes.
4. ***Kenyan Government Initiatives:*** The Kenyan government has committed to reducing post-harvest losses from 30% to 5% (African Union Commission, 2018). Efforts have included creating awareness among farmers about proper handling and storage techniques, improving drying methods, and enhancing transportation infrastructure to reduce losses during transit. The government has also funded initiatives such as the procurement of solar mobile grain dryers (Ministry of Agriculture and Livestock Development, 2024) and the development of Aflasafe, a product that is key for preventing aflatoxin contamination (Aflasafe, 2018). These measures are part of a broader strategy to ensure food security and align with the Malabo Declaration's goals of halving post-harvest losses by 2025.

These projects and initiatives highlight a concerted effort by various stakeholders, including government bodies, international organizations, and local farmers, to address the challenges of post-harvest food losses in Kenya. The RE-GAIN programme should work in addition to these initiatives on reducing the impact of climate on food losses to maximize the impact of the requested funding.

3 Climate Analysis - Adaptation

3.1 COUNTRY CLIMATE CHANGE BASELINE

The vast majority (approximately 85%) of Kenya is characterised by fragile arid and semi-arid ecosystems (The World Bank, 2021), or – under the Köppen Geiger climate classification system – largely a hot semi-arid climate (The World Bank, n.d.). The remaining land area, predominantly in the west and south-west of the country, is classified as having a tropical savanna climate (The World Bank, n.d.). Across its length and breadth, Kenya displays tremendous topographic diversity, including plains, hills, mountains, highlands, cliffs, and escarpments (The World Bank, n.d.). This also affects its climatic profile across regions, with it tending to be hot and humid at the coast, temperate inland, and very hot and dry towards the north and northeast (Republic of Kenya, 2015).

Kenya's climate is heavily influenced by the Inter Tropical Convergence Zone (ITCZ), a zone of trade winds convergence from the north and south, creating unique and shifting air circulation patterns. The ITCZ shapes four main seasons in Kenya, with two rainfall periods: January to March, which is typically the 'warm dry season', April to June which is the 'long wet season', July to September – the 'cool dry season', and October to December – the 'short wet season' (The World Bank, 2021).

Historical trends suggest that climate change has already influenced an increase in average temperatures since the 1960s, especially in inland areas (The World Bank, 2021). Records suggest that between 1960 and 2005/6 the annual mean temperature rose increase approximately 1.0°C, at an estimated average rate of 0.21°C per decade. (Republic of Kenya, 2015). Another estimate that examined temperature trends from 1985-2015 indicates that average temperature increased by approximately 0.34°C per decade from 1985–2015 (with the highest increase being in the already arid and semi-arid regions) (USAID, 2018).

In recent decades (since the 1970s, in particular) the trend of increased average temperatures has been even more pronounced, as depicted (World Bank, 2023).

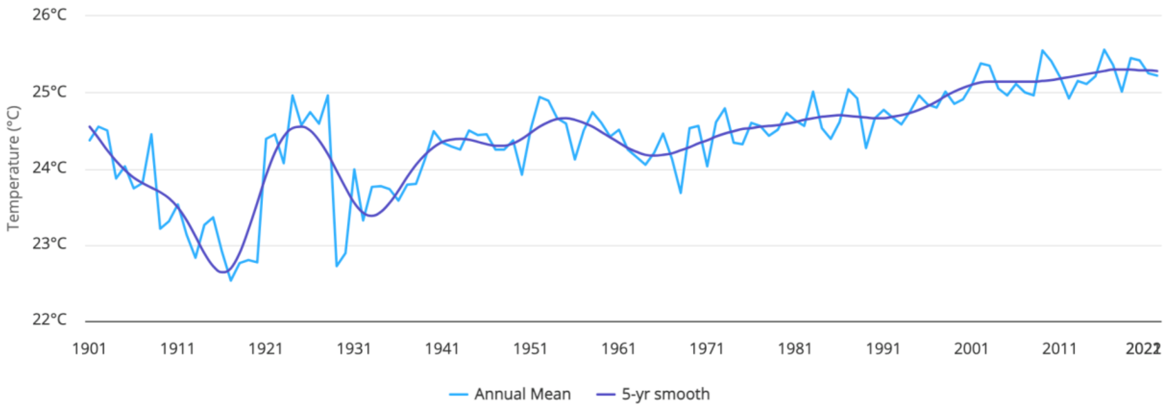


Figure 3-1 - Observed annual average mean surface air temperature of Kenya, 1901 - 2022 (World Bank, Climate Change Knowledge Portal)

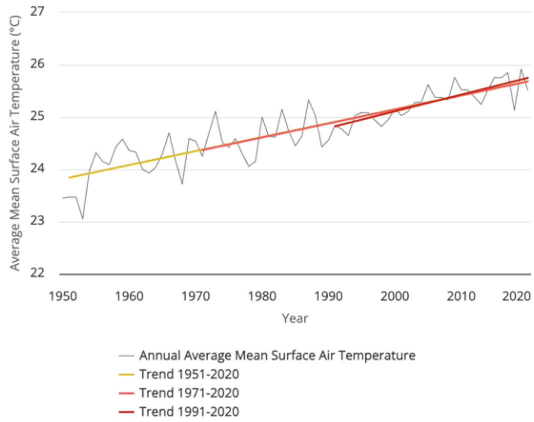


Figure 3-2 - Average mean surface air temperature annual trends with significance of trend per decade, 1951 - 2020, Kenya (World Bank, Climate Change Knowledge Portal)

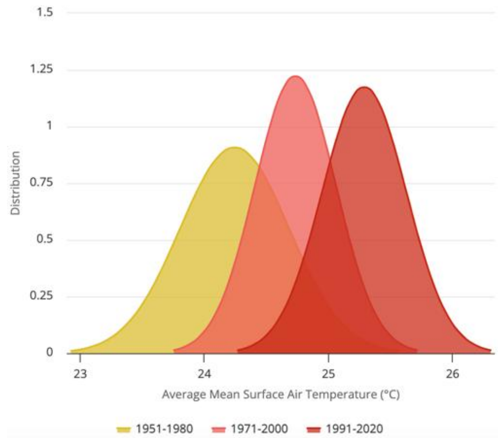


Figure 3-3 - Change in distribution of average mean surface air temperature, 1951-2020, Kenya (World Bank, Climate Change Knowledge Portal)

Rainfall trends in Kenya are extremely variable, both in terms of inter-annual rainfall and geographic variability across different regions. Records suggest that northern areas have become wetter, and southern areas have become drier since the 1960s. Extreme rainfall events have been occurring with greater frequency and intensity (The World Bank, 2021).

At the same time, Kenya has also experienced an increase in aridity and droughts, with moderate drought events recorded on average every three to four years and major droughts every ten years. Since 2000, observations indicate that prolonged droughts have become more common (The World Bank, 2021). Since the 1970s, the long rains in Kenya have decreased (USAID, 2018).

Figure 3-4 and Figure 3-5 below demonstrate the historic variability, and the slightly increasing signal in the most recent decades.

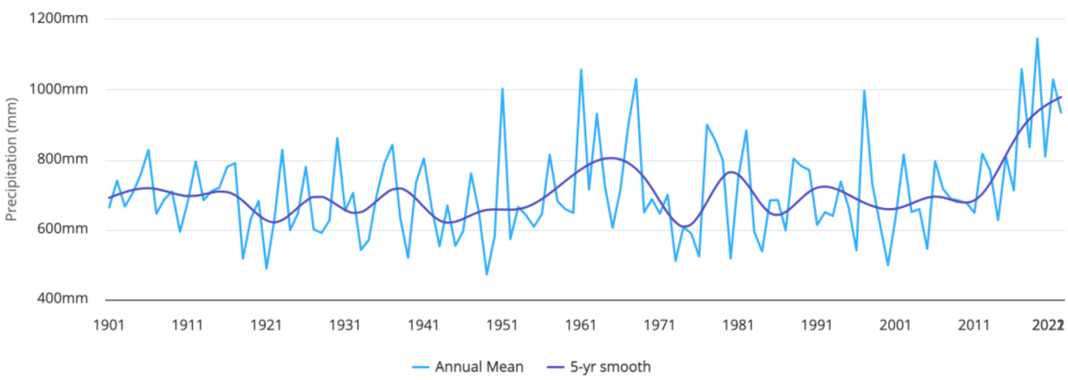


Figure 3-4 – Observed Annual Precipitation of Kenya (1901 - 2022) (The World Bank, Climate Change Knowledge Portal)

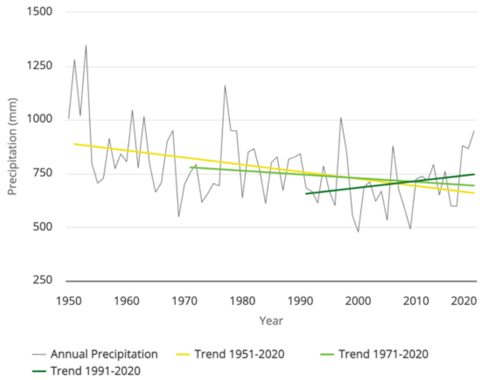


Figure 3-5 - Precipitation annual trends with significance of trend per decade in Kenya (1951-2020) (The World Bank, Climate Change Knowledge Portal)

Kenya has historically been highly prone to climate-related extreme weather events and disasters. The most recent Germanwatch climate risk index for cumulative disaster-related losses between 2000-2019 ranks Kenya 34th out of 180 countries (Eckstein, Künzel, & Schäfer, 2022). According to the European Union's (EU) INFORM climate risk index, Kenya's baseline risk level comprises an above-average vulnerability to climate-related hazards (6 out of 10), and a high lack of coping capacity (5.9 out of 10) (European Commission, n.d.). Estimates indicate that over **70% of natural disasters in Kenya are attributable to extreme climatic events, and the most common of these are floods and droughts** (Republic of Kenya, 2015). Historic trends suggest that major droughts tend to occur approximately every ten years, and moderate droughts or floods every three to four years.

3.2 AGRICULTURE SECTOR CLIMATE CHANGE BASELINE

Kenya's economy is heavily reliant on agriculture. Even though the services sector is the dominant contributor to GDP (at 42.7%; 2018 figures), the agriculture sector follows close behind in its share of GDP (34.4%; 2018 figures) (GIZ, 2020). According to official government estimates, the agricultural sector directly contributes about 25.4% of Kenya's GDP but another 27% is linked to agriculture indirectly, through agro-based industries and agriculture-oriented service sector activities, leading to an overall contribution as high as 52% of the GDP if indirect linkages are taken into account (Republic of Kenya, 2015). The sector accounts for 65% of Kenya's exports (Republic of Kenya, 2015). For the majority of Kenyans, agriculture is the primary source of livelihood, accounting for 18% of formal employment but as much as 60% of total (formal and informal) employment (Republic of Kenya, 2015).

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).

Maize is sensitive to changes in temperatures and rainfall. The IPCC's synthesis of global literature on observed climate change impacts on major crops indicates that maize, as well as rice yields in sub-Saharan Africa, have displayed negative trends under a steadily warming climate, as captured in Figure 3-6.

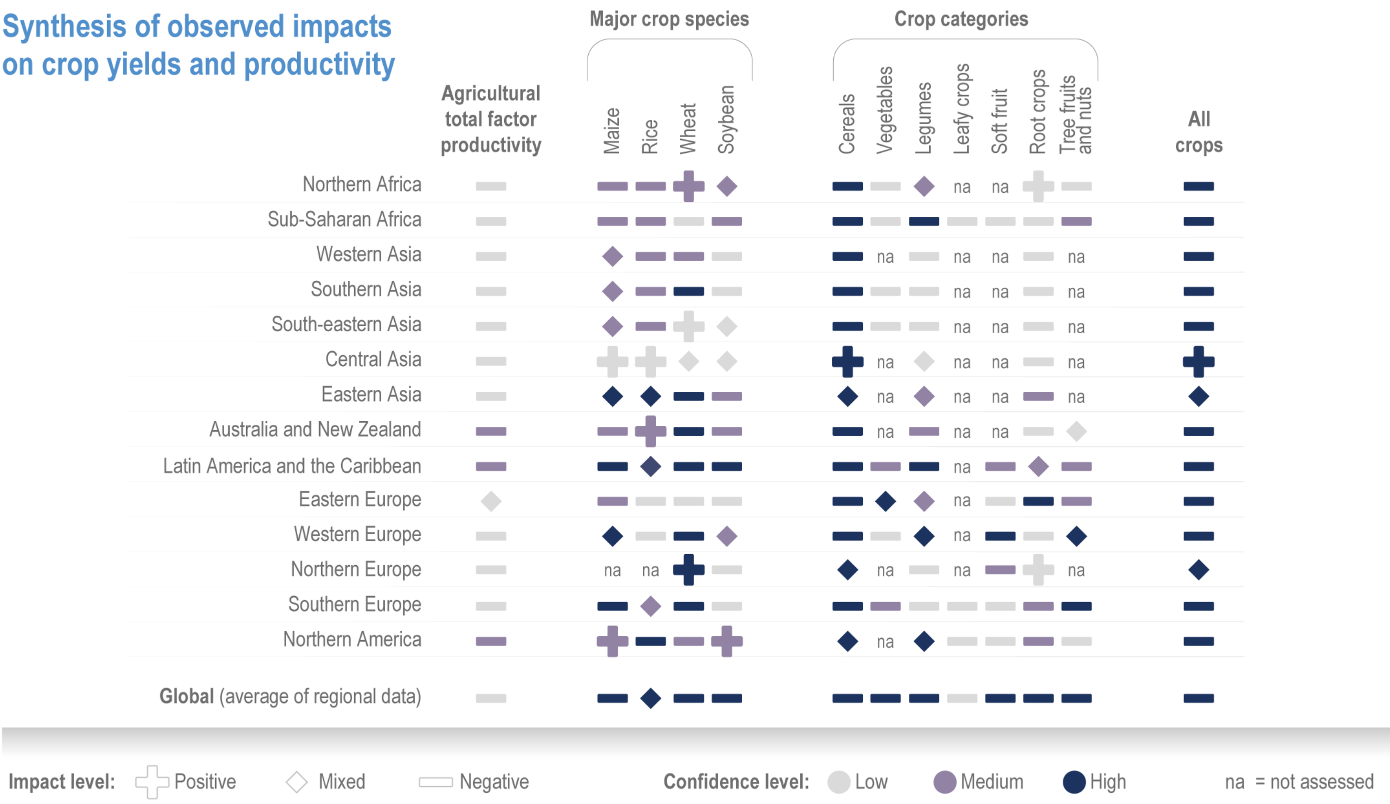


Figure 3-6 - Synthesis of literature on observed impacts of climate change on productivity by crop type and region (IPCC, 2021)

Researchers have voiced concern that the maize yield in Kenya has been on the decline over the past few years. One study notes it declined from 42.1 million bags in 2020 to 36.7 million bags in 2021, translating to a 12.8% decrease in total production, and that this decrease was largely linked to climate-related factors such as unreliable rainfall and an increase in temperatures, drought and related events (Mutiso & Kimtai, 2023).

Post-harvest losses in maize further exacerbate food security concerns. One source estimated post-harvest losses in the maize value chain at between 20-36%, due to mishandling, quality losses from **weevil infestation, discoloration, and broken grains** (USAID, 2015). Storage is limited due to liquidity constraints, uncertain returns from storage, technical knowledge gaps, and price unpredictability (USAID, 2015).

Beans production is also affected by climatic factors. For instance, in some parts of Kenya that have been experiencing intense and heavy rainfall (such as western Kenya), the higher moisture levels drive the spread of pests and diseases (like pod bores and blight) that damage beans (King, 2023).

In the beans value chain, post-harvest losses are attributable to damage in transit, mechanical damage during loading and packing, and improper packing of beans in gunny bags. USAID's estimate of total national losses of beans, at the farm and export levels, is approximately 12% of the total crop (USAID, 2015).

3.3 COUNTRY CLIMATE CHANGE FUTURE

For the analysis of future climate risk to the two crops of interest, maize (corn) and beans (French beans or common beans) our assessment looks at the 2040-time horizon (a timescale relevant to RE-GAIN's programmatic interventions). To identify future climate conditions that would *(i) signal the major climate-driven threats that could impact post-harvest losses to the crops being considered, and (ii) inform the range and typologies of post-harvest reduction loss interventions to be selected,* *our analysis examines mean climate projections (using a multi-model ensemble, generated by the sixth Coupled Model Intercomparison Project, CMIP-6).*

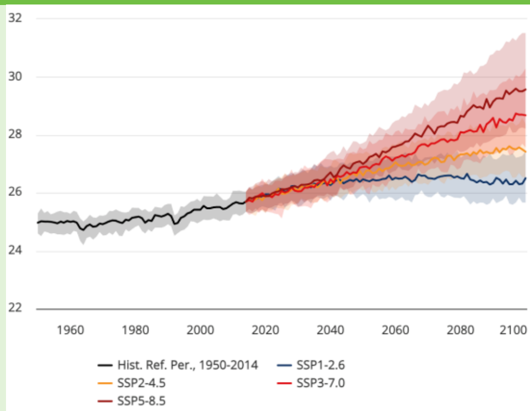
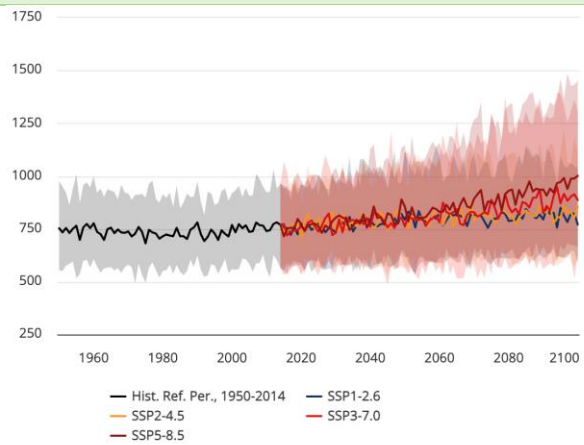
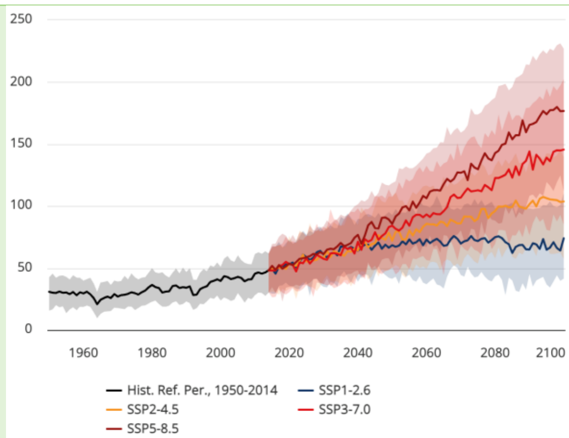
Specifically, we have taken into account two modelled futures based on future shared socioeconomic pathway (SSP) scenarios:

(1) **SSP2-4.5** (the intermediate, middle-of-the-road future likely if the current emissions trajectory is followed, with moderate radiative forcing); and

(2) **SSP5-8.5** (an extreme future with the highest range of warming this century, likely if no action whatsoever is taken to lower emissions and the world follows a fossil fuel-dominated pathway) (Hausfather, 2019).

We undertook a quantitative component of the climate risk assessment (see Annex Excel workbook Kenya), and have integrated the findings from that assessment with qualitative excerpts from relevant sources and literature, coupled with country-based crop experts, as presented below. Together, this mixed-methods approach offers a holistic view of climate change risk to the two chosen crops in Kenya, focused (to the extent possible) on post-harvest stages of the crop value chain.

Table 3-1 Table 3 2: Principal Climatic Variables

Variable Name	In-Country Context Description	Additional information
Average Mean Surface Temperature	Across all future climate scenarios (except SSP1-2.6), the average mean surface temperature in Kenya is projected to increase, relative to the historic baseline (reference period 1950-2014). In our assessment of the projected change of average mean surface temperature in 2040, between the two future scenarios (SSP2-4.5 and SSP5-8.5), we found that the **estimated rise in temperature from the historic baseline is moderate.**	 *Figure 3-7 - Projected average mean surface temperature under multiple future scenarios (World Bank Climate Change Knowledge Portal: Kenya)*
Mean Precipitation	Across all future climate scenarios, mean precipitation displays substantial variability in climate projections, relative to the historic baseline (reference period 1950-2014). There appears to be a slight upward trend for the future, however, the increasing signal carries a high degree of uncertainty. In our assessment of projected change in mean precipitation in 2040, between the two future scenarios (SSP2-4.5 and SSP5-8.5), **we found that the estimated change in rainfall from the historic baseline was moderate (with a slightly increasing signal).**	 *Figure 3-8 - Projected mean precipitation under multiple future scenarios (World Bank Climate Change Knowledge Portal: Kenya)*
Number of Hot Days over 35°C	Across all future climate scenarios, the average number of hot days with temperatures rising over 35°C displays a rising trend (except SSP1-2.6). The rise is more pronounced towards the end of the century, but even in 2040, the number of such days increases markedly from the historic baseline (reference period 1950-2014). Given that in the past there were on average 33 such days in the year, projections of potentially ~64 (SSP 2-4.5) or even ~76 (SSP 5-8.5) such days in 2040 is a notable percentage change. Thus, in our assessment, **we found that the estimated change in the number of hot days over 35°C is very high.**	 *Figure 3-9 - Projected change in number of hot days with temperature over 35°C, under multiple future scenarios (World Bank Climate Change Knowledge Portal: Kenya)*

Number of days with precipitation >20 mm

Across all future climate scenarios, the average number of days with rainfall greater than 20mm displays a rising trend (except SSP1-2.6). The rise is more pronounced towards the end of the century, but even in 2040, the number of such days increases markedly from the historic baseline (reference period 1950-2014).

Given that in the past there were on average 2.9 such days in the year, projections of potentially ~3.19 (SSP 2-4.5) or even ~3.46 (SSP 5-8.5) such days in 2040 is a notable percentage change. Thus, in our assessment, **we found that the estimated change in the number of days with precipitation >20 mm is very high**.

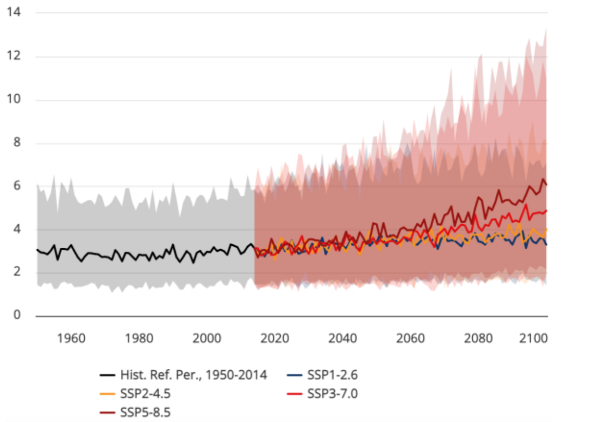


Figure 3-10 – Projected change in number of days with rainfall >20 mm, under multiple future scenarios (World Bank Climate Change Knowledge Portal: Kenya)

Average Largest 1-day Precipitation

Across all future climate scenarios, the average largest single-day (1-day) precipitation (a measure of heavy rainfall events) displays a high degree of variability in climate projections, relative to the historic baseline (reference period 1950-2014). Towards the end of the century, there is a slight apparent increasing signal (except in SSP1-2.6), however, for the 2040 period, the increase is more modest.

Nevertheless, in comparison to the baseline, in our assessment of projected change in single-day rainfall, between the two future scenarios (SSP2-4.5 and SSP5-8.5), **we found that the estimated change in rainfall was very high (with an increasing signal).**

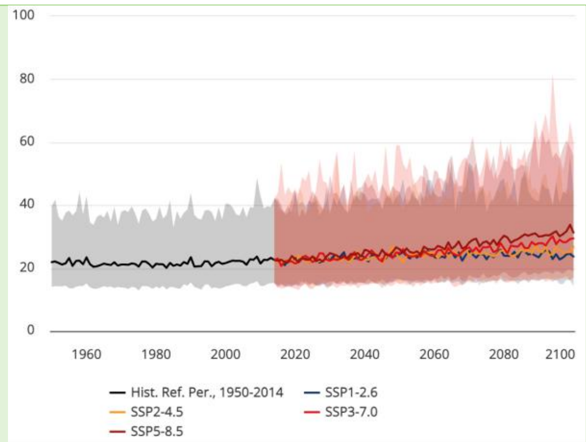


Figure 3-11 – Projected change in average largest single-day precipitation, under multiple future scenarios (World Bank Climate Change Knowledge Portal: Kenya)

Average Largest 5-day Precipitation

Across all future climate scenarios, the average largest five-day (5-day) precipitation (a measure of heavy rainfall events, which could trigger flooding) displays a high degree of variability in climate projections, relative to the historic baseline (reference period 1950-2014). The rainfall levels may increase towards the end of the century, however, for the 2040 period, the increase is less stark.

Nevertheless, compared to the baseline, in our assessment of projected change in five-day rainfall, between the two future scenarios (SSP2-4.5 and SSP5-8.5), **we found that the estimated change in rainfall was high (with an increasing signal).**

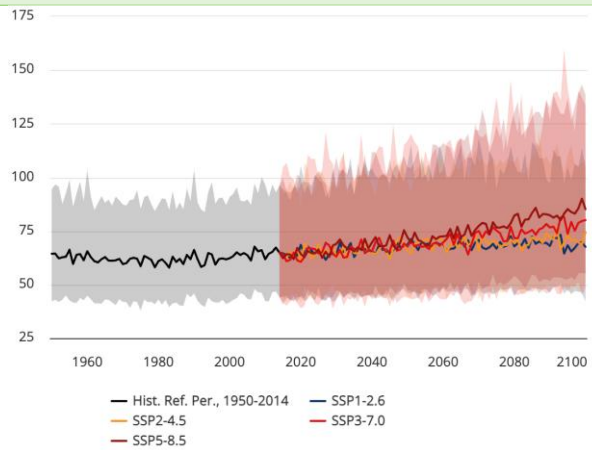
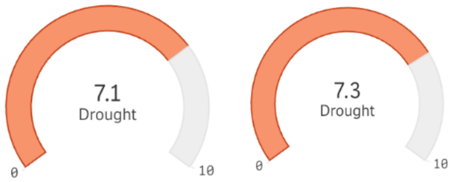
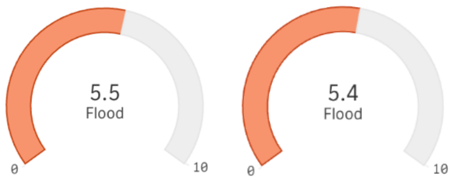
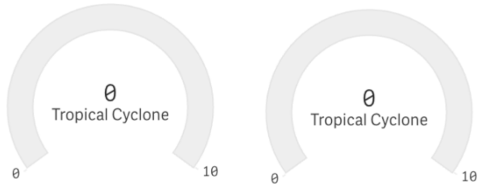


Figure 3-12 - Projected change in average largest five-day precipitation, under multiple future scenarios (World Bank Climate Change Knowledge Portal: Kenya)

Table 3-2 Extreme Weather Events and Climatic Disasters (GFDRR, n.d.)

Extreme Weather Events and Climatic Disasters (GFDRR, n.d.)		
Variable Name	In-Country Context Description	Additional Information
Water Scarcity (Linked to Drought Risk)	Kenya's future water scarcity risk in the face of climate change is regarded as **moderate (medium)**. This implies that "there is up to 20% chance droughts will occur in the coming 10 years." (GFDRR, n.d.). Under the INFORM climate risk index tool, future drought risk rises from a baseline of 6.7 (out of 10), under both SSP2-4.5 (to 7.1 out of 10) and SSP5-8.5 (7.3 out of 10) (European Commission, n.d.).	 *Figure 3-13 – Kenya's future drought risk in 2050 under SSP2-4.5 (left) and SSP5-8.5 (right), on a scale of 10 (INFORM Climate Risk Index, 2024)*
Extreme Heat/Heatwaves	Kenya's future extreme heat risk due to climate change is regarded as **moderate (medium)**. This implies that "there is more than a 25% chance that at least one period of prolonged exposure to extreme heat, resulting in heat stress, will occur in the next five years" (GFDRR, n.d.). [Note: the INFORM climate risk index does not provide data for extreme heat/heatwaves.]	N/A
Floods (Coastal, River, and Urban Floods)	Kenya's future flood risk due to climate change (and other factors) is regarded as **high**, including for river flooding (fluvial flooding, where river flows breach the banks) and urban flooding (pluvial flooding, or surface water flooding in built areas where rainfall exceeds infiltration capacity of the ground), as well as coastal flooding in low-lying coastal regions. "Potentially damaging and life-threatening river floods are expected to occur at least once in the next 10 years" (GFDRR, n.d.). According to the INFORM Climate Change Risk Index, Kenya's baseline risk of flooding (on a 0-10 scale) is 4.8 as of 2022. However, under the SSP2-4.5 scenario for mid-century (2050), this rises to 5.5, and under the SSP5-8.5 scenario this rises to 5.4 for the same period (European Commission, n.d.).	 *Figure 3-14- Kenya's future flood risk in 2050 under SSP2-4.5 and SSP5-8.5, on a scale of 10 (INFORM Climate Risk Index, 2024)*
Wildfire	Kenya's future wildfire risk due to climate change (and other factors) is regarded as **high**. This suggests that "there is greater than a 50% chance of encountering weather that could support a significant wildfire that is likely to result in both life and property loss in any given year." (GFDRR, n.d.). [Note: the INFORM climate risk index does not provide data for wildfires.]	
Landslides	Kenya's future landslide (or landslip) risk due to climate change (and other factors) is regarded as **high.** This indicates that the country "has rainfall patterns, terrain slope, geology, soil, land cover and (potentially) earthquakes that make localized landslides a frequent hazard phenomenon. (GFDRR, n.d.). [Note: the INFORM climate risk index does not provide data for landslides.]	

Extreme Weather Events and Climatic Disasters (GFDRR, n.d.)		
Variable Name	**In-Country Context Description**	**Additional Information**
Cyclones	Kenya's future tropical cyclone (or hurricane) risk due to climate change (and other factors) is regarded as **very low.** This denotes that "there is less than a 1% chance of potentially damaging cyclone-strength winds…in the next 10 years." (GFDRR, n.d.) According to the INFORM Climate Change Risk Index, Kenya's baseline risk of cyclones (on a 0-10 scale) is nil (0) as of 2022. Under both the SSP2-4.5 and SSP5-8.5 scenarios for mid-century (2050), this remains nil (0) (European Commission, n.d.)	 *Figure 3-15 - Kenya's future cyclone risk in 2050 under SSP2-4.5 and SSP5-8.5, on a scale of 10 (INFORM Climate Risk Index, 2024)*

3.4 THE FUTURE OF CROP AGRICULTURE UNDER CLIMATE CHANGE

Climate change poses a serious threat to agriculture-based livelihoods in Kenya. The majority of Kenyan agriculture relies on seasonal rains for production and, according to some analyses, projected changes in precipitation patterns are expected to increase the occurrence of short-term crop failures and long-term production declines (The World Bank, 2021). Beyond the likely increase in floods and droughts, further negative indirect impacts are also expected, such as increased rates of runoff and soil erosion, and rising rates of infestation by insects, diseases and weeds, which in turn also contribute to increased crop losses (The World Bank, 2021).

It should be noted that scholarly research and crop modelling suggest that some regions of Kenya may see a benefit from a changing climate, specifically the temperate and tropical highlands, the Rift Valley and high plateaus, as projected increases in rainfall and slightly warmer temperatures are likely to raise crop yields (The World Bank, 2021). However, Kenya's semi-arid and arid land areas, the vast majority of the country, where agriculture is already marginal, are projected to see a significant decline in agricultural productivity and livestock numbers, as climate change puts increasing pressure on water resources (The World Bank, 2021).

These trends appear to apply to both maize and beans, the two crops of interest for this study. Some literature indicates that, with climate change, rising temperatures are likely to expand the production of maize and beans into higher elevations, but farming in lower elevations is expected to see yield losses of up to 20% due to heat stress and highly variable rainfall patterns, with some areas (like central Kenya) becoming unsuitable for production (USAID, 2018).

3.4.1 Maize

There is a fair amount of variance in projections for what climate change implies for maize production in Kenya. Maize yields are expected to increase in some of the highland areas including the central and western highlands of Kenya, and the Great Lakes Region by the 2050s, equating to between 200-700 kg/ha (Republic of Kenya, 2015). Further, maize yields in the mixed rainfed temperate and tropical highland areas are projected to increase by 33.3% by the 2030s and 46.5% by the 2050s (Republic of Kenya, 2015). However, studies suggest that for large parts of the arid and semi-arid lands and lowlands, maize yields may decline by 20% by the 2050s, with losses in the range of 200-700 kg/ha (Republic of Kenya, 2015).

The regional variability in maize projections under higher temperatures, with some regions expected to see yield increases and others yield decreases, means that in multi-model projections the median national level yields of maize are largely unchanged, or – in some models - indicate considerable increases (GIZ, 2020). Broadly, the Kenyan government finds the projected trends encouraging, given the country's reliance on maize for caloric intake and its dominant role in agriculture (Republic of Kenya, 2015).

Some crop losses in the maize value chain are due to pest and insect infestations. According to one study, the loss from weevils in the long rains was estimated at 23%, in the short rains 18%, and annually at 21% (De Groote, Muteti, & Bruce, 2023). In this study, fewer farmers were affected by the **larger grain borer (LGB) than by maize weevils**. The losses from weevils were 42% in the long rainy season and 32% in the short rainy season, and the losses from the LGB were 19% in the long season, 17% in the short season, and 18% over the year (De Groote, Muteti, & Bruce, 2023). Total storage loss, from both species combined, was estimated at 36%, or 671 000 tonnes per year (De Groote, Muteti, & Bruce, 2023). The study also found a regional disparity in losses, with the greatest losses prevalent in more humid areas, especially the moist mid-altitudes (56%), with smaller losses in the drylands (20–23%) (De Groote, Muteti, & Bruce, 2023).

Note to readers: Published literature is scarce on the climate impacts on post-harvest stages of the maize value chain (in Kenya and globally).

3.4.2 Beans

Climate change threatens bean production in Kenya through the impacts of more frequent extreme weather events. In particular, drought is considered a serious challenge (King, 2023). Furthermore, if temperature increases reach as high as 2.5°C by 2050, in high emissions scenarios, projections suggest this could reduce bean-growing regions by 50% in Kenya (King, 2023). Other studies indicate mixed impacts, especially in terms of the variance between growing seasons, due to different levels of future water availability. For instance, researchers project that for beans during the March-April-May growing season, less water (rainfall and soil moisture) will be available to meet bean crop water requirements, across all future scenarios (sometimes by as much as a 10% decrease), and therefore water stress on the bean crop is likely to increase and bean yields are likely to decrease correspondingly (CGIAR, 2018). In contrast, for the October-November-December growing season, water availability for bean production is likely to increase in all growing areas, across all future scenarios (sometimes by as much as a 20% increase), with the implication that crop water stress for the bean crop is likely to reduce, and bean yields are likely to increase accordingly in this season (CGIAR, 2018).

Note to readers: Published literature is scarce on the climate impacts on post-harvest stages of the beans value chain (in Kenya and globally).

3.5 RISK ASSESSMENT FOR POST-HARVEST VALUE CHAIN STAGES

3.5.1 Maize

Our analysis of climate change risks to the maize value chain in Kenya indicates that the most significant hazards are the increases in the number of extremely hot days (where temperatures breach the 35°C threshold), in the number of days with precipitation over 20 mm, and heavy or intense precipitation (extreme volumes of rainfall in a single day or five-day period). Additional hazards of concern include flooding (pluvial, fluvial, and coastal), drought, wildfires, and landslides.

Kenyan stakeholders at the national and local levels affirmed that for the maize value chain, climate hazards that pose the most substantial risk at harvest and during the post-harvest stages are **heavy or intense rainfall (excessive and erratic), climate change driven pests and diseases (whose presence is influenced by temperature, humidity, and moisture), flooding, and drought.**

Specifically, stakeholders in Nairobi and Embu identified the three most important climate change-related hazards, corresponding to the three value chain stages RE-GAIN is concerned with, as follows:

Table 3-3 - Top three climate change hazards identified for Kenya's maize value chain, in post-harvest stages, by national and local stakeholders (2024)

Stakeholder Workshop Location	Harvesting Processes	Post-Harvest Handling and Storage	Processing, Transport, and Logistics
Nairobi	Excessive and erratic rainfall (with links to flooding) Flooding and drought Pests and diseases (e.g., aflatoxin)	Excessive and erratic rainfall (with links to flooding) Pests and diseases (e.g., aflatoxin) Humidity and moisture	Excessive and erratic rainfall High temperatures / extreme heat Humidity and moisture
Embu	Excessive and erratic rainfall (with links to flooding) Pests and diseases (e.g., aflatoxin) High temperatures / extreme heat	Pests and diseases (e.g., aflatoxin) High temperatures / extreme heat Excessive and erratic rainfall (with links to flooding)	Flooding High temperatures / extreme heat Humidity and moisture

A range of factors creates **vulnerability** in the maize value chain, including a very high percentage of undernourishment in the overall population, and the high prevalence of moderate to severe food insecurity, as well as high unemployment rates in the country (noting that some of these vulnerability factors apply to the value chain and the agricultural sector as a whole, and are not specific to post-harvest stages of the maize value chain in particular). Another contributor to vulnerability is that the majority of maize cultivators in Kenya are small-scale farmers (an estimated 70% (The World Bank, CGIAR, CIAT, 2015)).

Stakeholders in Nairobi and Embu added further granularity and insights to the understanding of vulnerability in the maize value chain, indicating that the principal drivers of vulnerability in Kenya's maize value chain – at harvest and during post-harvest stages – are: **a lack of access to appropriate technology and equipment and facilities (such as adequate drying and storage facilities and other post-harvest infrastructure); lack of necessary knowledge and skills, and the limited access to credit and other financial resources.**

Specifically, stakeholders in Nairobi and Embu identified the three most important vulnerability factors that make the maize value chain susceptible to climate change risks, corresponding to RE-GAIN's three value chain stages, as follows:

Table 3-4- Top three climate change vulnerability factors identified for Kenya's maize value chain, in post-harvest stages, by national and local stakeholders (2024)

Stakeholder Workshop Location	Harvesting Processes	Post-Harvest Handling and Storage	Processing, Transport, and Logistics
Nairobi	• Lack of/limited access to technology, equipment, facilities, infrastructure • Lack of/limited access to knowledge and skills Lack of/limited access to credit and financial resources	• Lack of/limited access to technology, equipment, facilities, infrastructure • Lack of/limited access to knowledge and skills Lack of/limited access to credit and financial resources	• Lack of/limited access to technology, equipment, facilities, infrastructure • Lack of/limited access to knowledge and skills Lack of/limited access to credit and financial resources
Embu	• Lack of/limited access to knowledge and skills Lack of/limited access to technology, equipment, facilities, infrastructure Lack of / poor early	• Lack of/limited access to knowledge and skills Lack of/limited access to technology, equipment, facilities, infrastructure Lack of / poor early	• Lack of/limited access to technology, equipment, facilities, infrastructure • Lack of/limited access to knowledge

	warning systems and climate information	warning systems and climate information	and skills Lack of/ poor market information

In terms of **exposure**, the key factor is the high share of cropland area under maize.

Our climate change risk assessment for post-harvest stages of 14 crop value chains, across seven countries, adopted the Intergovernmental Panel on Climate Change's (IPCC's) conceptual framework of risk, i.e., climate change risk being a combination of climatic hazards, vulnerability, and exposure. Our approach was to develop a hybrid, mixed-methods analysis that combined a quantitative estimation of climate risk (captured in a single composite numerical value, derived as a function of numerically graded levels of hazard indicators, vulnerability indicators, and exposure indicators) coupled with a qualitative elaboration of climate risk (narrative commentary about risks to each crop at each stage of the post-harvest value chain, derived from national and local stakeholder inputs and from literature review).

Overall, in our comparative *quantitative component* of the climate change risk assessment, the higher a crop scored across the numerically graded levels of hazards, vulnerability, and exposure, the higher the combined final numerical value of risk. It should be noted that these quantifications are indicative and were developed to offer a high-level signal of *relative risk* amongst 14 crops that all face significant degrees of risk from climate change. Crops with higher scores are even more at risk from climate change, in post-harvest stages, than crops with slightly lower scores, and thus may benefit from a relatively higher degree of attention for post-harvest loss-reduction solutions, vis-à-vis those slightly less at risk. This is reflected in the ranking that emerged (1 through 14) from the quantitative risk scores (noting that the quantitative signal is *not deterministic of prioritization* and should be read in conjunction with the accompanying qualitative commentary for a fuller picture of risk).

Quantitatively, the risk level of the maize value chain in Kenya scored: 26.40 out of 125, putting it at rank **8** of the 14 crop value chains similarly assessed.

Table 3-5 - Comparative scoring of climate change risk for crop value chains in RE-GAIN countries

Countries	Burkina Faso	Ethiopia	Kenya	Malawi	Tanzania	Uganda	Zambia
Crops	Cowpea 33.92	Teff 26.44	***Maize*** ***26.40***	Maize 73.31	Maize 37.33	Maize 26.69	Maize 47.90
	Rice 22.23	Wheat 35.25	***Beans*** ***13.20***	Groundnut 13.84	Rice 17.77	Beans 25.91	Soybeans 23.58

For maize grain storage, temperature and moisture are critical variables. High temperatures, for example, can cause alterations in the chemical constituents of grains, such as lipids, carbohydrates, and proteins (Coradi, Maldaner, Everton Lutz, Dai, & Teodoro, 2020). Higher temperatures and humidity levels cause deterioration of the grain quality, whereas storage at lower temperatures and humidity levels protects the viability and vigour of maize seeds (Rahmawati & Aqil, 2016). It should be noted that the quality of the harvested seed, including its initial moisture content at the time of harvest, plays a significant role in the post-harvest quality and level of deterioration (Rahmawati & Aqil, 2016). Managing climatic factors during maize storage is also complicated by the interplay between temperature and moisture**. For instance, temperature accelerates the reduction in grain moisture but increases deterioration.** Wetting, as a result of lower temperatures that may cause condensation during storage periods, also reduces the grain quality (Coradi, Maldaner, Everton Lutz, Dai, & Teodoro, 2020). Extreme weather events during storage can, of course, cause physical damage to storage infrastructure and cause loss of stored grains (e.g., through the infiltration of storage silos with water, or the washing away of stored grains in floodwaters and landslides, etc.).

In Kenya, temperature rise is a hazard of concern, given that maize (which accounts for about one-third of caloric intake in Kenya) can be damaged by temperatures over 35°C, which are increasingly common in lowland regions (USAID, 2018), and likely to rise in the future due to climate change. For instance, in the arid and semi-arid lands in Kenya, maize (which is the preferred crop in the farming systems in these regions) is not well adapted even for current climatic conditions; thus, in these areas, it is not well-suited under predicted future climate conditions (The World Bank, CGIAR, CIAT, 2015).

The impacts of temperature and moisture, as well as extreme weather events on other post-harvest processes such as processing, transportation, and distribution to markets (wholesale and retail), are relatively indirect, including through acute (fast-onset) and chronic (slow-onset) damage to machinery and equipment (e.g., via weathering, rusting, decay, and other weather-related depreciation of assets), transportation infrastructure (damage to roadways, railways, bridges, e.g., melting and buckling of roads or rail tracks, warping of joints on bridges), and distribution networks (supply chain disruptions, e.g., damage to market locations from extreme weather events).

While direct attribution of climate change to post-harvest losses of maize in Kenya is not feasible with current science, it is useful to examine the nature of post-harvest losses and draw some informed inferences about the role of climate.

According to data from the African Post-Harvest Loss Information System (APHLIS), an estimated 16.7% of the maize harvest in Kenya was lost as dry-weight loss in 2022, and over a ten-year period the total post-harvest dry-weight loss in Kenya for maize (average of 2013-2022) was 17.53% (APHLIS, n.d.). Based on decadal data from 2013 through 2022, of the various post-harvest value-chain stages (per APHLIS, these are: harvesting/field drying; further drying; threshing and shelling; winnowing; transport from field; household level storage; transport to market; and market storage), the three stages where the largest volume of maize losses occurred in Kenya (in decreasing order) are:

1. **Harvesting and field drying** (by far the stage of greatest losses) – an average annual loss of 7.26% of the crop
2. **Further drying** – an average annual loss of 4% of the crop; and
3. **Household-level storage** – an average annual loss of 2.76% of the crop (followed closely by market storage, which accounted for 2.7% of the average annual loss of the crop).

Together, these three stages represent an average annual loss of roughly 14% of the total losses in the post-harvest maize value chain in Kenya, and 79.86% (i.e., the vast majority) of the *post-harvest* losses in the maize value chain in Kenya.

In each of these three stages, **climatic factors are highly relevant**, given how temperature, moisture and humidity, and the prevalence of pests and plant diseases (themselves temperature-sensitive) cause damage to the harvested maize.

With climate change projected to exacerbate these factors, through rising temperatures, more erratic and heavy rainfall events, and the growing risk of floods and droughts in Kenya, ***these stages of the Maize value chain are most at risk from climate change and thus should be prioritized for adaptation (loss-reduction) responses.***

Since these stages (where the largest share of post-harvest losses happen) of the maize value chain are still largely linked to on-farm activities such as household storage, harvesting and field drying, it is fair to surmise that the areas in Kenya where maize is farmed are the dominant geographical locations for the losses at these stages. Based on the map of maize growing areas in Kenya (below) (USDA, n.d.), the districts of **Trans Nzoia** (accounting for 14% of maize production in 2018), **Usain Gishu** (10% in 2018), and **Bungoma** (7% in 2018) may be prioritized for climate-responsive, risk-reduction interventions.

Kenya: Total Corn Production

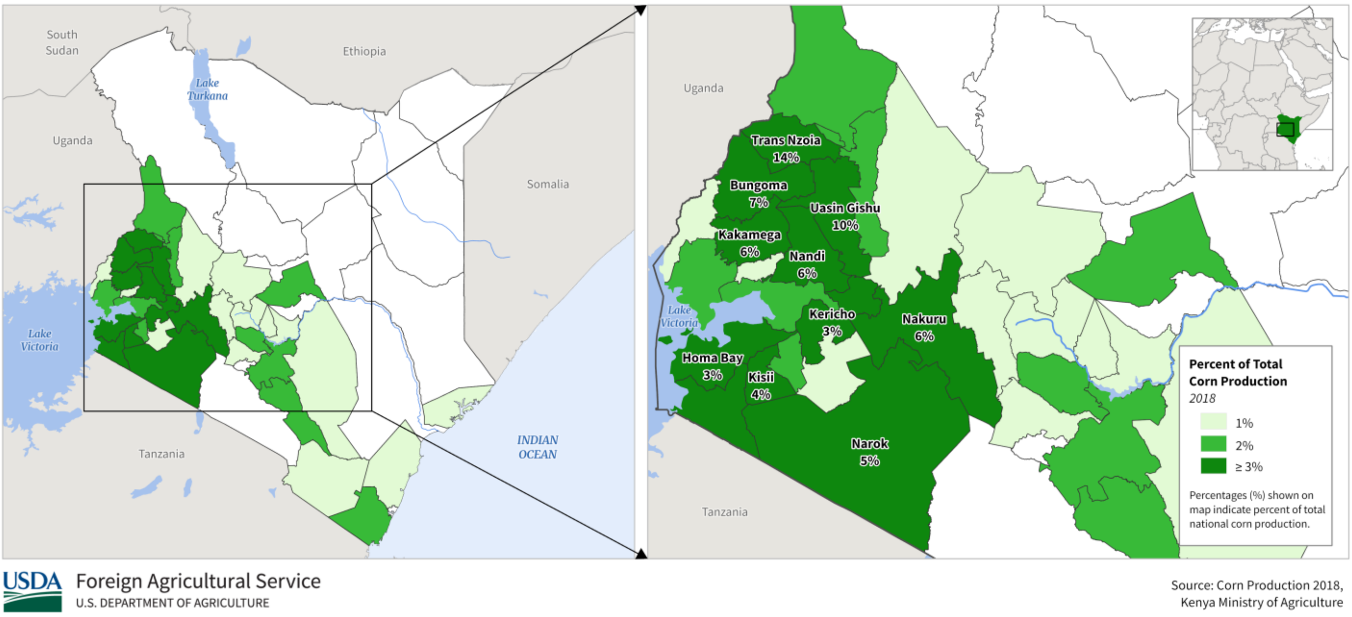


Figure 3-16 - Kenya: Maize Production by District, 2018 (USDA, n.d.)

Stakeholder workshops in Kenya with agricultural experts at the national and local levels clarified the priority target geographies for RE-GAIN interventions, based on local knowledge of where and to what degree climate change hazards have been impacting the maize value chain, particularly during harvest and post-harvest stages. Insights and guidance from stakeholders suggest that the priority target areas (districts) that should be the focus of RE-GAIN's post-harvest loss-reduction climate change solutions are:

- Embu,
- Kitui,
- Makueni,
- Tharaka Nithi,
-

3.5.2 Beans

Our analysis of climate change risks to the beans value chain in Kenya indicates that the most significant hazards are the increases in the number of extremely hot days (where temperatures breach the 35 °C threshold), in the number of days with precipitation over 20 mm, and heavy or intense precipitation (extreme volumes of rainfall in a single day or five-day period). Additional hazards of concern include flooding (pluvial and fluvial, and coastal), drought, wildfires, landslides.

Kenyan stakeholders at the national and local levels underscored that for the beans value chain, climate hazards that pose the most substantial risk at harvest and during the post-harvest stages are **heavy or intense rainfall (excessive and erratic), water scarcity or drought, and flooding**, as well as extreme heat and high temperatures.

Specifically, stakeholders in Nairobi and Embu identified the three most important climate change related hazards, corresponding to the three value chain stages RE-GAIN is concerned with, as follows:

Table 3-6 - Top three climate change hazards identified for Kenya's beans value chain, in post-harvest stages, by national and local stakeholders (2024)

Stakeholder Workshop Location	Harvesting Processes	Post-Harvest Handling and Storage	Processing, Transport, and Logistics
Nairobi	• Pests and diseases (e.g., aflatoxin, mould, fungi) • Excessive and erratic rainfall (with a link to flooding) High temperatures / extreme heat	• Humidity and moisture • Pests and diseases (e.g., mould, fungi) • High temperatures / extreme heat	• Excessive and erratic rainfall (linked to flooding) High temperatures / extreme heat Drought / water scarcity
Embu	• Pests and diseases (e.g., aflatoxin, mould, fungi) • Excessive and erratic rainfall (with a link to flooding) High temperatures / extreme heat	• Humidity and moisture • Pests and diseases (e.g., mould, fungi) • High temperatures / extreme heat	• Excessive and erratic rainfall (linked to flooding) High temperatures / extreme heat Drought / water scarcity

A range of factors create **vulnerability** in the beans value chain, including a very high percentage of undernourishment in the overall population, and the high prevalence of moderate to severe food insecurity, as well as high unemployment rates in the country (noting that some of these vulnerability factors apply to the value chain and the agricultural sector as a whole, and are not specific to post-harvest stages of the beans value chain in particular).

Stakeholders in Nairobi and Embu strengthened the understanding of vulnerability in the beans value chain, indicating that principal drivers of vulnerability in Kenya's beans value chain – at harvest and during post-harvest stages – are: **lack of necessary knowledge and skills, a lack of access to appropriate technology and equipment and facilities (such as adequate drying and storage facilities and other post-harvest infrastructure), and limited or poor early warning systems and climate information services.**

Specifically, stakeholders in Nairobi and Embu identified the three most important vulnerability factors that make the beans value chain susceptible to climate change risks, corresponding to RE-GAIN's three value chain stages, as follows:

Table 3-7 - Top three climate change vulnerability factors identified for Kenya's beans value chain, in post-harvest stages, by national and local stakeholders (2024)

Stakeholder Workshop Location	Harvesting Processes	Post-Harvest Handling and Storage	Processing, Transport, and Logistics
Nairobi	• Lack of/limited access to knowledge and skills • Lack of/limited access to technology, equipment, facilities, infrastructure • Lack of/poor early warning systems and climate information systems	• Lack of/limited access to knowledge and skills • Lack of/limited access to technology, equipment, facilities, infrastructure • Lack of/poor early warning systems and climate information systems	• Lack of/limited access to knowledge and skills • Lack of/limited access to technology, equipment, facilities, infrastructure • Lack of/poor market information
Embu	• Lack of/limited access to knowledge and skills • Lack of/limited access to technology, equipment, facilities, infrastructure • Lack of/poor early warning systems and climate information systems	• Lack of/limited access to knowledge and skills • Lack of/limited access to technology, equipment, facilities, infrastructure • Lack of/poor early warning systems and climate information systems	• Lack of/limited access to knowledge and skills • Lack of/limited access to technology, equipment, facilities, infrastructure • Lack of/poor market information

Our climate change risk assessment for post-harvest stages of 14 crop value chains, across seven countries, adopted the IPCC's conceptual framework of risk, i.e., climate change risk being a combination of climatic hazards, vulnerability, and exposure. Our approach was to develop a hybrid, mixed-methods analysis that combined a quantitative estimation of climate risk (captured in a single composite numerical value, derived as a function of numerically graded levels of hazard indicators, vulnerability indicators, and exposure indicators) coupled with a qualitative elaboration of climate risk (narrative commentary about risks to each crop at each stage of the post-harvest value chain, derived from national and local stakeholder inputs and from literature review).

Overall, in our comparative *quantitative component* of the climate change risk assessment, the higher a crop scored across the numerically graded levels of hazards, vulnerability, and exposure, the higher the combined final numerical value of risk. It should be noted that these quantifications are indicative and were developed to offer a high-level signal of *relative risk* amongst 14 crops that all face significant degrees of risk from climate change. Crops with higher scores are even more at risk from climate change, in post-harvest stages, than crops with slightly lower scores, and thus may benefit from a relatively higher degree of attention for post-harvest loss-reduction solutions, vis-à-vis those slightly less at risk. This is reflected in the ranking that emerged (1 through 14) from the quantitative risk scores (noting that the quantitative signal is *not deterministic of prioritization* and should be read in conjunction with the accompanying qualitative commentary for a fuller picture of risk).

Quantitatively, in our comparative climate change risk assessment, quantitatively the risk level of the beans value chain in Kenya scored: 13.20 out of 125, putting it at rank **14** of the 14 crop value chains similarly assessed.

Table 3-8 - Comparative scoring of climate change risk for crop value chains in RE-GAIN countries

Countries	Burkina Faso	Ethiopia	Kenya	Malawi	Tanzania	Uganda	Zambia
Crops	Cowpea 33.92	Teff 26.44	***Maize*** ***26.40***	Maize 73.31	Maize 37.33	Maize 26.69	Maize 47.90
	Rice 22.23	Wheat 35.25	***Beans*** ***13.20***	Groundnut 13.84	Rice 17.77	Beans 25.91	Soybeans 23.58

The limited available literature about post-harvest losses in the beans value chain in Kenya does not directly point to climatic factors as major causes of loss.

One report notes that due to the export quality requirements, grading and sorting are done on-farm. Most losses occur at this level due to poor harvesting practices and high rejection rates (USAID, 2015). At the export level, traders incur post-harvest losses due to produce damage on transit, mechanical damage during loading and packing, attributed to the packing of beans in gunny bags (USAID, 2015).

Studies of the bean value chain in Kenya have recorded that the optimum temperature range for beans is 20-25°C (and that anything in the range of 12-34°C is conducive) (USAID, 2015). Rising temperatures under climate change shift this window beyond what is considered conducive.

While direct attribution of climate change to post-harvest losses of beans in Kenya is not feasible with current science, it is useful to examine the nature of post-harvest losses and draw some informed inferences about the role of climate. According to data from the VP Group study (in the absence of corresponding data from APHLIS), the two stages where the largest volume of beans losses occurred in Kenya are (VP Group, 2019):

1. **Pre-harvest grading and packing** – an estimated loss of 37% of the harvested crop, out of post-harvest losses,
2. **Between packing and grading** – an estimated loss of 22% of the harvested crop, out of post-harvest losses.

Together, these two stages represent an estimated loss of a staggering 59% (almost two-thirds) of the losses in the post-harvest beans value chain in Kenya.

In each of these two stages, **climatic factors are relevant**, given the manner in which temperature, moisture, humidity, and the prevalence of pests and plant diseases (themselves temperature-sensitive) cause damage to the harvested beans. With climate change projected to exacerbate these factors, through rising temperatures, more heavy rainfall events, and through the growing risk of floods and droughts in Kenya, ***these stages of the bean value chain are most at risk from climate change, and thus should be prioritized for adaptation (loss-reduction) responses.***

Since these stages (where the largest share of post-harvest losses happen) of the beans value chain are still largely linked to on-farm activities such as pre-harvest grading and packing, and on-farm storage, it is fair to surmise that the areas in Kenya where beans are farmed are the dominant geographical locations for these losses, at these stages. Since the **five main growing areas are Rift Valley, Eastern, Lake Victoria zone, Western, and Central regions** - which account for 33%, 24%, 18%, 13%, and 20% of the production, respectively (CGIAR, 2018) – these five regions may be prioritized for climate-responsive, risk-reduction interventions.

Stakeholder workshops in Kenya with agricultural experts at the national and local levels clarified the priority target geographies for RE-GAIN interventions, based on local knowledge of where and to what degree climate change hazards have been impacting the beans value chain, particularly during harvest and post-harvest stages. Insights and guidance from stakeholders suggests that the priority target areas (districts) that should be the focus of RE-GAIN's post-harvest loss-reduction climate change solutions are:

- Embu,
- Kitui,
- Makueni,
- Tharaka Nithi,

3.6 OVERALL HAZARD RISK ASSESSMENT

We combined the quantitative scores of the hazards component of our risk assessment (i.e., scores reflecting the graded levels of change in hazard prevalence, from the baseline to the future) with qualitative inputs and guidance on climate change risk provided by stakeholders and country agriculture experts (at the national and local stakeholder workshops) to arrive at an indicative snapshot of risks for the two crops in each country, from major hazards, at each stage of the post-harvest value chain. A summary of the post-harvest Hazard risks for maize and beans in Kenya are presented in Table 3-9.

Table 3-9 - Summary Climate Change Hazard Risk Table for Kenya in Key Crop Value Chains (Post-Harvest)

CROP	CLIMATE HAZARD	*Hazard Risk Level in Stages of Agricultural Value Chain*			
		Harvesting Processes	Post-Harvest Handling and Storage	Processing, and Logistics	Transport,
MAIZE	Average temps				
	Rainfall variability				
	Average rainfall				
	Hot days over 35°C				
	Days with rainfall > 20mm				
	Avg. largest 1-day rain				
	Avg. largest 5-day rain				
	Water scarcity / drought				
	Extreme heat / heat waves				

	River and/or urban floods			
	Coastal floods			
	Wildfire			
	Landslides			
	Cyclones			
	Sea Level Rise			
	OVERALL RISK LEVEL	*HIGH*	*HIGH*	*MODERATE*
BEANS	Average temps			
	Rainfall variability			
	Average rainfall			
	Hot days over 35°C			
	Days with rainfall > 20mm			
	Avg. largest 1-day rain			
	Avg. largest 5-day rain			
	Water scarcity / drought			
	Extreme heat / heat waves			
	River and/or urban floods			
	Coastal floods			
	Wildfire			
	Landslides			
	Cyclones			
	Sea Level Rise			
	OVERALL RISK LEVEL	*HIGH*	*MODERATE*	*MODERATE*

Key:

High	
Medium	
Low	

4 Climate Analysis - Mitigation

4.1 COUNTRY AND SECTORAL CLIMATE CHANGE EMISSIONS BASELINE

4.1.1 National emissions

Kenya presented its National Greenhouse Gas Inventory in their Second National Communication (SNC) to the United Nations Framework Convention on Climate Change (UNFCCC) (NEMA, 2015). Agriculture and energy are the largest emitting sectors at ~53 million tonnes CO_2e and ~21 million tonnes CO_2e as of 2021, respectively (Figure 4-1) (Climate Watch, n.d.). While Kenya's national emissions have grown steadily in the last few decades, it still contributes only 0.21% of global emissions as of 2022 (Jones, et al., 2024).

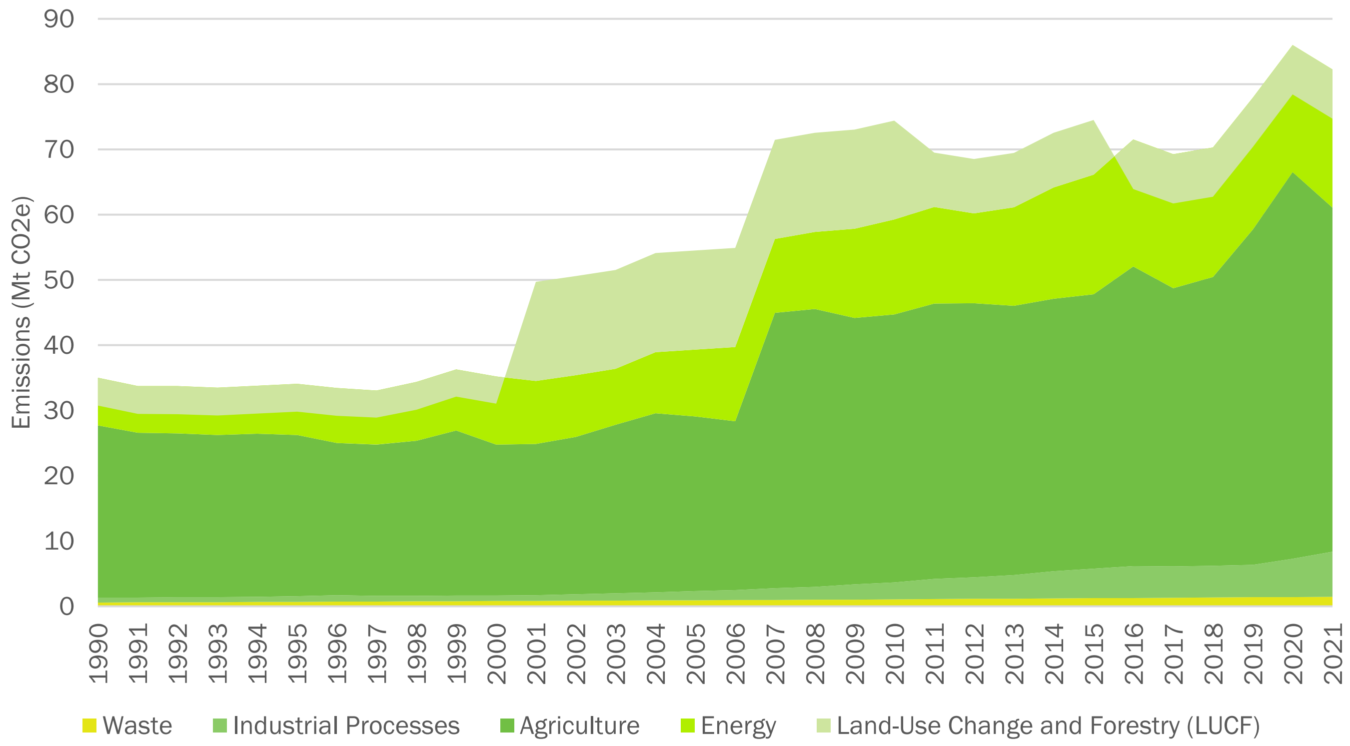


Figure 4-1 - Emissions (all GHG, $MtCO_2e$) across all sectors (total including LUCF) for Kenya (Climate Watch, n.d.)

4.1.2 Land-use change

By using available land use change datasets, we can ascertain that a loss of forest cover occurred in Kenya between 1960 and 2019, with forest loss occurring over ~18%[2] of the land area in AGRA's target regions (see Table 4-1). Cropland expanded by up to ~23% of these areas in that period (Table 4-1). Where deforestation occurred between 2001 and 2020, the most common land uses which replaced forest cover were small-scale agriculture, pasture, and forestry plantations (Table 4-1) (Masolele, et al., 2024).

[2] Calculated using zonal statistics in QGIS from HIstoric Land Dynamics Assessment (HILDA+) data layers (HILDA+).

Table 4-1 - Frequency (%) of land use types replacing forest where forest cover was lost between 2001 and 2020 in Kenya (Calculated from Masolele, et al. (2024))

	Large-Scale Cropland	Pasture	Mining	Small-Scale Cropland	Roads	Other Land With Tree Cover/ Regrowth	Plantation Forest	Coffee	Settlement	Tea Plantation	Water	Oil Palm	Rubber	Cashew	Cocoa
Samburu	12.1%	34.1%		20.9%		31.9%									1.1%
Isiolo	30.4%	52.2%	13.0%						4.3%						
Elgeyo-Marakwet	2.9%	6.4%	<1%	65.7%	<1%	<1%	22.9%	<1%	<1%	0.1%		<1%	<1%	<1%	
Bungoma	9.7%	30.8%		51.2%	<1%	1.5%	4.1%	<1%	1.8%	<1%				<1%	<1%
Uasin Gishu	7.2%	7.1%		54.0%	<1%	1.1%	11.0%	6.8%	4.7%	1.4%	<1%	3.7%		2.6%	
Kakamega	4.8%	25.2%		21.3%	1.8%	9.8%	15.6%	4.8%	2.5%	<1%	<1%	2.9%	<1%	11.0%	<1%
Laikipia	11.9%	21.7%	<1%	60.0%	<1%	<1%	2.6%	<1%	<1%					3.0%	
Meru	22.8%	1.3%	<1%	57.0%	<1%	<1%	12.7%	<1%	4.0%	<1%		<1%			
Nandi	1.0%	12.1%	<1%	54.2%	<1%	1.3%	9.1%	<1%	<1%	18.1%	<1%	1.6%		<1%	<1%
Siaya	9.5%	0.9%	5.1%	60.0%	1.6%	<1%	1.6%		11.4%		7.6%	1.6%		<1%	<1%
Nakuru	3.9%	10.3%	<1%	76.4%	<1%	<1%	3.9%	<1%	1.0%	1.4%	1.7%	<1%		<1%	<1%
Vihiga		11.3%		54.0%	<1%	12.0%	4.0%	4.0%	13.4%	<1%					
Nyandarua	4.8%	2.6%	<1%	78.5%	<1%	3.1%	5.2%		1.7%	<1%	<1%	3.3%		<1%	
Tharaka	5.0%	38.8%	<1%	44.5%		<1%			8.0%	<1%	<1%		<1%		2.3%
Nyeri	3.4%	4.3%	<1%	71.3%	<1%	3.8%	12.8%	<1%	<1%	<1%		1.5%	<1%	1.2%	<1%
Embu	2.8%	14.1%		71.6%	<1%	<1%	<1%		10.0%		<1%	<1%	<1%	<1%	
Murang'a	6.8%	1.7%	<1%	77.0%	<1%	<1%	4.4%	<1%	3.3%	3.2%	<1%	<1%	<1%	<1%	<1%
Kiambu	6.5%	1.9%	<1%	56.2%	<1%	5.6%	10.8%	1.4%	3.7%	11.4%	<1%	<1%		<1%	<1%
Machakos	5.3%	14.5%	<1%	72.4%	<1%	2.4%	<1%	<1%	2.4%		<1%			<1%	<1%
Makueni	12.0%	33.9%	<1%	50.7%	<1%	<1%			1.5%		<1%			<1%	<1%

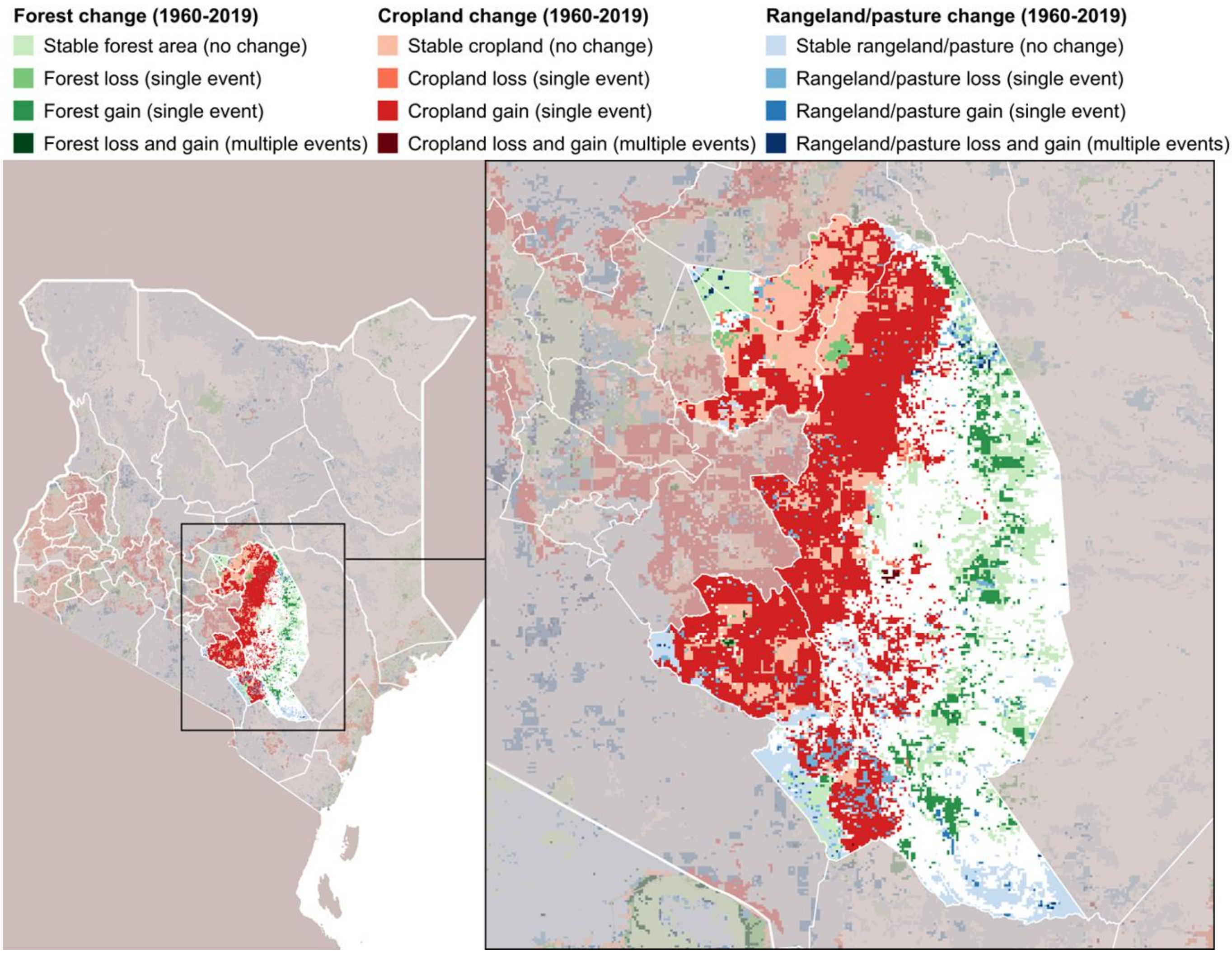


Figure 4-2 - Change in cover for land use categories forest, rangeland/pasture and cropland in AGRA target regions across Kenya between 1960 and 2019 (HILDA+)

4.2 CROP VALUE CHAINS CLIMATE CHANGE EMISSIONS BASELINE

Global analyses indicate that on-farm activities and land use are the greatest contributors to emissions for commodities related to maize and peas (presented here as a proxy for beans) (Poore & Nemecek, 2019). Farm activities account for up to 72% of emissions from both crops (Figure 4-3). Losses account for a significant proportion of emissions (Figure 4-3), particularly in smallholder value chains.

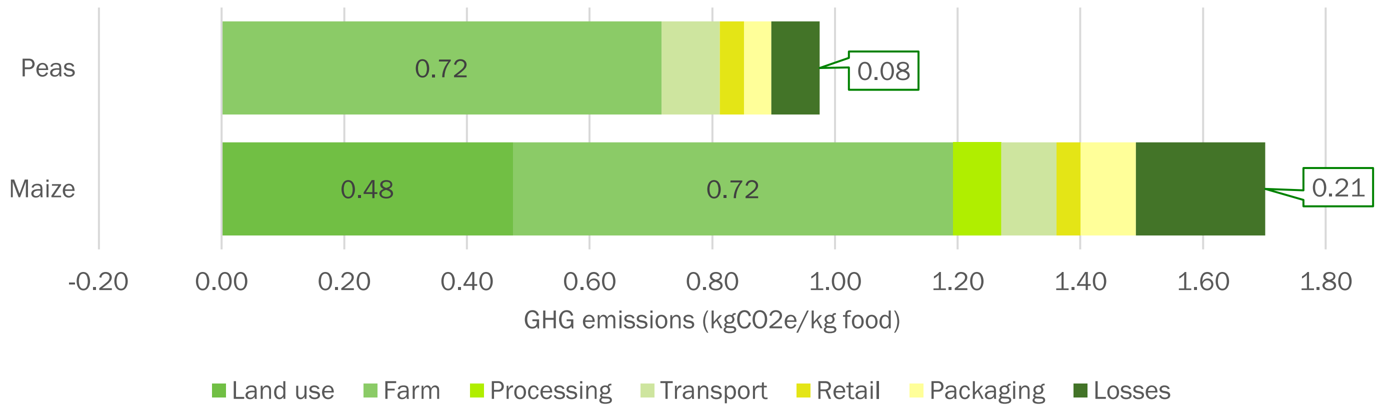


Figure 4-3 - Average GHG emissions (kgCO$_2$e/kg food) for agricultural commodities across value chains (Poore & Nemecek, 2019)

Typical losses and emissions sources across agricultural value chains are depicted in Figure 4-4 below. The bulk of post-harvest losses from field to market occur during processing and on-farm storage of agricultural produce. Pest damage, spillage, inefficient processing, and spoilage account for the bulk of losses.

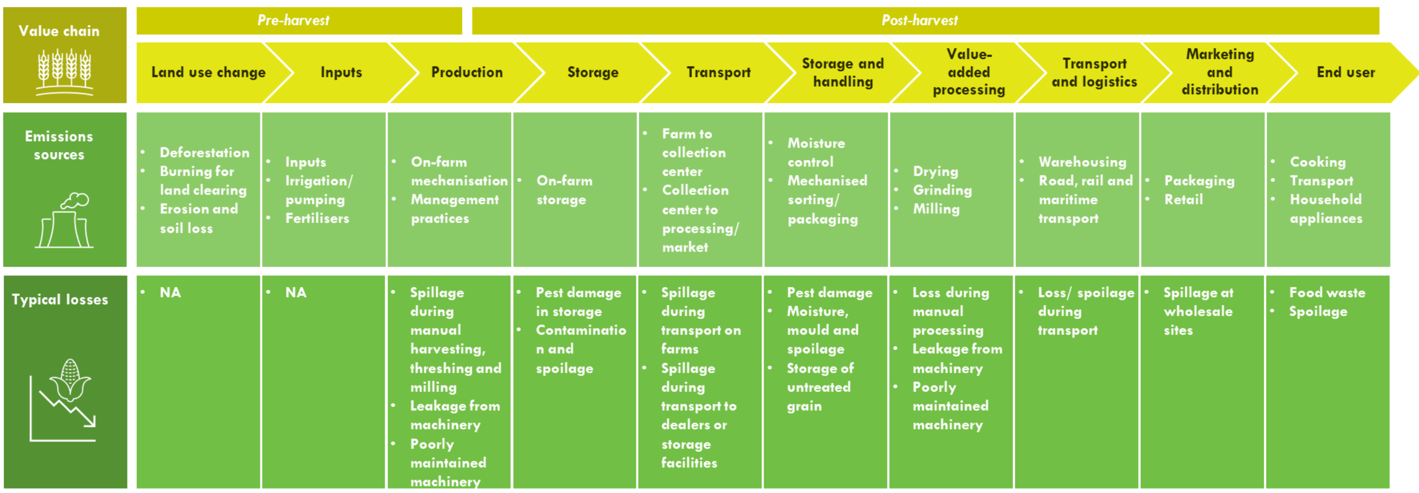


Figure 4-4 - Typical sources of emissions and food losses across agricultural value chains (Report Authors Analysis)

On-farm post-harvest losses resulting from climate impacts, inefficient processing practices, poor storage conditions, pests, and spoilage present a loss of income to smallholder farmers, as well as affecting household food security. To compensate for post-harvest losses, farmers are likely to expand their agricultural lands, resulting in transformation of forests and other natural vegetation types. This land-use change results in an increase in GHG emissions, both from the practices used to achieve the land use change (e.g., burning), as well as annual emissions from the loss of natural cover and carbon sequestration capacity. By reducing on-farm post-harvest losses in key crops, the planned interventions will reduce compensatory expansion of agricultural land, thereby avoiding upstream emissions associated with land use change.

4.2.1 Emissions related to food loss

Food loss along agricultural value chains risks not just the loss of edible food, but the waste of the natural resources associated with its production, such as land and water. The inefficient use of natural resources can be considered to have its own environmental footprint, with carbon emissions associated with food loss being among them.

4.2.2 Post-harvest losses per crop

4.2.2.1 Maize

On-farm post-harvest losses in the maize value chain occur largely as a result of inefficient harvesting and process practices, spoilage from pests and mould during storage and spillage during transport (Table 4-2). The largest reported losses occur during the household harvesting phase, estimated at 6.4% of total production (Table 4-2). This will be further discussed in more detail in Chapter 5.

Table 4-2 - Extent of post-harvest food loss and the main causes for maize in Kenya

Value chain stage	Losses (%)	Cause(s)	Reference
Harvesting, field drying	6.4%	Rain and/or excessive wind during crop maturation period, pest outbreaks, rotting and discolouration to open cob tips due to poor drying	(APHLIS, 2024) (FAO Food loss and waste database, 2024); De Lima (1979); FAO (2014); Ng'ang'a, et al. (2016); Ognakossan, et al. (2016)
Threshing/ shelling	1.3%	N/A	
Winnowing	N/A	N/A	
Drying	4.0%	Rotting and discolouration to open cob tips as a result of poor drying	
Transport to farm	2.4%	N/A	
On-farm storage	2.5%	Damage from rodents, insects (weevils), spoilage from mould, discolouration (quality loss) from poor storage practices	
Transport to market	1.7%	N/A	

4.2.2.2 Beans

On-farm post-harvest losses in the bean value chain occur as a result of inefficient harvesting, as well as poor storage practices. The largest reported losses occur during storage, estimated at 4.5% of total production (Table 4-3). This will be further discussed in more detail in Chapter 5.

Table 4-3 - Extent of post-harvest food loss and the main causes for beans in Kenya

Value chain stage	Losses (%)	Cause(s)	Notes on loss values	Reference
Harvesting, field drying	3.6%	Not meeting specifications; overgrown, deformations, damage	The FAO FLWD provides a value for losses during drying from Uganda, this value was assumed to be a reasonable proxy for Kenya, for which no estimates were available from APHILIS or the FAO FLWD.	(Sustainable Food Lab, 2019) (FAO Food loss and waste database, 2024) Muhammad, et al. (2010)
Threshing/ shelling	4.1%	Russeting, overgrown, dehydrated beans, beans with inadequate shape		
Winnowing	N/A	Wind scarring the beans		
Drying	1.8%	N/A		
Transport to farm	N/A	Loss from loading, transportation, and unloading		
On-farm storage	4.5%	Pest damage		
Transport to market	N/A	N/A		

4.2.3 Emissions associated with food loss

The emissions associated with food loss across the agricultural values chains considered by the RE-GAIN Programme in Kenya could amount to 596 023 tCO_2e for maize and 6 440 tCO_2e for beans, based on smallholder production values (Figure 4-5,

Table 4-4).

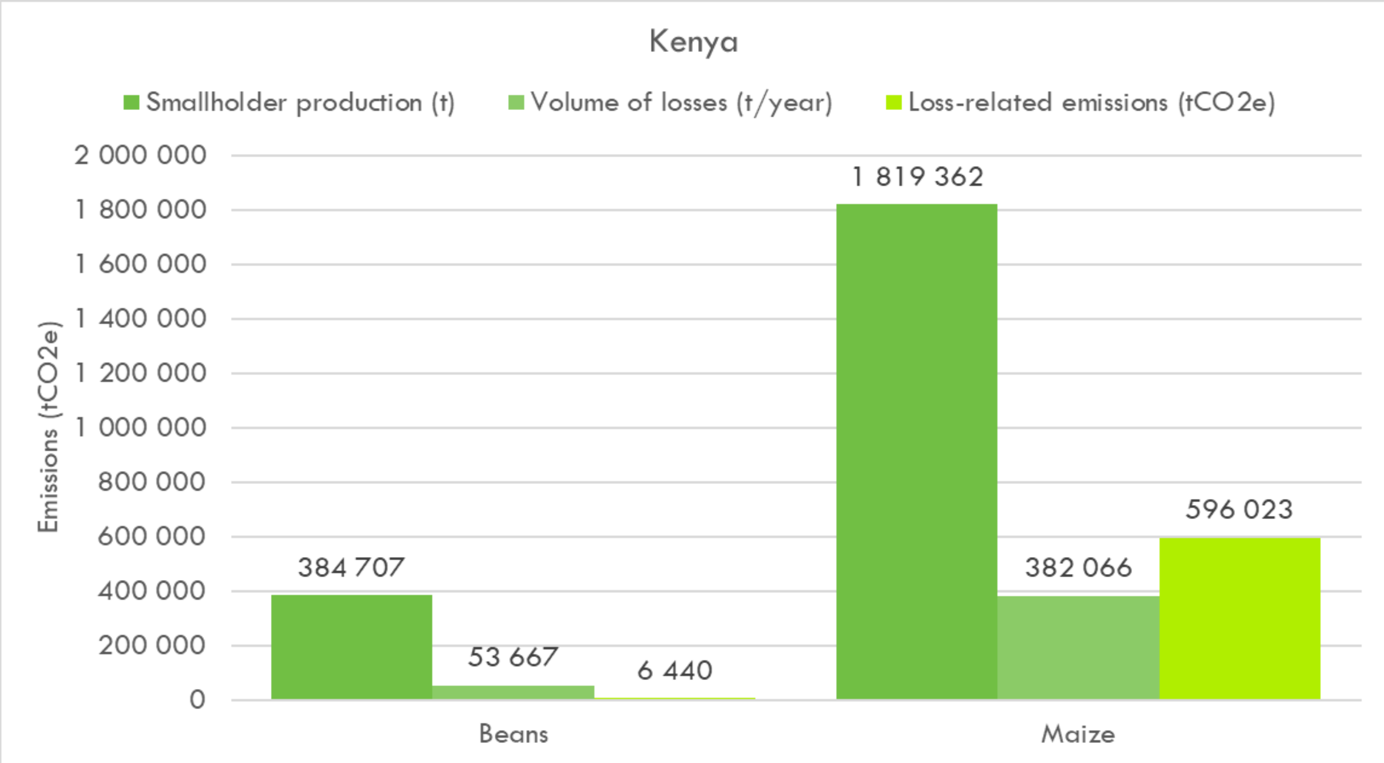


Figure 4-5 - Estimated emissions (tCO_2e) from post-harvest losses

A note on the calculation methodology: Using the total maximum losses possible under the loss scenarios presented in the tables above, a possible total loss (%) per commodity can be calculated, as presented in

Table 4-4 below. The maximum values were used to represent the worst-case scenario. Smallholder production statistics were sourced from production statistics provided by national statistical offices. Where smallholder production statistics were not made available, the national production statistics were adjusted to represent the percentage of smallholders in the relevant value chain. The emissions factors used were published in Porter et al. (2016) and have been used in several studies to estimate emissions.

Table 4-4 - Estimated emissions (tCO_2e/t food) calculated using total maximum losses per commodity, total national annual smallholder production (tonnes) and emissions factors for food loss emissions published (Porter, Reay, higgins, & Bomberg, 2016)

Country	Crop	Smallholder production (t)	Loss rate (%)	Volume of losses (t/year)	Loss-related emissions (tCO2e)
Kenya	Beans	384 707	14%	53 667	6 440
	Maize	1 819 362	21%	382 066	596 023
Total		**2 204 069**	**35%**	**435 733**	**602 463**

4.3 COUNTRY AND SECTORAL CLIMATE CHANGE EMISSIONS PROJECTIONS

The GHG inventory developed by Kenya provides projected emissions to 2030 for key sectors under BAU and alternative scenarios, which are also used as part of the NDC. The BAU emissions projections for Kenya as stated in the SNC (NEMA, 2015) are provided below (Figure 4-6, see also Figure 4-1 above). Emissions from the agricultural sector, are projected to increase by 2030 under the BAU emissions scenario, reaching 39 $MtCO_2e$. Similarly, emissions are projected to rise in the Land Use, Land-use Change and Forestry (LULUCF) sector between 2020 and 2030, reaching 22 $MtCO_2e$ by 2030 (Figure 4-6) (NEMA, 2015).

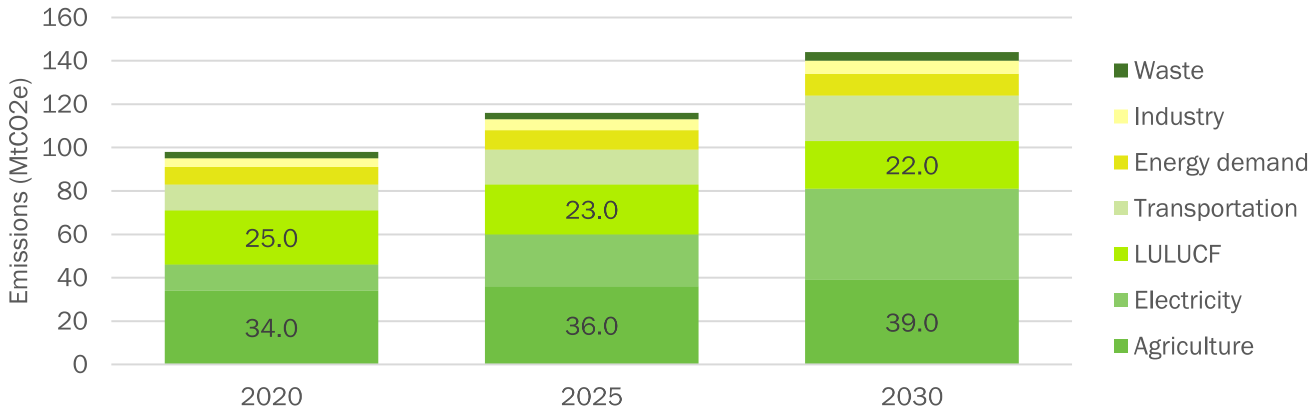


Figure 4-6 - Projected emissions across key sectors in Kenya (NEMA, 2015)

4.4 CROP VALUE CHAINS CLIMATE CHANGE EMISSIONS PROJECTIONS

The OECD-FAO Agricultural Outlook 2023–2032 (OECD & FAO, 2023a) highlights the necessity of raising crop production in Sub-Saharan Africa (SSA) over the coming decade to match the projected growth in demand. Production of agricultural and fish products is anticipated to grow by 24% in net value-added terms, but this is only a 2.2% average annual gain, which is lower than the projected population growth. Most of the projected growth in production is related to an increase in crop production, which is anticipated to account for 70% of the total agricultural value by 2032. The production of food crops in particular, is projected to increase by 27%, as a result of intensification, productivity gains and changes to the crop mix, with a 7% expansion in land used for crop production by 2032 (OECD & FAO, 2023a).

The gap between production and demand is concerning given that SSA has arguably the highest concentration of impoverished and undernourished people globally, with low calorie availability per capita across the region (OECD & FAO, 2023a). The COVID-19 pandemic and the war in Ukraine have exacerbated baseline food insecurity in many areas. Staple crops contribute approximately 70% of the total calories available to people in SSA as of 2020–2022. Maize, root crops, and tubers constitute the bulk of these staple crops. While this is unlikely to change towards 2032, the relative contribution of rice and maize is expected to increase while roots and tubers remain consistent (OECD & FAO, 2023a).

In Kenya, crop losses along the target value chains are estimated to increase by 2032, compared to the 2020–2022 period (Figure 4-7). Without significant intervention, losses will undermine regional efforts to improve food security.

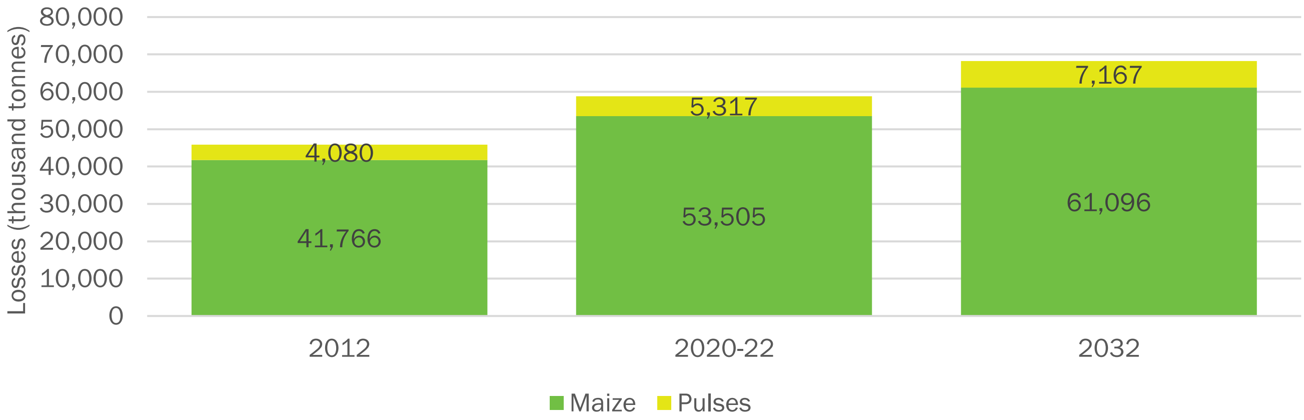


Figure 4-7 - Projected losses across global agricultural value chains for key commodities towards 2032 (OECD & FAO, 2023b)

By using available estimates of losses as presented in

Table 4-4 above, we can make use of the projected estimates for crop yields and harvested area as presented in the OECD-FAO Agricultural Outlook 2023–2032 (OECD & FAO, 2023b) to calculate potential post-harvest losses and associated emissions for the 2032. In

Table 4-5 below, projected emissions from post-harvest losses for the year 2032 are presented. These are an underestimation as they do not consider the impacts of climate change on either yields or post-harvest losses. Changing rainfall regimes and increasing temperatures, as well as the associated predicted increases in the occurrence and severity of droughts and floods, are likely to have negative impacts on smallholder agricultural production if no adaptation actions are undertaken.

A note on the calculation methodology: The OECD-FAO Agricultural Outlook (OECD & FAO, 2023b) provides projected estimates of changes in production, yields, and harvested area for key commodity groups across SSA. By using the data available from

Table 4-4 and its sources, the OECD & FAO (2023b) projections were used to calculate estimates for production of the crops in the target countries. These values assume that loss estimates remain unchanged by both adaptation interventions and climate change impacts.

Table 4-5 - Estimated emissions (tCO_2e) for the year 2032 calculated using projected losses per commodity, total smallholder annual production (tonnes) and emissions factors for food loss emissions published (Porter et al., 2016)

Country	Crop	Projected production 2032 (t)	Projected losses 2032 (t/year)	Projected loss-related emissions 2032 (tCO2e)
Kenya	Beans	465 629	64 955	7 795
	Maize	2 204 299	462 903	722 128
Total		**2 669 928**	**527 858**	**729 923**

Without intervention, emissions related to post-harvest losses on smallholder farms are expected to increase by ~21% (

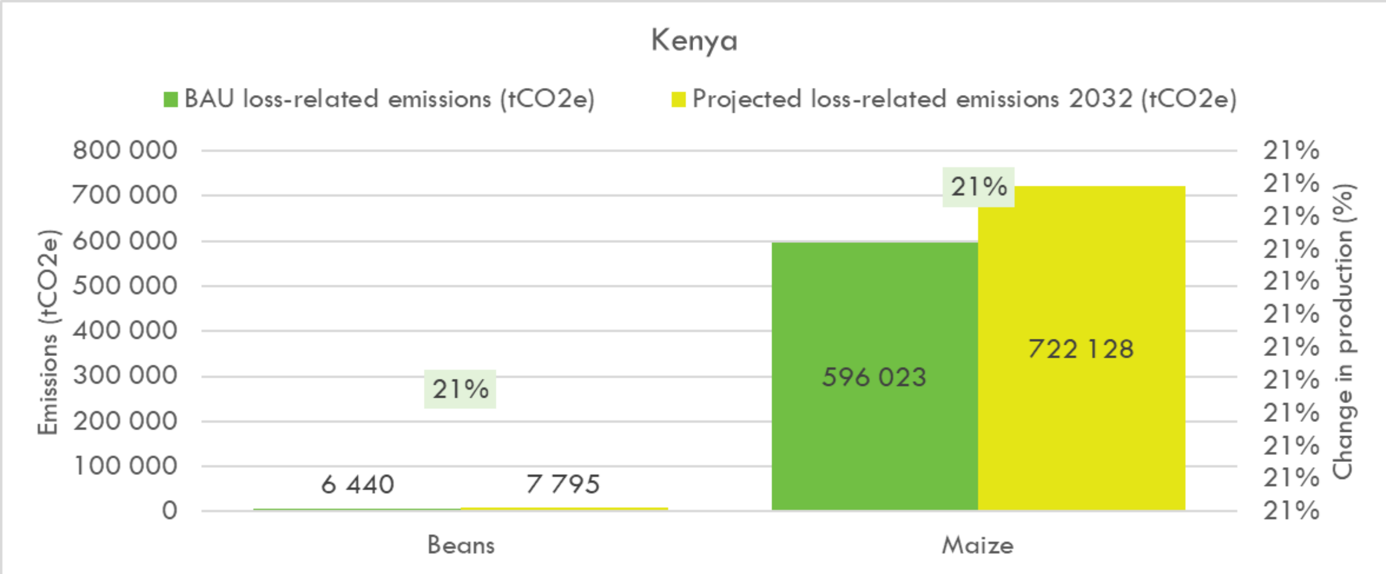


Figure 4-8). **For Kenya, this could amount to 722 128 tCO_2e for maize and 7 795 tCO_2e for beans by 2032 (**

Table 4-5**).** This presents the minimum expected losses as climate change is likely to exacerbate these numbers.

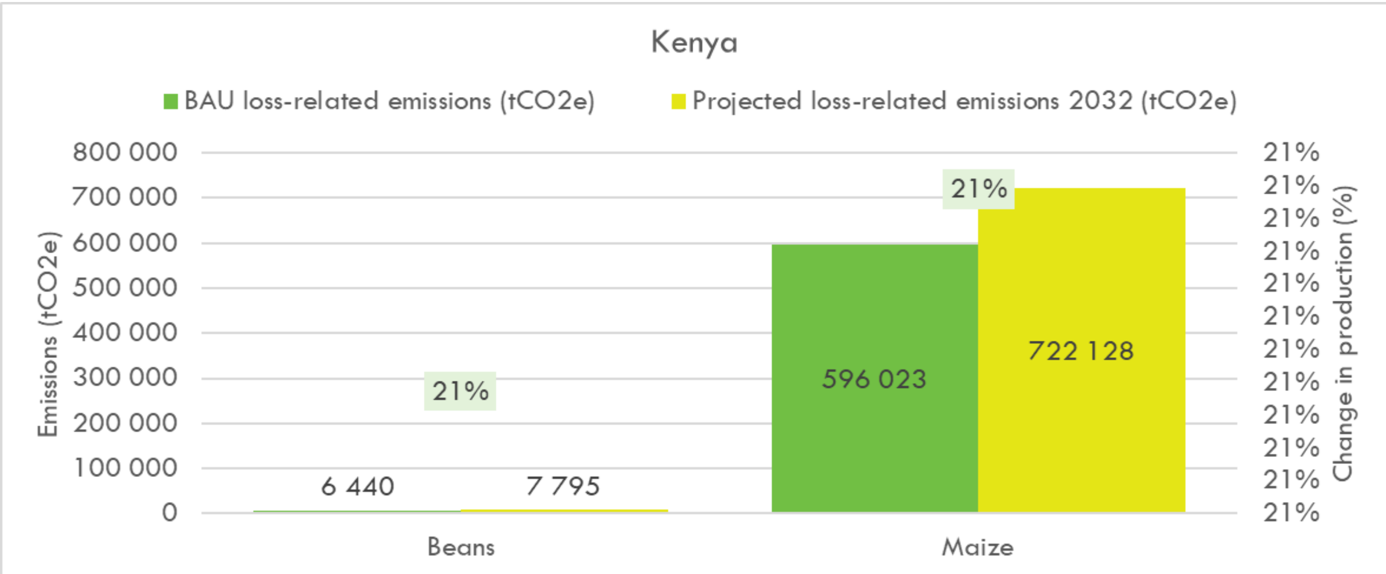


Figure 4-8 - Estimated emissions from post-harvest losses in 2022 and 2032 for key crops in Kenya, percentage values indicate projected increase in emissions

5 Design of Food Loss Reduction Solutions

5.1 STOCKTAKE OF FL-RS FOR POST-HARVEST VALUE CHAINS

5.1.1 Maize

The major maize growing regions in Kenya are presented in Figure 3-16. Maize is a warm-season crop requiring a minimum temperature of 10-15 °C for germination and growth (Greenlife Crop Protection Africa, 2024). Ideal maize farming conditions in Kenya are typically found at altitudes ranging from 900 to 2 500 meters above sea level (Greenlife Crop Protection Africa, 2024). These regions receive an average annual rainfall of 600 to 1 200 mm, evenly distributed throughout the growing season (Greenlife Crop Protection Africa, 2024). Nevertheless, maize can also be grown in arid areas with the aid of irrigation.

Maize holds a central role as Kenya's primary staple food, with approximately 70% of its production coming from smallholder farmers (Kang'ethe E. , Mutua,, Roesel, & Grace, 2020). This crop plays a crucial role in ensuring food security and bolstering the national economy, contributing 3% to the GDP and 12% to the agricultural GDP (Kang'ethe E. , Mutua,, Roesel, & Grace, 2020). Studies also indicate that maize constitutes around 20% of agricultural output and supports 25% of employment opportunities in Kenya (KNBS, 2019). It serves as the most cost-effective calorie source among cereal grains, providing 65% of household food calories in Kenya (TAAT, 2020). To meet this demand, maize is cultivated on 40% of the total crop area, predominantly by small-scale farmers (TAAT, 2020).

Most farming households (about 96%) grow maize primarily for household consumption, with any surplus sold to aggregators (Kirimi, et al., 2011). However, due to the small size of their farms (typically less than five acres), rural households often struggle to produce enough maize for year-round consumption. On average, only 20% of farmers engage in commercial maize sales, mainly comprising large-scale farmers who operate on more extensive land holdings (greater than 30 acres) (Kang'ethe E. M., 2020). Medium-scale farmers, managing 5–20 acres, also contribute to maize production, albeit at a moderate scale (Kang'ethe E. M., 2020).

Over the last three decades (1992-2022), the maize cultivation area has expanded significantly from 1 407 000 hectares to 2 156 376 hectares (FAO, 2022). Maize production in Kenya experienced a significant rise of 38,8% in 2024, reaching 47.6 million bags, as reported by the 2024 National Economic Survey of Kenya (KNBS, 2024). This surge was primarily driven by an expansion in cropped areas, governmental pledges to purchase maize at guaranteed minimum returns, favourable weather conditions, and greater access to subsidized fertilizers (KNBS, 2024). Concurrently, maize prices increased by 15,4%, climbing from 5 301,03 Ksh to 6 116,68 Ksh per 100 kilograms (KNBS, 2024). Despite these advances, maize yields per hectare in Kenya remain relatively low, ranging from 1 440 to 1 836 kilograms, compared to global averages of 5 751 kilograms and 2 070 kilograms in other African countries (FAO, 2022). This fluctuation in yields and production volumes is shown in Figure 5-1 is largely influenced by environmental factors and agricultural practices (FAO, 2022).

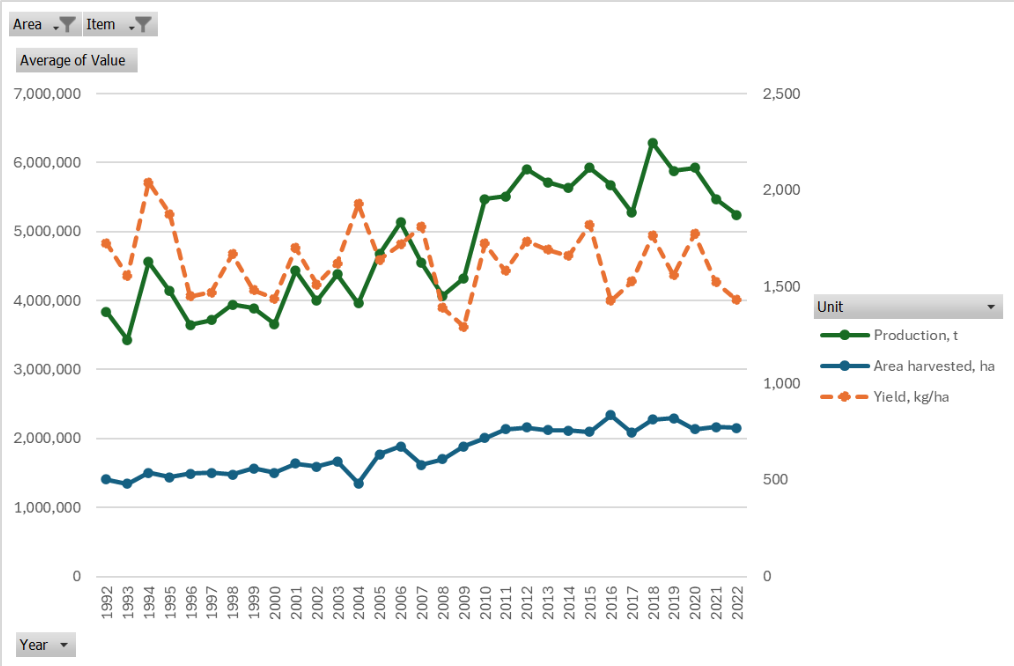


Figure 5-1 - Maize production, harvest area and annual yields in Kenya, 1992-2022 (FAO, 2022)

Maize farming in Kenya encounters significant challenges that hinder its full potential. Climate change and variability pose substantial threats, manifesting in erratic rainfall patterns, prolonged droughts, and occasional flooding, all of which severely impact crop yields and contribute to food insecurity and poverty. Implementing climate-smart agricultural practices, such as crop diversification, water harvesting, and soil conservation, could mitigate these challenges and enhance maize productivity.

Considering the data available and the focus of this study, improving yields and reducing post-harvest and storage losses along the maize value chain in Kenya has the potential to release pressure on land and reduce forest degradation triggered by cropland expansion.

According to recent data from FAOSTAT, in 2020 and 2021 Kenya is not producing enough maize to satisfy its domestic needs and consumption (Figure 5-2), but does export part of the production abroad.

Table 5-1– Maize production, domestic supply and consumption, export and losses in Kenya, 2011-2021 (FAO, 2022)

Year	Production (‘000 t)	Domestic supply quantity (‘000 t)	Export quantity (‘000 t)	Food supply quantity (kg/capita/yr)	Losses (‘000 t)
2011	3 377,00	5 221,00	15,00	88,05	159,00
2012	3 750,00	5 087,00	15,00	80,94	177,00
2013	3 593,00	4 170,00	6,00	82,68	170,00
2014	3 513,00	4 226,00	3,00	78,18	78,00
2015	3 825,00	4 716,00	8,00	86,11	83,00
2016	3 339,00	4 794,00	5,00	83,15	72,00
2017	3 186,00	4 459,00	6,00	77,95	146,00
2018	4 014,00	4 393,00	9,00	79,78	93,00
2019	3 582,00	4 675,00	5,00	75,30	51,00
2020	3 789,00	4 391,00	8,00	67,96	88,00
2021	3 303,00	4 207,00	10,00	61,13	74,00

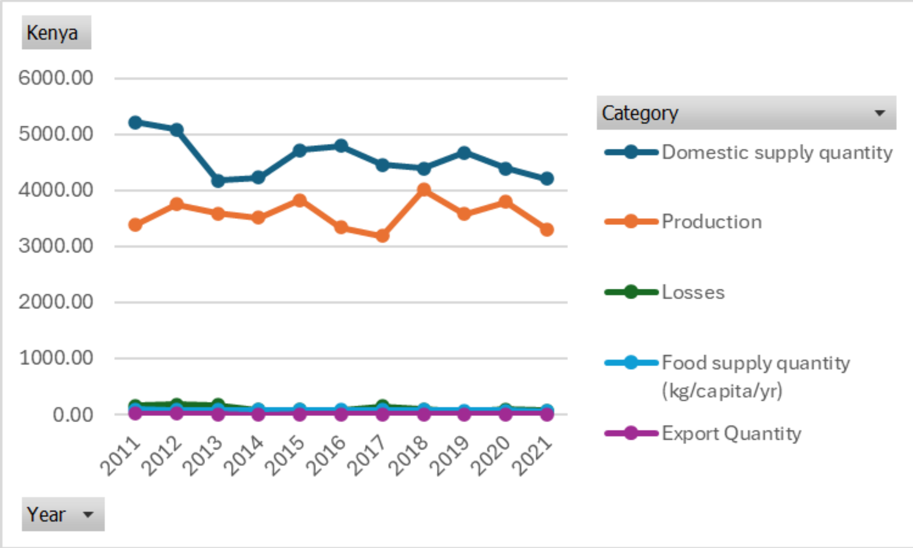


Figure 5-2 - Maize production, domestic supply, export quantities and losses in Kenya, 1000 t, 2011-2021 (FAO, 2022)

Maize in Kenya is typically harvested after 3 to 4 months for short-season varieties and up to 10 months or more for long-season varieties (Greenlife Crop Protection Africa, 2024). Maize can be harvested either when green or dry depending on the intended use of the maize. Maize cobs are harvested by hand or with mechanized harvesters. Although mechanized harvesting is faster and more efficient, it requires costly equipment that may be out of reach for most small-scale farmers. Hand harvesting, while labour-intensive, allows for the selective picking of mature cobs.

Once harvested, maize is dried either on the cob or as shelled grains. On-cob drying directly on the ground without a canvas sheet increases the risk of fungal contamination from soil, leading to potential aflatoxin issues in stored crops (Kang'ethe, et al., 2017). Studies by Kang'ethe et al. (2017) found that 39,1% of farmers in Makueni County and 37,1% in Nandi County dried their maize cobs on the ground without protective sheets. Such practices lower grain quality and pose public health risks (Mejía, 2003). Properly dried maize should have a moisture content of ≤ 13,5%, as higher levels encourage fungal growth and increase the risk of aflatoxin contamination if aflatoxigenic moulds are present.

Shelling maize from the cob can be done using manual shellers, shelling machines, or by pounding with sticks. The latter methods, especially pounding or improperly calibrated machines, can damage the grains, making them more susceptible to fungal infection and subsequent aflatoxin contamination. Despite these risks, manual methods remain prevalent among Kenyan farmers (Kang'ethe, et al., 2017).

Kenyan farmers further dry maize either in the sun or using mechanical dryers, especially during wet seasons, to prevent losses from fungal growth. To extend the shelf life and reduce post-harvest losses, some farmers treat their maize against storage pests such as weevils or use treated gunny bags.

Maize is vulnerable to pests and diseases, including stem borers, armyworms, and maize lethal necrosis disease, which can cause significant losses (Kang'ethe, et al., 2017). Kenya is a hotspot for aflatoxins—dangerous mycotoxins produced by moulds under warm, damp conditions, which can contaminate maize before or after harvest and during storage (Kang'ethe, et al., 2017). Mycotoxins are stable and can persist through food processing. Key factors contributing to this issue include improper drying, poor storage practices, and a lack of awareness among farmers and consumers (Kang'ethe, et al., 2017).

Storage losses are substantial, with farmers estimating maize storage losses of 21% due to weevils and 18% due to larger grain borers, leading to total storage losses of around 36%, especially high in Western Kenya (De Groote, Muteti, & Bruce, 2023). Farmers use chemical pesticides (49%), hermetic bags (16%), and botanicals (15%) to mitigate these losses (De

Groote, Muteti, & Bruce, 2023). The highest losses occur in humid areas (56%), with smaller losses in drylands (20-23%) (De Groote, Muteti, & Bruce, 2023).

Farmers store maize either as cobs in well-ventilated, raised cribs or as shelled grains in nylon bags (Tefera T. , 2012). Proper airflow in cribs helps the grains dry, with threshing done when market conditions are favourable (Tefera T. , 2012). However, storage of shelled maize in nylon bags often leads to moisture buildup, exposing the grains to fungal spores and aflatoxin risks (Tefera T. , 2012). Frequently, these bags are placed directly on the ground instead of on pallets, further increasing contamination risks (Tefera T. , 2012).

Persistent challenges in storage and post-harvest handling have affected maize farmers in Kenya. Limited access to credit and markets restricts their ability to invest in necessary inputs, technology, and infrastructure, impacting their productivity and potential for regional and international market participation (Bisheko & Rejikumar, 2023). Enhancing storage facilities and post-harvest practices, including proper drying, cleaning, and storage, could significantly reduce losses and improve grain quality. Establishing credit facilities and market linkages would also address these challenges, fostering improvements in maize farming across Kenya.

Various reports and projects suggest that Kenya can achieve maize self-sufficiency without expanding the planted area by making modest improvements in yields and reducing post-harvest losses (USAID, 2015). Initiatives that focus on enhancing farm productivity and minimizing post-harvest losses are expected to yield the greatest benefits, not only in boosting national supply but also by increasing income for farmers and traders. As shown in Table 5-2, the most critical stages of the value chain for food losses are harvesting, on-farm storage, and drying. Maize is particularly susceptible to moisture, aflatoxin development, and pest and rodent attacks during storage. Therefore, it must be dried to a moisture content of 12% before being placed in storage facilities.

Table 5-2 - Comparison on Maize food losses in the different stages of the value chain in Kenya

Value chain stage	APHLIS database (2022)	FAO Food loss and waste database (2021)
Harvesting/ field drying	6.4%	6.2%
Further drying	4.0%	4.0%
Threshing and Shelling	1.3%	1.4%
Transport from field	2.4%	2.4%
Household-level storage	2.5%	4.5%
Transport to market	1.7%	1.6%
Market storage	2.7%	2.7%
Overall:	16,7%	17,3%

A general overview of the maize value chain in Kenya, covering key stages, processes, stakeholders, climate data, and potential solutions to reduce food losses is presented in the Table 5-3. In the future, proactive measures will be essential to manage risks to Kenya's rain-fed farming system, particularly by addressing technological and management deficiencies amid the increasing challenges of shrinking farm sizes, greater climatic variability, and the emergence of new pests and diseases.

Table 5-3 - Overview of Maize Chefood losses in Kenya in the different steps in the value chain, relevant parameters, and suggested solutions

FSC Stage/ process	Processes	% losses (APHLIS, n.d.)	Cause of Losses	Affected stakeholders	Climate aspects	Suggested solutions
Harvesting						
Harvesting/field drying	Cutting/gathering the cobs, manually or using mechanical harvesters Field drying in stooks	6.4%		Farmers	Heat stress for workers/farmers and animals, increased humidity/ moisture of crops and fungi development Rains, winds	Capacity building trainings on harvesting techniques and harvesting tools Capacity building on drying
Hauling	Transport from the field to the farm, carrying by hand or by using various vehicles	2.4%		Farmers	Rains, winds	Using trucks and other types of vehicles
Post-harvest processes (on-farm)						
Threshing / shelling of cobs	Manual or mechanical shelling, using manual and mechanical shellers	1.3%	Mechanical damage	Farmers	Rains, winds, temperature	Capacity building on threshing technique, or using mechanical threshers
Drying	Additional drying using cribs, tarpaulins, and similar solutions	4.0%	Mold, insects, rodents, livestock foraging	Farmers	Rains, winds, temperature	Plastic sheets and tarpaulins, rectangular cribs
On-farm storage	Storage in bags, silos, or baskets	2.5%	Mold, insects, rodents	Farmers	Heat/ high temperatures	Metal and plastic silos, sheds, plastic and hermetic bags, baskets and cribs, solid brick bins, Insecticides/ fumigation
Primary processing	Grinding, hulling, pounding, milling, etc. using manual, partially mechanised or fully mechanised small-scale and industrial mills	Not Reported	Spillage, contamination	Millers		
Transport, logistics, further processing						
Collection from farm	Aggregating and grain collection; transportation to collection centres/ aggregation depot/ markets using vans and trucks of various capacity	1.7%	Spillage	Aggregators/ collectors and traders		Plastic hermetic bags; non-hermetic polypropylene bags
Grading and packing	Sorting, pre-cleaning, re-packaging and packaging	Not Reported		Collectors and traders		
Storage	In bulk and/or in bags	2..7%	Spillage, qualitative losses	Storage companies, warehouses		Plastic hermetic bags, non-hermetic polypropylene bags. Insecticides/ fumigation
Wholesale	Packaging, storage, transportation to the sale points (markets, supermarkets)	Not Reported	Spillage, qualitative losses	Traders		
Secondary processing	Further processing into roller meal, flour, animal feed, products for snack and brewing industry, etc.	Not Reported		Secondary processors		

5.1.2 Beans

Kenya ranks as the seventh largest producer of common beans worldwide and holds the position of the second-largest producer within East Africa (Duku, et al., 2023). Beans are the second most crucial food crop after maize in Kenya (Duku, et al., 2023). . Major bean-producing regions include the Rift Valley, Eastern, Lake Victoria zone, Western, and Central areas, which contribute 33%, 24%, 18%, 13%, and 20% respectively to the national output (Duku, et al., 2023). Annually, national bean consumption is estimated at about 755 000 tonnes, compared to an annual production of approximately 600 000 tonnes (Duku, et al., 2023).

According to FAO (Figure 5-3), domestic production of dry beans was relatively stable between 2011 and 2022, with the majority of beans consumed locally in Kenya (FAO, 2022).

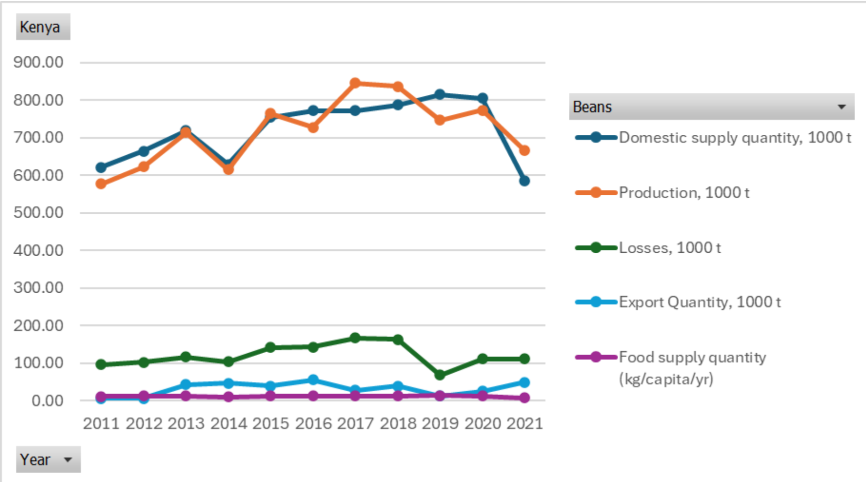


Figure 5-3 - Dry beans in Kenya: domestic supply, production volumes, losses and consumption per capita in 2011-2022 (FAO, 2022)

Figure 5-4 shows the harvested area and yields of dry beans in Kenya (FAO, 2022). Harvested area has doubled since 1992, with annual yields changing drastically from year to year.

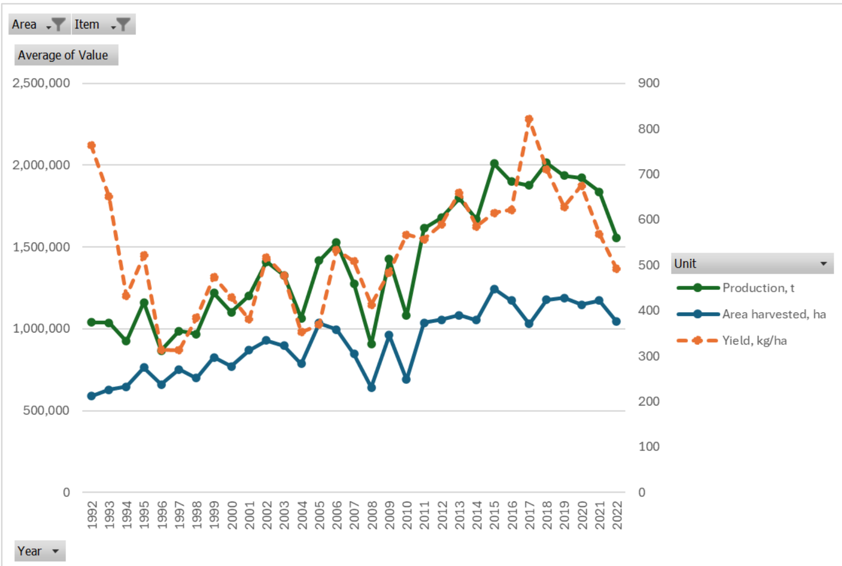


Figure 5-4 - Dry beans in Kenya: harvested area and yields, 1992 - 2022 (FAO, 2022)

Despite the increasing demand and favourable market prices, bean production in Kenya faces significant challenges, primarily from climate change. Factors such as rising temperatures, more frequent heat waves, heightened water stress, and heavy precipitation have disrupted production (Ministry of Agriculture, Livestock, Fisheries and Cooperatives, 2020).

These environmental changes, alongside unpredictable rainfall patterns and the spread of pests and diseases, have contributed to declining bean production and productivity in Kenya. Beans, like many other crops, are vulnerable to temperature fluctuations and irregular precipitation due to climate change. Additionally, inadequate distribution to demand areas and increased pest and disease pressures before and after harvest further threaten productivity.

In Kenya, beans are predominantly grown by small-scale farmers, particularly women, due to their short growth cycle of approximately 70 days, which allows for production even in erratic rainfall conditions (Katungi, et al., 2010). Despite having two growing seasons, many farmers opt to plant beans only once a year due to challenging climatic conditions (Duku, et al., 2023). Regions like the Rift Valley and Western Kenya allocate land for beans during the March-May season annually, while Central and Eastern regions typically plant beans twice a year, with 70% of Eastern farmers doing so during the longer rainy season (Duku, et al., 2023). Almost all farmers in these areas plant beans during the shorter rains from October to December, though production in Eastern regions and coastal areas is constrained by adverse weather conditions (Duku, et al., 2023).

Although specific studies on the bean value chain in Kenya detailing exact post-harvest losses are lacking, various sources estimate that losses on farms range from 30% to 50% (Karanja et al., 2021; CRAFT & Ministry of Agriculture, Livestock, Fisheries, and Cooperatives, 2020). These losses occur across different stages, including harvesting (20-30%), threshing (10-20%), transportation (5-15%), and storage (10-40%).

Harvesting methods vary, with most farmers opting for manual harvesting, though some use mechanized techniques. While bush beans are collected from the field and uprooted as whole plants, for the climbing types one picks the single pods and are threshed before winnowing. Beans are typically ready for harvest 75 to 90 days after planting, with signs of maturity including yellowing or browning of plants or plant collapse (Karanja, et al., 2021). Timing the harvest is crucial to avoid grain loss due to overexposure in the field. Premature harvesting results in poor-quality, immature grains, while delayed harvesting increases losses and spillage (Karanja, et al., 2021). Pods should ideally be harvested when fully dry, but they can also be picked when withered and sun-dried. Completely dry pods split open, exposing beans with a moisture content of 20-25%, which feels firm to the touch. For safe storage, the moisture content should be between 10 and 12%. Moisture content above 25% can cause the grain to rot.

Losses during harvesting are significant in Kenya, typically ranging from 20% to 30%, primarily due to improper timing and high moisture content. Harvesting often occurs during the wet season which exacerbates losses due to bean discoloration and rot from delayed drying. Climate change has made sun drying more challenging.

Harvested plant pods or whole plant hills are placed on nylon canvas and threshed on clean material to avoid impurities. Winnowing is crucial for separating grains from pods, typically done in windy conditions to minimize losses. Manual threshing and winnowing are labour-intensive, and primarily handled by women and youth. Introducing mechanized harvesters and threshers could reduce labour burdens, speed up operations, and minimize grain loss (Karanja, et al., 2021).

Storage stage losses range from 10% to 40%, primarily due to pest infestations, such as bruchids, and inadequate storage conditions like high moisture levels and poor facilities. Effective pest management and the use of hermetic storage bags can mitigate these losses, ensuring beans remain safe for consumption and sale. The threat of insect damage often forces farmers to sell their produce at low prices at harvest and buy it back later at higher prices. Dry beans should be stored in insecticide treated gunny or air-tight hermetic bags which help to prevent major damages caused by storage pests. In the absence of hermetic bags, it is advisable to use an insecticide dust to prevent damage of grain while in the store. Bags should be placed on pallets, not directly on the floor.

During transportation, losses range from 5% to 15%, largely due to mechanical damage and poor handling practices. Improved packaging materials, such as sturdy containers and sacks, and dedicated transport vehicles can minimize these losses by reducing jostling and damage.

General overview of the common dry beans value chain in Kenya, covering key stages, processes, stakeholders, climate data, and potential solutions to reduce food losses are presented in Table 5-4.

Table 5-4 - Overview of dry (common) beans food losses in Kenya in the different steps in the value chain, relevant parameters, and suggested solutions

FSC Stage/ process	Processes	% losses (De Groote, Muteti, & Bruce, 2023)	Cause of Losses	Affected stakeholders	Climate aspects	Suggested solutions
Harvesting						
Harvesting	Bush beans are collected from the field and uprooted as whole plants, or the single pods are collected	20-30%	Immature grains, spillage	Farmers	Heat stress for workers/farmers and animals, increased humidity/ moisture Rains, winds	Capacity building trainings on harvesting techniques and harvesting tools Capacity building on drying
Threshing / shelling	Manual or mechanical shelling, using manual and mechanical shellers	10-20%	Mechanical damage	Farmers	Rains, winds, temperature	Capacity building on threshing technique, or using mechanical threshers
Winnowing	Separating the edible seeds from the chaff and other debris	Not Reported	Spillage	Farmers	Winds, rains	
Transport from the field	In bulk, using different types of available transport	5-15%	Spillage, mechanical damage	Farmers	Rains, winds	Using trucks and other types of vehicles
Post-harvest processes (on-farm)						
Drying	Drying of the threshed beans using tarpaulins, dryers, and similar solutions	Not Reported	Insects, rodents, contamination	Farmers	Rains, winds, temperature	
Packing, grading	Sorting, pre-cleaning and packaging	Not Reported	Spillage	Farmers		
On-farm storage	Storage in bags, silos, or baskets	4.45%	Humidity/ mould, insects, rodents	Farmers	Heat/ high temperatures; rains/floods, humidity	Metal and plastic silos, sheds, plastic and hermetic bags, baskets and cribs, solid brick bins, Insecticides/ fumigation
Transport, logistics, further processing						
Collection from farm	Aggregating, transportation to collection centres/ aggregation depot using vans and trucks of various capacity	Not Reported	Spillage	Aggregators/ collectors and traders		
Storage	In bags	Not Reported	Spillage, mould, pests and rodents	Storage companies, warehouses		
Wholesale	Packaging, transportation to the sale points (markets, supermarkets)	Not Reported	Spillage, mould, pests and rodents	Traders		

5.2 SHORT-LIST OF FL-RS BASED ON RESULTS OF CLIMATE ANALYSIS

This sub-chapter provides an overview of the most suitable physical and non-physical food loss reduction solutions for Kenya. RE-GAIN Programme aims to increase awareness of smallholder farmers in Kenya regarding the proper utilization of those key FL-RS. Its objectives include ensuring the correct handling and maintenance of these solutions and achieving the maximum reduction of food losses across targeted value chains. This initiative will be executed through a range of capacity-building efforts, including training sessions and the provision of educational materials. The training will be implemented through two primary methods: direct training for smallholder farmers and a "training of trainers" approach. The latter involves capacity-building activities aimed at community focal points, who, upon completion of their training, will facilitate the transfer of knowledge to their communities, encompassing men, women, and youth. Specific proposed activities for Kenya are described in Subchapter 5.2.1.

Besides the soft FL-RS, subchapters from 5.2.2 to 5.2.12 provide evaluation of the different types of physical FL-RS, their quantitative impact on postharvest food loss reduction, and summarizes technical and implementation feasibility, and existing bottlenecks/barriers of those FL-RS in Kenya. The proposed FL-RS in those subchapters have been short-listed considering the specific context of Kenya as well as the overarching project goal, objectives and elements of RE-GAIN programme in sections 5.3 and 5.4.

5.2.1 Awareness raising and capacity building

To ensure the successful adoption of FL-RS and overcome the knowledge barriers that hinder their demand, usage, and maintenance, the RE-GAIN program will incorporate non-physical interventions aimed at raising awareness and strengthening capacity building amongst smallholder farmers. These efforts will focus on key areas, including the effects of climate change on harvesting and post-harvesting processes, the correct use of FL-RS, and proper maintenance practices to maximize the reduction of avoidable food losses within targeted value chains and fostering strong market linkages. This extension service initiative will be executed through a range of a comprehensive range of capacity-building activities, such as hands-on training and educational resources. Two primary methods will be employed to deliver this training: direct instruction to smallholder farmers and a "training of trainers" model. In the latter approach, community focal points will undergo in-depth capacity-building activities. Upon completing their training, these focal points will be equipped to share their knowledge with their communities, ensuring the inclusion of men, women, and youth in the transfer of critical skills and information.

These extension activities have different target audiences: smallholder farmers and production aggregators (or traders) and food processors. For smallholder farmers, raising awareness about critical issues such as food losses, quality, moisture content, aflatoxin contamination, pests, and proper storage methods is essential. Understanding the linkage of these food losses with climate change’s impact is also key, raining awareness of the need for farmers to better understand how different agricultural processes, such as timing of harvesting, use of weather forecast data (for timing of harvesting and drying), and appropriate harvesting methods need to evolve to account for the higher variability farmers will encounter with the changing climate.

Environmental and safety aspects, such as the safe use of storage protectants, the safe way of operating different machinery, and correct disposal of the physical solutions, are also part of the training curriculum. Next to the technical aspects of the physical solutions, farmers also need to be trained on the proper use and maintenance of some of those FL-RS such as moisture meters, drying methods, and storage techniques such as hermetic bags, and silos, cleanliness and product quality management to ensure a long-term usage and sustainability of these solutions. Finally, farmers must also be aware of how they can access finance to invest in FL-RS, and farm business management such as quality management, record keeping, and marketing (for generating revenue to repay loans).

For traders and processors, the focus of the capacity building and awareness raising activities will be on transport logistics, packaging, adherence to quality standards, and the use of storage protectants. Emphasis on value addition through whole grain processing and effective marketing strategies can enhance the profitability and sustainability of their operations.

The indicative extension activities include awareness raising, and capacity building programme is outlined in Table 5-5.

Table 5-5 Indicative Awareness Raising and Capacity Building elements of RE-GAIN Programme in Kenya

	Awareness Raising	Capacity building
Objectives:	To increase awareness and understanding of post-harvest food losses and the impact of climate change among farmers, stakeholders, and the general public, with the aim of reducing these losses through education, technology adoption, and active involvement of all key stakeholders.	To educate smallholder farmers on improved climate smart crop management and storage techniques and use of available climate information for reducing food losses and to maintain quality of produce, increase farmers' income by reducing losses and improving marketability, and improve supply of financial services and FL-RS to smallholders and other value chain actors
Target Audience	Smallholder farmers, agricultural extension workers, (local) government officials, NGOs and agricultural organizations, agro-dealers, other stakeholders, and the general public	
Key topics and modules	1. **RE-GAIN programme** and its objectives to reduce food losses and for climate change adaptation. 2. **Impact of post-harvest losses on food security**, income, economy, and the environment (incl. climate change) and the importance to reduce FL. 3. **Causes of PH-FL and best practices and improved technologies and methods** (e.g., timing of harvesting, methods and technologies for harvesting, storage, etc.) to reduce in post-harvest losses and their benefits (food security, income environment). 4. Role of different actors (local government, extension services, farmer organisations, agro-dealers, financial institutions) to provide access for FL-RS. 5. **Cross-cutting themes**: climate change awareness, climate smart agriculture, farm management, marketing, product quality management, access to finance, gender and youths, etc.	**1. For all groups of stakeholders:** Introduction to the REGAIN programme, climate change, PH food losses, causes, overview of solutions, providers of solutions, financial literacy and access to credit, product quality, farm records, food security, marketing and aggregation. Gender, youths, food security, environmental aspects and climate change. **2. Training of trainers for extension workers, agro-dealers** Introduction to the RE-GAIN programme, overview of PH losses, climate change and use of available climate information for harvest and post-harvest decision making, causes, priority solutions, providers of loss reduction solutions, setup of trainings and demonstrations, use of promotion materials, advise to smallholders, etc. **3. Trainings for smallholder farmers:** • Identification of the optimal timing of harvesting • Use of available weather forecast information. • Appropriate harvesting methods. • Key reasons of food losses during harvesting and post-harvest management and storage. • Major impacts of climate change on agriculture and postharvest management. • Technical approaches on maintaining crop quality during harvesting, post-harvest handling and storage. • Approaches to measuring and keeping optimal moisture content in crops to prevent aflatoxin contamination. • Approaches and solutions to prevent pest attacks, and proper storage methods. • Best harvesting methods and tools, including mechanization to reduce food losses. • Proper use and maintenance of physical FL-RS, including operation and maintenance of machinery, and their environmental and safety aspects. • Record-keeping, financial literacy and access to finance. Packaging and marketing of crops. • Methods and materials for proper on-farm storage, safe and proper use of pesticides and fungicides, pre-storage crop treatment and preparations, and monitoring storage losses and quality of crops during storage • Facilitate linkages between small holders and market actors **4. Training for agricultural traders and processors:**

	Awareness Raising	Capacity building
		Proper package materials and methods, quality control, proper transport / aggregation methods and systems. Climate change and PH food losses at the trade and processing stages, their causes and solutions, quality management and adherence to quality standards, transport logistics and packaging, sustainable use of storage protectants and storage, processing (including whole grain processing), value addition, supplier management, effective marketing strategies, access to finance. **5. Training for FI-RS providers (manufacturers, importers, agrodealers)** Proper service management, safe, effective, efficient and sustainable operation of the equipment and provision of the services. **6. Institutional capacity building** Enhancing the capacities of extension services, meteorological services, monitoring of FL, FL reductions and opportunities for upscaling and replication. Capacities for value chain and market networking.
Activities	• Mass media campaigns: radio, television, digital platforms and social media. • Collaboration with local governments and farmer organisations. • Monitoring outreach and impact.	**For smallholders:** • Information/training meetings at district and community level • Demonstrations, using e.g. the "mother-baby" approach practiced by VBAs in other AGRA programmes, • Exchange visits. **For providers of FL-RS and institutional target groups:** • training seminars/workshops • exchange visits.
Materials	**For smallholder farmers:** • Training and capacity building (including advisory services) organized through the network of village-based advisors (VBAs), complemented by extension workers and NGOS (where necessary) • Educational materials • Demonstration materials • Training of trainers **For traders, processors, FL-RS manufacturers and suppliers/ importers/ agrodealers** • Printed and online materials • Trainings and seminars	

To ensure the most effective introduction of the physical FL-RS, RE-GAIN programme envisions the launch of capacity building and awareness raising activities already in the first year of its implementation. This will create the awareness about the project across country and the target stakeholders and ensure that smallholder farmers are aware and capable of utilizing the provided physical FL-RS in the most effective and suitable way.

Development of education materials will be implemented by AGRA national teams involved in the project, based on the most crucial topics identified for Kenya, and considering those shortlisted FL-RS identified as priority.

Training of trainers for farmers, and trainings and seminars for the traders, processors, FL-RS manufacturers and agrodealers will be conducted in two stages: curriculum development by AGRA staff and actual training sessions delivered by AGRA in collaboration with the VBAs.

Effective financial mechanisms are essential for enhancing access to food loss reduction solutions in all seven countries. They are of particular importance for smallholder farmers, struggling with the lack of financial resources and barriers to access finance, that are needed for investment into the improved postharvest management technologies and tools. Delivery of the physical FL-RS through the selected financial mechanisms to farmers and other target stakeholders will be implemented starting from the 2nd year of the Programme.

Monitoring of the outreach, effect and impact of the awareness raising, and the training and capacity building and adaptation of FL-RS is essential to document project progress, but also as management information to adjust the project activities to achieve the desired effect and impact. The monitoring should specifically identify possible barriers that smallholders and other stakeholders might experience, to timely identify project constraints and to make adjustments for overcoming these barriers. Another aspect will be the monitoring of the technical aspects of quality and impact of the demonstrations including the cost effectiveness. The outreach of local awareness activities and local capacity building will help to create a network for information feedback from project stakeholders that can be used for monitoring purposes. The described activities will be aligned with the country stakeholder engagement plans, and the general monitoring and evaluation (M&E) of RE-GAIN programme

5.2.2 Wholegrain processing

Besides the capacity building and awareness raising on those key FL-RS, it is also important to consider **additional measures to prevent postharvest losses, such as for example value added (whole grain) processing.** Wholegrain processing offers substantial benefits in mitigating food losses, which is a critical concern in contemporary food systems in RE-GAIN's target countries. Wholegrains, encompassing the bran, germ, and endosperm, retain more nutrients compared to refined grains, which undergo significant nutrient removal during processing.

Wholegrain processing optimizes the use of the entire grain, ensuring that fewer resources are wasted during milling and production. This comprehensive utilization aligns with sustainable food production practices, reducing the environmental impact associated with food loss and waste. Wholegrain processing is applicable to key staple crops such as maize, wheat, and rice. The integration of wholegrain processing in food systems also promotes health benefits due to the higher fibre content and essential nutrients retained, which can improve public health outcomes and reduce healthcare-related food wastage.

Raising awareness about the benefits of wholegrain processing will be an important part of the Component 1 of the RE-GAIN programme in Kenya, as it belongs to both adaptation of existing food loss technologies to climate change, and awareness raising activities of the Programme. It will respond to the existing barriers to the increased adoption of wholegrain processing, such as urbanization and related low availability of wholegrain processing, shorter shelf life of wholegrain products, and consumer preferences for processed white flour as a prestige, premium product. Raising awareness about the benefits of wholegrain processing will assist in changing consumers' mindset about wholegrain flour towards their better understanding of the nutritional values of wholegrain products and its importance in ensuring food security in Kenya.

5.2.3 Physical solutions

In addition to capacity building and awareness raising activities, a package of physical FL-RS is envisaged for each RE-GAIN target country. **During the initial stage of consultations with the AGRA programme development team, several criteria were identified for pre-selecting FL-RS for each target country.** The primary focus was to identify context-specific technologies and practices that exhibit the highest potential to mitigate food losses caused by climate change-driven hazards. This process targeted the seven focus countries and concentrated on the key crops and value chain stages where losses are most prevalent.

The FL-RS shortlisting evaluation criteria included:

a) Unit cost and cost-effectiveness and of the solution.

b) Target audience, distinguishing between agricultural cooperatives and individual farmers.

c) Accessibility of the solution, including available supply, location of target farmers and suppliers.

d) Estimated reduction in food losses/ Positive impact of the FL-RS.

e) Possibility of using the solution for different crops, and

f) Technical and implementation feasibility, and existing bottlenecks/barriers.

The general FL-RS evaluation matrix is presented in Figure 5-5 below.

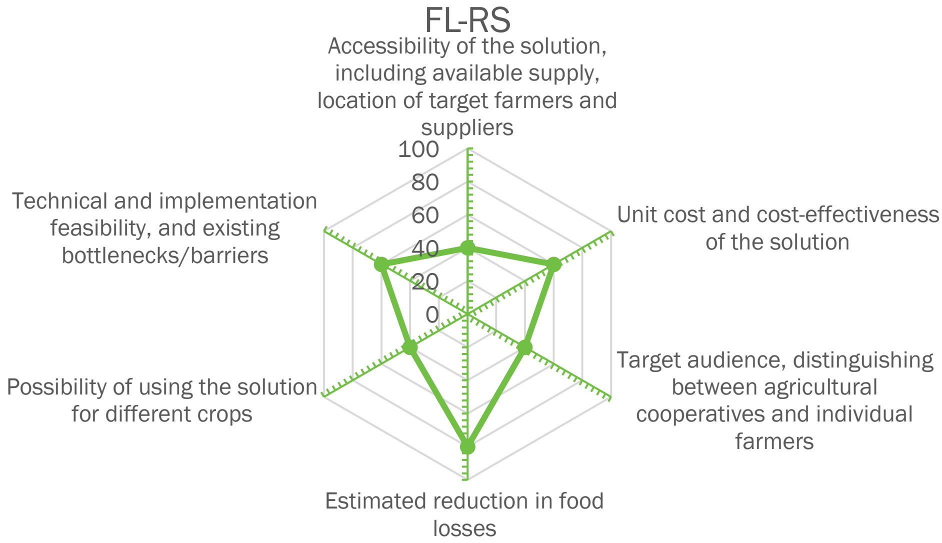


Figure 5-5 - FL-RS evaluation matrix

- Based on the results of the analysis provided in the previous sections for the baseline study, 10 key physical FL-RS were identified, including:
- Harvesting machinery (e.g., multi-crop harvesters)
- Mechanical multi-crop threshers and shellers
- Tarpaulins and plastic sheets
- Wooden and metal cribs
- Metal and plastic silos
- Hermetic and other plastic bags
- Moisture meters
- Storage structures (e.g., huts, baskets, grain sheds)
- Storage protectants and control agents (biological fumigants, insecticides and pesticides)
- Transport packaging (e.g., wooden crates and bags)

Postharvest food loss reduction volumes, together with the specific evaluation of each FL-RS and other critical points per each solution are provided below.

5.2.3.1 Harvesting machinery

Integration of harvesting machinery (including multi-crop harvesters) into the harvesting processes has demonstrably reduced food losses during the harvest period. Empirical studies indicate that the efficiency of mechanical harvesters, such as combine harvesters, leads to substantial conservation of crops that would otherwise be lost through traditional manual harvesting techniques (Hasan, 2020). For instance, mechanized rice harvesters have been shown to reduce grain loss from the typical 10-15% observed in manual harvesting to as low as 2-5% (Muhammad Yasin, 2019). Similarly, the use of corn harvesters optimizes the timing and condition of harvest, enhancing yields by 20-30% compared to manual methods (Mutungi, 2023).

Mechanized harvesting systems have also proven effective in reducing losses in various other crops, such as wheat and beans. For example, wheat harvesters can decrease losses by ensuring precision in cutting, threshing, and cleaning, thus saving between 5-10% of the total harvest (Aparna Kumari, 2023). Multi-crop harvesters, which are adaptable for various crops, have significantly reduced grain losses by efficiently managing multiple hectares per day with minimal resources (Mathanker, 2014). These machines not only improve the quantity of harvest saved but also enhance the quality, resulting in higher market value and profitability for farmers.

The evaluation of harvesting machinery is provided in Figure 5-6.

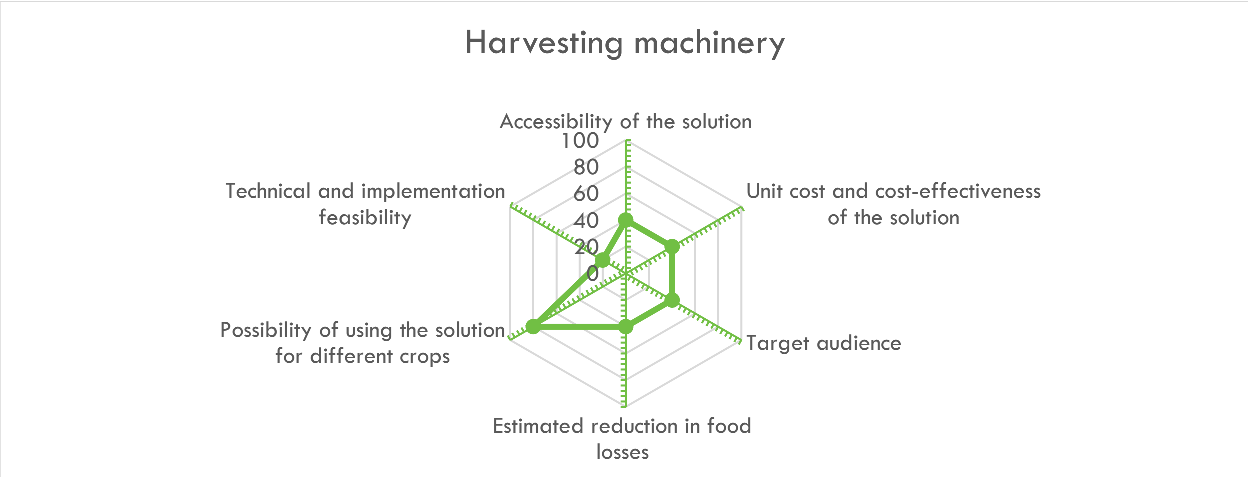


Figure 5-6 - FL-RS evaluation for harvesting machinery

5.2.3.2 Mechanical multi-crop threshers and shellers

Proper utilization of mechanical multi-crop threshers and shellers has the potential to significantly enhance the efficiency and effectiveness of post-harvest processing, leading to substantial savings in the harvest (Amponsah, 2017). The exact amount of harvest saved varies based on factors such as the type of crop, the machine's efficiency, and the traditional methods being replaced. However, in comparison to traditional manual methods that often result in higher losses due to incomplete threshing, spillage, and grain breakage, proper and timely threshing of crops such as maize and soybeans using mechanical devices can reduce these losses significantly, typically by 10-20% (Amponsah, 2017) and up to 25-30% (FarmBiz Africa, 2020). Besides that, using more environmentally friendly machinery, such as solar-powered portable threshers and shellers is beneficial for farmers from two points: they reduce air pollution, and allow farmers to save money, as solar-powered machinery does not require fuel, that is costly in many cases.

Additional benefits of mechanical threshers and shellers include their ability to process larger volumes of crops in a shorter time compared to manual methods, aiding in timely processing and reducing the risk of losses due to delays such as weather damage or pest infestations. Besides that, machines generally handle crops more gently and uniformly, resulting in fewer damaged grains, which can enhance the market value of the produce. There are also significant labour and related financial savings associated with mechanical threshers and shellers (Getachew, 2022). The reduced need for manual labour is particularly beneficial during peak harvest times when labour shortages are common, leading to cost savings and ensuring timely processing of the harvest.

Across Sub-Saharan Africa, the Soybean Innovation Lab (SIL) developed multi-crop threshers that have shown remarkable results, reducing post-harvest losses to less than 2% compared to up to 30% with traditional methods (Soybean Innovation Lab, 2016). SIL threshers can process crops up to 80% faster than manual methods, requiring only two operators, thus saving time and reducing labour costs significantly (Soybean Innovation Lab, 2016).

Despite the benefits of the multi-crop threshers and shellers, there are also challenges to consider (Trans-Sec, 2013). The initial investment in mechanical threshers and shellers can be high for smallholder farmers (Getachew, 2022), though the long-term benefits of reduced losses and increased efficiency often outweigh these costs. Proper training for operators and regular maintenance are crucial to ensure the optimal performance of these machines (Getachew, 2022). Without technical know-how, there is a risk of underutilization or breakdowns, which can negate the potential benefits.

The evaluation of mechanical multi-crop threshers and shellers is provided in Figure 5-7.

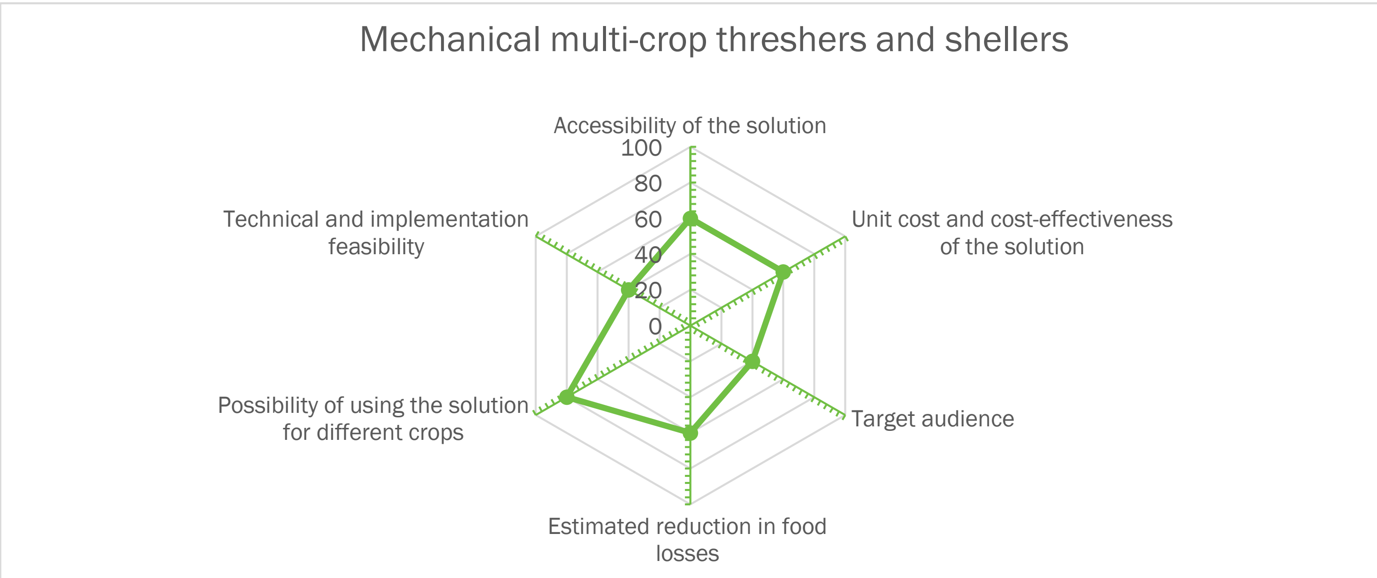


Figure 5-7 - FL-RS evaluation for mechanical multi-crop threshers and shellers

5.2.3.3 Tarpaulins and plastic sheets

Effectiveness and efficiency of using **tarpaulins and plastic sheets** for drying harvested crops such as maize and beans varies depending on the type of crop, local climate conditions, and pre-existing postharvest practices. For instance, in the case of grains and cereals such as rice, maize, and wheat, traditional drying methods often result in postharvest losses ranging from 10% to 30%, primarily due to spillage, spoilage, and contamination. However, the use of tarpaulins and plastic sheets can reduce these losses to between 5% and 10% by providing a clean, controlled drying environment (Hodges, 2011). Legumes and pulses, such as beans and lentils, which traditionally experience losses of 15% to 35%, can see a reduction to 5% to 15% when using improved drying methods with tarpaulins and plastic sheets (Grolleaud, 2002). This is primarily due to better protection from environmental factors and pests.

Various case studies highlight the effectiveness of tarpaulins and plastic sheets for drying. A study from Kenya demonstrated that using plastic sheets for maize drying reduced postharvest losses from 20% to less than 5% (Affognon, 2015). In Nigeria, improved drying methods for cowpeas resulted in a reduction of losses from 25% to around 10% (Opara, 2013).

The benefits of using tarpaulins and plastic sheets for drying are manifold. These materials provide enhanced protection by shielding crops from rain, pests, and soil contamination, thereby ensuring cleaner drying conditions (Kitinoja L. S., 2011). They also improve drying efficiency by enabling faster and more uniform drying, which reduces the risk of mould and spoilage (FAO, 2010). Additionally, tarpaulins and plastic sheets are relatively inexpensive and accessible, making them particularly beneficial for smallholder farmers (Affognon, 2015). The use of these drying methods often results in higher quality produce, which can command better market prices (Kader, 2005).

The evaluation of tarpaulins and plastic sheets is provided in Figure 5-8.

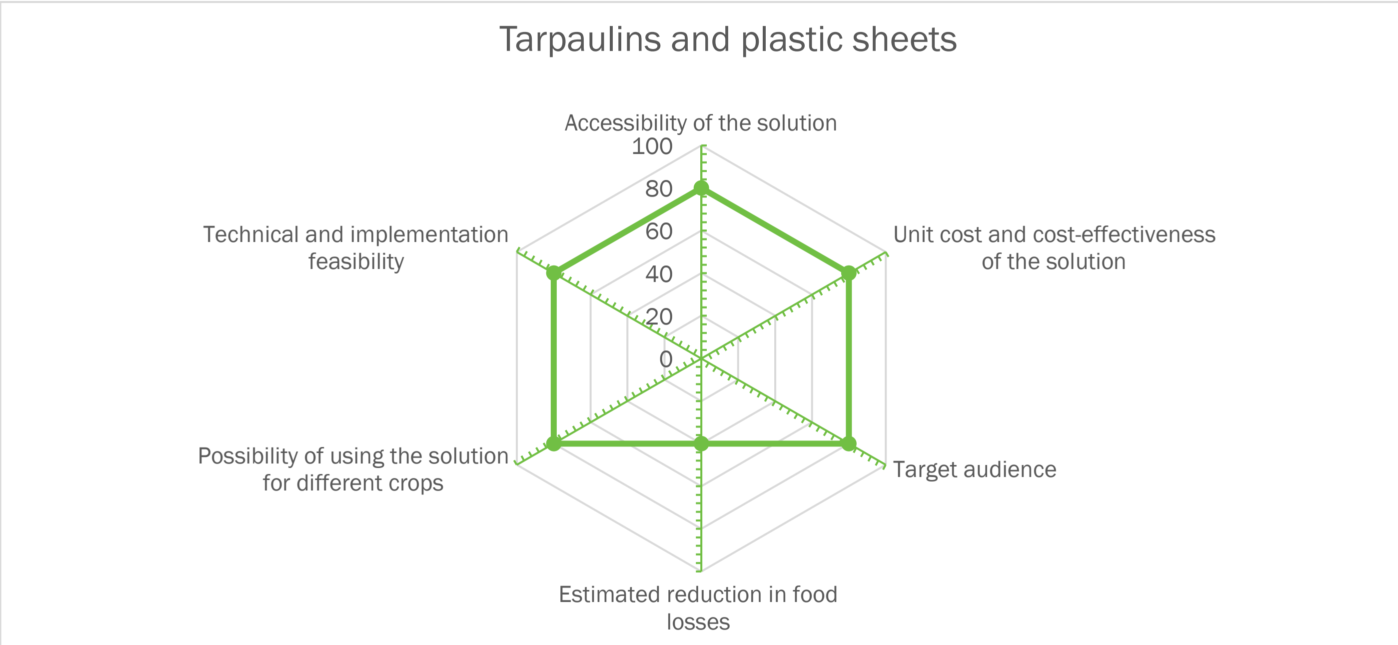


Figure 5-8 - FL-RS evaluation for tarpaulins and plastic sheets

5.2.3.4 Wooden and metal cribs

Appropriate use of wooden and metal cribs for on-farm storage of harvested crop offers can decrease postharvest losses by 30-50%, providing substantial benefits to smallholder farmers in developing regions prone to high losses due to pests, moisture, and physical damage (Julius, 2021). The effectiveness of these storage methods varies with crop type, with cereals like maize and rice benefiting notably (FAO, 2011). In humid regions, the loss reduction efficacy of cribs may be less unless supplemented with additional drying mechanisms. Maintenance is crucial to sustain the cribs' effectiveness over time.

Wooden cribs achieve this loss reduction by enhancing air circulation, aiding in drying and reducing moisture, which curtails fungal and bacterial proliferation. These cribs also offer protection from rodents and insects, and minimize physical damage, potentially reducing postharvest losses by 30-40%, particularly in grains like maize (FAO, 2011). Conversely, metal cribs are noted for their durability and superior sealing against pests and environmental elements such as rain and humidity. Despite potential heat conduction issues in hot climates, which can be alleviated through proper design, metal cribs can reduce losses by 40-50%, especially in regions with significant pest and weather challenges (Tadele Tefera, 2011).

The evaluation of wooden and metal cribs is provided in Figure 5-9.

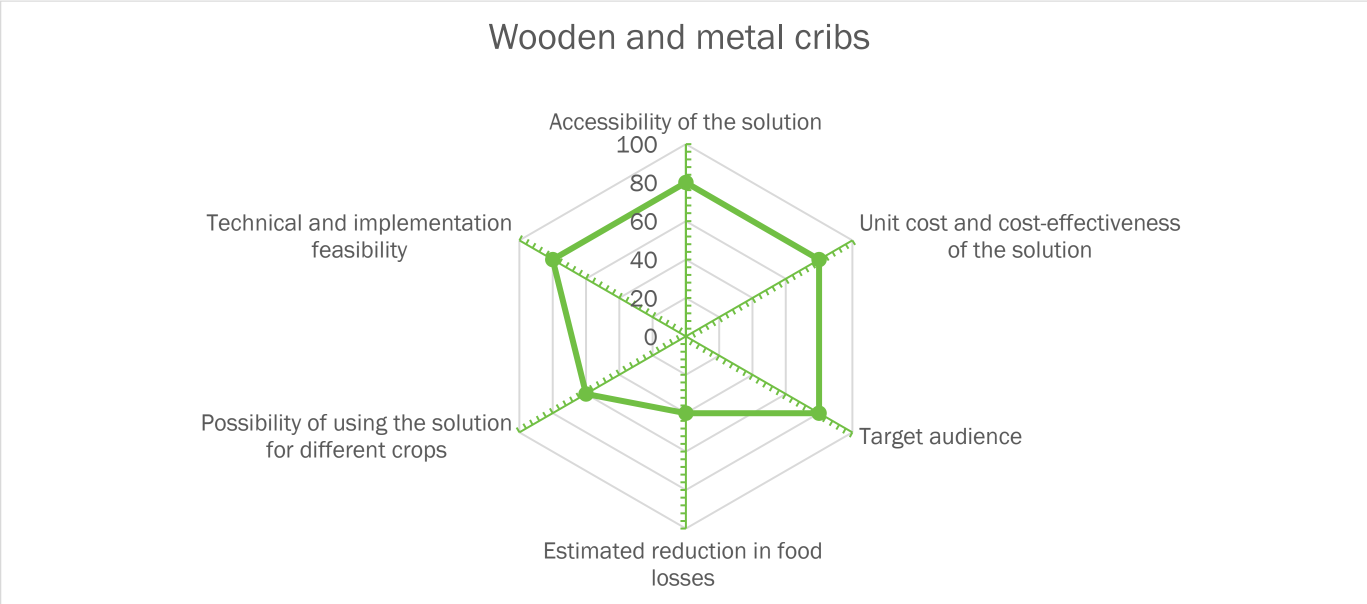


Figure 5-9 - FL-RS evaluation for wooden and metal cribs

5.2.3.5 Metal and plastic silos

The use of metal and plastic silos for grain storage has long been identified as an effective solution to mitigate postharvest food losses, particularly in Africa, as silos offer a hermetically sealed environment, protecting the grains from pests, moisture, and other spoilage factors that are prevalent in traditional storage methods such as bags or earthen pits.

Metal silos, typically made from galvanized steel, provide robust protection against rodents and insects, which are common causes of postharvest losses. Studies have shown that grain stored in metal silos can have losses reduced to less than 1-2% compared to traditional methods which often exceed 10-15% (Njoroge, 2019). This significant reduction in losses translates to increased food security and economic benefits for farmers, who can store their produce for longer periods without quality degradation.

Plastic silos, while not as durable as their metal counterparts, offer a cost-effective alternative that still provides substantial benefits. These silos are typically made from high-density polyethylene (HDPE) and can be locally manufactured, reducing costs and making them accessible to smallholder farmers. In Kenya, the introduction of plastic silos has proven its ability to reduce postharvest losses in small-scale maize farming by up to 50% compared to traditional storage methods (De Groote H. K., 2013). The lightweight nature of plastic silos also makes them easier to transport and install, facilitating their adoption in remote areas.

The economic implications of using these improved storage technologies are profound. Case studies have shown that the adoption of metal silos by smallholder farmers can lead to an average increase in annual household income by approximately 20% (Gitonga, 2015). This increase is attributed not only to the reduction in postharvest losses but also to the ability to sell stored grain when market prices are higher, thereby optimizing income. While the initial investment in metal and plastic silos can be a barrier for some farmers, the long-term benefits in loss reduction and economic gains make them a worthwhile investment (Kuyu, 2022). Moreover, the use of silos contributes to environmental sustainability by reducing the need for chemical preservatives, which are often used in traditional storage methods to combat pests and mould (Kuyu, 2022). The hermetic nature of both metal and plastic silos eliminates the need for such chemicals, thereby promoting safer food practices and reducing environmental contamination.

The evaluation of metal and plastic silos is provided in Figure 5-10.

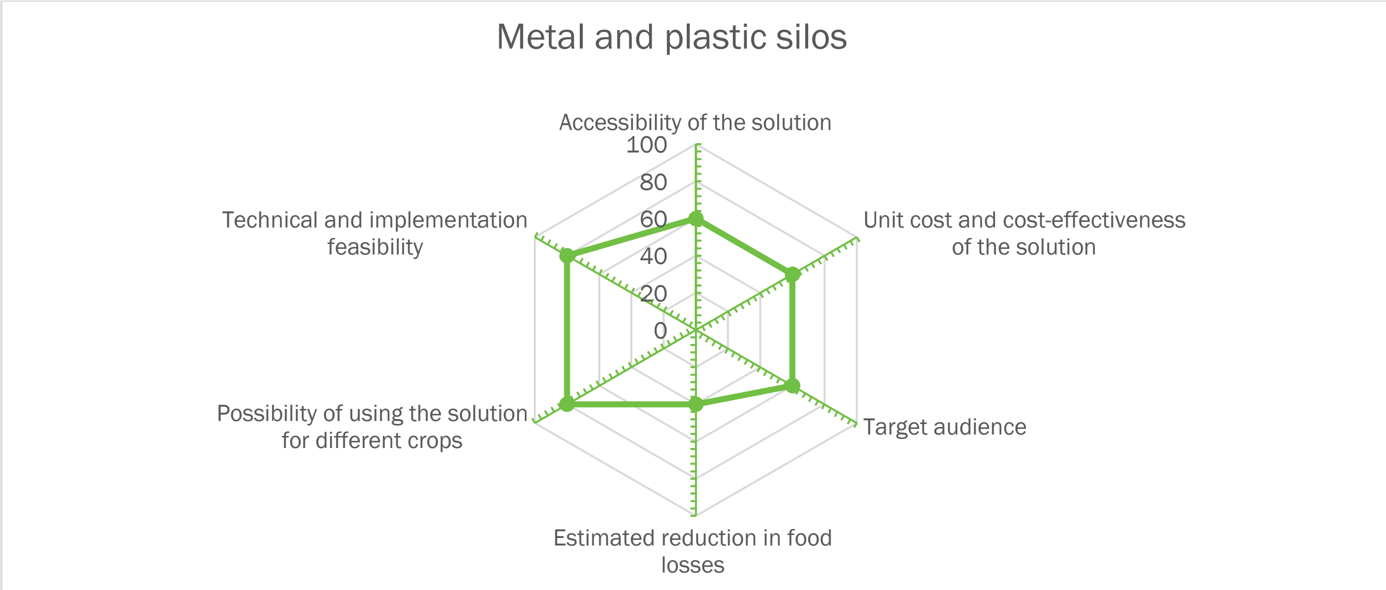


Figure 5-10 - FL-RS evaluation for metal and plastic silos

5.2.3.6 Hermetic bags

Hermetic storage technologies, such as Purdue Improved Crop Storage (PICS) bags and other plastic bags, have shown great promise in mitigating postharvest food losses across various African countries (Williams, 2017). Hermetic storage involves airtight conditions that prevent the entry of oxygen, thereby inhibiting the growth of aerobic organisms like fungi and insects. This method has proven particularly effective for staple crops such as maize, cowpeas, and rice, which are prone to significant postharvest losses (Baributsa, 2020). The benefits of hermetic bag storage extend beyond mere loss reduction; they include improved food security, enhanced grain quality, and increased incomes for farmers (Williams, 2017).

For instance, research conducted by the Purdue Improved Crop Storage project found that PICS bags could reduce grain losses by up to 20% compared to traditional storage methods such as polypropylene bags or open-air storage. Specifically, in a study conducted across multiple countries in Africa, it was observed that the use of PICS bags reduced cowpea storage losses to less than 1%, compared to losses of 20-30% in traditional storage methods (De Groote H. K., 2012).

In Kenya (Koskei, 2020), introduction of PICS bags led to a substantial reduction in maize postharvest losses. In the Rift Valley region, farmers who adopted PICS bags reported a decrease in losses from an average of 25% to below 5% over a six-month storage period (Koskei, 2020). This reduction is significant, considering that maize is a critical staple crop for both consumption and income generation in Kenya. The economic impact of reduced postharvest losses is profound, as it translates to increased food availability and reduced financial losses for farmers (Koskei, 2020).

Despite the initial cost of hermetic bags being higher than traditional storage methods, the long-term economic and food security benefits make them a viable and beneficial investment (Baributsa, 2020). Scaling up the use of hermetic storage solutions could significantly impact the fight against food insecurity in Sub-Saharan Africa, making it a key strategy in postharvest loss reduction efforts. As hermetic storage tools are made of plastics, within the scope of RE-GAIN programme we are looking primarily into the solutions made of recycled plastics. It is also important to consider the existing reuse and recycling approaches used in the target regions and encourage increased collection and recycling of the solutions previously being in use.

The evaluation of hermetic storage bags is provided in Figure 5-11.

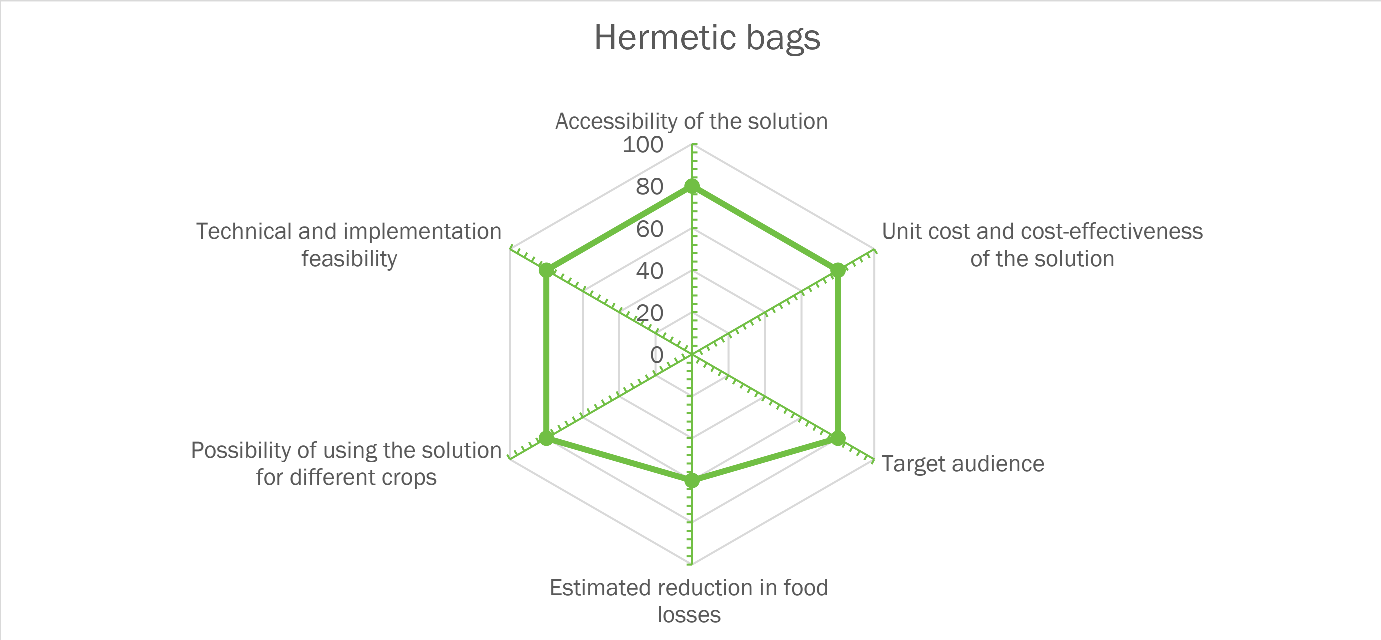


Figure 5-11 - FL-RS evaluation for hermetic bags

5.2.3.7 Moisture meters

Moisture meters over the recent years have emerged as a crucial technology in mitigating postharvest food losses in many African countries, helping to avoid up to 25%of postharvest food losses, and offering a practical solution to preserving the quality and quantity of harvested crops (Hossain, 2016). By accurately measuring the moisture content in grains and other produce, farmers can make informed decisions about the timing and conditions of storage, thereby preventing spoilage and degradation. Through minimizing the risks associated with improper storage, moisture meters help ensure that a greater proportion of the harvested produce reaches consumers in optimal condition, supporting the livelihoods of farmers and contributing to the stability of the food supply chain (Hossain, 2016). Studies show that Kenya has already successfully integrated moisture meters into postharvest management practices for grains, particularly maize, resulting in improved storage and reduced losses (Koskei, 2020).

The evaluation of moisture meters is provided in Figure 5-12.

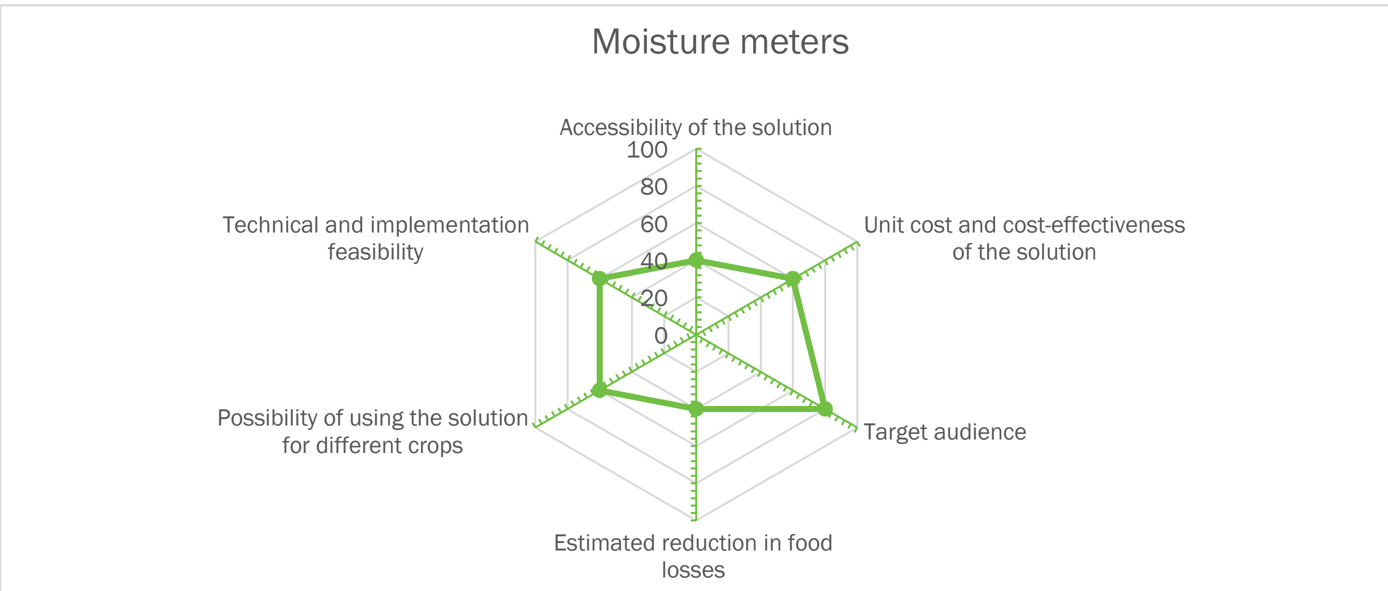


Figure 5-12 - FL-RS evaluation for moisture meters

5.2.3.8 Storage structures

Storage structures (e.g., huts, baskets, grain sheds) when designed and utilized correctly, offer practical and effective solutions to the pervasive problem of postharvest losses in Africa (World Bank, 2011). They provide controlled environments that protect crops from various biotic and abiotic factors that contribute to deterioration. Grain sheds have proven their effectiveness in Africa, by reducing losses from 20% to as low as 5%, achieved through better control of storage environment conditions, such as temperature and humidity (Befikadu, 2014). Moreover, grain sheds facilitate the aggregation of produce, making it easier for farmers to manage and monitor their stored crops, further enhancing loss prevention.

Huts, traditionally used in many African communities, can also be optimized to improve storage outcomes. In regions like West Africa, modifications to traditional storage huts have included elevating the structures to prevent rodent access and incorporating materials like mud plaster or cement to deter insects (FAO, 2014). In Ghana, such improvements in storage huts have led to a reduction in postharvest losses from an estimated 15% to 7%. These huts, when properly maintained, provide a cost-effective and culturally acceptable solution for smallholder farmers to safeguard their harvests (Ansah, 2018).

The evaluation of storage structure is provided in Figure 5-13.

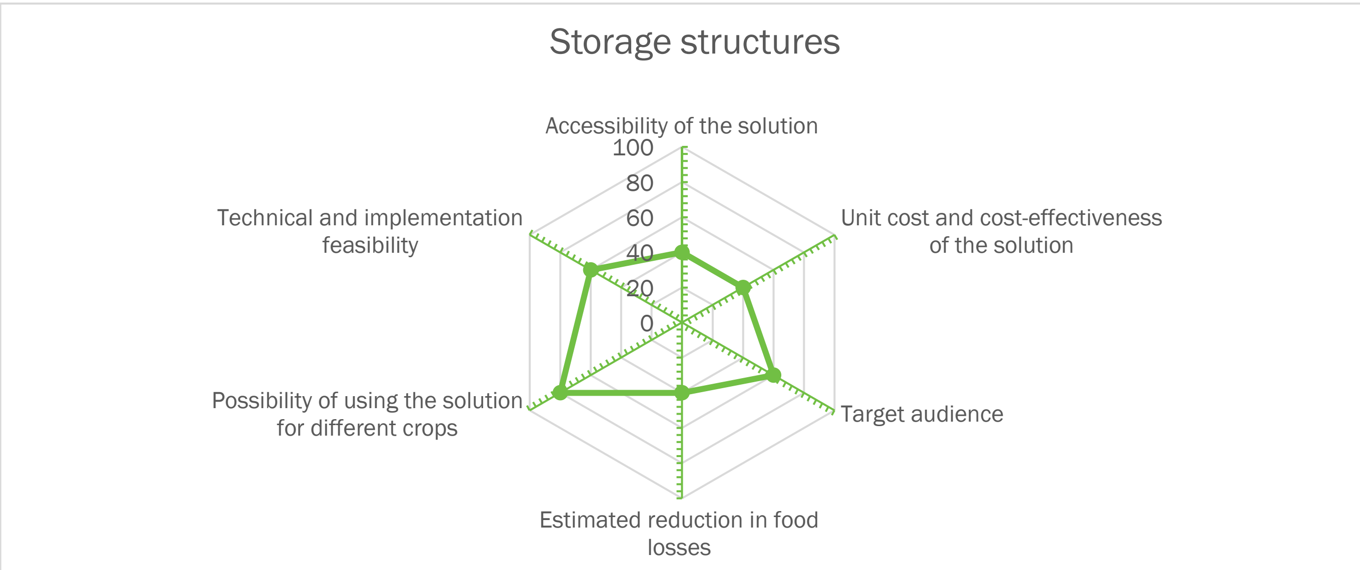


Figure 5-13 - FL-RS evaluation for storage structures

5.2.3.9 Storage protectants and control agents

Storage protectants and control agents (such as fumigants, insecticides and pesticides) are very common and popular solutions for food loss reductions and are widely used by smallholder farmers in Africa due to their affordability and availability (Nukenine, 2010). Insecticides, when judiciously applied, can help to prevent pest damage. For example, a study in Kenya demonstrated that the application of synthetic pyrethroids reduced maize weevil infestation by 35%, consequently lowering postharvest losses by approximately 30% (Tefera T. M., 2011). Pesticides, though controversial due to potential health and environmental impacts, have shown effectiveness in maintaining grain quality (Nukenine, 2010). Research conducted in Ethiopia indicated that the proper use of phosphine fumigation decreased losses in stored wheat by over 40% (Negussie, 2012). As an organic alternative, biological fumigants, including products like Bacillus thuringiensis and diatomaceous earth, provide an eco-friendly approach to pest control, reducing losses by up to 25% in some studies. Plus there remains a considerable need to raise awareness regarding the proper use (dosage and application of chemical protectants) across the countries. Additionally, there is a need to develop the supply of biological protectants and control agents in the markets.

The application of these protectants not only preserves the quantity but also the quality of stored produce, ensuring that grains remain fit for consumption and marketable. This has a direct economic benefit for smallholder farmers, who constitute a significant portion of the agricultural sector in Africa (Obeng-Ofori, 2015). For instance, integration of chemical treatments with improved storage facilities, such as hermetic bags, can lead to a reported reduction in maize postharvest losses by up to 50% (Abass, 2014). However, it is essential to balance the use of chemical protectants with environmental sustainability and health safety considerations, advocating for integrated pest management approaches that combine chemical and non-chemical methods to achieve optimal results. Therefore, within the scope of proposed FL-RS for the RE-GAIN project, our focus will be primarily on the organic/ natural protectants, as well as their combinations with other physical FL-RS.

The evaluation of storage protectants and control agents is provided in Figure 5-14.

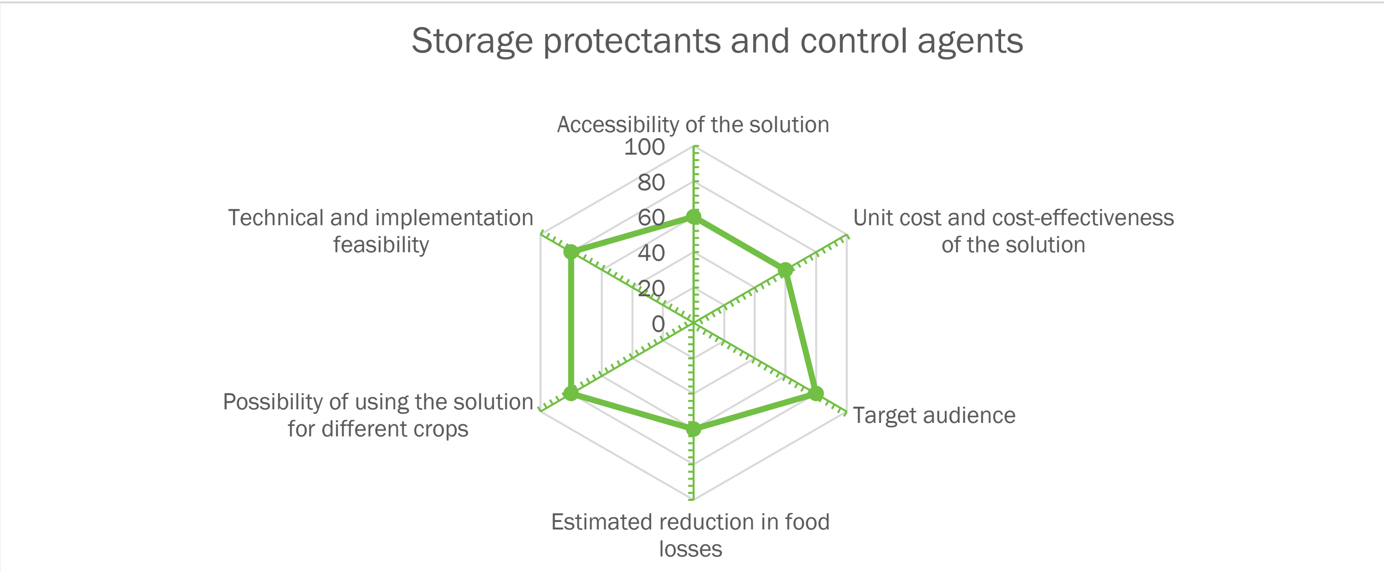


Figure 5-14 - FL-RS evaluation for storage protectants and control agents

5.2.3.10 Transport packaging

Proper transport packaging (e.g., wooden crates and bags) used for the crop's transportation from farm to the market or an aggregation centre, plays a crucial role in preserving the quality and quantity of produce (Kitinoja L. , 2016). It helps to reduce mechanical damage, spillage, contamination, and spoilage, that in some cases might be significant. For instance, research indicates that in Sub-Saharan Africa, postharvest losses can range between 30-50% of total agricultural output, primarily due to poor handling and inadequate packaging (Kitinoja L. S., 2011). Implementing better packaging solutions can reduce these losses by up to 15%, as evidenced by various case studies (Affognon, 2015). For example, use of improved packaging materials for transporting beans cut postharvest losses by nearly half, from 35% to 18% (Adejumo, 2007). But as identified by (AGRIFIN, 2020), farmers rarely have financial capacity and physical access to transport packaging of suitable quality.

The evaluation of transport packaging is provided in Figure 5-15.

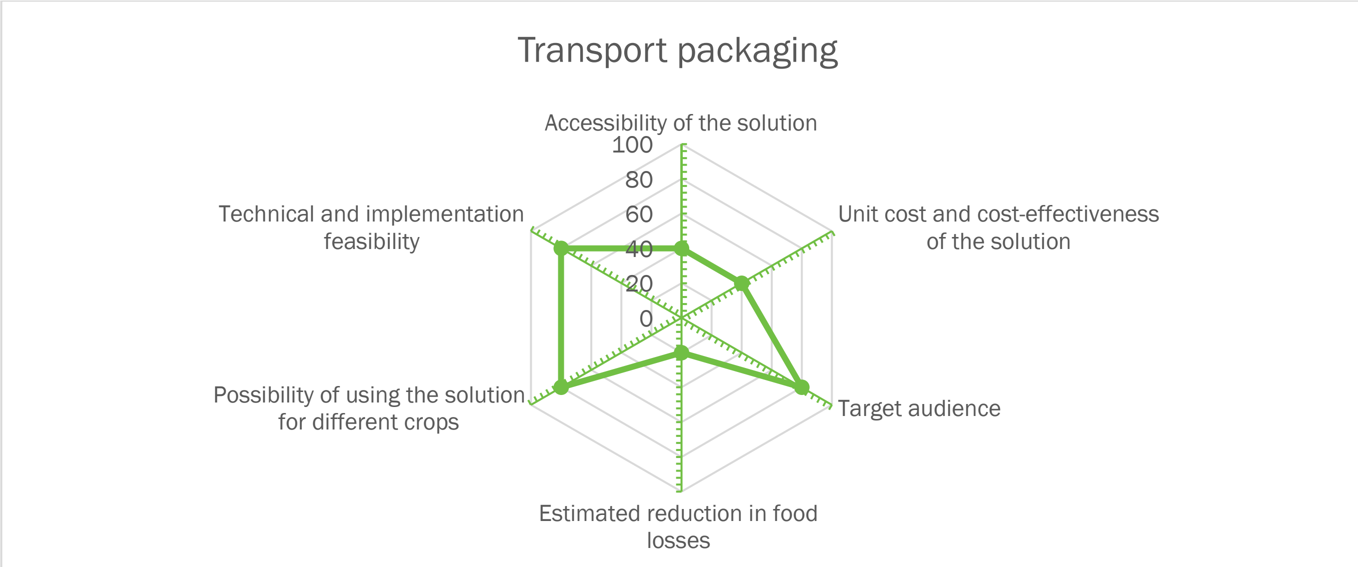


Figure 5-15 - FL-RS evaluation for transport packaging

Summary of the above-mentioned reduction in postharvest losses attributed to those 10 key physical FL-RS are presented in the Table 5-6.

Table 5-6 - Key physical FL-RS and their potential in reducing postharvest losses

Solutions	Estimated reduction in post-harvest losses, %
Harvesting machinery	10-15% *Sources:* (Hasan, 2020); (Mutungi, 2023); (Muhammad Yasin, 2019); (Aparna Kumari, 2023); (Mathanker, 2014)
Mechanical multi-crop threshers and shellers	10-30% *Sources:* (Amponsah, 2017); (FarmBiz Africa, 2020); (Getachew, 2022); (Soybean Innovation Lab, 2016)
Tarpaulins and plastic sheets	10-20% *Sources:* (Hodges, 2011); (Grolleaud, 2002); (Affognon, 2015); (Kitinoja L. S., 2011)
Wooden and metal cribs	30-50% *Sources:* (Julius, 2021); (FAO, 2011); (Tadele Tefera, 2011)
Metal and plastic silos	10-50% *Sources :* (Njoroge, 2019); (De Groote H. K., 2013)
Hermetic and other plastic bags	20-30% *Sources:* (Williams, 2017); (De Groote H. K., 2012); (Koskei, 2020)
Moisture meters	Up to 25% *Sources:* (Hossain, 2016); (Koskei, 2020)
Storage structures	Up to 15% *Sources:* (Befikadu, 2014); (FAO, 2014); (Ansah, 2018)
Storage protectants and control agents	30-40% *Sources:* (Tefera T. M., 2011); (Abass, 2014)
Transport packaging	10-15% *Sources:* (Affognon, 2015); (Adejumo, 2007)

5.3 DEFINITION OF FEASIBILITY AND PRIORITISATION CRITERIA FOR FL-RS

Based on the evaluation provided in the previous subchapter and the round of national and local stakeholder consultations, three key criteria were shortlisted for the selection of those FL-RS, namely:

- Solutions that respond to the identified climate risks in the value chains of beans and maize
- Solutions that can help with food loss reductions and have the potential to be scalable with smallholder farmers

- Solutions that are appropriate to the local context

5.3.1 Solutions that respond to the identified climate risks in the value chains of beans and maize

In terms of climate risks, both maize and beans are highly vulnerable and susceptible to increased moisture, caused by the rains and floods, as well as extremely hot days, as identified in Table 3-7. This vulnerability can lead to spoilage and aflatoxin development, emphasizing the importance of precise harvesting timing, meticulous threshing and shelling, and adequate drying and storage facilities.

An evaluation of the ten shortlisted flood resilience solutions (FL-RS) and their potential to mitigate the impacts of key climate hazards in the beans and maize value chains is presented in Table 5-7 and Table 5-8 below. This evaluation employs a scoring approach, with the following grades: very low mitigation/adaptation impact (1 point), low mitigation/adaptation impact (2 points), medium mitigation/adaptation impact (3 points), high mitigation/adaptation impact (4 points), and very high mitigation/adaptation impact (5 points). The scoring of each solution is derived from research results detailed in previous chapters and outcomes from stakeholder engagements.

Table 5-7 – Evaluation of the potential solutions in addressing key climate hazards in Kenya for maize value chain

Solutions	Climate hazards			Average rate
	Hot days over 35 °C	Heavy rains (days with rainfall > 20mm, large 1-day rains and large 5-day rains)	River and/or urban floods	
Harvesting machinery	4	2	2	2,67
Mechanical multi-crop threshers and shellers	4	4	4	4,00
Tarpaulins and plastic sheets	5	2	2	3,00
Wooden and metal cribs	3	2	2	2,33
Metal and plastic silos	4	5	4	4,33
Hermetic bags	4	4	4	4,00
Moisture meters	4	4	2	3,33
Storage structures	4	4	4	4,00
Storage protectants and control agents	4	2	2	2,67
Transport packaging	4	1	1	2,00

Table 5-8 - Evaluation of the potential solutions in addressing key climate hazards in Kenya for beans value chain

Solutions	Climate hazards			Average rate
	Hot days over 35 °C	Heavy rains (days with rainfall > 20mm, large 1-day rains and large 5-day rains)	River and/or urban floods	
Harvesting machinery	4	2	2	2,67
Mechanical multi-crop threshers and shellers	4	4	4	4,00
Tarpaulins and plastic sheets	5	2	2	3,00
Wooden and metal cribs	2	2	2	2,00
Metal and plastic silos	4	5	4	4,33
Hermetic bags	4	4	4	4,00
Moisture meters	3	3	2	2,67
Storage structures (e.g., huts, baskets, grain sheds)	4	4	4	4,00
Storage protectants and control agents	4	2	2	2,67
Transport packaging (e.g., wooden crates and bags)	3	1	1	1,67

Based on the Table 5-7 and Table 5-8, the FL-RS with the highest average scoring are the following, presented in the order of importance:

- Metal and plastic silos (4,33 points for both maize and beans)

- Hermetic bags (4,00 points for both maize and beans)
- Mechanical multi-crop threshers and shellers (4,00 points for both maize and beans)
- Storage structures (4,00 points for both maize and beans)
- Tarpaulins and plastic sheets (3,00 points for both maize and beans)
- Moisture meters (3.33 points for maize and 2,67 points for beans)
- Storage protectants and control agents (2,67 points for both maize and beans)
- Harvesting machinery (2,67 points for both maize and beans)

Baseline research findings, as detailed in subchapter 5.1 and confirmed by stakeholder engagements, have identified harvesting and subsequent threshing and shelling of beans and maize as critical loss factors. To mitigate these losses, there is a need for the widespread adoption of mechanical multi-crop threshers and shellers within rural communities. Such equipment can ensure proper threshing and shelling, reduce labour costs, and diminish both quantitative and qualitative physical crop losses.

Moreover, pest and rodent infestations represent another significant factor contributing to postharvest food losses in the maize and beans value chains. These infestations are primarily exacerbated by heat and inadequate storage facilities and techniques. Therefore, it is imperative to ensure the provision of durable, well-ventilated, and dry storage facilities. Effective storage solutions must encompass both on-farm storage and wholesale or communal storage options to safeguard the crops from such threats.

5.3.2 Solutions that can help with food loss reductions and have the potential to be scalable with smallholder farmers

In terms of solutions that would be accessible and scalable for the smallholder farmers, factors such as affordability, durability and availability of those FL-RS were considered. Average estimations of prices for all 10 types of FL-RS in Kenya are presented in the Table 5-9 below. For the evaluation, the scoring approach was employed, using the following grade: very high price (1 points), high price (2 points), moderate price (3 points), low price (4 points) and very low price (5 points).

Table 5-9 Estimation of the costs of the top 10 FL-RS

Solutions	Estimated cost of the solution in Kenyan shillings	Estimated cost of the solution in US dollars	Scoring
Harvesting machinery	250 000 – 900 000	2 000 – 7 000	1
Mechanical multi-crop threshers and shellers	15 000 – 70 000	120 - 550	2
Moisture meters	10 000 – 20 000	78 - 157	3
Metal and plastic silos	3 000 – 24 000	24 - 188	3
Wooden and metal cribs	Est. 3 000 – 10 000	24 - 78	3
Storage structures (e.g., huts, baskets, grain sheds)	Est. 3 000 – 10 000	24 - 78	3
Tarpaulins and plastic sheets	2 000 – 4 000	16 - 32	4
Transport packaging (e.g., wooden crates and bags)	Est. 250 – 2 500	2 - 20	4
Storage protectants and control agents	Est. 250 – 2 000	2 - 16	4
Hermetic bags	250 - 540	2 - 4	5

Source: (Jiji Kenya, 2024) (Kenya Agri, 2024)

Smallholder farmers generally require low-technology, familiar solutions that are relatively easy to acquire and maintain. Additionally, it is crucial to ensure that farmers possess the specific knowledge and capacity to utilize these solutions effectively. This will be supported by capacity-building and awareness-raising activities under Component 1 of the RE-GAIN Programme.

5.3.3 Solutions that are appropriate to the local context

In selecting solutions appropriate to the local context, it is critical to balance the climate challenges in the target regions with the awareness and utilization of these tools by smallholder farmers. The primary challenges for reducing postharvest losses in Kenya include the limited financial capacity of smallholder farmers to invest in mechanized high-tech solutions, coupled with restricted access to credit and bank loans. Additionally, there is a scarcity of quality low-technology solutions for harvesting, drying, and storing maize and beans coupled with insufficient knowledge regarding the optimal use of most food loss reduction solutions (FL-RS) available on the market.

In terms of key stages of postharvest losses identified for Kenya during the baseline assessments (Chapters 3 and 4), and first round of stakeholder engagement on national and local levels, major losses in both maize and beans value chains are observed on the harvesting, and post-harvest handling and storage stages.

During the first round of stakeholder consultations in Kenya (conducted in Nairobi, Embu and Kitui during May – June 2024), participants of local and national workshops shortlisted top three solutions, that would be relevant for both maize and bean production, as well as for building resilience against climate risks, and impact potential for smallholder farmers. The results of the shortlisting are provided in the Table 5-10.

Table 5-10 – Top three solutions for maize and beans production, resilience against climate risks, and impact potential for smallholder farmers in Kenya

Relevance for maize production	Relevance for bean production	Relevance to build resilience against climate risks	Impact potential for smallholder farmers
Tarpaulins and plastic sheets	Moisture meters	Hermetic bags	Tarpaulins and plastic sheets
Mechanical multi-crop threshers and shellers	Storage protectants and control agents	Storage structures	Hermetic bags
Hermetic bags	Storage structures	Mechanical multi-crop threshers and shellers	Storage protectants and control agents

For the final evaluation provided in the Table 5-11, 1 point was given for a single mention of the solution. Solutions that were not included, scored o points.

Other solutions proposed during the workshops included use of solar dryers, development of appropriate policies, establishment of village collection centres, implementation of stoves on the local level, promotion of alternative crops, and creation of favourable tax policies.

5.3.4 Final evaluation

Taking into consideration all the above-mentioned factors, and considering the major climate risks for Kenya specified in the previous chapters, the physical FL-RS for Kenya with the highest potential to reduce postharvest food losses is highlighted in Table 5-11 below:

Table 5-11 – Final evaluation of the shortlisted physical FL-RS in Kenya

Solutions	Climate risks		Costs of the solutions	Best solutions in the local context	Final score
	Maize	Beans			
Harvesting machinery	2,67	2.67	1	0	6.33
Mechanical multi-crop threshers and shellers	4,00	4.00	2	2	12.00
Tarpaulins and plastic sheets	3,00	3.00	3	2	11.00
Wooden and metal cribs	2,33	2.00	3	0	7.33
Metal and plastic silos	4,33	4.33	3	0	11.67
Hermetic bags	4,00	4.00	3	3	14.00
Moisture meters	3,33	2.67	4	1	11.00
Storage structures (e.g., huts, baskets, grain sheds)	4.00	4.00	4	1	13.00
Storage protectants and control agents	2.67	2.67	4	2	11.33

Transport packaging (e.g., wooden crates and bags)	2.00	1.67	5	0	8.67

Detailed evaluation of their advantages, disadvantages, and existing barriers to the implementation of those shortlisted FL-RS within the Re-GAIN Programme is provided in the next subchapter.

5.4 IN-DEPTH EVALUATION AND PRIORITISATION OF SHORT-LISTED FL-RS

Based on the results of stakeholder engagements in Kenya, each out of shortlisted physical solutions were evaluated, including key strategic points such as the advantages and disadvantages of each solution, and key barriers for their use particularly in the context of smallholder farmers. The results of the evaluation are provided in the Table 5-12.

Table 5-12 – Results of the shortlisted FL-RS evaluation in Kenya

Solution	Strategic advantages of the solution	Key disadvantages of the solution	key barriers to solution implementation	Additional points based on the baseline research results and discussions with stakeholders
Mechanical multi-crop threshers and shellers	Mechanical multi-crop threshers and shellers are effective tools that significantly reduce labor costs and processing times, enhancing value addition and minimizing post-harvest losses. These machines can be locally fabricated, making them accessible for a range of farmers, from small to large scale.	The high cost of these machines and their maintenance poses a significant barrier to adoption. They are also heavily reliant on fossil fuels, leading to high carbon emissions and increased operational costs. Additionally, these machines can cause increased grain breakage and contamination risks, reducing the overall quality of the harvest.	The barriers include prohibitive costs, limited accessibility and availability, high fuel costs, and technical challenges in both acquisition and use.	Mechanical multi-crop threshers and shellers are generally referred to as expensive machinery, not available for common farmers. They require technical training and capacity building on their operation and maintenance. They are generally procured and operated by communities and youth groups and rented out to stallholder farmers for the harvesting period.
Tarpaulins and plastic sheets	Tarpaulins and plastic sheets are widely regarded as accessible, affordable, and practical solutions for post-harvest handling and storage. They are easy to use, waterproof, flexible, and durable, offering multiple uses at a reasonable cost. They are particularly effective for drying grains and preventing crop contamination with stones and sand.	Their use is limited by their susceptibility to damage and contamination, especially during humid or rainy seasons. They require substantial space and are exposed to weather patterns and pests, which can affect their durability and effectiveness.	Barriers to their widespread adoption include potential unavailability or affordability issues for some smallholders and the variable quality and limited durability of the materials, which can compromise their reliability.	Tarpaulins are widely utilized in Kenya; however, their common usage involves drying grains and other crops directly along roadsides, leaving them vulnerable to animal foraging and contamination. Recently, the price of tarpaulins has surged by up to 70%, presenting a substantial barrier for smallholder farmers. Addressing this issue requires capacity-building and awareness-raising activities, ensuring smallholder farmers maximize benefits and minimize risks, to complement the distribution of tarpaulins.
Metal and plastic silos	Maintain grain quality, easy pest control, durable, and effective against pests. They are particularly useful during rainy seasons and can store grains efficiently	Expensive, limited availability, and challenging aeration of grains. They are static and often unaffordable for smallholder farmers	High costs, limited awareness, and logistical challenges in transportation and provision.	Long-lasting and effective for pest control, maintaining grain quality. They are durable and easy to use, but require awareness and knowledge among farmers on the proper usage
Hermetic bags	Hermetic bags offer an effective, portable, and durable solution for grain storage, prolonging shelf life and maintaining produce quality with minimal pesticide use. These	Their relatively high cost and occasional limited availability can be prohibitive for smallholder farmers. Additionally, if the grain stored in these bags is not properly dried, there	Barriers to their use include affordability, limited availability, durability issues, and the environmental	Hermetic bags are widely recognized in Kenya. However, their increased adoption is hindered by the availability of low-quality bags marketed as high-quality hermetic bags. Additionally, farmers often lack the necessary knowledge about the quality and proper maintenance of

Solution	Strategic advantages of the solution	Key disadvantages of the solution	key barriers to solution implementation	Additional points based on the baseline research results and discussions with stakeholders
	bags are adaptable for different crops, including rice and cowpeas, and are affordable and widely available.	is a risk of aflatoxin contamination. Environmental concerns also arise from the use of non-biodegradable plastics.	impact of plastic waste if not properly managed.	these bags. Consequently, they may become disillusioned with the expected food loss reductions and revert to traditional storage methods. While smallholder farmers and individual households purchase hermetic bags for on-farm use, the substantial number of bags required per household imposes financial strain on these stakeholders.
Moisture meters	Moisture meters are essential tools for post-harvest handling, providing accurate and efficient measurements of grain moisture content. These devices help farmers ensure proper storage conditions, thereby reducing the risk of aflatoxin development. They are effective, portable, and relatively affordable.	However, their cost can be prohibitive for small-scale farmers, and they require technical skills for proper operation and maintenance.	Barriers include high initial procurement costs, limited availability, and a lack of knowledge about their usage and management.	Moisture meters, besides the relatively high costs, require also technical knowledge about their proper use, therefore making them less favored by the farmers in Kenya. Their increased adoption therefore depends first and foremost on the improved knowledge about their use.
Storage structures	Storage structures like huts, baskets, and grain sheds are cost-effective solutions for storing large quantities of crops, particularly for small-scale farmers, SMEs, and cooperatives. They are locally available and easy to construct, making them accessible for many farmers.	These structures are prone to contamination, weather impacts, and are not durable. They are susceptible to rodent and flood damage, which can lead to significant losses.	Barriers include high initial costs, lack of quality materials, accessibility issues, and security concerns that can affect the overall effectiveness and sustainability of these storage solutions.	The majority of consulted stakeholders have expressed a strong interest in community or government-owned storage facilities situated near their communities. These facilities would enable farmers to store their crops for several months, to sell them during periods of increased prices for specific crops. This interest highlights a demand for accessible, secure storage solutions that can help farmers maximize their profits by timing the market effectively.
Storage protectants and control agents	Storage protectants and control agents are portable, effective, and scalable solutions for reducing pest damage during storage. They are affordable, easy to use, and help prolong the storage period for cereals.	These chemical products pose significant health hazards due to exposure risks and can contribute to environmental pollution.	Barriers include high costs, the need for proper knowledge and safety measures, and concerns about the safety of pesticide residues on stored produce.	In Kenya, awareness of the health risks posed by chemical pesticides and other storage protectants is high. Consequently, stakeholders have expressed a growing interest in transitioning to organic, natural high-quality protectants. Two primary strategies for increasing the adoption of storage protectants have been identified, including raising awareness/ capacity building about the correct application of chemical protectants, and diversifying the market to include natural and organic solutions. These strategies aim to promote safer, more sustainable practices among smallholder farmers and other stakeholders.

These assessments facilitated the development of a shortlist of seven relevant physical FL-RS solutions that could be tailored to meet specific country needs. This shortlist aims to guide the final selection of solutions to be supported and disseminated by the RE-GAIN programme.

In addition to the above-mentioned prioritizations following the climate rationale, the final selection of solutions considered additional prioritization factors to ensure the success of the RE-GAIN Programme and achieve lasting systemic changes in all target countries. These include:

- Impact of the solution on the environment (environmental pollution/ GHG emissions during the use of the solutions),
- current level of awareness of the farmers about the solution's proper use and maintenance,
- frequency of the solutions' uses during the year,
- solution's estimated potential in reducing food losses,
- availability of selected FL-RS in the country, and
- potential for supply scalability and job creation through locally produced or assembled solutions and improving market linkages.

Given these factors, affordable solutions such as solar-powered small-scale mechanized solutions with the highest potential to protect harvests from high moisture and pests are prioritized.

Additionally, considering the critical loss points for the target crops, particularly during post-harvest handling and storage, proper access to appropriate storage technologies for farmers is essential. Combining hermetic storage solutions (hermetic bags, silos, storage structures) with moisture meters is crucial for preventing spoilage and aflatoxin development, particularly in crops like maize and groundnut. This combination offers an enhanced opportunity to reduce food losses effectively.

To further prioritize the list of solutions for each country, a high, medium, and low scoring approach was applied, considering synergies and increased potential impact of the solutions on food loss reduction. The final shortlist of prioritized solutions for each country is presented in Table 5-13:

Table 5-13 Prioritized physical FL-RS for Kenya

Solutions	Level of priority
Harvesting machinery	low
Mechanical multi-crop threshers and shellers	medium
Tarpaulins and plastic sheets	medium
Wooden and metal cribs	low
Metal and plastic silos	medium
Hermetic bags	high
Moisture meters	medium
Communal storage structures	high
Storage protectants and control agents	medium
Transport packaging	low

Concerning storage protectants and control agents, stakeholders in Kenya identified these as affordable and beneficial. However, there remains a considerable need to raise awareness regarding the proper use (dosage and application of chemical protectants) across the countries. Additionally, there is a need to develop the supply of biological l protectants and control agents in the markets.

For the effective introduction and maintenance of communal storage, adequate facility management and maintenance, proper road infrastructure and sufficient transport availability will be crucial.

Based on the above, we propose delivery of shortlisted solutions using the following approach:

- *Communal use by the target communities/farmer groups*: mechanical multi-crop threshers and shellers (preferably solar-powered), moisture meters and communal storage structures
- *Individual use by the target farmers*: tarpaulins and plastic sheets, metal and plastic silos, hermetic bags, and storage protectants and control agents of biological origin.

Considering the above mentioned points, we recommend the **FL-RS adaptation strategy for Kenya to be deployed as a basket of options,** bespoke combinations such as **mechanical multi-crop threshers and shellers (preferably solar-powered) combined with moisture meters** for monitoring the level of moisture in the target crops, and communal storage structures, with the FL-RS uses on the individual farm level, such as **tarpaulins and plastic sheets** for drying crops**, hermetic storage technologies (hermetic bags, silos) used for storage of the crops**, and **storage protectants and control agents, preferably biological origin**.

Taking into consideration the shortlisted solutions for Kenya, as well as their potential to reduce postharvest losses and existing barriers, Table 5-14 provides a brief overview of the proposed solutions' delivery mechanism for Kenya.

Table 5-14 Proposed delivery mechanism for shortlisted physical FL-RS in Kenya

Solution	Estimated reduction in PHL, % (Table 5-1)	Barriers to solution implementation	Proposed delivery mechanisms
Tarpaulins and Plastic Sheets	10-20%	• Potential unavailability and affordability • Variable quality and limited durability of the materials, which can compromise their reliability	• Improved access to solutions through a subsidy scheme • Training and capacity building on the appropriate use of tarpaulins and plastic sheets
Mechanical Multi-Crop Threshers and Shellers	10-30%	• Prohibitive costs • Limited accessibility and availability • High fuel costs • Technical challenges in both acquisition and use	• Improved access to solutions through a subsidy scheme • Capacity building (training of trainers) on managing and maintaining the machinery
Metal and plastic silos	10-50%	• High costs • Limited awareness, • Challenges in transportation and provision	• Improved access to solutions through a subsidy scheme • Training and capacity building on the appropriate use of silos
Hermetic Bags	20-30%	• Affordability • Limited availability • Durability issues • Environmental impact of plastic waste if not properly managed	• Improved access to solutions through subsidy scheme • Training and capacity building on the appropriate use of hermetic bags
Moisture Meters	Up to 25%	• High initial procurement costs • Limited availability • Lack of knowledge about their usage and management	• Improved access to solutions through a subsidy scheme • Training and capacity building on the appropriate use of moisture meters, and their maintenance
Storage Structures	Up to 15%	• High initial costs • Lack of quality materials • Accessibility issues • Security concerns	• Improved access to solutions through a subsidy scheme • Capacity building (training of trainers) on the best practices in using storage structures
Storage Protectants and Control Agents	30-40%	• High costs • Need for proper knowledge about the safety measures • Safety of pesticide residues on stored produce	• Improved access to solutions through a subsidy scheme • Capacity building on the right usage and dosage of pesticides, training and awareness raising on alternative biological /organic storage protectants

For the successful implementation of RE-GAIN programme, it is also critical to consider additional aspects and factors, such as improved access to finance for women and youth groups, traditional roles of both genders in the agricultural sector in Kenya, land tenure/ ownership rights, and the ways communities operate in the Programme's target regions.

5.5 RECOMMENDATIONS AND PROGRAMMATIC CONSIDERATIONS FOR INTRODUCTION OF FOOD LOSS REDUCTION SOLUTIONS (FL-RS)

To ensure the success of the RE-GAIN Programme and achieve lasting systemic changes across the target countries beyond the programme's duration, several key factors must be in place:

- Strong alignment of the proposed physical solutions with the capacity-building and awareness-raising activities
- Availability of selected FL-RS in the country, and potential for the supply scalability
- Focus on strengthening market-driven approach, and developing strong market linkages
- Efficient communication and information dissemination about the programme
- Proactive inclusion of women in the training and capacity-building activities
- Effective financing mechanisms
- Enabling environment for the uptake of FL-RS

Strong alignment of the proposed solutions with the capacity-building and awareness-raising activities

Raising awareness is a fundamental for reaching a large number of smallholder farmers and MSMEs, motivating them to adopt and increase the use of FL-RS. Training and capacity-building efforts focused on the technical and managerial aspects of FL-RS are vital for the program's success. These efforts will enhance farmers' understanding of climate information, the effects of climate change on harvest and post-harvest activities, and the practical application of FL-RS to significantly reduce food losses. This, in turn, will support farmers in boosting food security, increasing income, and ensuring a return on investment, all contributing to the overall success of the program. The requirements for awareness-raising and capacity-building, which are key to achieving these outcomes, have been detailed earlier in this chapter. These activities will not only empower farmers but also strengthen their ability to adopt sustainable practices that are essential for long-term resilience and program sustainability.

Availability of selected FL-RS in the country, and potential for the supply scalability

The success of the RE-GAIN Programme relies heavily on the availability, affordability, quality, and scalability of the selected FL-RS technologies. These include harvesting machinery, mechanical multi-crop threshers and shellers, tarpaulins, plastic sheets, metal and plastic silos, hermetic bags, moisture meters, and storage structures. It is crucial that these technologies not only exist in sufficient quantities within the market but also remain continuously accessible to target farmers in remote and rural areas, both during and after the programme.

This will be accomplished through market mapping and the development of a robust network of local manufacturers and importers/agro-dealers to assess the current supply of FL-RS and their potential for scalable production, as part of creating sustainable market linkages. To ensure FL-RS reach remote regions, stronger collaboration between solution manufacturers and local agro-dealers will be essential. This partnership will help guarantee both the availability and accessibility of these solutions for farmers, fostering long-term adoption and sustainability.

Focus on strengthening market-driven approach, and developing strong market linkages

For RE-GAIN Programme to create sustainable change, it will focus on fostering market linkages between smallholders, MSMEs, and potential buyers such as retailers, processors, and exporters using AGRA's proven consortia model. This will build on the market mapping, which will identify key agricultural value chain actors, including potential institutional markets not yet fully accessible to smallholders. Utilising this information, the RE-GAIN Programme will support farmers in connecting with other actors in the value chain, including providing technical assistance to secure formal off-take agreements for produce that meets quality standards of institutional markets.

Efficient communication and information dissemination about climate risk and the programme

Effective communication about the programme, its goals, and its benefits—notably reducing post-harvest food losses amid changing climate conditions—is vital for achieving successful outcomes across all seven countries. Communication efforts will focus on ensuring that available weather information is widely shared, complemented by the development of informational materials. A dedicated communication platform will be established, enabling FL-RS suppliers, manufacturers, and other key stakeholders to communicate with one another and provide information on their available solutions. Additionally, outreach to farmers, including details on available financial resources like bank loans and FL-RS distribution opportunities, will be facilitated through village-based advisors, ensuring that essential information reaches even the most remote communities.

Proactive inclusion of women, youth, and Indigenous people (where present) in the training and capacity-building activities

As identified during the stakeholder engagements and confirmed by the official data, women, youth and indigenous people (where present) play crucial roles in the agricultural sector in Sub-Saharan Africa, especially in the stages of harvesting and post-harvest handling. Therefore, it is critical to ensure their efficient representation and active participation in the capacity building and awareness raising activities of RE-GAIN programme. This will be achieved by targeted selection of participants/ audience for the capacity-building activities. Beyond this, RE-GAIN will also encourage MSMEs to engage with informal youth groups to engage in the services provision of FL-RS services, in which the youth groups will operate under the supervision and contractual responsibility of the MSMEs, ensuring accountability and providing the youth group with an opportunity to build a track record of successful operations and governance.

Effective financing mechanisms

Effective financing mechanisms are crucial for expanding access to food loss reduction solutions across all seven countries. These mechanisms are particularly important when the benefits and return on investment for harvest and post-harvest technologies are not yet well-established among smallholder farmers and agribusinesses, and when the private sector needs to develop new product-market combinations. The delivery of physical FL-RS to farmers and other target stakeholders, facilitated by these financial mechanisms, will begin in the second year of the programme, ensuring that access to these solutions is supported by sustainable financial models that foster long-term adoption and growth.

Enabling environment for the uptake of FL-RS

For the successful implementation of the RE-GAIN programme, it is essential to prioritize activities that ensure its long-term sustainability. As the programme builds knowledge about climate risks and their impact on agriculture, enhances both the demand for and supply of FL-RS, improves access to financing, and strengthens market linkages, it will also focus on supporting policy development and reform. Key policy initiatives will include advocating for tax exemptions, establishing certification and quality standards for FL-RS, promoting scalable and replicable FL-RS business models, and improving the accessibility of weather information for smallholder farmers.

Active involvement and support from both central and local government organizations will be critical to the programme's success. The RE-GAIN programme will align with other relevant projects and initiatives to create synergies, leverage existing laws and policies related to food loss reduction, MSME development, and smallholder support, and ensure effective programme management. This will involve rigorous monitoring, continuous improvement, and the integration of lessons learned to enhance outcomes and ensure long-term impact.

5.6 PROPOSED DESIGN OF THE RE-GAIN PROGRAMME

The RE-GAIN programme tackles climate change and food losses by addressing both physical and non-physical solutions within the selected value chains. It is organized into three key components and five targeted outputs; each designed to maximize impact and ensure a comprehensive approach to reducing post-harvest losses. Each component is designed with targeted activities to improve awareness, access, and the enabling environment, all aimed at increasing the adoption of FL-RS and driving significant reductions in post-harvest food loss. The expected outputs and respective activities, together with the identified barriers they aim to address, are presented in Table 5-15:

Table 5-15 Proposed Activities Set and Outputs of the RE-GAIN Programme, aligned with the identified risks, needs and barriers in access to FL-RS

Identified risks, needs and barriers	Activity sets	Outputs
Technical and Operational Challenges • Technical challenges in use of technologies and equipment • Susceptibility of crops to weather conditions, pests, and contamination • Limited access to markets for smallholder products • Limited awareness of impact of climate change on harvest and post-harvest crop management • Limited awareness of the use of climate information for decision making Skills and Knowledge Requirements • Limited awareness of impact of climate change on harvest and post-harvest crop management • Limited awareness of the use of climate information for decision making • Need for proper training, knowledge, and technical skills for effective use and maintenance of equipment and post-harvest technologies • Limited awareness and knowledge about proper usage and management of FL-RS Health, Safety, and Environmental Risks • High pollution risks and environmental impacts of certain harvesting technologies • Health and safety concerns associated with the use of chemical products as storage protectants	Activity Set 1 • Gender-responsive awareness campaign on the impacts of CC on post-harvest food losses and the availability of FL-RS. • Demonstration, training and tech. transfer for the use of weather/ climate information, FL-RS and related practices • Capacity development of extension services and agro-dealers	Output 1.1. Smallholder farmers supported to adopt FL-RS
	Activity Set 2 • Facilitate market linkages between institutional markets & other buyers & smallholders, Support to structuring of value chains & coordination between market actors	Output 1.2. Improved market linkages between agri-value chain actors
Cost and Economic Constraints • High initial costs and ongoing maintenance expenses of machinery and technologies • Affordability challenges, especially for vulnerable communities • Lack of capital and limited access to finance • Inaccessibility of fuel and high fuel costs in some areas, high energy consumption and	Activity Set 3 • Provide business development support & market intelligence for FL-RS manufacturers • Capacity and market development for all market actors • Training of new FL-RS providers (MSMEs, cooperatives, incl. women- and youth -led initiatives)	Output 2.1. Business development support for the improved provision of FL-RS on local markets

Identified risks, needs and barriers	Activity sets	Outputs
maintenance requirements of harvesting machinery Market constraints • Lack of available FL-RS, especially in remote and rural areas • Limited accessibility and (perceived) high cost of FL-RS, especially in rural areas • Limited availability of quality materials and resources for production of FL-RS	• Facilitate access to finance for FL-RS providers through innovative de-risking schemes	
	Activity Set 4 • Support inclusion of FL-RS in climate-resilient input packages • Structure prefinancing partnership arrangements that include FL-RS • Facilitate the development and deployment of smart subsidy and catalytic grant models, as well as 'lease-to-own models for FL-RS focussing on women and youth as key beneficiaries.	Output 2.2. Financial mechanisms for smallholders and MSMEs to support the adoption of FL-RS
Quality and Reliability Concerns • Variable quality and limited durability of FL-RS present in the market, affecting their reliability Other concerns • Lack of access to solutions and agricultural finance for women • Limited awareness among farmers about the effectiveness and economic benefits of FL-RS	Activity Set 5 • Support the revision of policies that enable FL-RS investments, including tax exemptions, certification and standards for FL-RS quality • Promote successful FL-RS business models for scaling-up & replication	Output 3.1. Enhanced capacity of national institutions to enable investments in FL-RS

5.7 OVERVIEW OF IMPLEMENTATION ARRANGEMENTS

For the RE-GAIN to be a successful programme, it will leverage AGRA's expertise both from its headquarters as well as its country offices.

AGRA HQ senior leadership and technical leads will be responsible for the overall supervision and coordination of the project including ensuring: i) funds are effectively managed to deliver results and achieve objectives; ii) the quality of project monitoring; and iii) liaison with the GCF. AGRA will also leverage expertise from its wider technical leadership and support by AGRA's Heads of Markets and Trade, Inclusive Finance, Sustainable Farming, Private-sector Partnerships, Strategy, Policy and State Capability, Monitoring and Evaluation and Knowledge Management. The AGRA HQ team will be the primarily liaison with the GCF.

5.7.1. Executing Entity (EE)

The project will be executed directly by AGRA through its) Programme Implementation Unit (PIU). Through this unit, AGRA will provide key resources, including Finance, Grant Management and Procurement Officers who will provide financial and administrative management, overseeing financial, contractual, procurement and logistics aspects for the project from the Nairobi Headquarters. The unit will oversee planning and quality assurance; supervise programme monitoring, evaluation and reporting; ensure timely realization of all programme deliverables; provide leadership and technical support to implementing partners; and ensure smooth communication flow across all programme partners. This executing role will be fulfilled both through the Nairobi-based headquarters, and AGRA's country offices, and will report to the AGRA senior leadership.

The EE is responsible for:

- Execution of the project,
- Procurement of services specifically (major procurement and Subgrant contracting),
- Facilitating partnerships,

- Managing contracts, monitoring results,
- Annual reporting by county offices to the PIU

AGRA deploys a diverse set of delivery models to deliver its country and institutional strategy. It offers services through its **expert staff**, placed at headquarters in Nairobi; at the East, Southern and West Africa regional offices; as well as at country offices. AGRA staff work with downstream partners and local organizations to implement **specific components** of a contracted programme area with the aim to improve local organizations' capacity, build institutional capacity and ensure long term ownership and sustainability of its interventions. AGRA provides **Technical Assistance (TA) in the form of short- to medium-term expertise support** (through consultants where needed) embedded within or seconded to mandated national, regional and continental institutions (e.g., government ministries, regional economic communities) to drive desired change, and in some instances consultants are hired to support specific assignments that require skilled expertise. AGRA is a **convener (brings stakeholders together around a change agenda, e.g., the Africa Food Systems Summit)** facilitating connections and interactions between different actors and stakeholders within the agriculture and food systems sector. AGRA utilizes advocacy and communication as key tools for change. The specific delivery models will be determined at the implementation stage and will depend on each country context.

5.7.2. Responsible Units

The EE team at the Nairobi HQ will be supported by AGRA country offices in each of the seven target countries who will serve as responsible units. These units will support on-the-ground coordination and implementation, as well as being mandated for specific outputs/activities.

5.7.3. Programme Governance

Programme Advisory Group:

AGRA will establish a Programme Advisory Group (PAG) made up of senior representatives from AGRA's Integrated Programme Management (IPM) unit[3] that will serve as the starting point to guide innovation, impact scale and adaptive thought leadership to shape the partnership at continental level. AGRA envisions this Advisory Group will meet quarterly as part of IPM meetings

Programme Implementation Unit

A central Programme Implementation Unit (PIU) will be established at AGRA's Nairobi headquarters to oversee implementation of the entire programme across all seven countries. This unit will report to the PAG and be comprised of two sub-groups; a Programme Management Unit (PMU) and a Technical Expert Group (TEG), as described below.

- *Programme Management Unit*

  The Programme will establish a management unit that will be functional for the entire duration and be responsible for day-to-day implementation of the project. The PMU will offer overall management, implementation and general technical direction of the entire programme, ensuring an integrated vision among different components. The PMU will consist of five full time positions: i) PMU Lead; ii) Senior Finance Officer; iii) Procurement Officer; iv) Project Analyst; and v) M&E Officer. The PMU will be based in AGRA Nairobi Headquarters, with in-country support from responsible units in the country offices.

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[3] Vice presidents, relevant business line or programme directors/heads, Lead of PMU , Head of MEL

- *Technical Expert Group*

  The TEG, also situated within the Nairobi Headquarters, will provide expertise to assist the PMU in the technical implementation of the RE-GAIN programme. The TEG will include several full-time positions, including: i) Program Officer — Gender, Youth and Inclusion; ii) Technical Advisor — Inclusive Finance and BDS; iii) Technical Advisor — Extension and Value Chain Development. These full-time roles will be supported by several part-time technical team members, including: i) Technical Advisor — Inclusive Markets and Finance; ii) Lead — Sustainable Farming, Distribution and Youth in Extension; iii) Technical Advisor — Livelihood Resilience and Climate Adaption; iv) Head: M&E; and v) Technical Advisor — Food Loss Reduction Analytics.

Country-level Implementation Units

The PIU will be assisted in project implementation within each target country by a country-level implementation unit (CIU) which will be established in each of the AGRA country offices[4] and will be comprised of country-office staff. The CIUs will be responsible for managing day-to-day operations in each country, reporting directly to the PIU, as well as providing regular reports to the relevant Project Steering Committee (see below).

Programme Steering Committee

At the country level, the programme will be implemented under the overall guidance of a Programme Steering Committee (PSC) co-chaired by a representative of the NDA, and AGRA country managers. The PSC will include representatives of other key government departments and agencies, the private sector and civil society organizations. These partners will likely include Ministries of Agriculture and their Departments for Land Resources Conservation, Crop Development, Agriculture Extension Services and Agriculture Planning Services. The role of the PSC will be to: i) provide overall guidance and direction to the project in country; ii) address project issues as raised by the advisory group; iii) review the project progress and provide direction and recommendations to ensure that the agreed deliverables are produced satisfactorily and within the approved project framework; iv) review and approve annual work plan and budget (AWPB) and provide necessary strategic guidance for its implementation; v) appraise the annual project implementation report, including the quality assessment rating report; vi) make recommendations for subsequent work plans to build on achievements and address any shortcomings; and vi) provide ad hoc direction and advice for exceptional situations or when requested by the GCF, strategic advisory group or PSC members.

Each national PSC will include representatives of private sector actors in addition to key government institutions. A list of potential private partners is presented in Appendix 9 of Annex 2. The selection of specific partners for each country will be led by AGRA and will be dependent on specific criteria as outlined in Annex 2. At country level there will annual forums for feedback and policy dialogues that will be organized by each county office. The lessons learned through the project monitoring, evaluation and learning systems in each participating country will be shared to all other participating countries through two approaches: i) Cross-country presentations at AGRA's internal Quarterly Performance Review Meeting, where all country directors and program officers participate; and ii) an annual planning and review session organized by the PMU in which all countries and partners participate to promote cross country learnings, exposure and innovation. In addition, at continental level, the AFSF will organization special sessions for cross country learning and feedback.

[4] Which fall under the same legal entity as the PSAA Applicant

Each National PSC will convene in an interval of 3 months (quarterly) with a provision for additional extraordinary meetings when required and to be called by the chair and co-chair or if requested by members. The PSC will report to the NDA who oversees all GCF project in the individual countries.

Table 5-16: Country PSC Representatives

Country	PSC Representatives
Burkina Faso	• Ministry of Agriculture • Ministry of Treasury • Ministry of Environment • Council of Governors

Stakeholder Engagement

Across the different countries, AGRA will liaise with different governmental agencies during the implementation of the different outputs to ensure that the RE-GAIN programme is aligned with country-specific policies. A non-exhaustive list of these stakeholders is provided is section B.4 of the funding proposal band will be further updated through engagement with the NDA's selected representative in each country.

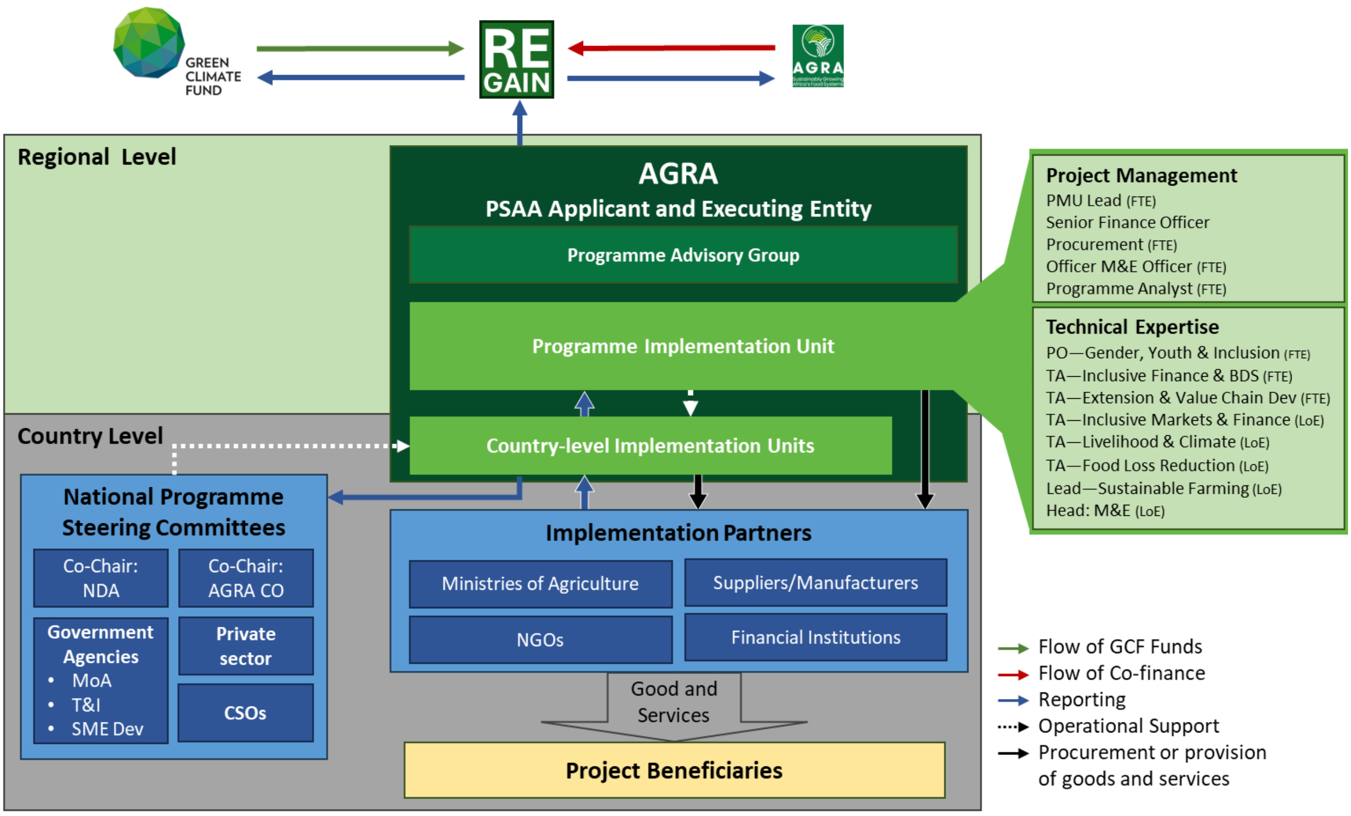

Figure 5-16 Implementation Arrangements for the RE-GAIN Programme

5.8 PROGRAMME AREA

Climate risks were carefully considered for the countries under consideration (as detailed in Chapter 3), evaluating factors to identify locations that align with the programmes goals. This analysis helps us make informed decisions, ensuring the selected location is well-suited for long-term success without causing any adverse impacts. Alongside this assessment, we have carefully considered the additional criteria listed below to further refine our choice, ensuring a holistic approach to decision-making.

5.8.1 Eligibility criteria for programme area

- Selection of geographical location in the target countries for the RE-GAIN project. Below is the selection criteria that will be considered:
- Areas that have significant smallholder agriculture production.
- Production areas that are recognized by local government as high productivity areas. Consultation will be key in the selection process
- Proximity to or existing agro-dealer network and or agriculture input and output businesses,
- Where selected value chains are being produced and or traded
- Where there is existing AGRA investments in extension systems, enhanced productivity and support to market systems
- Areas that have previously and are currently being serviced by financial products by financial institutions
- Existing infrastructure communications infrastructure to allow accessibility to the area
- Demographics: Areas that have a potential for spillover or scaling effect due to the existence of a significant number of value chain actors (farm to market).
- Synergies with other existing projects and initiative

6 Market Dynamics Study

RE-GAIN Programme is designed to promote market-led adoption and implementation of FL-RS, to reduce food losses, increase incomes and contribute to climate change adaptation and mitigation. Under Component 1 the market demand for FL-RS will be stimulated through awareness raising, capacity building, demonstrations and other activities (Chapter 5.2.1). Under Component 2 the supply of FL-RS will be stimulated through support for FL-RS manufacturers and traders and providing access to finance for smallholders so that they can invest in the FL-RS, while under Component 3 the market linkages (for FL-RS) between agro-value chain actors will be improved. This chapter describes the supply and demand for prioritized FL-RS, the supply of FL-RS and Financial Services.

6.1 CURRENT DEMAND FOR THE PRIORITISED FL-RS

The demand and supply of agricultural machinery and other post-harvest food loss reduction technologies among smallholder farmers in Kenya reflects existing challenges and opportunities within the sector. Literature reviews and stakeholder consultations confirmed the presence of several barriers that impede the demand for improved FL-RS in Kenya, including:

a) Lack of information and awareness about the importance of food losses and available postharvest technologies.

b) Lack of appropriate knowledge and skills within the farming community that hinders the adoption of modern agricultural techniques and more efficient resources management.

c) Low literacy levels among women farmers which hinders their full participation in awareness and training activities, inhibiting their adopting improved agricultural activities, including FL-RS.

d) High cost of some of the FL-RS, such as threshes/shellers, silos, moisture meters and even hermitic bags making them unaffordable.

e) Poor market linkages and market and product information asymmetries which hamper farmers' ability to connect effectively with suppliers.

f) Limited supply of affordable finance due to high interest rates, short loan periods, or lack of access to collateral, limits farmer’s access to loans for investing in FL-RS.

g) Unstable market prices add another layer of uncertainty, making it difficult for farmers to plan and invest in their operations confidently.

Below we explore specifics on the demand and supply of the specific prioritized physical solutions discussed in the previous chapter.

6.1.1 Demand for specific FL-RS

Mechanical multi-crop threshers and shellers in Kenya are in significant demand among farmers cultivating grains and legumes, to enhance productivity and reduce labor costs. Yet, supply is constrained by the high cost of equipment and limited local manufacturing.

Tarpaulins and plastic sheets are also very popular for drying crops in Kenya. While the supply chain is robust, affordability remains an issue, especially considering the recent price fluctuations, and high-quality, affordable products are often in short supply.

Hermetic bags have seen increased demand due to their effectiveness in protecting stored grains against pests and spoilage. Awareness and supply have improved, but they are still considered expensive and not always durable due to improper usage by some farmers, owing to knowledge and capacity gaps. There are also cases of cheap bags sold as high-quality hermetic ones, that fail to protect crops, and therefore put future investments into them at risk.

Metal and plastic silos are only in moderate demand for their effectiveness in reducing post-harvest losses, due to their high costs and the need for proper installation and ongoing maintenance. In addition, the high production costs limit their supply.

Moisture meters have low but growing demand as farmers become more aware of their use in preventing spoilage. Most devices are imported, and supply is constrained by high costs and limited distribution. There is a need for farmer training to promote their proper usage.

Improved storage structures are in high demand to reduce post-harvest losses and store crops for longer in line better prices. However, the availability of modern storage solutions is low due to high costs, making them inaccessible to smallholder farmers who often rely on less effective traditional structures.

Storage protectants and control agents are very popular among farmers in Kenya due to their effectiveness and availability. Nevertheless, the market requires more protectants of natural/ biological origin, to ensure food safety.

6.2 MARKET OF SUPPLIERS AND MANUFACTURERS OF FL-RS

On the supply side of FL-RS, agricultural sector in Kenya depends often on expensive imports and relatively weak distribution networks which can severely restrict the availability of FL-RS in sufficient quantities at the right time/price. In Kenya, numerous manufacturers and/or importers of priority FL-RS operate regionally and locally. They are primarily located in big cities and collaborate closely with agricultural dealers as well as agricultural service providers. Markets are quite fragmented and consists of companies and service providers operating at different scales. Dealers and service providers engage directly with smallholder farmers, cooperatives and associations, selling the equipment and other solutions directly, or renting them out for certain periods.

The largest agricultural machinery companies such as Hardi Kenya Ltd, Ndume Ltd, Farm Engineering Industries Ltd, Hobra Manufacturing Limited, Camco Equipment Ltd, Marina Machineries Ltd, FMD East Africa Limited, Nyagah Mechanical Engineering Limited, Chaff Cutters kenya Limited, Macire Limited and online stores such as Kreatives provide agricultural machinery solutions such as **mechanical multi-crop threshers and shellers**, tractors and harvesting machinery. They mainly import the threshers, and then distribute their products across the country through a network of dealers and agricultural machinery suppliers. The estimated supply capacity varies depending on the company. Specific information about major Kenyan supplier of FL-RS including their capacities, main solutions produced/supplied, and whether those solutions are locally produced or imported, together with the average costs of solutions, is provided in the Appendix 9.

Among the prioritised FL-RS, **tarpaulins and plastic sheets** are commonly available in Kenya. They are mostly produced locally by companies such as Elgon Kenya Ltd, Africa PVC Industries ltd (TEMBO), TARPO, AgroZ, and sold by agricultural dealers directly to the farmers. Besides those, in Kenya several online shops, such as JiJi , Imagine Care Limited and Jumia, offer a wide range of tarpaulins and plastic sheets for sale.

Hermetic bags are among the most popular primary physical solutions in Kenya. Leading suppliers/importers in this sector are Packaging Industries Ltd, AGROZ, Bell industries Ltd, GrainPro, Eline Innovations Kenya Ltd, among others. The bags then being distributed and sold through local vendors.

Metal and plastic silos in Kenya are often being locally produced, by the big companies such as Kentainers, Brazafric Limited – Kikapu, Polytanks, and others.

Moisture meters in Kenya are primarily imported by companies such as Milima Africa, ISAM kenya, Brazafric Limited – Kikapu, metro Tools Limited, Myagrovet, among others, which also provide distribution services throughout the country, often partnering with agrodealers and other third-party distributors to reach a wide range of customers in both urban and rural areas. Moisture meters can also be bought online via agricultural marketplaces such as for example Jumia kenya and Kilimall.

Improved communal **storage structures**, such as communal grain sheds, are being either produced in the country, or imported as prefabricated items (primarily from China) and assembled locally. Few private sector companies offer these kind of storage structures for sale. Those companies include African Grain Care Equipment Limited (AGCE), Cimbria East Africa Ltd, Kentainers, and Transwide Grain Equipment.

As for the **storage protectants and control agents**, companies such as Balton CP/Amiran Kenya, Elgon Kenya Limited, UPL, Syngenta, A to Z and others import those from other countries.

6.3 ACCESS TO FINANCE

Innovative financing models tailored to the needs of smallholder farmers can improve both access and affordability by relieving farmers of the need to securitize loans, mitigating the burden of high interest rates or compressed repayment periods, thus facilitating access to necessary capital. Among the crucial ways to resolve existing financial barriers, RE-GAIN Programme proposes to explore the following opportunities:

- Support and test/ pilot the development of financial products tailored for agriculture MSMEs.
- Leverage partnerships between financial institutions, NGOs and MSMEs, to redistribute the burden of risks and costs (such as interest rate costs) and enabling access to working capital for farmers to purchase FL-RS
- Link MSMEs to organizations that can provide basic business management and recordkeeping capabilities, bringing them into line with information thresholds for banks' creditworthiness checks.

6.3.1 Barriers to access

6.3.1.1 Smallholder farmers barriers to FL-RS adoption

The benefits and importance of using FL-RS are not known or not implementable by all smallholder farmers across the RE-GAIN programme's target countries. Adoption of new technology by farmers requires awareness creation and evidence that adoption of the FL-RS will give a return on investment to farmers. Farmers are cash constrained, especially at harvest time, and that limits their ability to invest in FL-RS such as hermetic bags and threshing or storage services at the time these investments are most needed. Farmers are hesitant to secure credit from credit institutions, such as microfinance institutions, not only because they are not sure of the return on investment of the FL-RS and the quality of the product but also due to their inability to generate cash from the sales of produce because they lack access to markets. This lack of market access further exacerbates their financial instability, creating a cycle of limited investment in production and low productivity. To address these issues, a multifaceted approach involving improved access to knowledge and incentives to adopt new technology and enhanced market linkages are essential.

6.3.1.2 Agricultural MSMEs barriers to FL-RS adoption

The use of FL-RS to be operated by Agricultural MSMEs including youth groups and cooperatives, is limited by the lack of proven business cases (capacity utilization, cost of operation, level of service fee) but also due to their limited access to loan facilities because they lack collateral, a credit history, and have limited investment readiness (insufficient records of transactions and business operations).

6.3.1.3 Financial Institutions' barriers to supply agricultural solutions

Financial institutions consider the agricultural sector as high-risk, due to the inherently unpredictable nature of agricultural profitability, influenced by factors like weather and market volatility. The high risk and cost of the agricultural sector, results in banks charging high interest rates over short tenors, which put financial products beyond the reach of Agricultural MSMEs or add to their existing financial burdens. There is a notable lack of financial products tailored to the unique needs of agricultural value chains, which should ideally account for seasonality, climate risk, and the extended lead times between production, off-taking and selling to end consumers.

6.3.2 Overview of key financing products that currently serve farmers in Kenya

Existing agricultural financing products in Kenya are designed to support farmers in accessing the necessary resources for enhancing their productivity and sustainability. These products are provided by various financial institutions, including commercial banks, microfinance institutions, and government programs.

Agricultural loans come in various forms tailored to different needs. Short-term loans are typically used for purchasing seeds, fertilizers, pesticides, and other inputs needed for a single planting season. These loans are usually repaid after the harvest. Medium-term loans are used for purchasing equipment, livestock, or other assets that improve farm productivity over a few years, with repayment periods usually between one to five years. Long-term loans are designed for significant investments such as purchasing land or constructing farm infrastructure, with repayment periods often exceeding five years.

Credit facilities provide farmers with additional financial flexibility. Overdrafts allow farmers to withdraw more money than is available in their account up to a certain limit, covering immediate expenses. Trade finance includes products like letters of credit and invoice discounting, helping farmers manage cash flow and trade operations effectively.

Microfinance institutions offer loans to groups of farmers, which reduces the risk for the lender and encourages collective responsibility. They also provide individual microloans, which are small, unsecured loans for individual farmers, typically used for purchasing inputs or small equipment.

Agricultural insurance products are crucial for managing risks. Crop insurance protects farmers against the loss of crops due to natural disasters, pests, and diseases, while livestock insurance covers losses due to disease, accidents, or natural disasters affecting livestock. Index-based insurance provides payouts based on predefined indices such as rainfall levels, rather than actual loss assessments, simplifying the claims process.

To address the challenges associated with access to and supply of affordable financing, several key initiatives have been undertaken in recent years to reduce the costs associated with agricultural solutions in Kenya. These initiatives encompass a variety of interventions and have had varying degrees of success and impact.

Among the initiatives launched by the Government of Kenya, one of the most prominent ones in the area of food storage and handling is the Warehouse Receipt System (WHRS) - mechanism designed to facilitate agricultural trade, improve access to credit for farmers, and enhance the overall efficiency of the agricultural value chain. WHRS facilitates post-harvest financing, allowing farmers to store their produce in certified warehouses and receive a receipt that can be used as collateral for loans, allowing them to access funds while waiting for better market prices. However, this intervention had limited reach due to a lack of awareness and limited technical know-how among the targeted beneficiaries.

The **Kenya Cereal Enhancement Programme – Climate Resilient Agricultural Livelihoods Window (KCEP-CRAL)** e-voucher system, funded by the government, the European Union, IFAD, Equity Bank, and Agrodealers (AgroZ), facilitated access to small post-harvest management equipment such as hermetic bags and tarpaulins. It aimed at enhancing food security, improving agricultural productivity, and promoting climate resilience among smallholder farmers in Kenya. A key component of this programme is the e-voucher system, which facilitates the delivery of inputs and services to farmers. It replaced traditional paper vouchers with electronic ones, improving efficiency, transparency, and accountability. The system aims to support farmers in accessing quality inputs such as seeds, fertilizers, and training, thereby enhancing their productivity and resilience to climate change.

E-vouchers were provided to farmers, which they can redeem for agricultural inputs and services at designated agrodealer shops. Farmers are registered into the system, and their details are captured digitally, ensuring that the right beneficiaries receive the support. Registered and certified agrodealers are integrated into the system to provide inputs and services in exchange for e-vouchers. The e-voucher system is typically accessed via mobile phones, making it accessible even to farmers in remote areas.

By ensuring timely access to quality inputs, the e-voucher system has contributed to increased agricultural productivity among smallholder farmers. The programme has helped farmers improve their incomes and livelihoods by enhancing their production capacity. The focus on climate-resilient practices has enabled farmers to better cope with the impacts of climate change, securing their agricultural livelihoods. This intervention successfully increased access to hermetic bags for storing maize and other grains but was limited in its geographic coverage.

Government and donor programs overall play a significant role in agricultural financing in Kenya. The Agricultural Finance Corporation (AFC) provides affordable credit to farmers, focusing on long-term and development loans. The Kenya Agricultural and Livestock Research Organization (KALRO) sometimes offers financing or subsidized inputs as part of development projects. Various international donor programs provide grants, low-interest loans, and technical assistance to Kenyan farmers. Savings and Credit Cooperative Societies (SACCOs) offer a range of financial services. Savings accounts enable farmers to save regularly, earning interest and creating a financial buffer. SACCOs also provide various loan products to members at competitive rates, often with more favourable terms than traditional banks.

Among the donor-funded initiatives in Kenya, the "**One to Many**" approach is particularly noteworthy. This initiative, launched by Bonntifiel in collaboration with the International Organization for Education (IOE) and the Cereal Growers Association (CGA), focuses on derisking access to finance through equipment capacity building and technology. The project involved the introduction of multicrop maize shellers, which saw high adoption rates among farmers. This intervention significantly reduced post-harvest management costs, improved the quality of shelled maize, and saved time for farmers. It also offered a fee-based service that reduced breakage and enhanced efficiency. Despite these benefits, broader adoption faced challenges such as limited awareness, outreach difficulties, cost implications, and variability in weather conditions, which affected the effectiveness and reliability of the shellers in different regions.

The **E-soko initiative**, a mobile marketplace developed by the private sector and development partners, was another important initiative targeting improved access to harvesting and post-harvest handling solutions. E-soko in Kenya is an innovative digital platform designed to enhance agricultural productivity and market access for farmers. It serves as a mobile and web-based platform that provides farmers with real-time information on market prices, agricultural inputs, weather forecasts, and best farming practices. The primary objective of E-soko is to bridge the information gap that often hinders smallholder farmers from making informed decisions and maximizing their agricultural potential.

One of the key components of E-soko is its provision of market price information. The platform offers up-to-date details on the prices of various agricultural commodities across different markets in Kenya. This information helps farmers identify the best places and times to sell their produce, ensuring they get competitive prices. Additionally, E-soko provides weather updates and forecasts, enabling farmers to plan their farming activities better and mitigate risks associated with adverse weather conditions. E-soko also disseminates information on modern farming techniques, pest and disease management, soil health, and other agronomic practices. Moreover, the platform provides information on where to buy quality seeds, fertilizers, pesticides, and other agricultural inputs, ensuring that farmers use the best materials for their crops. E-soko further facilitates market linkages by connecting farmers with buyers, reducing the reliance on middlemen and improving farmers' profitability.

By providing crucial market and weather information, the platform empowers farmers to make better decisions regarding when and where to sell their produce, what crops to plant, and how to manage their farms. Access to real-time market prices helps farmers negotiate better prices for their products, thereby increasing their income and improving their livelihoods. Information on best farming practices and quality inputs supports farmers in enhancing their crop yields and overall farm productivity. Additionally, weather forecasts allow farmers to anticipate and prepare for adverse weather conditions, reducing crop losses and enhancing resilience.

E-soko can be accessed via mobile phones through SMS, USSD codes, and mobile apps, making it widely accessible to farmers, even in remote areas. The platform is also available online, providing a comprehensive suite of services to users. However, some challenges remain. Some farmers, particularly older ones, may have limited digital literacy, which can hinder their ability to use the platform effectively. In some remote areas, limited mobile network coverage can affect the accessibility of E-soko services. Ensuring that all farmers are aware of and trust the platform can be challenging, especially in areas where traditional farming practices are deeply ingrained.

Jubuhi Kilimo, an agricultural financing initiative by KREP Bank, aimed to facilitate access to agricultural assets for farmer groups. Juhudi Kilimo, originally launched in 2004 as an agricultural microlending initiative under the K-Rep Development Agency, has evolved into an independent for-profit social enterprise dedicated to improving the livelihoods of rural smallholder farmers and micro-entrepreneurs in Kenya. By 2009, Juhudi Kilimo had established itself as a leading provider of financial services tailored to the agricultural sector. The core mission of Juhudi Kilimo is to provide customized loans for agricultural assets, which enable farmers to generate immediate and sustainable income. The initiative focuses on financing specific agricultural assets such as dairy cows, poultry, and crop farming equipment. This model diverges from traditional microfinance, which generally provides loans for working capital to informal businesses.

Juhudi Kilimo serves over 70,000 clients through 52 branches across 33 counties in Kenya, with an outstanding loan book of KES 2.5 billion, of which more than 84% is dedicated to the agricultural sector. The institution has partnered with various organizations, such as Oikocredit, which provided a five-year loan of US$ 5 million to support smallholder farmers and micro enterprises. This funding helps Juhudi Kilimo expand its reach and improve its financial offerings to underserved communities.

Despite the variety of financing products available, many farmers face challenges in accessing financing due to lack of collateral, credit history, and financial literacy. High interest rates can be a barrier for small-scale farmers. Furthermore, many farmers are unaware of the available financing options and how to access them. Effective risk management tools such as insurance are crucial to protect farmers from unforeseen losses.

Overall, these initiatives have collectively contributed to reducing the costs of agricultural solutions in Kenya. However, agricultural financing in Kenya is still evolving with a need for specific financing products tailored to meet the diverse needs of farmers. The key to maximizing the impact of these financing options lies in improving accessibility, affordability, and farmer awareness, alongside robust risk management strategies.

6.3.3 Suppliers of financial products and services

AGRA has secured letters of interest (LoI) with several financial institutions that intend to increase their agricultural portfolio using clear loan targets, as part of RE-GAIN's overarching strategy. AGRA and the banks have agreed to collaborate to develop the agricultural finance sector through mutually reinforcing opportunities and products.

RE-GAIN programme provides an opportunity where AGRA will conclude agreements with financial institution partners, whereby grants will be used to offset interest rate charges that would normally be paid by farmers, thus enabling smallholder farmers to access loans for working capital, facilitating transactions and financial flows between manufacturers and traders of FL-RS.

The following financial institutions have been identified in Kenya as potential partners:

Table 6-1 Potential financial partner institutions considered for RE-GAIN programme Kenya (Matara, 2020)

Financial partner	Comment
Equity Bank	offers various loan products for farmers, including the Farm Inputs Loan, Kilimo Biashara, Kilimo Supa, Kilimo Maendeleo, and Kilimo Kisasa. These products cater to different scales and types of agricultural activities, with loan amounts ranging from Kshs. 1,000 to over Kshs. 500,000, repayable within 1 to 3 years depending on the product. Additionally, Equity Bank provides financial literacy training and agricultural extension services to help farmers manage their loans effectively
Agricultural Finance Corporation (AFC)	Signed LoI with AGRA, interested provides loans to individuals and groups engaged in various agricultural activities, including dairy, beef, poultry, and fish production. The loans are typically repaid over 2 to 5 years. Farmers must provide security and a viable project proposal to qualify for these loans
Co-operative Bank of Keny	In partnership with Mastercard, Co-operative Bank offers loans to smallholder farmers at below-market interest rates. This initiative aims to enhance financial inclusion and support green technology adoption in agriculture. The Co-op Bank Soko platform also facilitates timely access to farm inputs, which is crucial for improving agricultural productivity
Juhudi Kilimo	Provides microfinance loans that enable smallholder farmers to access high-quality agricultural assets, such as equipment and livestock, to enhance farm productivity. This institution focuses on financially excluded farmers, helping them improve their livelihoods through better access to financial services

The selection of the ideal partner for the deployment of the financial models will follow the eligibility criteria outlined in section 6.4 for the specific models proposed to be used in the RE-GAIN programme.

6.4 RE-GAIN FINANCING MECHANISMS TO ENHANCE ACCESS TO FOOD LOSS REDUCING SOLUTIONS

The approach taken in the financial model design is focused on strategically using grants to catalyse the development of the market for food loss reducing solutions (FL-RS). These financial mechanisms are designed to address the current market dynamics and challenges faced by smallholder farmers and agricultural MSMEs. The mechanisms do this by enhancing the supply and affordability of FL-RS, thus creating a self-sustaining market and reducing the need for continued programme support.Despite the potential benefits these models offer, there are several challenges that need to be addressed to ensure effective access and leveraging of FL-RS through financing. One of the primary challenges in accessing FL-RS is the high initial cost of these solutions. Smallholder farmers and agricultural MSMEs often operate with limited capital, making it difficult for them to invest in new technologies and equipment without substantial financial support. This high-cost barrier discourages adoption and limits market penetration. Another significant challenge is the lack of financial products tailored specifically to the agricultural sector. Many financial institutions are hesitant to develop and offer products for smallholder farmers and MSMEs due to perceived high risks and low profitability. Consequently, there is a scarcity of suitable financing options that can support the acquisition and implementation of FL-RS. Smallholder farmers and MSMEs often face difficulties in accessing credit due to stringent requirements set by financial institutions. These requirements typically include collateral, credit history, and other financial credentials that many small-scale agricultural enterprises lack. Without access to credit, these enterprises cannot afford to invest in FL-RS, hampering efforts to reduce food loss.

The effectiveness of FL-RS depends on the quality and appropriateness of the equipment for the local context. Manufacturers need to demonstrate innovation and reliability, but logistical challenges in distribution and maintenance can hinder the uptake of these solutions. Smallholder farmers and MSMEs require assurance that the products will be effectively distributed and maintained, which often involves local partnerships and training programs that are not always readily available. Financial institutions participating in the programme must have robust risk management frameworks to support the sustainability of financial models. However, the agricultural sector is inherently risky due to factors such as weather variability, market fluctuations, and pest outbreaks. These risks need to be adequately managed and mitigated to ensure the viability of FL-RS financing mechanisms.

Activities include interventions at the smallholder and youth group/co-operative levels, improving market linkages, and awareness creation to incentivize adoption of FL-RS. By leveraging partnerships, these models aim to share risks and incentivize market development. Manufacturers must meet specific eligibility criteria, demonstrating innovation and reliability, while financial institutions are required to develop inclusive financial products tailored to the agricultural sector. The programme also includes pathways for MSMEs to access FL-RS through input packages and prefinancing partnership arrangements. Conditional procurement and smart grants will reduce the cost and risk of providing loans to Agricultural MSMEs, aiming to create a self-sustaining market and reduce food loss.

The models developed to enhance adoption and uptake of FL-RS consists of (1) conditional procurement for smallholder farmers to reduce the cost of hermetic technology and drying sheets and (2) smart grants to reduce the cost and risk of providing loans to Agricultural MSME buying FL-R equipment and storage solutions.

6.4.1 Solutions for smallholder farmers (part of activity 2.2.1)

Model 1 encourages the local provision of FL-RS interventions by employing conditional procurements to subsidize interventions at the smallholder farmer level, termed 'smart-subsidies.' Essentially, this model allows agro-dealers to offer FL-RS to smallholder farmers at a lower cost by using GCF funds to purchase one item for every two items bought and sold by an agro-dealer, passing the subsidy as a discount on the purchase price to the smallholder farmers:

- to boost production and manufacturing capacity by placing pre-emptive orders of FL-RS while managing risk by conditionally releasing funds to the manufacturer; and
- to lower the cost of interventions at the smallholder farmer level, thereby increasing profitability, driving additional demand, and promoting knowledge sharing about the benefits of these interventions.

An overview of Model 1 is presented in Figure 6-1, with more detailed descriptions of each step in the text that follows.

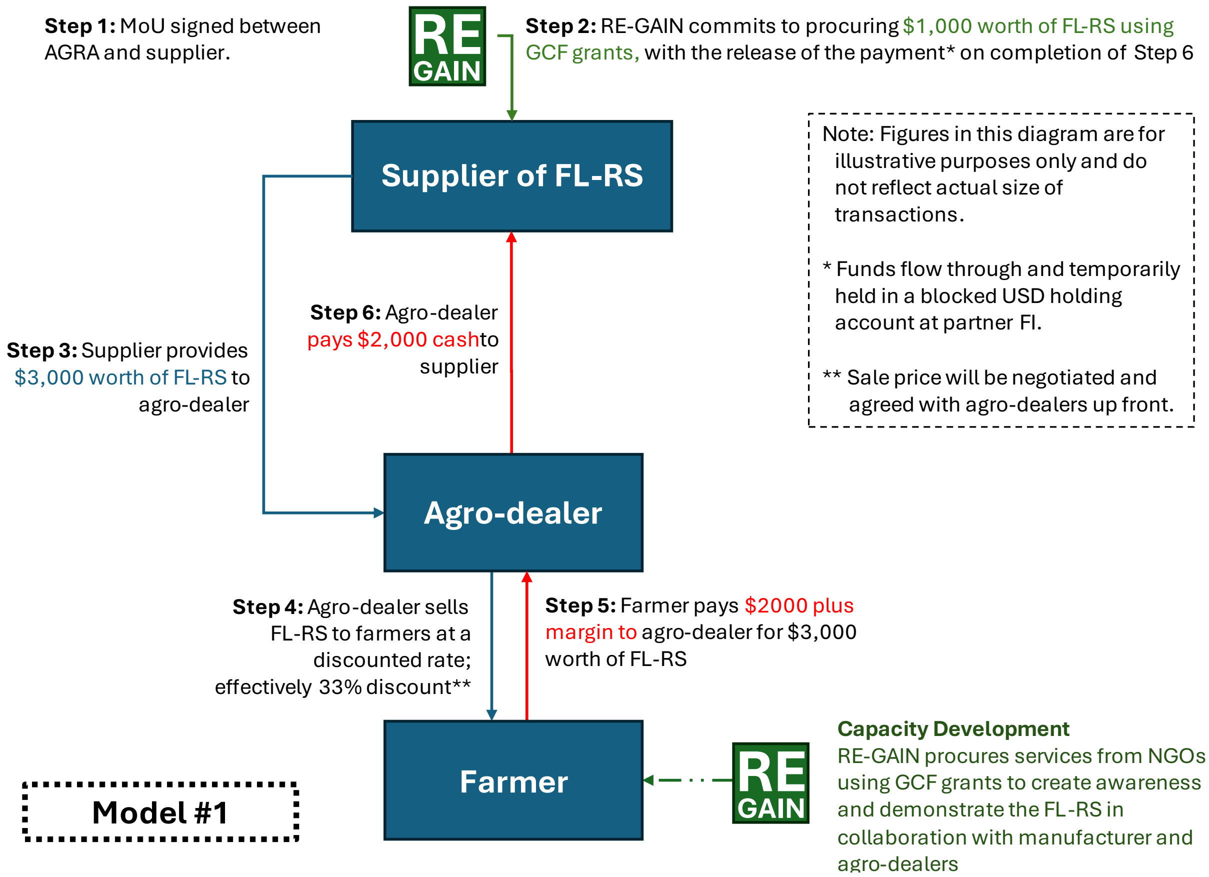

Figure 6-1 Model 1 for RE-GAIN Programme

The implementation of Financial Model 1 within the RE-GAIN programme begins with a facilitation process where AGRA enters into a memorandum of understanding with a supplier. Each supplier will act through and its network of agro-dealers in regions where eligible smallholder farmers are located. This agreement sets out the details of the smart subsidy provided by RE-GAIN and the conditions on final sale price offered to the smallholder farmers. This initial step ensures that the eligibility criteria for the subsidies are clearly communicated to the agro-dealers, guaranteeing that the benefits reach the intended target groups.

The next step involves RE-GAIN placing an order for the FL-RS and depositing the value of the order into a holding account. This deposit remains in the holding account until the completion of subsequent steps. The supplier then provides three units to the participating agro-dealers for every one unit procured by RE-GAIN. Depending on the terms of the agreement, agro-dealers either pay for the two non-subsidized units upon delivery or receive them on credit.

Following this arrangement, the agro-dealers offer the FL-RS to smallholder farmers at a discounted rate, effectively transferring the full value of the smart subsidy provided through GCF support. The agro-dealers keep detailed records of the buyers of the subsidized goods, including a limit on how many units each person can purchase to prevent resale and maintain the demonstration goal. This monitoring allows RE-GAIN to ensure the benefits are reaching the target groups and achieving the intended impact.

Smallholder farmers then buy the FL-RS at the discounted rate. The agro-dealers subsequently makes payment to the manufacturer for two units for every one unit of the initial procurement from RE-GAIN (if not already paid on delivery). In cases where an FI is not involved, this payment and a corresponding report trigger the release of the smart subsidy payment from RE-GAIN to the supplier. If an FI was involved, the release of the smart subsidy depends on the repayment of the loan.

Suppliers, agro-dealers, or farmers requiring additional financing for their role in the system can seek support from local financial institutions available in all target countries. For instance, if a supplier needs extra working capital or capital investment to meet increased FL-RS demand, they can arrange a loan with a financial institution to address liquidity requirements for providing FL-RS. Although AGRA may offer guidance to suppliers or agro-dealers on such matters, the agreements themselves will fall outside the scope of the RE-GAIN Programme and will not involve AGRA. The orders placed through RE-GAIN will help mitigate the financial institution's risk in providing loans to suppliers. However, no RE-GAIN Programme funds will be used to lend to suppliers or make payments to financial institutions.

This model benefits all parties involved, with the manufacturer receiving full payment for the FL-RS, the agro-dealer earning income from their markup, and the farmers acquiring FL-RS at a discounted rate. The established market will allow manufacturers to increase production with reduced risk, ultimately lowering the cost of FL-RS in the local market and enabling the smart subsidies to be phased out over time.

The selection of the specific partners AGRA will engage with in the deployment of this model follows the eligibility criteria below:

6.4.1.1 Eligibility Criteria for Suppliers of FL-RS for Individual Farmers

These partners will be selected in the RE-GAIN programme's target countries based on the criteria below:

- Legal capacity to operate: Registration (and ability to produce registration certificate) as a sole trader, partnership, franchise, cooperative, or limited liability company in good order with the local tax authorities
- If operating as an importer, evidence of compliance with import permits
- If appropriate, demonstrated compliance with any Environmental standards or requirements to obtain licences or environmental impact assessments, reports or management plans as required by local laws
- Proof of VAT registration
- Preferably a track record of producing and selling FL-RS as defined as part of the RE-GAIN programme that is approved by the national authorities
- Evidence of record keeping, including financial records;
- Willingness and financial capacity to expand the production levels and distribution network (agrodealers, cooperatives, development projects,) for the FL-RS
- Willingness and financial and human capacity to develop and deploy (subsidized) marketing efforts to enhance uptake of the FL-RS among small scale producers
- Presence in the target regions in the selected countries for the programme;
  Preferably engaging in the provision of solutions for smallholder farmers

6.4.1.2 Eligibility Criteria for Agricultural Traders, Processors, and Agrodealers

These partners will be selected in the RE-GAIN programme's target countries based on the criteria below:

- Legal capacity to operate: Registration (and ability to produce registration certificate) as a sole trader, partnership, franchise, cooperative, or limited liability company in good order with the local tax authorities;
- If operating as an importer, evidence of compliance with import permits;
- If appropriate, demonstrated compliance with any Environmental standards or requirements to obtain licences or environmental impact assessments, reports or management plans as required by local laws;
- Proof of VAT registration;

- Preferably a track record of stocking and selling FL-RS as defined as part of the RE-GAIN programme preferably of the selected manufacturer or importer;
- Evidence of record keeping, including financial records;
- Willingness and financial capacity to stock hermetic technology at the right time (harvest);
- Presence in the target regions in the selected countries for the programme;
- Preferably engaging in the provision of additional services to small scale producers like moisture meters, training, credit and after sales services (aggregation, access to markets).

6.4.1.3 Eligibility Criteria for Smallholder Farmers and Communities

- Smallholder farmers in specific or selected project geographical location with land sizes of between 0 – 2.5 hectares;
- Smallholder farmers (as defined above) that growing relevant crops (usually staples crops);
- Smallholder farmers that are members of local farmer groups in the targeted geographical areas;
- Smallholder farmers with limited access to farming inputs;
- Smallholder farmers with limited level of access to extension services;
- Smallholders that are below the local poverty line or that are food insecure;
- Farmers selected by local community and/or government leadership as priority and or vulnerable farmers (these usually include productive farmers that serve as model farmers, youth, women, special/marginalised groups)

6.4.2 Solutions for Agricultural MSMEs

The second financial model is specifically targeted at assisting Agricultural MSMEs to invest in high value items FL-RS (equipment and storage) with prioritisation given to vulnerable groups by employing grants to enable acquisitions

The primary objectives of Model 2 are twofold:

- Enhancing Creditworthiness: By leveraging repurchase assurances from suppliers, the model aims to reduce the loss given default, thereby enhancing the creditworthiness of the youth groups and cooperatives involved.
- Reducing borrowing costs: Through a combination of the lowered credit risk (as per above) and subsidies on the purchase price. The structure will ensure high-valueFL-RS become more affordable and thus accessible to youth groups who provide services to smallholder farmers.

At the core of Model 2 is the engagement of local youth groups, poised to act as service providers for FL-RS, requiring high-cost equipment that can service multiple farmers. This includes harvesting machinery, mechanical multi-crop threshers and shellers (preferably solar-powered), moisture meters, and communal storage structures. The establishment of these service operations will be supported through business development initiatives, ensuring that youth groups have a solid foundation to provide reliable services. This approach leverages several key concepts to achieve the targeted benefits:

- **Collectivism:** By pooling resources, smallholder farmers benefit from economies of scale through cost sharing and increased bargaining power with off-takers, promoting further profitability and additional demand for FL-RS.
- **Post-harvest Handling:** Enhancing the quality and quantity of agricultural produce allows smallholder farmers to capture more value, thereby increasing their incomes.

Inclusion of Financiers: Engaging financial institutions will unlock access to finance in a traditionally underserved market. The structure aims to reduce credit risk by providing a partial subsidy, which will lower borrowing costs due to the smaller loan size and reduced interest payments.

The concessional support under this model is primarily aimed at youth groups as a means of fostering livelihood development for these vulnerable community members. However, when paired with business development assistance, the RE-GAIN programme enables youth groups to structure their service fees to reflect the actual (discounted) cost of the equipment. This approach allows them to offer services at fair rates, thereby indirectly transferring the benefits of the concessional support to the farmers utilizing these services.

An overview of Model 2 is presented in

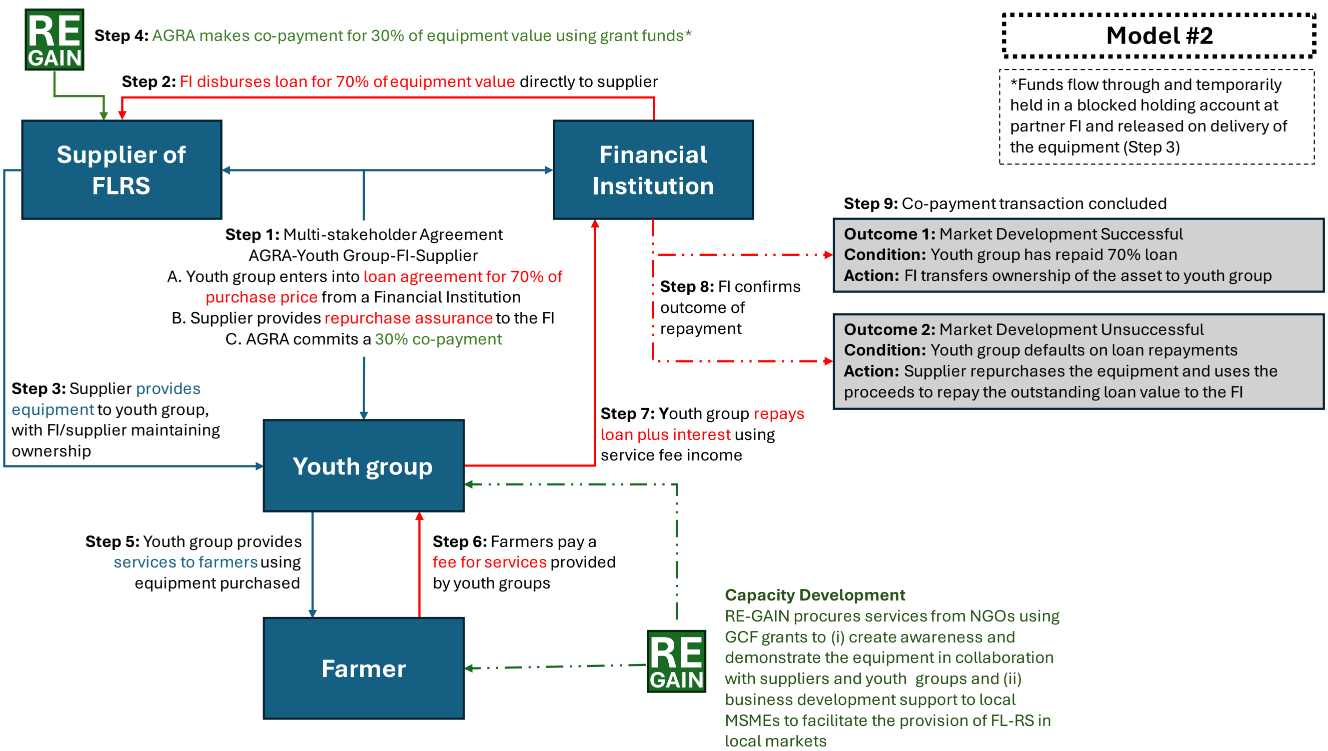

Figure 6-2, with detailed descriptions of each step in the following text. While RE-GAIN will facilitate the establishment of the entire process, its active involvement beyond Step 4, with ownership of Steps 5-9 transitioning to the three partners: youth groups, suppliers, and financial institutions who will enter into a separate loan agreement to which AGRA will not be a party.

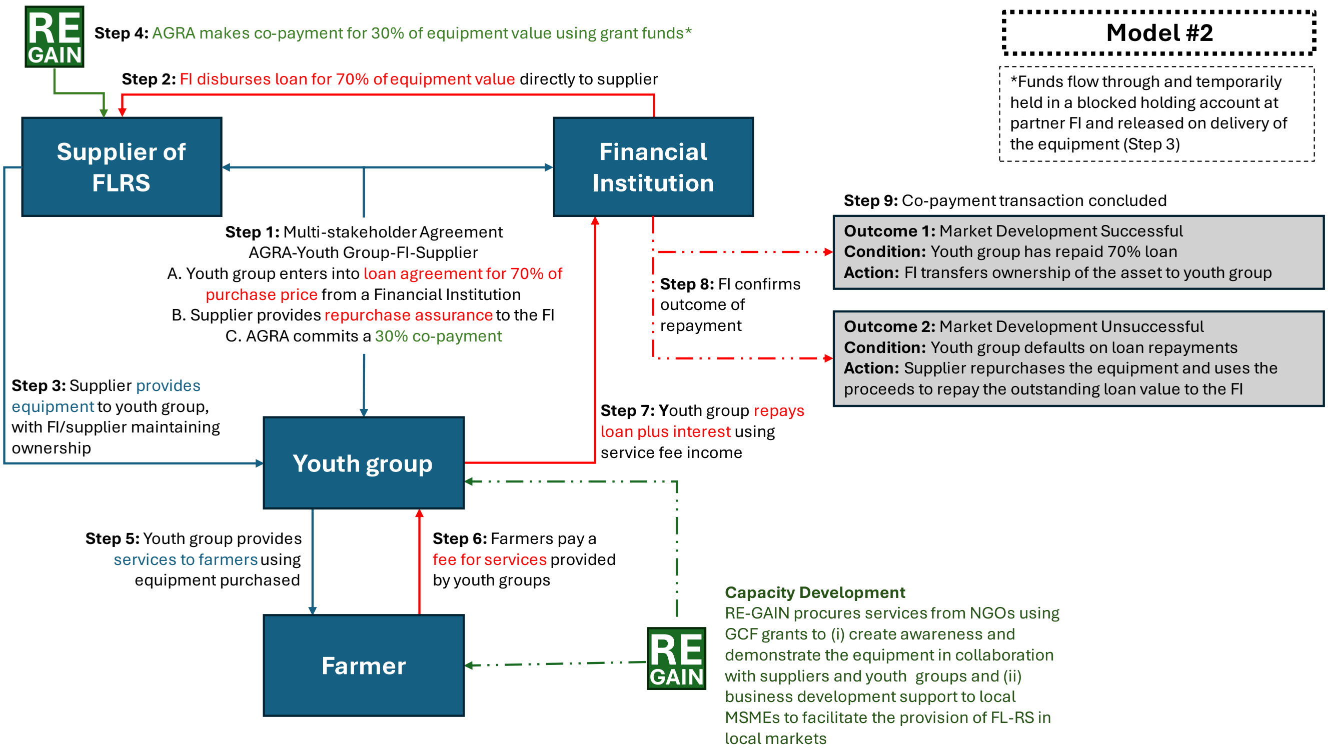

Figure 6-2 Model 2 for RE-GAIN programme

RE-GAIN programme will facilitate the initiation of collaborations between youth groups, suppliers, and financial institutions (FIs). This collaborative effort will be formalized through the signing of a multi-stakeholder agreement. According to this agreement, AGRAcommits to an upfront co-payment covering 30% of the purchase price for the specified equipment. This commitment is contingent upon the youth group agreeing to cover the remaining 70% of the cost. To facilitate this payment, the youth group will secure a loan from the partner FI, while the supplier will provide a repurchase assurance, thus distributing the financial risk between the supplier and the FI. RE-GAIN will oversee the negotiations, ensuring that all aspects of the agreement align with the established eligibility criteria.

Once the multi-stakeholder agreement is in place, the FI will transfer the 70% down-payment directly into the supplier's account on behalf of the youth group. This transaction will initiate the next steps. Concurrently, the remaining 30% co-payment will be deposited into a blocked USD holding account, where it will remain until the equipment is delivered, at which point its release will be triggered.

Upon receiving the 70% payment from the FI, the supplier is obligated to deliver the equipment to the youth group. Following the delivery, the supplier will report the successful receipt of the equipment to AGRA's RE-GAIN PIU.

Upon receipt of the delivery report from the supplier, RE-GAIN will release the 30% co-payment from the holding account to the supplier, thereby completing the initial purchase agreement. At this juncture, the youth group will assume control over the use of the equipment. However, the ownership of the assets will remain with the supplier or the FI, depending on the terms agreed upon during the initial negotiations.

With the equipment now in their possession, the youth group will commence providing FL-RS services to local farmers. To ensure the successful operation of the service enterprise, capacitation support will be provided, ensuring that the youth groups are adequately trained and capacitated to offer reliable and efficient service.

The smallholder farmers will pay the youth group for the FL-RS service, with the youth group collecting income from multiple farmers, thereby distributing the cost of the equipment across multiple beneficiaries. The youth groups will use the income from the services to make repayments to the FI on the loan, covering the cost of the loan and the agreed interest. The upfront co-payment through RE-GAIN reduces the repayment burden on youth groups compared to a scenario where a 100% loan would have been required, thereby decreasing the loan loss given default.

At the end of the agreed loan period, the FI will conclude the transaction and report on the outcome of the repayment. The conclusion of the transaction will lead to one of two possible outcomes:

- In the first scenario, market development was successful, indicated by the youth group operating an FL-RS service and enabling the full repayment of the loan. Under this outcome, the ownership of the asset will be formally transferred to the youth group, allowing them to continue offering the service beyond the initial agreement, without the costs of servicing the loan.
- In the second scenario, market development was unsuccessful, indicated by the failure of the youth group to make the required repayments on the loan. In this case, the supplier's repurchase assurance is triggered, through which the supplier buys back the asset (accounting for depreciation). The value of the repurchase will first go towards the repayment of any outstanding loan amount and any associated transaction fees. Should the repurchase value exceed the outstanding loan amount, any remaining value after transaction fees will be transferred back to the youth group to compensate for any payments made before default.

Model variations may be introduced depending on the local context and nature of FL-RS. In all cases, GCF grants will be used to make a co-payment on the equipment on behalf of the beneficiary (youth group or MSME), thereby reducing the financial burden of the transaction and de-risking the transaction for the suppliers or FIs involved in the agreement

The selection of the specific partners AGRA will engage with in the deployment of this model follows the eligibility criteria below:

6.4.2.1 Eligibility Criteria for Supplier FL-RS for Equipment

These partners will be selected in the RE-GAIN programme's target countries based on the criteria below:

- Legal capacity to operate: Registration (and ability to produce registration certificate) as a sole trader, partnership, franchise, cooperative, or limited liability company in good order with the local tax authorities
- If operating as an importer, evidence of compliance with import permits
- If appropriate, demonstrated compliance with any Environmental standards or requirements to obtain licences or environmental impact assessments, reports or management plans as required by local laws
- Proof of VAT registration
- Preferably a track record of producing and selling FL-RS as defined as part of the RE-GAIN programme that is approved by the national authorities
- Evidence of record keeping, including financial records;
- Willingness and financial capacity to expand the production levels and distribution network (agrodealers, cooperatives, development projects,) for the FL-RS
- Willingness and financial and human capacity to develop and deploy (subsidized) marketing efforts to enhance uptake of the FL-RS among small scale producers
- Presence in the target regions in the selected countries for the programme;
- Preferably engaging in the provision of solutions for smallholder farmers

6.4.2.2 Eligibility criteria for financial institutions

These partners will be selected competitively in the RE-GAIN programme's target countries based on the criteria below:

- Financial institutions must demonstrate they are licensed, regulated and supervised by the relevant authorities (Central Bank, MFI regulatory body, cooperative agency) and in compliance with any prudential liquidity requirements
- Experience and willingness to offer asset financing facilities of between USD 1.000 and USD 10.000 to equipment buyers and/or operators
- Willingness and ability to engage with Agricultural MSMEs or cooperatives and other key actors in the value chains; Willingness to open an escrow account in AGRA's name at no/low cost and interest rate offered on the AGRA deposit
- Preferable presence (branch or agents) in the regions where the programme will be implemented

6.4.2.3 Eligibility criteria for Youth Groups, MSMEs and Cooperative

These partners will be selected in the RE-GAIN programme's target countries based on the criteria below:

- Registration certificate if formally required under national laws;
- Copy of constitution, and full list of members and officials;
- Preferably a track record (based on physical records) as a service provider to small scale producers (can be in extension, aggregation of produce, selling of inputs or provision of mechanized services);
- Preferably presence in the target regions in the selected countries for the programme and qualified staff or members that have experience in operating, repairing and servicing the machinery;
- Willingness and ability to buy machinery for the purpose of renting it out to small scale producers;
- Willingness and financial capacity to develop and deploy marketing efforts to enhance uptake of the FL-RS services among farmers;
- Preference will be given to women and youth-led MSMEs;
- Preference will be given to those already engaging with business planning activities

6.5 MARKET OF PROVIDERS FOR AWARENESS RAISING AND CAPACITY BUILDING

Awareness raising and capacity building covered by the Component 1 or RE-GAIN Programme requires experienced partners in awareness campaigns and smallholder training. AGRA has historically worked in Kenya leveraging village-based advisors (VBA). The goal is that this component of the programme will be implemented by working with lead farmers, preferably with young ones, as VBAs. Leveraging this network, implementation will include demonstrations (mother-demos) with local agro-suppliers, that can help VBAs and locally-led cooperatives or other organisation of farmers with the opportunity to start viable local agro-services.

Beyond leveraging AGRA's current VBA network in the country, the RE-GAIN programme can also work closely with additional partners to implement these extension services in Kenya. To have maximum impact in the country, the awareness campaign should use mass media, such as TV, radio and social media. Several other major agricultural NGOs and farmers' organizations are actively working to support the agricultural sector through various initiatives and programs. These organizations play a crucial role in enhancing agricultural productivity, promoting sustainable practices, and improving the livelihoods of farmers.

Therefore, we recommend involving those agricultural NGOs and farmers' organizations to closely work on the RE-GAIN programme implementation in the area of capacity building and awareness raising. Recommended implementation partners are further shortlisted in Table 6-2.

Table 6-2. Potential implementation partners for implementing the awareness campaign and the capacity building programmes in Kenya

Organization	Description
Kenya National Farmers Federation (KENAFF)	KENAFF is the apex umbrella farmers' organization in Kenya, representing and promoting the interests of Kenyan farmers. It focuses on advocacy, policy influence, and capacity building to enhance the agricultural sector's productivity and sustainability. KENAFF also provides a platform for farmers to engage with policymakers and other stakeholders to address challenges faced by the agricultural community
Nuru Kenya	Nuru Kenya focuses on lifting smallholder farmers out of poverty by supporting community-led agribusinesses. It provides training, resources, and support to improve agricultural practices, increase yields, and promote sustainable farming. Nuru Kenya operates primarily in southwestern Kenya, implementing programs that enhance food security and economic resilience
Association Of Women in Agriculture Kenya (AWAK)	AWAK empowers women in agriculture by providing training, financial inclusion, market linkages, and support for climate-smart agriculture. The organization aims to enhance food security and nutrition, advocate for climate justice, and promote economic empowerment for women farmers. AWAK's programs also focus on value addition and creating sustainable agricultural practices
Farming Systems Kenya (FSK)	Established in 1981, FSK works to reduce poverty through agricultural development. It supports smallholder farmers by providing technical advice, extension services, and affordable credit. Their approach emphasizes sustainable and climate-friendly farming practices
Participatory Ecological Land Use Management (PELUM) Kenya	PELUM Kenya is part of a larger network that promotes agroecological principles and practices. It supports small-scale farmers through capacity development, advocacy, and promoting sustainable agriculture methods
Agriculture Sector Network (ASNET)	ASNET is a collective voice for the agricultural sector in Kenya, comprising various associations and stakeholders. It aims to influence policy, promote sustainable practices, and enhance the overall growth of the sector

These organizations play a critical role in advancing Kenya's agricultural sector by providing essential services, advocating for farmers' interests, and implementing programs to enhance productivity and sustainability. For the selection of the specific organisations that AGRA will partner with for the delivery of the extension services, the partner selection will follow the eligibility criteria in the section below, as well as the selection of those receiving the extension services across the value chains.

6.5.1 Eligibility Criteria for Extension Services Recipients

The different training activities will target actors across the agricultural value chain, including smallholder farmers and the communities that they form, agrodealers, food processors, manufacturers of FL-RS, financial service providers, and MSMEs or service providers that act across the value chain. Below is the eligibility criteria across these different groups under the RE-GAIN programme. to be included in extension services.

6.5.1.1 Eligibility Criteria for Smallholder Farmers and Communities (for activity 1.1.1, activity 1.1.2, activity 1.1.6 and activity 1.2.1)

- Smallholder farmers in specific or selected project geographical location with land sizes of between 0 – 2.5 hectares;
- Smallholder farmers (as defined above) that growing relevant crops (usually staples crops);
- Smallholder farmers that are members of local farmer groups in the targeted geographical areas;
- Smallholder farmers with limited access to farming inputs;
- Smallholder farmers with limited or level of access to extension services;
- Smallholders that are below the local poverty line or that are food insecure;

- Farmers selected by local community and/or government leadership as priority and or vulnerable farmers (these usually include productive farmers that serve as model farmers, youth, women, special/marginalised groups)

6.5.1.2 Eligibility Criteria for Agricultural Traders, Processors, and Agrodealers (for activity 1.1.3 and activity 1.1.7)

These partners will be selectedin the RE-GAIN programme's target countries based on the criteria below:

- Legal capacity to operate: Registration (and ability to produce registration certificate) as a sole trader, partnership, franchise, cooperative, or limited liability company in good order with the local tax authorities;
- If operating as an importer, evidence of compliance with import permits;
- If appropriate, demonstrated compliance with any Environmental standards or requirements to obtain licences or environmental impact assessments, reports or management plans as required by local laws;
- Proof of VAT registration;
- Preferably a track record of stocking and selling FL-RS as defined as part of the RE-GAIN programme (hermetic bags or tarpaulins) preferably of the selected manufacturer or importer;
- Evidence of record keeping, including financial records.
- Willingness and financial capacity to stock hermetic technology at the right time (harvest);
- Presence in the target regions in the selected countries for the programme:
- Preferably engaging in the provision additional services to small scale producers like moisture meters, training, credit and after sales services (aggregation, access to markets).

6.5.1.3 Eligibility Criteria for Village- Based Advisors (VBAs) (for activity 1.1.4)

The selection process should ensure that the VBA is:

- A resident of the community or resides in the geographical location/area of the target beneficiaries/farmers;
- At least 10th grade education;
- Knowledge of farming, must have at a minimum .05 hectare of farmland
- Existing 'lead farmers' that have been identified in communities by other government or partner programmes
- A member of existing community-based groups (farmer cooperative, farmer groups, nutrition groups youth groups etc)
- Entrepreneurial skills are an advantage
- Where local practices demand, the VBA will be selected or endorsed by local community leaders
- Women and youth will be preferred VBA candidates

6.5.1.4 Eligibility Criteria for Manufacturers of FL-RS (for activity 1.1.5)

These partners will be selectedin the RE-GAIN programme's target countries based on the criteria below:

- Legal capacity to operate: Registration (and ability to produce registration certificate) as a sole trader, partnership, franchise, cooperative, or limited liability company in good order with the local tax authorities
- If operating as an importer, evidence of compliance with import permits
- If appropriate, demonstrated compliance with any Environmental standards or requirements to obtain licences or environmental impact assessments, reports or management plans as required by local laws
- Proof of VAT registration
- Preferably a track record of producing and selling FL-RS as defined as part of the RE-GAIN programme (that is approved by the national authorities

- Evidence of record keeping, including financial records; Willingness and financial capacity to expand the production levels and distribution network (agrodealers, cooperatives, development projects,) for the FL-RS
- Willingness and financial and human capacity to develop and deploy (subsidized) marketing efforts to enhance uptake of the FL-RS among small scale producers
- Presence in the target regions in the selected countries for the programme;
- Preferably engaging in the provision of solutions for smallholder farmers

6.5.1.5 MSMEs and Cooperatives (for activity 2.1.1 and activity 2.1.2)

These partners will be selected in the RE-GAIN programme's target countries based on the criteria below:

- Registration certificate if formally required under national laws
- Copy of constitution, and full list of members and officials
- Preferably a track record (based on physical records) as a service provider to small scale producers (can be in extension, aggregation of produce, selling of inputs or provision of mechanized services)
- Preferably in the target regions in the selected countries for the programme and qualified staff or members that have experience in operating, repairing and servicing the machinery
- Willingness and ability to buy machinery for the purpose of renting it out to small scale producers
- Willingness and financial capacity to develop and deploy marketing efforts to enhance uptake of the FL-RS services among farmers
- Preference will be given to women and youth-led MSMEs;
- Preference will be given to those already engaging with business planning activities

6.5.2 Eligibility Criteria for Extension Services Delivery Partners

The potential [programme/implementing] partners are not-for-profit, non-governmental organizations, private sector organizations, regional economic or specialized bodies, government departments with technical expertise and competencies in agrifood systems, policy development, monitoring and implementation, project management, scientific and social research, natural resources management, climate change, training, capacity building, knowledge management and other relevant areas.

6.5.2.1 Fit for Purpose

Institutions/organizations intending to work with AGRA in this area of work must demonstrate that they meet the following requirements to be eligible to receive financing from AGRA:

- Unless specifically stated otherwise in this section, must be registered in the national country with valid registration documents;
- For its stated area of expertise, organization must produce certifications, marks or permits as required by national legislations, demonstrating adherence with relevant codes of practice, industry standards etc
- Organization's primary business activity must be in the stated focal countries;
- Organization must be in a sound financial condition;
- Organization must have sufficient existing capability/capacity to perform as required. AGRA may consider limited funding for capacity building only if the entity's proposal is determined to be of interest to AGRA;
- Organization must have demonstrated favorable past performance record;
- Organization must have accounting systems, procurement practices and corporate integrity/ethics aligned to AGRA systems and values;

- Organization must not have been previously excluded from the eligibility to receive funding from any of AGRA's partners;
- Demonstrate inclusivity and promote sustainability principles in past project activities

6.5.2.2 Technical Competencies

Other key considerations – these will be dependent on the thematic focus of the work being undertaken:

a) Minimum of 5-7 years of demonstrable organization working experience in any/all or a combination of the following systems level areas: Value Chain Development, Sustainable Farming, Seed systems, Fertilizer and Soil health systems, Market and Financial Access systems, MSME development, Agriculture and/or Food systems policy, Climate Change, Natural Resources Management, Extension and Input Distribution systems, and Climate-smart Agriculture in Africa;
b) Demonstrable ability to work with private sector partners and have experience leading/facilitating value chain development, linkage of smallholder farmers to markets, and resilience building initiatives;
c) Experience working with women and youth (and other underserved groups);
d) A team with experience working in smallholder agriculture value chains in Africa; experience in natural resources management, climate change, MSME development and working with national institutions;
e) Present qualified personnel/CV's of key staff proposed
f) Applications should be in line with the RE-GAIN Programme's E&S policy, as further described on Annex 6

AGRA may request additional documentation to be submitted as part of the pre-award process. Organizations are advised that any funds made available are subject to AGRA's accountability and audit requirements.

6.5.2.3 Evaluation Criteria/Scoring Weights

The selection of partners will follow the below scoring criteria, and percentages may vary slightly.

1.	Fit-for-Purpose (Governance and management)	20%
2.	Technical Ability and past experience	50%
3.	Personnel Qualification and others	20%
4.	Approach and methodology	10%

6.6 SUPPORTING AN ENABLING ENVIRONMENT FOR FL RS ADOPTION AND UPTAKE

Besides the availability and affordability of FL-RS, building a strong enabling environment remains a critical factor for the success of RE-GAIN programme implementation. The lack of progress in food loss reduction is attributable to several factors, including inadequacies in policy and regulatory frameworks and the general lack of capacity among mandated institutions to drive effective strategies, technologies, practices, and initiatives for post-harvest loss reduction. These barriers can be solved by leveraging activities that can strengthen policy and regulatory frameworks and institutions on post-harvest losses, enhancing the enabling environment in the programme countries to best drive systemic changes in the post-harvest food loss space. This will be addressed through the Component 3 of the Programme and its specific activities, working with mandated government institutions in the areas of focus across the different countries in scope of the programme. The activities include:

1. Examine existing national and sub-national legislation and policies related to food loss reduction, to identify gaps, and inconsistencies and address policy barriers.
2. Support policy and regulatory reforms that change the incentive structure; create an enabling environment to attract investments; and encourage the adoption of best practices on food loss reductions. Specific policy reforms include:
   - Regulated quality-based pricing system as an incentive to invest in loss-reduction technologies and practices;
   - Tax exemption on imports, financial incentives (including subsidies) for local manufacturers of postharvest technologies to make proven technologies more available, accessible, and affordable;
   - Efficient Warehouse Receipt Systems to accelerate the efficient removal of the crop from the farmer into safe centralized storage;
   - Development of national policy and technical regulation for aflatoxin control;
   - Policies and programs that promote science, innovation and the adoption of climate-smart technologies and practices;
   - Develop new legislation to promote compliance with regulatory standards and uptake of interventions to reduce postharvest loss

AGRA will also support legislative bodies and mandated institutions to enact necessary laws and regulations to support the implementation of these policies:

1. Support domestication of existing Regional Postharvest Loss Management Strategies;
2. Support the development of national strategies, policies, and legislation enabling food loss reduction in line with national agrifood system objectives and policy frameworks;
3. Support the development of programmes and initiatives to improve the availability of accessible weather information;
4. Support the development and implementation of national food loss strategies and action plans, ensuring policy coherence and mutual accountability through multistakeholder, intersectoral and inter-ministerial collaboration and coordination to align visions and interests of all stakeholders and sectors;
5. Support the development of collaboration platforms across industry players and key value chain actors, including academia, research centers and innovation hubs to share knowledge and best practices on food loss reduction;
6. Supporting Public-Private Partnerships, that allow for greater collaborations between the government and private sector to invest in innovative postharvest technologies, modern storage facilities and transportation logistics;
7. Strengthen institutional capacity for effective partnership, cooperation, and engagement of postharvest management stakeholders to facilitate the execution of planned interventions

Active involvement and support from government organizations, both central and local, will be crucial. RE-GAIN programme will align with other projects and programmes mentioned in Chapter 2, to leverage synergies, utilize existing laws and policies on FL reduction, smallholder farmer support, and ensure effective and efficient programme management. In all seven countries, RE-GAIN programme will prioritize inclusivity for women, youth, indigenous people (where present), and minority groups, and all value chain actors in the planned activities.

Table 6-3 summarises strategic approach for the RE-GAIN programme for Kenya:

Table 6-3 Systematic approach to creating enabling environment for the success of the RE-GAIN programme

Strategic pillar	Key activities	Expected Outcome
Policy Support and Revision	• **Examine existing national and sub-national legislation and policies:** Review current legislation and policies related to food loss reduction to identify gaps, inconsistencies, and barriers.	A supportive policy environment that enables the successful implementation of

	• **Support policy and regulatory reforms**: Facilitate reforms that change the incentive structure, create an enabling environment for investments, and encourage the adoption of food-loss best practices. Specific policies and regulatory frameworks are described above.	the RE-GAIN programme and widespread adoption of FL-RS solutions.
Legislative Support and Capacity Building	• **Develop national strategies and policies:** Support the creation of strategies and legislation that align food loss reduction efforts with national agrifood system objectives. • **Support Public-Private Partnerships (PPPs):** Promote PPPs to enhance collaboration between government and the private sector, investing in innovative postharvest technologies, modern storage facilities, and transportation logistics. • **Strengthen institutional capacity:** Build capacity for effective partnerships and stakeholder engagement to facilitate the execution of planned interventions.	Advocate for the development of initiatrives and legislation that can strengthen both food-loss reduction activities as well as strehgnten institutions to drive systematic transformation.
Awareness and Communication:	• **Establish platforms for knowledge sharing**: Support the creation of collaboration platforms among industry players, value chain actors, academia, and research centers to share best practices in food loss reduction • **Advocate for distribution of accessible weather information:** • Support governments' initiatives to provide more easily accessible weather information, and support campaigns to raise the profile of these initiatives across the different countries	Strong awareness about the impact of increased FL-RS adoption and its impact on food loss reduction, climate change mitigation, and incomes of smallholder farmers
Government Alignment and Synergy Building	• **Actively involve central and local government:** Establish formal partnerships with relevant government bodies at both central and local levels. Facilitate regular meetings and consultations to ensure alignment of the RE-GAIN programme with national and regional development priorities. • **Promote collaboration across sectors**: Facilitate the development and implementation of national food loss strategies and action plans through multistakeholder, intersectoral, and inter-ministerial collaboration. • **Coordinate with other projects to create synergies:** Work closely with other development projects and programmes to identify areas of overlap and collaboration. Develop joint action plans, share resources, and coordinate activities to maximize impact and avoid duplication of efforts.	Strong collaboration with government entities and other programmes, leading to a more cohesive and impactful implementation process.

6.7 CONCLUSIONS ON THE MARKET STUDY

The proposed solutions at the RE-GAIN programme are not unknown in the Kenyan market. However, there are clear challenges and gaps that the programme aims to focus on to tackle by empowering both supply and demand of these solutions, as well as improving the capacity of those using these solutions, alongside with mainstreaming knowledge related to climate resilience in the harvest and post-harvest stages of the selected value chains. Beyond working closely with smallholder farmers, there is also a need to influence and strengthen the enabling environment to reduce food losses.

The proposed RE-GAIN programme leverages what already exists in Kenya when it comes down to harvest and post-harvest food and aims to further strengthen and build the market in the country for harvest and post-harvest solutions, but tackling the challenge from different angles and ultimately strengthening the country's agricultural sector's climate resilience.

7 Conclusion

Food loss is a growing challenge in Kenya, with significant losses within the harvest and post-harvest stages for key crops in the country; maize and beans. As previously discussed, climate change is likely to exacerbate this situation, further impacting the resilience of smallholder farmers involved in these value chains and threatening food security in Kenya. Given the critical role of these crops in the country's economy and overall food supply, food losses have significant implications for the livelihoods of smallholders and the nation's nutrition. Additionally, food losses contribute to emissions and influence land use change dynamics. This context underscores the critical need for a programme like RE-GAIN, which plays a pivotal role in fostering greater climate resilience in Kenya by addressing the key barriers identified during this phased study, as described in the image below:

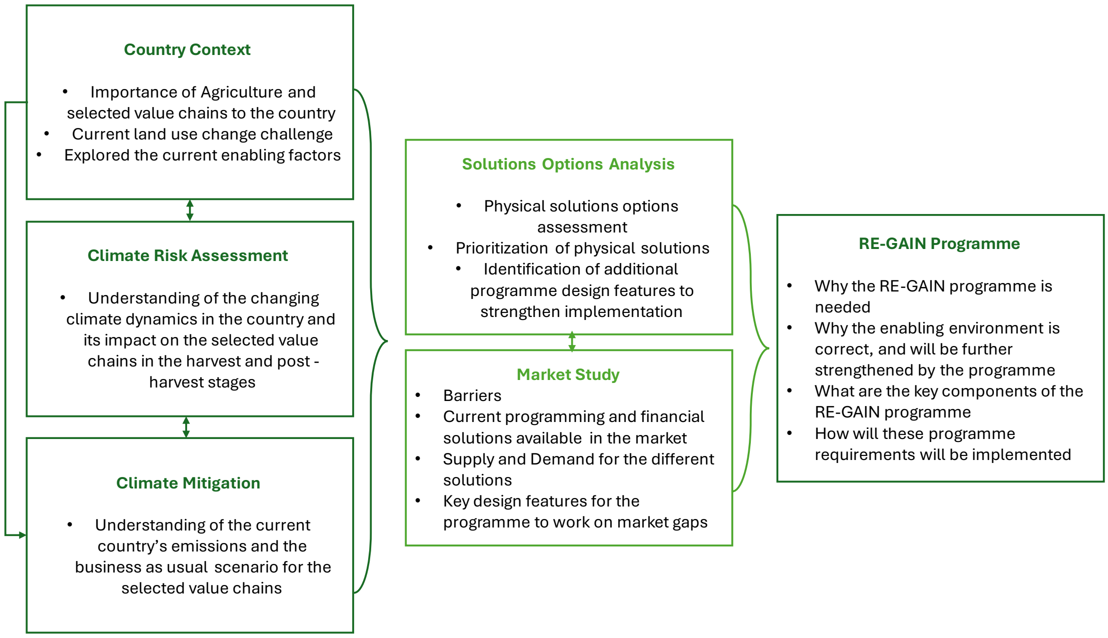

Figure 7-1 Content Summary of Feasibility Study for the RE-GAIN programme

With this in mind, this feasibility study aimed to assess the most viable programme to support smallholder farmers in the harvest and post-harvest stages of the maize and beans value chains within the Kenyan context. Our analysis focused on the country's vulnerability to climate change, the structure of its agriculture sector, its economic profile, and the current food-loss landscape. Kenya is highly vulnerable to the impacts of climate change, which constrain the country's sustainable development ambitions and threaten the lives and livelihoods of vulnerable communities. These findings underscore the necessity of this project.

The identification and analysis of relevant policies in the agricultural and environmental sectors demonstrate that Kenya has a foundational enabling environment for a comprehensive food-loss reduction programme aimed at promoting both the supply and demand of these solutions. However, despite this supportive framework, there is a clear need for a programme like RE-GAIN. Currently, no existing programs specifically focus on simultaneously building climate resilience and addressing harvest and post-harvest food losses. Most initiatives either concentrate solely on enhancing climate resilience in Kenya or focus independently on improving preharvest agricultural production.

Our analysis revealed that the challenges with food-loss solutions and their effective usage are complex and multifaceted. Notably, our market study revealed that the current solutions available are insufficient for smallholders to build their resilience in worsening climate conditions. There are both supply and demand challenges for the physical food-loss solutions in the market, particularly regarding financial accessibility and sufficient availability of high-quality solutions. Additionally, smallholder farmers face capacity challenges in various areas, such as understanding the impact of climate on their harvest and post-harvest activities and leveraging physical solutions to mitigate climate challenges and improve food security. Building on the current enabling environment, the programme will collaborate with various levels of the Kenyan government and the national private sector to further enhance existing frameworks. This includes implementing quality standards and other regulatory policies to enhance the supply and demand of food-loss solutions. These interconnected barriers and challenges underscore the need for a comprehensive programme like RE-GAIN. By addressing these diverse issues, RE-GAIN can significantly reduce food loss and bolster the resilience of smallholder farmers, with a co-benefit of GHG emission reduction.

This study has provided a comprehensive analysis of how climate is impacting harvest and post-harvest activities in Kenya, and highlighted the lack of a unified initiative that can respond to these growing challenges and support Kenya's mitigation initiatives. RE-GAIN offers a solution by reducing food losses across the maize and beans value chains, ultimately benefiting the large population involved in their production and enhancing food security. It facilitates access to physical solutions that bolster smallholders' climate resilience and adaptive capacity, while also providing additional support through extension services that can guarantee the long-lasting impact of the programme. By also focusing on strengthening the enabling environment, RE-GAIN aims to drive systemic changes that promote effective food loss management during harvesting and post-harvesting activities.

Ultimately, this study illustrates how the RE-GAIN programme has been strategically designed to address the challenges of increasing food loss and escalating climate vulnerability in the identified regions. A successfully implemented RE-GAIN programme will provide comprehensive solutions to harvest and post-harvest food loss challenges, resulting in a lasting, transformative impact on Kenya. Over time, this programme will become self-sustaining, significantly improving the resilience and sustainability of the country's agricultural sector.

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