ANNEX 2

Tanzania

Maize and Rice

Version 4

2024

RE-GAIN: Scaling Solutions for Food Loss in Africa

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ACRONYMS

APHLIS	African Postharvest Losses Information System
BAU	Business As Usual
CAADP	Comprehensive Africa Agriculture Development Program
CCRA	Climate Change Risk Assessment
CMIP	Coupled Model Intercomparison Project
COVID	Coronavirus Disease
CREW	Climate Resilient Wheat Value Chain Development Project
ENSO	El Nino-Southern Oscillation
EU	European Union
FAO	Food and Agriculture Organization
FAOSTAT	Food and Agriculture Organization Corporate Statistical Database
FL-RS	Food Loss Reduction Solutions
GCF	Green Climate Fund
GDP	Gross Domestic Product
GGW	Great Green Wall
GHG	Greenhouse Gas
GHGI	Greenhouse Gas Inventory
GTP	Growth and Transformation Plan
IFAD	International Fund for Agricultural Development
IGREENFIN	Inclusive Green Financing Initiative
INFORM	Index for Risk Management
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Intertropical Convergence Zone
LUCF	Land Use Change and Forestry
MSMEs	Micro, Small, and Medium Enterprises
NAIP	National Agriculture Investment Plan
NAP	National Adaptation Plan
NDA	National Designated Authority
NDC	Nationally Determined Contributions
OCP	Office Chérifien des Phosphates
OECD	Organisation for Economic Co-operation and Development
PIF	Policy Investment Framework
PHMS	Post Harvest Management Strategy
PHL	Post Harvest Losses
PSNP	Productive Safety Net Programme
RE-GAIN	Resilience and Food Security Gain Initiative
SCALA	Scaling up Climate Ambition on Land Use and Agriculture
SDG	Sustainable Development Goals
SME	Small and Medium Enterprises

SO	Strategic Objective
SSA	Sub-Saharan Africa
SSP	Shared Socioeconomic Pathways
TAAT	Technologies for African Agricultural Transformation
TNC	The Nature Conservancy
TANIPAC	Tanzania Initiative for Preventing Aflatoxin Contamination
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
USD	United States Dollar

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 Tanzania, maize and rice, two key crops, are significantly affected, with post-harvest losses reaching up to 36% for maize (APHLIS, African Post Harvest Loss Information System, 2024; Abass, et al., 2013) and between 12.3% and 15.7% for rice (APHLIS, African Post Harvest Loss Information System, 2024). These losses impact food security and economic stability in Tanzania. The country's rising temperatures, erratic rainfall, prolonged dry spells, and frequent and severe flooding exacerbate these food losses, jeopardizing the livelihoods of over 70% of the population employed in agriculture and threatening the national food supply (Rweyemamu, Mruma, & Nkanyani, Tanzania agricultural policy profile, 2024).

Given the significant impacts of climate change on post-harvest losses and the crucial role of agriculture in Tanzania's economy, the management of these losses, particularly for maize and rice, is essential for maintaining socio-economic stability. Agriculture is the backbone of Tanzania's economy, supporting livelihoods and contributing approximately 25% to the GDP and employing approximately 70% of the workforce (Rweyemamu, Mruma, & Nkanyani, Tanzania agricultural policy profile. CGIAR Initiative on Diversification in East and Southern Africa., 2024). Smallholder farmers, who manage 80% of the agricultural land, primarily cultivate maize and rice, among other crops. Maize is a staple crop integral to Tanzania's cuisine, largely used for human consumption and animal feed. Rice is a critical cereal crop for Tanzania, used for various food products, including staple meals, and is vital for reducing import dependency and ensuring food security. The country's agricultural activities are concentrated in regions such as Dodoma, Arusha, and Dar es Salaam, with distinct growing seasons: the Vuli (short rains) from October to December, the Masika (long rains) from March to May, and the dry season from June to September. Therefore, addressing the impacts of climate change through effective mitigation and adaptation measures in crop production, processing, and post-harvest management is crucial for ensuring socio-economic stability (Republic of Tanzania, 2014).

To support climate change adaptation, mitigation, and post-harvest food loss management efforts, Tanzania has developed several strategic policies and interventions. The National Postharvest Management Strategy (2019-2029) aims to combat post-harvest food loss by promoting awareness, adopting efficient technologies, and improving market access to minimize losses. The Agricultural Sector Development Programme Phase II (2017/18 – 2027/28) focuses on modernizing agriculture, enhancing infrastructure, and improving smallholder market access. The Agriculture Climate Resilience Plan (2014-2019) strengthens pest management, promotes conservation agriculture, and improves weather forecast dissemination to farmers. The Nationally Determined Contributions (2021) targets a substantial reduction in greenhouse gas emissions, emphasizing the agricultural sector's role in adaptation and resilience building. Additionally, the National Agriculture Policy (2013) and the Rural Development Strategy (2001) highlight the need for sustainable practices and the importance of reducing post-harvest losses through improved storage and infrastructure. While these policies aim to tackle the issues of adaptation, mitigation and post-harvest losses through various strategies, there are gaps and limitations in their implementation, funding, capacity, infrastructure and coverage that need to be addressed for more effective outcomes.

Gaining a more comprehensive understanding of the climate risks impacting Tanzania's agricultural sector is crucial for identifying suitable climate adaptation measures. The climate risks in Tanzania predominantly affect regions such as Dodoma, Manyara, and the Southern Highlands, including areas like Mbeya and Iringa (Masolele, et al., 2024). These regions are particularly vulnerable to climate change impacts, which include reduced crop yields, increased pest infestations, water insecurity and soil erosion. Specifically, climate risks such as increased temperatures, erratic rainfall, prolonged dry periods, and severe flooding significantly disrupt agricultural productivity. These adverse effects lead to heightened food insecurity, as they not only reduce the quantity and quality of crops like maize and rice but also threaten the livelihoods of the population heavily reliant on agriculture. Over the past decades, climatic changes in Tanzania have become more pronounced, with average temperatures increasing by 1°C from 1960 to 2006. This trend has accelerated in recent years, and future projections indicate further temperature rises of 1.5°C to 3°C by the 2050s, depending on the emissions scenario. By the 2080s, temperatures could increase by up to 4°C. Additionally, the number of hot days exceeding 35°C is expected to rise markedly, potentially reaching 20 to 30 days annually by 2040 (Future Climate Africa, 2017; USAID, 2018).. Rainfall patterns have shown substantial variability, with some regions experiencing a drying trend, while others see moderate increases in rainfall. Future projections suggest that the long rains (Masika) will become shorter and more intense, while the short rains (Vuli) may become less reliable. Extreme weather events, such as floods and droughts, are anticipated to become more frequent and severe, further impacting agricultural productivity and food security (Future Climate Africa, 2017; USAID, 2018). These projected trends underscore the urgent need for comprehensive climate adaptation and mitigation strategies in Tanzania.

The extent of these climate risks requires the implementation of adaptation measures to minimize post-harvest food losses. Maize cultivation relies on rainfed systems, making it highly vulnerable to climate variations. Rising temperatures and unpredictable rainfall patterns result in inconsistent maize yields. Projections indicate an average temperature increase of 1.4-2.3°C by 2050, with more frequent and intense heatwaves and dry spells (USAID, 2018). Rainfall is also expected to become more variable, with increased frequency and intensity of heavy rainfall events. These climatic changes are predicted to reduce national maize production by 8-13% by 2050 due to increased heat stress, drying conditions, soil erosion, and flood damage. The regions of Dodoma, Arusha, and Dar es Salaam are particularly at risk, with Dodoma projected to experience the largest yield reductions (Winter & Jang, 2017). Additionally, post-harvest losses are exacerbated increased temperatures and erratic rainfall, causing spoilage during drying and storage phases. Maize stored under inadequate conditions faces greater risks of mould growth, pest infestations, and spoilage, particularly during periods of high humidity and heavy rains. These losses will exacerbate food insecurity and translate into reduced income, and increase reliance on Maize imports, making the management of climate change adaptation measures critical to reduce harvest and post-harvest losses.

Similarly, rice is highly sensitive to climatic variations. Rice cultivation is highly dependent on water availability, is vulnerable to climatic variations such as temperature changes and precipitation patterns. These changes are predicted to reduce rice yields slightly by about 0.1% by 2050 (CCAFS, 2019). However, under extreme climate scenarios, yields might surge by 18% by 2080 due to the CO_2 fertilization effect (AGRICA, 2021). Despite these potential yield increases under extreme scenarios, the variability and unpredictability of rainfall, combined with the increased risk of floods and droughts, present significant challenges for rice production, particularly in regions like Morogoro, Mbeya, and Pwani, which are critical for rice cultivation (USDA, 2024). Post-harvest losses are exacerbated as these climatic conditions favour pests and diseases, leading to higher spoilage rates, and prolonged droughts can lead to poor grain quality. Therefore, climate adaptation measures specifically for the post-harvest management of rice are vital to mitigate the negative effects of drought and irregular rainfall on production.

Like adaptation, mitigation efforts are needed to minimize the negative effects of climate change on Tanzania's post-harvest losses. Tanzania's land use has undergone considerable changes, with nearly 48% of its total land area now used for agriculture. This expansion has come at the cost of wetlands and forests, leading to an average annual deforestation rate of around 0.97% (Yusuph, 2022).. The primary drivers of this deforestation include agricultural expansion, particularly for subsistence crops like rice and maize, and the production of charcoal and firewood, which are vital energy sources for over 90% of Tanzanian households. These changes have significantly impacted the country's landscapes and ecosystems.

Additionally, according to the GHG inventory developed by Tanzania, emissions are projected to increase significantly across key sectors under the business-as-usual (BAU) scenario by 2030 (The United Republic of Tanzania, 2021). The agriculture and land use sectors are pivotal, contributing approximately 62 million tonnes of CO_2e and 71 million tonnes of CO_2e respectively as of 2021 (Climate Watch, n.d.). Specifically, emissions related to food loss across the agricultural value chains for maize and rice are substantial. For instance, by 2032, the emissions associated with post-harvest losses for maize are expected to be around 1 031 835 tonnes CO_2e, while rice is projected to contribute 932 633 tonnes CO_2e (Porter, Reay, higgins, & Bomberg, 2016). These projections underscore the need for robust mitigation strategies. Tanzania's updated Nationally Determined Contributions (NDC) of 2021 targets an economy-wide reduction of approximately 153 $MtCO_2e$ in GHG emissions, emphasizing the importance of the agriculture and land use sectors, as well as management of post-harvest losses in achieving these goals (The United Republic of Tanzania, 2021).

Most of the emissions associated with post-harvest losses in Tanzania occur during the processing and on-farm storage stages of the agricultural value chain. For maize, these losses amount to approximately 851 645 tonnes of CO_2e, while for rice, they contribute about 807 651 tonnes of CO_2e. Significant losses and associated emissions arise from inefficient processing practices, poor storage conditions, pest infestations, and spoilage. For maize, the largest reported losses occur during the household storage phase, estimated at up to 10.5% of total production (APHLIS, African Post Harvest Loss Information System, n.d.), while for rice, the major losses occur during harvesting and drying, estimated at 4.4% of total production (APHLIS, African Post Harvest Loss Information System, 2024). Non-climatic factors contributing to post-harvest losses in Tanzania include inadequate storage facilities, poor handling and transportation methods, lack of market access, insufficient infrastructure, and limited access to modern technologies. These emissions contributions, make management of post-harvest losses more salient.

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, SME 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 Tanzania's maize and rice 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 Tanzania. 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.

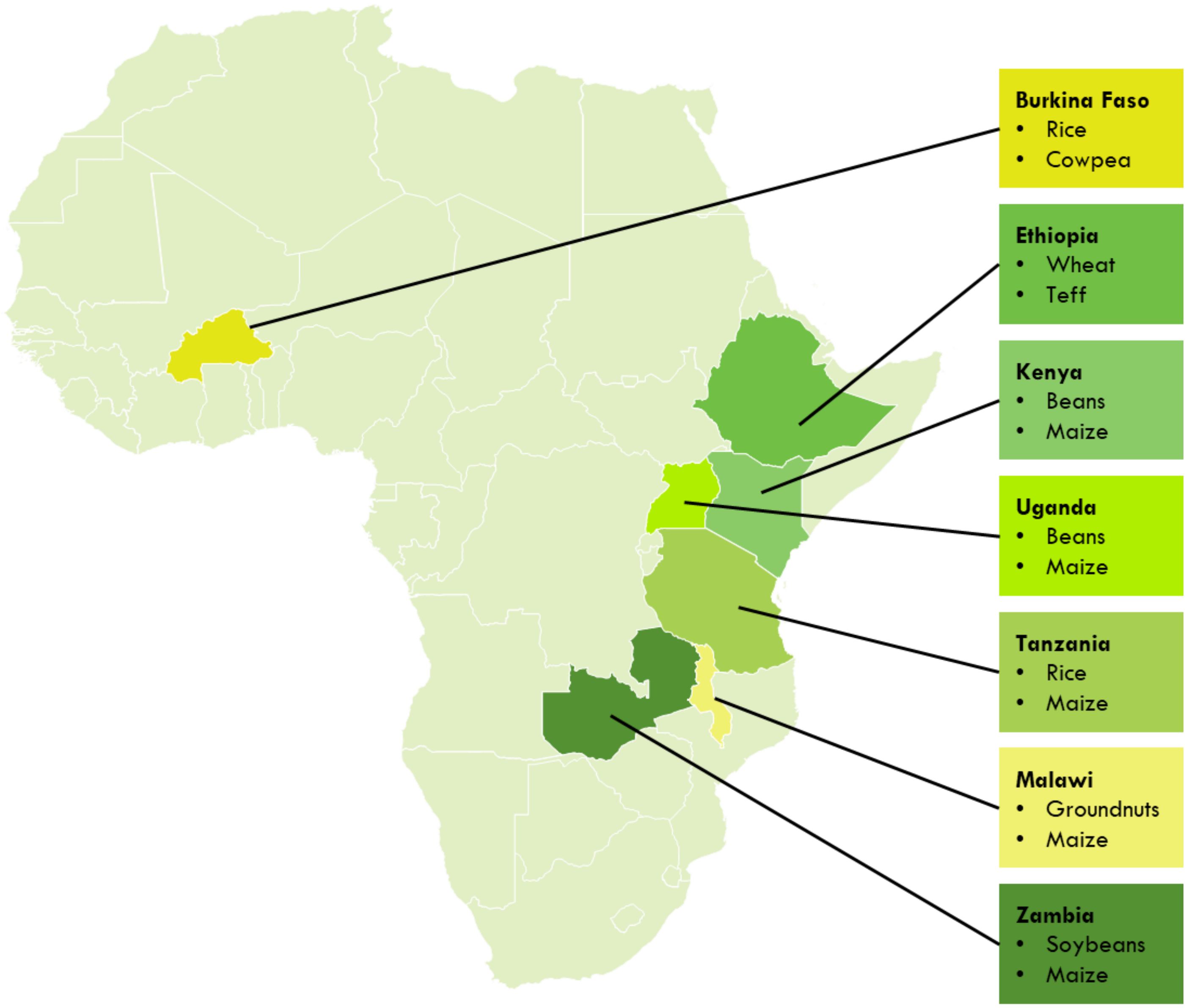


Figure 1-1 Focus Geographies for AGRA (2023-2027)

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

Tanzania covers an area of approximately 945.087 square km, making it the 13th largest country in Africa. Country includes both mainland Tanzania and the Zanzibar Archipelago, consisting of Zanzibar and Pemba islands (Ministry of Foreign Affairs and East African Cooperation, The United Republic of Tanzania, 2024).

A significant proportion of Tanzania's land area is utilized for agricultural activities (Figure 2-1), with cropland accounting for 44.62% of the country's land area, 24% of which is being utilized for cropland cultivation. Agriculture is a vital sector in Tanzania's economy, contributing approximately 25% of GDP and 85% of exports (AECF, 2022). The sector is the primary economic activity for 70% of Tanzanian households, and 75% of all jobs in the country are within the agricultural sector (Rweyemamu, Mruma, & Nkanyani, Tanzania agricultural policy profile, 2024).

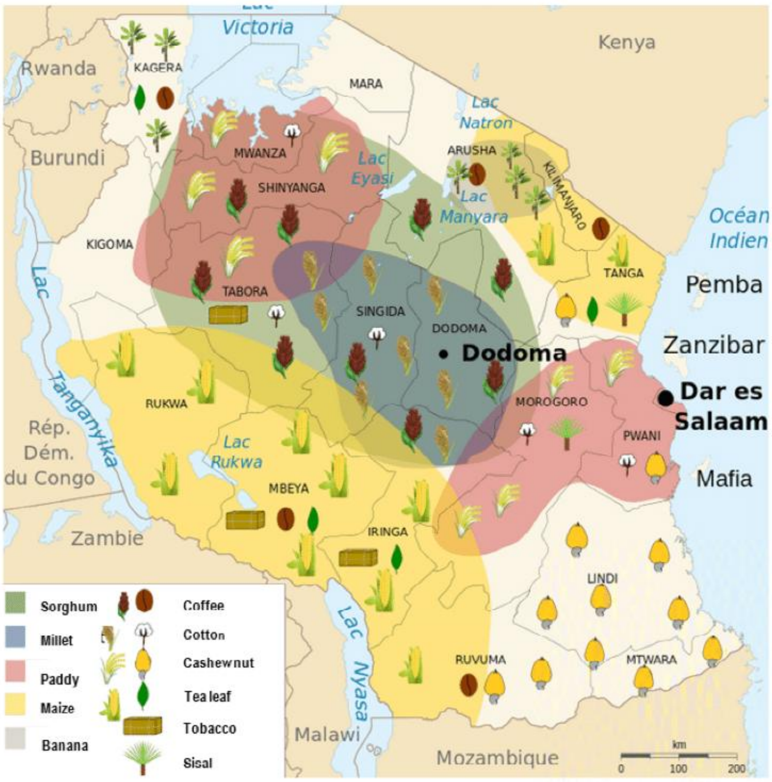


Figure 2-1 - Agricultural map of Tanzania

Notably, up to 80% of all agricultural produce comes from smallholder farmers, who play a crucial role in the country's agricultural sector, cultivating a diverse range of crops (United States of America, Department of Commerce, 2022). On average, smallholder farmers in Tanzania own and cultivate small plots of land, typically ranging from 0.5 to 2 hectares. Land tenure varies, with many farmers holding customary rights rather than formal titles. The great majority of Tanzania's farming systems are rainfed small scale farms. Small-scale farming, typically characterized by mixed crop–livestock systems and partial commercial production, occupies approximately one-third of the country's land area.

The majority of Tanzania's smallholder farmers largely practice subsistence farming, growing crops predominantly for their own consumption, with any surplus sold in local markets. Intercropping is common, allowing them to maximize land use and reduce risks associated with crop failure. Farming activities are predominantly manual, relying on family labour, with limited use of machinery (Rweyemamu, Mruma, & Nkanyani, Tanzania agricultural policy profile, 2024).

The agricultural landscape of Tanzania consists of a variety of staple foods, with maize being the main staple, followed by rice, sorghum, millet, pulses, cassava, and bananas (Rweyemamu, Mruma, & Nkanyani, Tanzania agricultural policy profile, 2024). More specifically, up to 80% of maize is produced by smallholders, and it is responsible for roughly 40% of all calorific consumption in Tanzania.

Forming part of both the East Africa Community (EAC) and the Southern African Development Community (SADC), Tanzania holds a significant position in the regional trade of essential staples across the ESA region (Rweyemamu, Mruma, & Nkanyani, Tanzania agricultural policy profile, 2024). It typically produces an excess of staple cereals and pulses, exporting substantial amounts of these goods to nearby countries such as Kenya, Malawi, Zambia, Uganda, Rwanda, Burundi, and the Democratic Republic of Congo (Famine Early Warning Systems Network, 2018). The observed domestic surplus in staples is owed to the Rukwa, Mbeya, Njombe and Ruvuma regions.

Between 2013 and 2018, Tanzania consistently observed a food surplus ranging from 120% to 125% (Ministry of Agriculture, United Republic of Tanzania, 2019). Nationally, 11 regions achieved a high self-sufficiency ratio, with production exceeding local needs by 128-227%, while seven regions were self-sufficient (109-119%). However, eight regions experienced significant deficits (3-99%) and required external support.

In 2022, Tanzania's agriculture, forestry, and fisheries sector contributed 27% to national GDP as of December 2023 (Trading Economics, 2023)**. The crop subsector is the largest contributor of Agriculture's GDP. As of 2022 the subsector contributed 15.4% towards national GDP,** growing at an annual rate of 5% with a target of 5.7% by 2026 (The United Republic of Tanzania, 2022). Tanzania's agricultural sector **experienced a 3.3% growth in value added as a percentage of GDP. This is a slight decline from the 3.7% growth recorded in 2021** (World Bank, 2023). The reduction is attributed to erratic and poorly timed rains in specific areas, leading to droughts and floods. Additionally, the region's agricultural growth is hindered by low land productivity, limited access to financial services, ineffective agricultural technical support, and underdeveloped infrastructure (Famine Early Warning Systems Network, 2018).

Tanzania's climate varies from tropical along the coast to temperate in the highlands. The coastal regions experience high humidity and warm temperatures, while the inland areas can be more temperate or even cool at higher altitudes. The prevalence and impact of climate change in the country are evident and significant. Recent climate analyses indicate a concerning pattern of declining yearly rainfall, with an average decrease of 2.8mm per month (3.3%) per decade. The most notable reductions in rainfall have occurred in the southern regions of Tanzania. Subsequently, the mean yearly temperature in Tanzania has increased by 1.0^{0}C since the year 1960 (Climate Action Network (CAN), 2020).

Although other staple crops such as millet may be more resilient in low rainfall conditions, dietary preferences of the local population favour maize. Maize is also relatively easy to grow in varied geographies compared to rice, another favoured staple. Maize covers approximately 70% of the land planted with arable crops, compared to that of rice which covers approximately 17% (AECF, 2022).

The effects of climate change on agriculture in Tanzania are both considerable and severe, especially at the local level. Rising temperatures and erratic rainfall patterns have disrupted traditional planting seasons and impeded crop growth, resulting in a notable reduction in agricultural productivity. Extended drought periods have become more frequent, exacerbating water scarcity issues for both crops and livestock. The increased prevalence of pests and diseases has further strained crops such as maize, rice, and wheat. Additionally, climate-related hazards like floods and storms have inflicted significant damage on agricultural lands, infrastructure, and storage facilities, leading to substantial post-harvest losses. These adverse climate impacts not only pose a significant threat to food availability but also jeopardize the livelihoods of millions of Tanzanian farmers. Therefore, it is crucial to swiftly implement climate-resilient agricultural practices and policies to mitigate these effects (Climate Action Network (CAN), 2020).

Post-harvest food losses significantly impact food security in Tanzania. Tanzanian smallholder farmers lose up to 40% of their harvests due to poor handling and storage methods. Postharvest losses are of particular concern for grains, especially cereal and pulses which form the base for food and income for the majority (Ministry of Agriculture of Tanzania, 2019). Post-harvest food losses in Tanzania occur at various stages of the supply chain, with the highest losses observed during storage (30%) and harvesting (20%). The primary causes include inadequate storage facilities, poor handling and transportation conditions, and inefficiencies in harvesting and processing techniques. These losses occur throughout the year but are exacerbated during the rainy season and specific market days. Addressing these issues through improved storage solutions, better handling practices, and enhanced infrastructure is crucial for reducing food losses and improving food security in Tanzania (Ministry of Agriculture of Tanzania, 2019). These losses directly affect farmer incomes, as they make up a significant portion of their potential revenue is lost.

Maize and rice are chosen as the primary focus of this study due to their significant roles in Tanzania's agricultural landscape and food security. Key crops were identified by expert assessment, supported by AGRA and the National Designated Authority (NDA) of each target country. Two crops per target country under AGRA's portfolio were selected 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. 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.

2.2 TRENDS OF LAND USE CHANGE

Since 2010, Tanzania has undergone significant land use changes, largely driven by agricultural expansion, deforestation, urbanization, and growing population. These transformations have substantial environmental and socio-economic impact, altering landscapes and livelihoods (Msofe, Sheng, & Lyimo, Land Use Change Trends and Their Driving Forces in the Kilombero Valley Floodplain, Southeastern Tanzania., 2019).

Overall, nearly 48% of Tanzania's total land area is now used for agriculture. Of this, 78% consists of meadows and pastures, while the remaining 22% is devoted to agriculture, with 21% as arable land and 1% as permanent crops. The key agricultural regions are situated in the Central, Western, and Rift Valley areas (World Bank, CGIAR, CIAT, 2015).

Since 1990, there have been an extensive agricultural land area expansion in some regions like the Kilombero Valley. On average, the agricultural land and grassland increased by 11.3% and 13.3%, respectively, while the floodplain wetland area decreased from 4.6% to 0.9% (Msofe, Sheng, & Lyimo, Land Use Change Trends and Their Driving Forces in the Kilombero Valley Floodplain, Southeastern Tanzania., 2019). This expansion is primarily for subsistence crops such as rice and maize. Similarly, the Wami River Basin has seen extensive changes, with grasslands, bushlands, and woodlands being converted to cultivated land to meet the demands of a growing population and increased agricultural production (Twisa, Mwabumba, Kurian, & Buchroithner, 2020).

Deforestation, as a result of agricultural expansion, has significantly impacted Tanzania's landscapes. The country has lost about 8 million hectares of forest between 1990 and 2010, representing 19% of its forest cover. This translates to an average annual deforestation rate of around 0.97%. The Kilombero Valley, for example, has experienced substantial forest loss, leading to the degradation of wildlife habitats and a decline in biodiversity (Geowetlands, 2020). The Miombo woodlands, a significant forest type in Tanzania, shrunk by 13% between 1990 and 2000. Coastal forests and mangrove areas have also faced severe deforestation, with some regions experiencing up to 70% loss by the mid-1990s. Besides the agricultural expansion, charcoal and firewood production also significantly contribute to forest degradation, as over 90% of Tanzanian households rely on wood for energy (Yusuph, 2022).

Wetlands also have been heavily impacted by land use changes. The conversion of wetlands to agricultural land has significantly reduced floodplain areas, disrupting ecological balances and reducing the provision of ecosystem services. This transformation affects not only biodiversity but also the livelihoods of communities that depend on these ecosystems (Msofe N. K., 2019).

Finally, urbanization and the expansion of infrastructure have further driven land use changes in Tanzania. Improved road networks and market access facilitate agricultural expansion but also lead to habitat fragmentation and increased human-wildlife conflicts (Leah Worrall, 2017).

2.3 NATIONAL AND SECTORAL POLICY LANDSCAPE

Tanzania places a significant emphasis on the importance of its agricultural sector, acknowledging its pivotal role in both the economy and the livelihoods of its citizens. Several long- and mid-term development strategies and policies define current agricultural challenges and priorities in the country, including:

- ***Tanzania Development Vision 2025 (TDV 2025)*** - document that sets forth the long-term vision for the development of Tanzania. It provides guidance for the overall national goals and sets up the goal of ensuring food self-sufficiency and food security.
- ***Tanzania Long Term Perspective Plan (LTPP) 2011-2021*** is a strategy roadmap that emphasizes the long-term development outlook within certain timeframes.
- ***National Strategy for Growth and Reduction of Poverty II (NSGRP II 2010),*** among other priorities, emphasizes the importance of management of post-harvest losses.
- ***Third National Five-Year Development Plan (FYDP III; 2021/22 – 2025/26)*** outlines precise developmental objectives and strategies for a five-year period, offering a systematic way to achieving short to medium-term targets.

More specifically, the following are considered key strategies and policies related to the agricultural landscape of Tanzania.

Rural Development Strategy (2001) (United Republic of Tanzania. Prime Minister's Office, 2001) **targets reduction of post-harvest losses and emphasize the lack of appropriate storage technologies and sufficient infrastructure**. It also acknowledges that climatic changes compounded with poor agricultural technologies result in poor harvests, negatively impacting the livelihoods of rural households. According to the strategy, many rural Tanzanian households are exceptionally vulnerable to adverse shocks because they lack most agricultural technologies (irrigation, pesticides, disease and drought resistant crop varieties), increasing their exposure to weather related risks, pests, and plant diseases. Additionally, the strategy notes that rural households have minimal savings and limited access to financial instruments designed to stabilize income and reduce risks to climate volatility, making them highly susceptible to harvest failures and market price fluctuations.

Agricultural Sector Development Programme Phase II (ASDP II 2017/18 – 2027/28) (The United Republic of Tanzania. Ministry of Agriculture, 2018) **focuses on modernizing agriculture, improving infrastructure, and enhancing market access for smallholders, that would result in increased smallholder farmer incomes as well as food and nutrition security.**

Agricultural Sector Development Strategy (ASDS II 2015/2016 – 2024/2025) (Ministry of Agriculture Food Security and Cooperatives of Tanzania, 2015) **highlights the importance of farm mechanization, especially for land preparation, planting and harvesting, as one of the elements for the agriculture sector's commercialization.** It acknowledges low productivity as one of the weaknesses of Tanzania's agricultural sector, starting from seed, input like fertilizer and pesticide, watering, harvesting, drying and other processing by farmers and other stakeholders including traders and processors. It encourages expanded and inclusive private sector-driven value chain development and integration, facilitated by expanded land use models, effective and viable public-private partnerships, and expanded rural infrastructure (especially small-scale irrigation, post-harvest facilities and rural feeder roads) that would contribute to much needed expanded off-farm employment opportunities. It also emphasizes the importance of collaboration with the private sector on mechanization promotion through demonstrations of modern technology (tractors, power-tillers, harvesters, etc.).

ASDP II Communication Strategy (2020 - 2028) (The United Republic of Tanzania, Prime Minister's Office, 2020) **identifies postharvest management as one of the key value chain areas.** Solutions to reduce post – harvest losses are considered, as well as facilitation to access harvesting, storage and transportation techniques and information, reduction of commodity, affordable postharvest handling technologies and tax incentives on storage facilities (hematic bags, pack house, milk storage facilities etc.) as some of the strategic interventions. Besides that, among of the key information needs of smallholders, it lists Information on appropriate and affordable post -harvest technologies; knowledge and skills on post -harvest management of specific commodity Information on appropriate transportation means; cost/price for the technology; production information; Information on modern storage facilities available; and available information about tax incentives.

National Agriculture Policy (2013) (Ministry of Agriculture, Food Security and Cooperatives of Tanzania, 2013) **delineates strategies to boost productivity, ensure food security, and enhance the socio-economic conditions of farmers.** The policy underscores the importance of sustainable practices and the adoption of technology.

The *Agriculture Climate Resilience Plan (2014–2019)* (Ministry of Agriculture, Food Security and Cooperatives of Tanzania, 2014)***, outlines strategic interventions to enhance agricultural resilience***. Key initiatives include strengthening integrated pest management techniques, promoting indigenous knowledge practices, agro-forestry systems, minimum tillage, efficient fertilizer use, and conservation agriculture technologies. The plan emphasizes the importance of improving weather forecast information sharing with farmers, enhancing agro-infrastructural systems (including input, output, marketing, and storage), and strengthening post-harvest processes to promote value addition.

Tanzania's updated *Nationally Determined Contributions (NDC) of 2021* (Vice President's office, The United Republic of Tanzania, 2021), targets an economy-wide reduction of approximately 153 $MtCO_2e$ in greenhouse gas emissions. The agriculture and land use sectors are pivotal to achieving this goal. The NDC identifies the agricultural sector as a significant contributor to emissions while highlighting opportunities for reduction. Key adaptation priorities in agriculture include improving the utilization of land and water resources, increasing productivity, promoting resilience at the smallholder farm level, and strengthening extension services. These objectives align with the food loss reduction project, supporting sector-wide adaptation and mitigation goals.

In terms of environmental and climate change challenges, the following documents define Tanzania's vision and strategic development goals:

- National Environment Policy (NEP 2021)
- National Master Plan for Strategic Environmental Interventions (2022 – 2032)
- National Environment Policy - Implementation Strategy (NEP 2021)
- Nationally Determined Contribution (NDC 2021)
- National Climate Change Strategy (2012-2018)
- National Climate Change Communication Strategy (2012-2017)

- National Climate Change Response Strategy (2021-2026)
- National Environmental Action Plan (2013)
- National REDD+ Strategy (2013)
- Zanzibar Climate Change Strategy (2014)

Specifically in terms of post-harvest losses management, the Government of Tanzania prepared its first ***National Postharvest Management Strategy (PHMS) (2019 - 2029)*** (The United Republic of Tanzania, Ministry of Agriculture, 2019) and respective ***Postharvest Management Strategy - Implementation Plan (2019–2024)*** (The United Republic of Tanzania, Ministry of Agriculture, 2019)**.**

The *National Postharvest Management Strategy (PHMS) (2019 - 2029)* (The United Republic of Tanzania, Ministry of Agriculture, 2019) **addresses the causes of food losses and outlines strategic objectives and management interventions to combat post-harvest food loss in Tanzania.** The strategy focuses on raising awareness about post-harvest management to improve efficiency and reduce crop losses along the value chain. It advocates for the availability, accessibility, affordability, and adoption of proven technologies and processes to mitigate post-harvest losses. Additionally, it emphasizes the need to enhance agricultural marketing systems to improve market access and minimize losses. The strategy promotes research and innovation in new technologies and methods to reduce crop losses and calls for the review and implementation of legislation to ensure compliance with standards and best practices. Strengthening institutional capacity, coordination, partnerships, and stakeholder participation among post-harvest management actors is highlighted to support the implementation of strategic interventions. The strategy also underscores the importance of adapting post-harvest management systems to mitigate climate change effects and addressing financing inadequacies. Finally, it recommends developing a standard methodology for collecting data and estimating post-harvest losses nationwide.

The mission **of the *Tanzania's National Postharvest Management Strategy Implementation Plan (2019–2024) (NPHMS)*** (Ministry of Agriculture of Tanzania, 2019) **is to enhance post-harvest management by ensuring the availability of appropriate practices and technologies, providing incentives for investment in marketing systems, and improving the capacities and coordination of strategic interventions.** The NPHMS outlines strategic objectives to comprehensively address post-harvest management issues. These include raising awareness of post-harvest management to improve efficiency and reduce crop losses along the value chain, and promoting the availability, accessibility, affordability, and adoption of tested technologies and processes to mitigate post-harvest losses. Another key objective is to enhance agricultural marketing systems to improve market access and minimize losses. The strategy emphasizes the promotion of research and innovation in new and appropriate technologies and methods to reduce crop losses. It calls for reviewing and implementing legislation to ensure compliance with standards and best practices to minimize post-harvest losses. Strengthening institutional capacity, coordination, partnerships, and stakeholder participation among post-harvest management actors is highlighted to support the implementation of strategic interventions. Adapting post-harvest management systems to mitigate the effects of climate change and addressing financing inadequacies are also crucial objectives. Lastly, the strategy recommends developing a standard methodology for collecting data and estimating post-harvest losses nationwide.

2.4 LEGAL AND REGULATORY LANDSCAPE

Tanzania's Climate-smart Agriculture (CSA) Guideline (Ministry of Agriculture, Livestock and Fisheries of Tanzania, 2017) **is a step towards achieving global and national goals of sustainable agriculture production in a changing climate.** The main objectives of the Guideline are to:

- Guide the identification of suitable technologies and practices for successful implementation of CSA to enhance agricultural production.
- Guide in the identification of approaches and crucial requirements for successful CSA implementation.
- Facilitate planning for the implementation and scaling up of CSA.
- Inform policymakers to formulate policies, regulations, programs, and related incentives for CSA implementation and scaling up.
- Guide development actors, extension services, research institutions, and the private sector to promote CSA practices and technologies.
- Create awareness, build knowledge, and enhance capacity on CSA as an approach for climate change mainstreaming and environmental management in the agriculture sector.
- Monitor CSA implementation.

This Guideline is based on an inclusive multi-level approach (i) gender-responsive approach; (ii) community-based approach; (iii) farmer-cantered research, learning, and training approach.

Different strategies are employed to adapt to the changing climate and, although they vary from place to place, generally they include early land preparation, early planting, dry planting, planting of drought tolerant crops, planting of early maturing crops, mulching, irrigation, tree planting, and the use of indigenous knowledge. Other strategies include replanting, intercropping, crop rotation, minimum tillage, use of water harvesting pits, digging irrigation trenches, and terracing (Ministry of Agriculture, Livestock and Fisheries of Tanzania, 2017). Livestock farmers adapt by growing grasses and perennial fodders, using farm by-products, and doing additional activities such as crop farming.

In addition to farmer initiatives, extension agents build the capacity of farmers to adapt to climate change impacts by promoting the use of improved seeds, and adoption of improved agricultural practices that conserve soils and water, ridging, and agroforestry. In livestock production, extension agents promote the use of improved livestock breeds, improved livestock management, artificial insemination, milk value addition, improved fodder, and supplemental feeding of concentrates. Agents have been training farmers through Farmer Field Schools (FFS), demonstrations, studies, visits, and exhibitions.

Identified practices that need to be implemented to reduce the impact of climate change in agriculture are (i) enhancement of climate information services; (ii) improved cooking stoves for the efficient conversion of energy from biomass to heat; (iii) improved post-harvest to reduce food losses and improve food safety (Ministry of Agriculture, Livestock and Fisheries of Tanzania, 2017).

2.5 GCF COUNTRY PROGRAMME DETAILS

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

The Green Climate Fund (GCF) in Tanzania is implementing 8 projects (Table 2-1), with a total GCF financing of 284.4 million USD. It has approved so far 2 country level readiness activities, with a total budget of 3.3 million USD readiness support approved, and 2.4 million USD readiness support disbursed.

Table 2-1 – GCF Portfolio in Tanzania (GCF, 2024)

Project code	Focus	Geographical scope	Project title

FP223	Cross-cutting	Asia-Pacific, Africa, Latin America and the Caribbean (19 countries)	Project GAIA ("GAIA")
FP220	Adaptation	Africa (Kenya, Tanzania, Rwanda, Uganda)	Africa Rural Climate Adaptation Finance Mechanism (ARCAFIM) for East Africa region
FP218	Adaptation	Tanzania	Building climate resilience in the landscapes of Kigoma region, Tanzania
FP179	Adaptation	Tanzania	Tanzania Agriculture Climate Adaptation Technology Deployment Programme (TACATDP)
FP122	Adaptation	Africa (Madagascar, South Africa, Mozambique, Tanzania)	Blue Action Fund (BAF): GCF Ecosystem Based Adaptation Programme in the Western Indian Ocean
FP095	Cross-cutting	Africa, Latin America and the Caribbean (17 countries)	Transforming Financial Systems for Climate
FP041	Adaptation	Tanzania	Simiyu Climate Resilient Project
FP027	Mitigation	Africa (Benin, Kenya, Uganda, Nigeria, Ethiopia, Namibia, Tanzania)	Universal Green Energy Access Programme (UGEAP)

Of specific relevance for the agriculture sector in Tanzania are the projects: FP220 "Africa Rural Climate Adaptation Finance Mechanism (ARCAFIM) for East Africa region", FP218 "Building climate resilience in the landscapes of Kigoma region, Tanzania", and FP179 "Tanzania Agriculture Climate Adaptation Technology Deployment Programme (TACATDP)".

FP220: "In East Africa, climate models predict a continual rise in average temperatures and an increase in the frequency and intensity of heavy rainfall events. This places significant pressure on the region's farmers, as they will grapple with worsening conditions for crop production and livestock keeping. However, progress in developing more sustainable agricultural processes has been slow, as farmers in Kenya, Uganda, Tanzania, and Rwanda lack access to the necessary funding for Climate Change Adaptation (CCA) investments. There is an urgent need for private sector CCA finance to spearhead long-term, market-driven change" (GCF, 2024).

"The ARCAFIM programme, launched in 2023, strives to introduce a practical and widely applicable financing model to mobilise private sector investments for rural CCA initiatives in East African micro, small, and medium-sized enterprises (MSMEs) and smallholders involved in the food systems. These MSMEs and smallholders have the potential to drive sustainable, long-term changes in response to market needs. The programme supports climate adaptation for smallholders and MSME by crowding in international and local financing, including from regional commercial banks and local financial institutions. The programme model can serve as proof-of-concept to be replicated in other regions, offering potential to make a significant impact on private sector financing for rural CCA projects on a broader scale" (GCF, 2024).

FP218: "The project has an estimated lifespan of 6 years (2023-2029). In the Republic of Tanzania's Kigoma Region, climate data show more frequent and unpredictable periods of heavy rainfall causing an increase of flood events. Dry spells are also expected to increase in frequency and severity. Coupled with the rise in average temperatures, this puts immense pressure on Kigoma's already limited surface water resources. Consequently, both the refugee and host communities in the area face significant threats to their livelihoods since they rely on rainfall to deliver ecosystem goods and services. Given the existing humanitarian and environmental challenges in the region, Kigoma lacks the necessary tools and resources to effectively tackle climate challenges" (GCF, 2024).

"This project bridges the gap between efforts in development, humanitarian, and climate by adopting an integrated landscape-level approach that addresses the distinct climate adaptation requirements of both host communities and refugees residing in Kigoma. The key components of the project span from creating land use plans, rehabilitating degraded ecosystems to mainstreaming climate change adaptation measures into the region's developmental plans and policies. Directly benefitting over half a million of the most-vulnerable people, the project will ensure the long-term sustainability of the communities through clear land-use demarcation, increased provision of ecosystem services and land productivity, increased water availability for irrigation during dry periods and improved food security through improved crop production" (GCF, 2024).

FP179: "Agriculture is essential to Tanzania's economy and the livelihoods of its people, accounting for 27% of its gross domestic product (GDP) and 67% of jobs. However, the agriculture sector is particularly vulnerable to the adverse effects of climate change, including extreme weather events. Climate change and changing temperature patterns have already contributed to a decline in agricultural productivity and to the share of the sector's contribution to national economic growth – losses that are being exacerbated by weather-related risks. With agriculture playing an integral role in the lives of the country's most marginalized and vulnerable populations – 80-90% of agricultural land is held by smallholder farmers and 98% of economically active rural Tanzanian women are engaged in farming – the adverse effects of climate change will disproportionately harm those groups and hamper the country's sustainable development" (GCF, 2024).

"This programme has a lifespan of 7 years (2021-2027) and will strengthen resilience of Tanzania's agriculture sector by facilitating access to agriculture climate adaptation technologies. This will be achieved by establishing a lending and de-risking facility that will make these technologies affordable to local farmers and agricultural enterprises, accompanied by technical assistance and support from government authorities. The project will also strengthen awareness of climate threats and risk-reduction processes among government, industry actors and the financial sector" (GCF, 2024).

2.5.2 Other relevant projects (on food losses)

The Ministry of Agriculture of Tanzania is currently running several projects and programmes specifically focused on post-harvest food losses. Those are:

Tanzania Initiative for Preventing Aflatoxin Contamination (United Republic of Tanzania, 2019).

The TANIPAC project aligns with the Tanzania Development Vision 2025 (TDV 2025), which prioritizes the agriculture sector. This project aims to reduce aflatoxin contamination in maize and groundnut food chains through an integrated approach. The anticipated outcomes include enhanced food safety, improved food and nutrition security, better health for communities, increased agricultural productivity, and enhanced trade. The project comprises three main components:

- Infrastructure Development for Prevention of Pre- and Post-Harvest Contamination.
- Awareness Creation and Institutional Strengthening.
- Project Coordination and Management.

The specific objectives of the TANIPAC project are to:

- Improve pre- and post-harvest infrastructure, technology, and management.
- Increase public awareness of health risks and malnutrition related to aflatoxin and boost private sector participation in mitigation measures.
- Strengthen institutional capacity to develop value chains for safe and nutritious foods and create innovative marketing incentives.

The project targets all stakeholders in the maize and groundnut value chains. It aims to directly benefit approximately 60 000 farmers, 120 extension and technical staff, 400 youth, 2 000 traders and transporters, and 2 000 small and medium enterprises (SMEs) involved in food processing. Seed and agricultural input traders, as well as research institutes, will also benefit from the project. Indirectly, the entire population of Tanzania will benefit as the project aims to reduce aflatoxin contamination in staple foods, thereby improving public health nationwide.

Agri-Connect (The United Republic of Tanzania Ministry of Agriculture, 2021)

AGRI-CONNECT is an EU-funded programme aimed at fostering inclusive economic growth, promoting private sector development, and creating jobs in the agricultural sector, while also enhancing food and nutrition security in Tanzania. Agriculture plays a pivotal role in Tanzania's industrialization efforts, as outlined in the Government's Five-Year Development Plan, the Agricultural Sector Development Plan Phase Two (ASDP II), and the Zanzibar Agricultural Sector Development Programme (ZASDP). Boosting agricultural productivity is crucial for the country's industrialization and job creation. AGRI-CONNECT is closely aligned with the government's priorities as detailed in ASDP II and ZASDP.

Agricultural Sector Development Programme Phase II (ASDP II) (The United Republic Of Tanzania, 2024)

The Agriculture Sector Development Programme II (ASDP II) is a ten-year initiative divided into two five-year phases, with the first phase spanning from 2017/2018 to 2022/2023. This programme follows ASDP I, which was implemented from 2006/2007 to 2013/2014.

ASDP II aims to transform the agricultural sector, including crops, livestock, and fisheries, towards higher productivity, increased commercialization, and improved smallholder farmer income. The ultimate goals are to enhance livelihoods, ensure food and nutrition security, and boost GDP contribution. The strategy focuses on gradually converting subsistence smallholders into sustainable commercial farmers by enhancing sector drivers, increasing productivity of target commodities within sustainable systems, and establishing market linkages for competitive surplus commercialization and value chain development.

Agriculture is a cornerstone of Tanzania's socio-economic growth, with smallholder farmers, including those in livestock and fisheries, accounting for over 90% of cultivated land. The sector provides approximately 77.5% of employment, supports more than 70% of the population, contributes 29% to GDP, 30% to exports, and supplies 65% of inputs to the industrial sector (URT 2014). In 2016/17, the sector's contribution to GDP was 29.1%, up from 23% in 2014 (FYDP 2015/16), and it provided 65.5% of employment (NBS 2017). However, food self-sufficiency declined to 123% from 125% (2014/15), partly due to rainfall scarcity among other factors.

The Southern Agricultural Growth Corridor of Tanzania (SAGCOT, 2024)

The SAGCOT was established at the World Economic Forum (WEF) Africa Summit in Dar es Salaam in 2010, is a Public-Private Partnership aimed at transforming agriculture over a 20-year period ending in 2030. Its primary goals are to enhance agricultural productivity, improve food security, reduce poverty, and ensure environmental sustainability through the commercialization of smallholder agriculture. SAGCOT aims to attract investments and boost agricultural productivity in southern regions, aligning with the "Kilimo Kwanza" initiative, which prioritizes agriculture in national development. This initiative emphasizes private sector involvement, technology adoption, and increased agricultural productivity.

An important project under this initiative is the partnership in Tanzania for the maize component of the Yield Wise Food Loss Reduction Initiative (YWS), implemented by AGRA and supported by the Rockefeller Foundation between 2016 and 2019.

One notable initiative is the **Tuhifadhi Chakula ("Let's Save Food") project**, launched by USAID in collaboration with the Tanzania Horticulture Association and the Southern Agricultural Growth Corridor of Tanzania (SAGCOT). This $24 million, five-year project aims to reduce food loss and waste, thereby enhancing food security, improving livelihoods, creating jobs, and opening export opportunities. The project involves various stakeholders, including farmers, traders, and processors, and aligns with Tanzania's National Post-Harvest Management Strategy to tackle post-harvest losses across several regions (Arusha, Morogoro, Mbeya, Pwani, Njombe, Tanga, and Zanzibar) (Tanzania Invest, 2023).

Tanzania Agrodealer Strengthening Program (TASP) (CNFA, 2024)**:**

The Tanzania Agrodealer Strengthening Program (TASP), launched in 2007 by the international non-profit organization Cultivating New Frontiers in Agriculture (CNFA), aims to enhance the distribution and access to agricultural inputs, services, and marketing for smallholder farmers. The programme has trained and certified over 2.600 agrodealers, facilitating the sale of 214.867 metric tonnes of inputs and securing $3 million in direct trade credit for agrodealers. TASP plays a critical role in improving agricultural productivity and market access by empowering local agrodealers and integrating smallholder farmers into the broader agricultural value chain.

Grameen Foundation (Grameen Foundation, 2024)**:**

The Grameen Foundation has launched initiatives in Tanzania to support smallholder farmers by enhancing their access to finance, agricultural inputs, and training. One of their key projects involves a digital toolkit that provides a unique digital savings plan for inputs and tailored farming advice. This initiative addresses critical challenges faced by farmers, including financial access, input availability, and the need for agricultural knowledge, ultimately aiming to improve productivity and livelihoods for smallholder farmers in poor areas.

3 Climate analysis - Adaptation

3.1 COUNTRY CLIMATE CHANGE BASELINE

According to the Köppen climate classification, Tanzania has several distinctly identifiable climate regions in its landscape. These include the Hot/warm Semi-Arid Climate (Bsh), Tropical Savanna Climate (Aw), Tropical Monsoon Climate (Am), Hot-summer Mediterranean Climate (Csa) and Warm-Summer Mediterranean Climate (Csb) (Climate Data, n.d.).

The geographical landscape of Tanzania can be classified into four main zones based on elevation and rainfall patterns (Republic of Tanzania, 2014). The Lowland Coastal Zone extends from sea level to 1 000 meters and is characterized by consistently wet conditions, receiving annual rainfall between 1,000 to 1,800 mm. The Highlands Zone includes the Northeastern and Southern Highlands, acting as significant catchment areas with high rainfall averaging up to 2,000 mm annually. The Plateau Zone comprises regions surrounding Lake Victoria and much of the West, characterized by predominantly dry conditions with an average rainfall of approximately 600 mm. Lastly, the Semi-Arid Zone, located in the central regions of the country, receives minimal rainfall, typically less than 600 mm annually. It is characterized by two main rain seasons namely the long rains *(Masika)* and the short rains *(Vuli)* which are associated with the southward and northward movement of the Inter-Tropical Convergence Zone (ITCZ). The long rains begin in the middle of March and end at the end of May, while the short rains begin in the middle of October and continue to early December (Republic of Tanzania, 2014). The majority of the country experiences rainfall below 1,000 mm annually, except for the highland areas and some parts of the far southern and western regions where rainfall ranges from 1,400 to 2,000 mm. In the central regions, the average annual rainfall is approximately 600mm.

Temperature fluctuates based on geographical factors such as location, terrain, and elevation. Along the coast and offshore islands, the average temperature typically falls between 27°C and 29°C, whereas in the central, northern, and western regions, temperatures vary from 20°C to 30°C. The highest temperatures are usually recorded from December to March, while the coolest months are June and July. In the Southern Highlands and mountainous regions of the north and northeast, nighttime temperatures may occasionally drop below 15°C, with sub-zero temperatures also possible during the colder months of June and July (Republic of Tanzania, 2014).

Historical trends suggest that climate change has already influenced an increase in average temperatures. The main observed trends over this period, include (Future Climate Africa, 2017; USAID, 2018):

- Increased average temperature of 1°C (1960– 2006);
- Rainfall patterns in Tanzania exhibit significant variability, with notable differences in both the amount of rainfall and the timing of wet and dry seasons from one year to the next;
- Between 1981 and 2016, certain regions in the northeast and much of southern Tanzania experienced drying trends, while moderate increases in rainfall were observed in central Tanzania and more pronounced wetting trends occurred in the northwest. Since the early 2000s, specific years such as 2003 and 2005 were notably dry, whereas 2006 was characterized by exceptionally wet conditions;
- Rise in sea levels of 4–20 cm per decade (1955 –2003) everywhere except Zanzibar, which recorded a decrease in sea levels (1984–2004) (USAID, 2018).

In recent decades the trend of increased average temperatures has been even more pronounced, as depicted in Figure 3-1, Figure 3-2, and Figure 3-3.

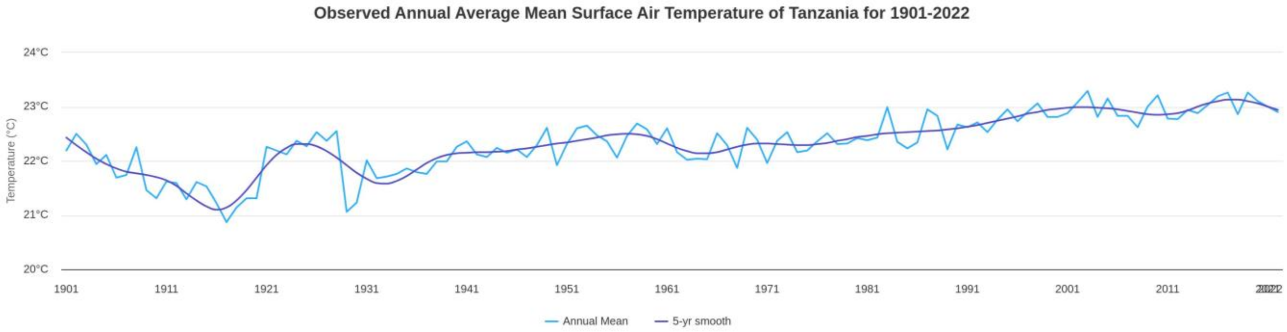


Figure 3-1- Observed annual average mean surface air temperature of Tanzania, 1901 - 2022 (WBCCKP, 2024)

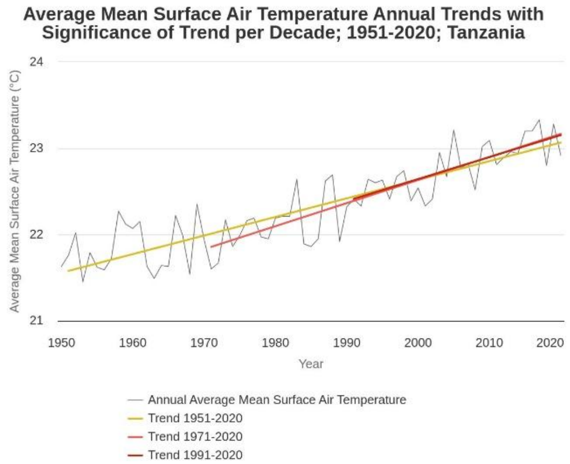


Figure 3-2 - Average mean surface air temperature annual trends with significance of trend per decade, 1951 - 2020, Tanzania (WBCCKP, 2024)

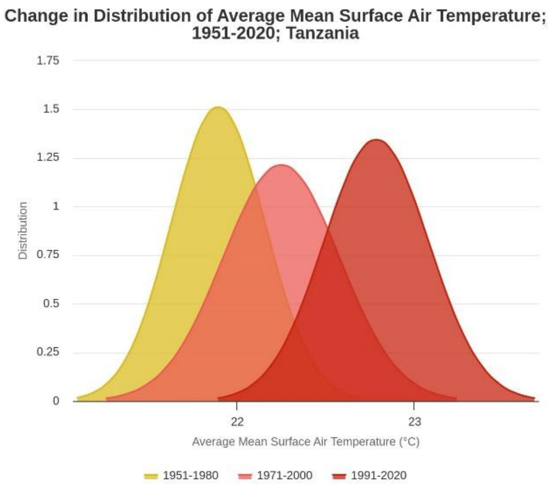


Figure 3-3 - Change in distribution of average mean surface air temperature, 1951-2020, Tanzania (WBCCKP, 2024)

Tanzania faces recurring challenges from both floods and droughts, with the frequency and severity of these events increasing in recent decades. According to the World Bank, floods have been the most common natural disaster, comprising just under half (43%) of all incidents over the past forty years, as illustrated in Figure 3-4 (WBCCKP, 2024).

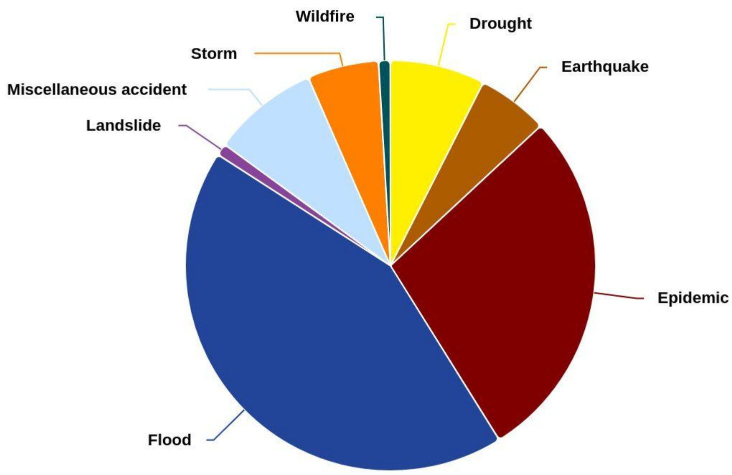


Figure 3-4 - Average Annual Natural Hazard Occurrence in Tanzania for 1980-2020 (Source: WBCCKP, 2024)

In 2019, catastrophic storm events caused significant disruption, impacting the livelihoods of over 2,000,000 individuals, as seen in Figure 3-5. The frequency of floods has exhibited a consistent upward trend over time, with approximately 65 000 people affected by floods in 2020 alone. Droughts, ranking as the second most prevalent disaster, have had a substantial disruptive effect on the population, typically affecting an average of 1 000 000 people with each occurrence (The World Bank, n.d.).

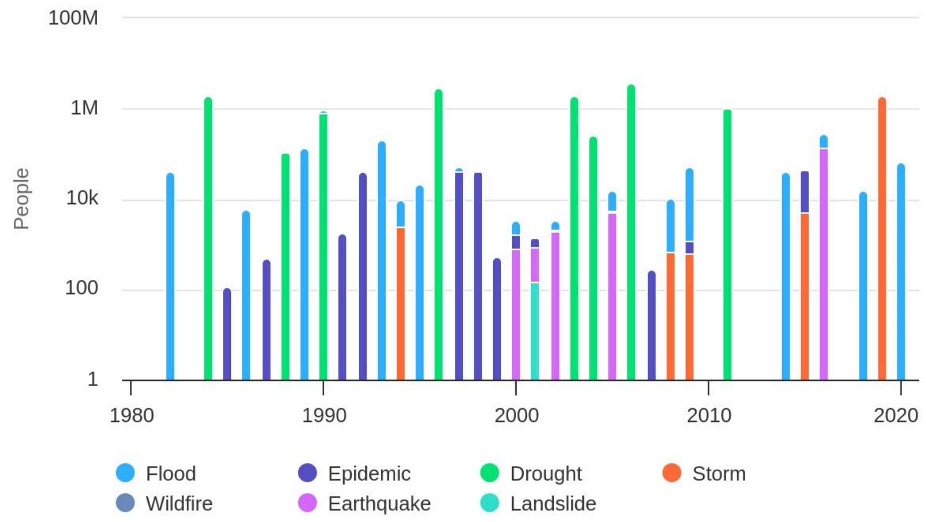


Figure 3-5 - Key Natural Hazard Statistics for 1980-2020 - Number of People Affected (Source: WBCCKP, 2024).

Tanzania has historically been 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 Tanzania 122nd out of 180 countries (Eckstein, Künzel, & Schäfer, 2022). According to the EU's INFORM climate risk index, Tanzania's baseline risk level comprises of an above average vulnerability to climate-related hazards (5.6 out of 10), and a high lack of coping capacity (6.3 out of 10) (European Commission, n.d.).

Tanzania has been grappling with severe rainfall induced by an intense El Niño and Indian Ocean dipole system as recently as 2023, leading to devastating floods and landslides. A significant incident occurred near Mount Hanang in the Manyara region, where a massive landslide in 2023 affected nearly 44,000 people and resulted in 89 fatalities. The heavy rains have persisted into 2024, expanding from four to eight regions, including Morogoro, Mbeya, Kilimanjaro, Unguja, Geita, Dar es Salaam, Manyara, and Pwani. These floods have caused further destruction to homes, crops, and agricultural assets. The rains and floods since January have resulted in 155 deaths, 236 injuries, and have affected 200 000 people and 51 000 households. Particularly in the Pwani and Morogoro regions, 76,700 hectares of farmland were flooded, and 10 800 households were displaced. Additionally, Cyclone Hidaya made landfall on May 4, bringing strong winds and heavy rains to coastal areas south of Dar es Salaam. Regions like Pwani, Morogoro, Lindi, and Mtwara experienced heavy rainfall, with some areas receiving more than 140% of their average monthly rainfall (IFRC, 2024).

3.2 AGRICULTURE SECTOR CLIMATE CHANGE BASELINE

Tanzania remains categorized as a least developed country (LDC), with a real GDP per capita of 1.211.1 USD (in 2023). The services sector is the largest contributor to the economy, making up 37.9% of the GDP in 2017, followed by agriculture at 28.7% and thereafter industry 25.1% (AGRICA, 2021). Despite the growth of the services sector, a significant portion of Tanzania's population, about 75%, relies on agriculture for employment and livelihoods. Main crops include maize, rice, cassava, sorghum, and millet. According to (CCAFS, 2019), maize and rice yields on average have been 1,370 kg/ha and 2

122 kg/ha respectively, see Figure 3-6. However, Tanzania faces challenges in agricultural productivity compared to other sub-Saharan African countries, leading to heavy reliance on imports, particularly wheat from Russia and sorghum from South Africa and Sudan (AGRICA, 2021).

Most of the agricultural output in Tanzania comes from smallholder farms, which depend largely on rainfall. Only a small fraction, about 1.5%, of the suitable crop land (29.4 million hectares) is currently irrigated. This lack of irrigation infrastructure raises concerns about the impact of climate change, including rising temperatures, water scarcity, and extreme weather events like floods. These changes pose significant challenges to smallholder farmers, increasing the risk of food insecurity and poverty. Tanzania's limited ability to adapt to these challenges highlights its vulnerability to climate change in the agricultural sector (AGRICA, 2021).

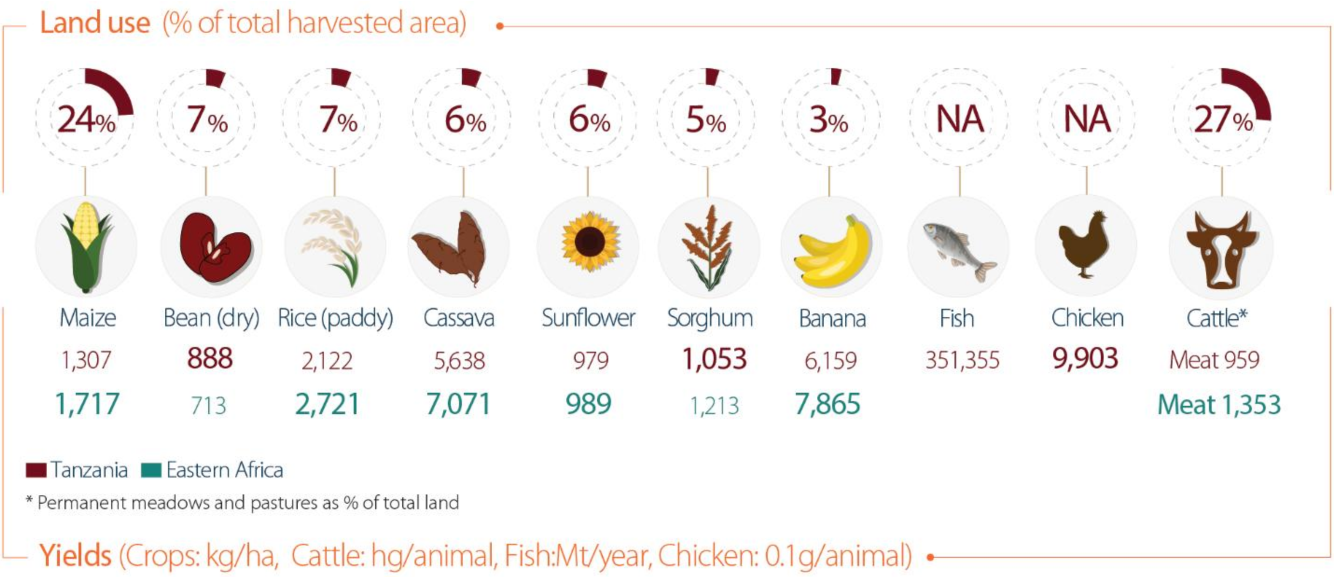


Figure 3-6 - Production systems key for food security in Tanzania (CCAFS, 2019))

In the foreseeable future, yields of essential crops such as maize, beans, sorghum, and rice are expected to decline, posing risks to both livelihoods and food security (USAID, 2018).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 3-7.

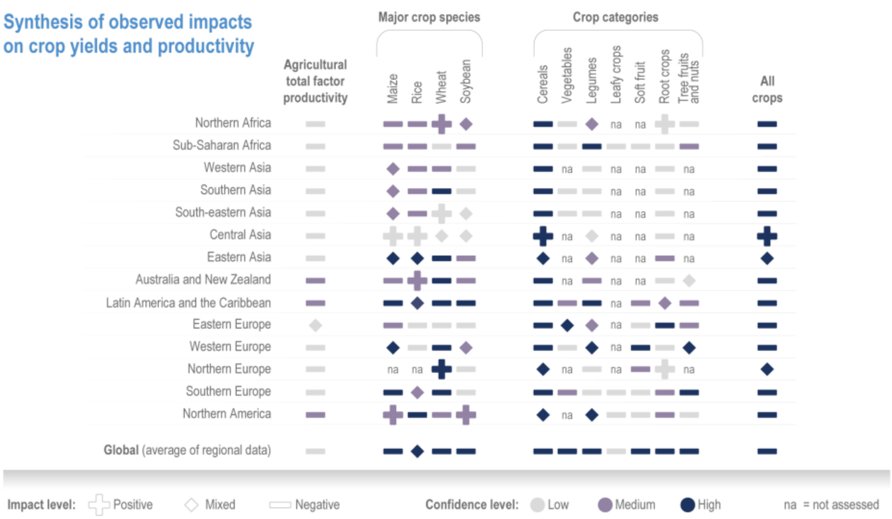


Figure 3-7 - Synthesis of literature on observed impacts of climate change on productivity by crop type and region (IPCC, 2021)

Rising temperatures, extended dry periods, and more frequent and intense rainfall events are posing significant risks to croplands in Tanzania, as seen in Table 3-1. Approximately one-third of the cultivated land, totalling 4 million hectares, is dedicated to maize production, which constitutes 40% of the national caloric intake (USAID, 2018).

Table 3-1- Climate Stressors and Climate Risks in Agriculture (adapted from: (USAID, 2018)

Stressors	Risks
Rising temperature	Reduced food crop due to heat stress
Increased heat wave duration	Heat stress in livestock leading to reduced reproduction, growth rates and milk production; higher morbidity and mortality
Increased frequency and intensity of heavy rainfall	Damage to crops and land from heavy rainfall, flooding, erosion and waterlogging.
	Increased pest and disease damage
Sea level rise	Salinization, waterlogging and inundation of coastal agriculture

3.3 COUNTRY CLIMATE CHANGE FUTURE

For the analysis of future climate risk to the two crops of interest, Maize (corn) and Rice 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:

- **SSP2-4.5** (the intermediate, middle-of-the-road future likely if the current emissions trajectory is followed, with moderate radiative forcing); and
- **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 "Tanzania") 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 Tanzania, focused on the post-harvest stages of the crop value chain.

Table 3-2: Principal Climatic Variables (The World Bank, n.d.)

<table>
<tr><th>Variable Name</th><th>In-Country Context Description</th><th>Additional information</th></tr>
<tr><td>Average Mean Surface Temperature</td><td>Across all future climate scenarios, the average mean surface temperature in Tanzania is projected to increase, relative to the historic baseline (reference period 1950-2014).

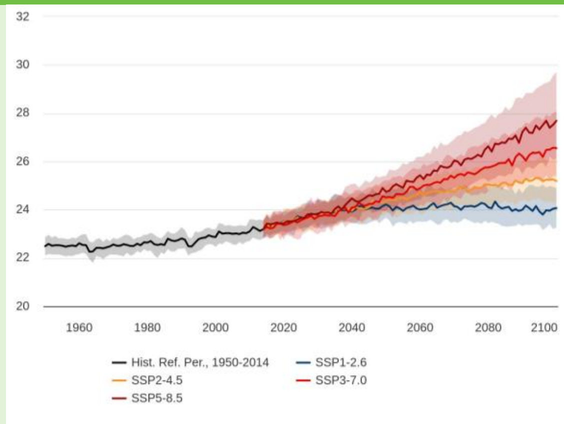
In our assessment of the projected change of average mean surface temperature in 2040, between the two future scenarios, we found that the estimated rise in temperature from the historic baseline is very high.</td><td>

Figure 3-8 - Projected average mean surface temperature under multiple future scenarios (WBCCKP, 2024)</td></tr>
<tr><td>Mean Precipitation</td><td>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, however the increase is not statistically significant.

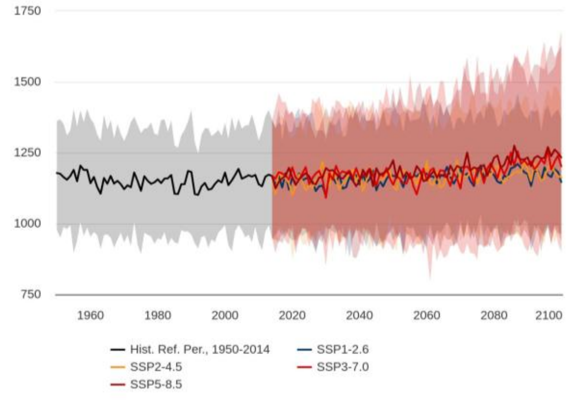
In our assessment of projected change in mean precipitation in 2040, between the two future scenarios, we found that the estimated change in rainfall from the historic baseline was very low (with a marginal increasing signal).</td><td>

Figure 3-9- Projected mean precipitation under multiple future scenarios (WBCCKP, 2024)</td></tr>
<tr><td>Number of Hot Days over 35°C</td><td>Across all future climate scenarios, the average number of hot days with temperatures rising over 35°C displays a rising trend. The rise is more pronounced towards end-century, but even in 2040 the number of such days increases markedly from the historic baseline (reference period 1950-2014).

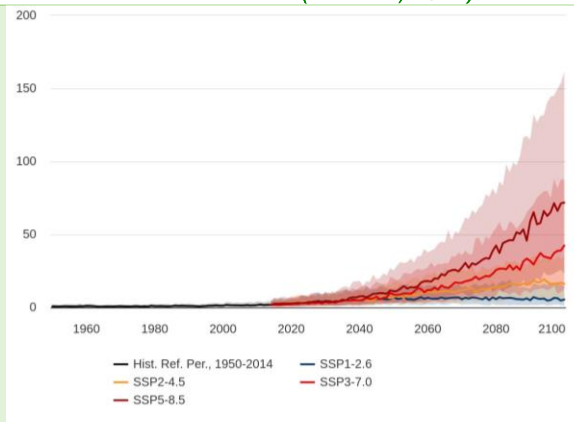
Given that in the past there were only, on average 1 such day in the year, projections of potentially 7 (SSP 2-4.5) or even 11 (SSP 5-8.5) such days in 2040 is a notable percentage change. Thus, in our assessment, we found that estimated change in the number of hot days over 35°C is very high.</td><td>

Figure 3-10 - Projected change in the number of hot days with temperatures over 35°C, under multiple future scenarios (WBCCKP, 2024)</td></tr>
</table>

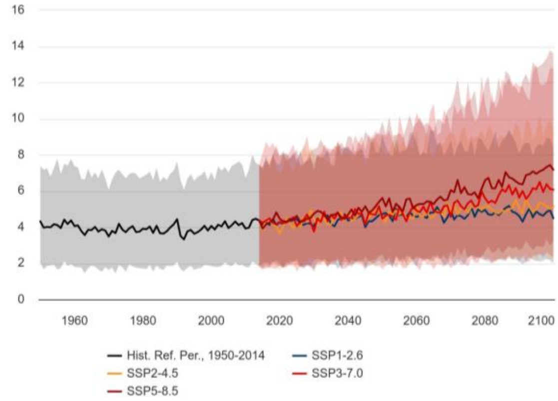
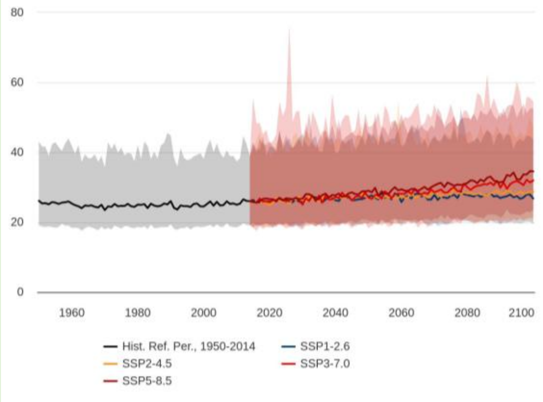
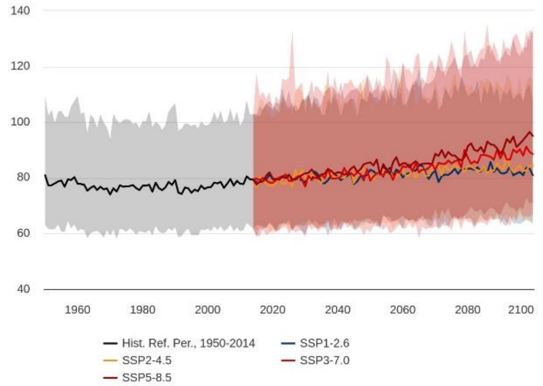
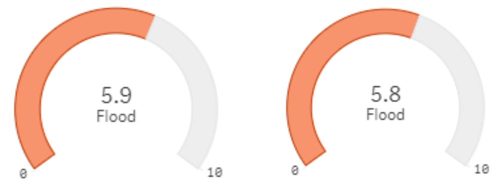
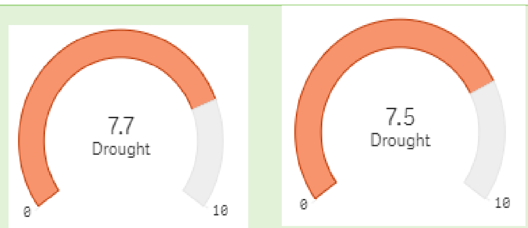
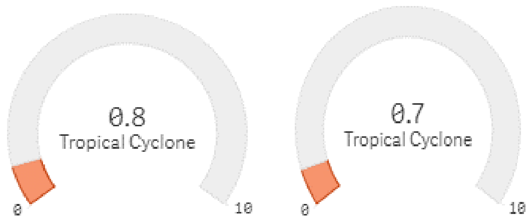
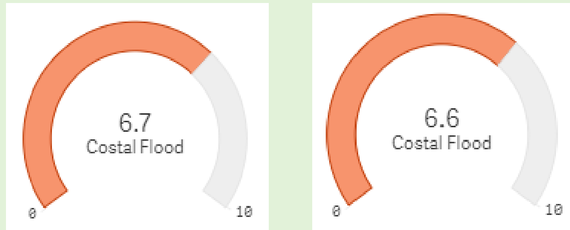
Variable Name	In-Country Context Description	Additional information
Number of days with precipitation > 20 mm	Across all future climate scenarios, the average number of days with rainfall greater than 20mm displays a rising trend (except SSP1-2.6). The trend does demonstrate a particularly marked increase from the historic baseline (reference period 1950-2014). Given that in the past there were on average 3.96 such days in the year, projections of potentially ~4.63 (SSP 2-4.5) or ~5.11 (SSP 5-8.5) such days in 2040 show a very 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 3-11 - Projected change in number of days with rainfall >20 mm, under multiple future scenarios (WBCCKP, 2024)*
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 an increasing trend in climate projections, relative to the historic baseline (reference period 1950-2014). Towards the end of the century, there is a greater increasing signal, 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, we found that the estimated change in rainfall was **very high** (with an increasing signal).	 *Figure 3-12 - Projected change in average largest single-day precipitation, under multiple future scenarios (WBCCKP, 2024)*
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 an increasing trend 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, we found that the estimated change in rainfall was **high** (with an increasing signal).	 *Figure 3-13 - Projected change in average largest five-day precipitation, under multiple future scenarios (WBCCKP, 2024)*

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

Variable Name	In-Country Context Description	Additional Information
Extreme Heat/Heatwaves	Tanzania's future extreme heat risk due to climate change is regarded as **moderate**. This means 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.).	N/A

Variable Name	In-Country Context Description	Additional Information
	[Note: the INFORM climate risk index does not provide data for extreme heat / heatwaves.]	
Floods	Tanzania's future flood risk due to climate change (and other factors) is regarded as **high**, particularly 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). "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, Tanzania's baseline risk of flooding (on a 0-10 scale) is 5.3 as of 2022. However, under the SSP2-4.5 scenario for mid-century (2050), this rises to 5.9, and under the SSP5-8.5 scenario drops slightly to 5.8 for the same period (European Commission, n.d.).	 *Figure 3-14- Tanzania's future flood risk in 2050 under SSP2-4.5 and SSP5-8.5, on a scale of 10 (Eurpoean Commission, 2024)*
Drought	Tanzania's future drought risk due to climate change (and other factors) is regarded as **high.** According to the INFORM Climate Change Risk Index, Tanzania's baseline risk for drought (on a 0-10 scale) is 6.6 as of 2022. However, under the SSP2-4.5 scenario for mid-century (2050), this rises to 7.7, and under the SSP5-8.5 scenario drops slightly to 7.5 for the same period (European Commission, n.d.). Tanzania'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."**Invalid source specified.**.	 *Figure 3-15: Tanzania's future drought risk in 2050 under SSP2-4.5 (left) and SSP5-8.5 (right), on a scale of 10 (Eurpoean Commission, 2024)*
Wildfire	Tanzania'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.]	N/A
Landslides	Tanzania's future landslide (or landslip) risk due to climate change (and other factors) is regarded as **medium** (moderate). This indicates that the "area has rainfall patterns, terrain slope, geology, soil, land cover, and (potentially) earthquakes that make localized landslides a known but nevertheless infrequent hazard phenomenon." (GFDRR, n.d.). [Note: the INFORM climate risk index does not provide data for landslides.]	N/A

Variable Name	In-Country Context Description	Additional Information
Cyclones	Tanzania's future tropical cyclone (or hurricane) risk due to climate change (and other factors) is regarded as **low.** This means that there is a 1% chance of potentially damaging wind speeds in your project area in the next 10 years." (GFDRR, n.d.) According to the INFORM Climate Change Risk Index, Tanzania's baseline risk of cyclones (on a 0-10 scale) is 0.6 as of 2022. Under the SSP2-4.5 scenario for mid-century (2050), this rises to 0.8, and under the SSP5-8.5 scenario this shifts to 0.7 for the same period (European Commission, n.d.)	 *Figure 3-16 - Tanzania's future cyclone risk in 2050 under SSP2-4.5 and SSP5-8.5, on a scale of 10 (Eurpoean Commission, 2024)*
Coastal Flooding	Tanzania's future coastal flood risk due to climate change (and other factors) is regarded as **high**. "This means that potentially damaging waves are expected to flood the coast at least once in the next 10 years". (GFDRR, n.d.). According to the INFORM Climate Change Risk Index, Tanzania's baseline risk of coastal flooding (on a 0-10 scale) is 5 as of 2022. However, under the SSP2-4.5 scenario for mid-century (2050), this rises to 6.7, and under the SSP5-8.5 scenario drops slightly to 6.6 for the same period (European Commission, n.d.).	 *Figure3-17 - Tanzania's future coastal flooding risk in 2050 under SSP2-4.5 and SSP5-8.5, on a scale of 10 ((Eurpoean Commission, 2024)*
Sea Level Rise	Tanzania's future sea level rise risk due to climate change (and other factors) is regarded as **high**. Based on the IPCC's Interactive Atlas, Tanzania's baseline for sea level rise, rated on a scale from 0 to 1, is slightly below 0.25. However, under the SSP2-4.5 and SSP5-8.5 mid-century scenarios, this figure rises to approximately 0.3 at the 50th percentile. Although the initial increase is modest, it escalates to 0.6 and 0.8 by the end of the century (IPCC, n.d.).	 *Figure 3-18 - Tanzania's future sea level rise risk in 2050 under SSP2-4.5 and SSP5-8.5 (IPCC, n.d.).*

3.4 THE FUTURE OF CROP AGRICULTURE UNDER CLIMATE CHANGE

3.4.1 Maize

The predominant agricultural practice in Tanzania for maize cultivation relies on rainfed systems. As such, the sector faces significant challenges stemming from the impacts of climate change and meteorological phenomena such as El Niño (Winter & Jang, 2017). Rising temperatures and unpredictable rains make maize production and yields less consistent. A study conducted by (USAID, 2018) projects an increase in average temperature by 1.4-2.3°C by 2050 as well increases in duration of heat waves and dry spells. A similar pattern is noted for rainfall with projected increases in frequency and intensity of heavy rainfall. Sea levels are projected to rise by 16-42 cm by 2050. Based on the average of all models used in the (AGRICA, 2021) study, the portion of crop land in the country experiencing at least one drought annually is projected to increase fivefold due to the effects of climate change. Under RCP6.0, the annual drought exposure of national cropland is projected to increase from 0.05–1.0% in 2000 to 0.5–6.2% in 2080. The very likely range increases from 0.01–1.8% in 2000 to 0.2–10.1% in

2080. This indicates that most models predict a significant rise in drought exposure over this period. While higher temperatures may initially benefit rainfed maize farming in the highlands, overall national production is expected to decline by 8-13% by 2050 due to increased heat stress, drying conditions, soil erosion, and flood damage (USAID, 2018). Projections for bean, sorghum, and rice yields show similar downward trends, with anticipated decreases ranging from 5-9% by 2050.

Modelled projections indicate a rise in temperature of at least 2°C by the 2080s in regions like Dodoma, Arusha, and Dar es Salaam, alongside heightened precipitation either in the early or middle phases of the rainy season has been. While the (USAID, 2018) study shows that national production is expected to decline by 8-13% by 2050, (Winter & Jang, 2017) predict that maize yields will drop by 9% across Tanzania by 2080, with Dodoma seeing larger reductions (9.2%) compared to Dar es Salaam (6.6%) and Arusha (4.5%), see Figure 3-19. Further concerns include the increasing risk of catastrophic losses due to droughts, storms, pests, or diseases linked to unpredictable weather. These challenges not only lower yields but can destroy entire harvests (Winter & Jang, 2017).

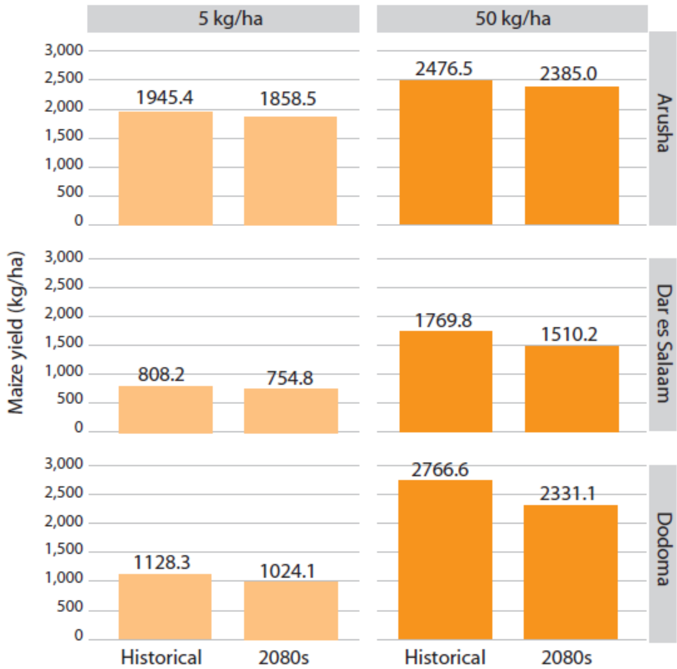


Figure 3-19 - Climate Change and Maize Yields (Winter & Jang, 2017)

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

3.4.2 Rice

Rice holds strategic importance in Tanzania as the second most crucial staple food after maize and as a significant commercial crop. The country's focus on boosting production and exports of rice is essential for augmenting export revenue and fostering economic growth (REPOA, 2021). Inter-and-intra seasonal changes in precipitation and temperature are associated with changes in rice yields (Rowhani, Lobell, Linderman, & Ramankutty, 2011). The same study (Rowhani, Lobell, Linderman, & Ramankutty, 2011) shows that cereal yields increase with more seasonal precipitation and decrease with higher temperatures. However, increased precipitation variability during the growing season reduces yield. Based on the findings by (REPOA, 2021), climate change and agricultural production are closely linked as recurrent and intensified weather extremes coincide with years of decreased rice production.

Another study estimates that climate change is likely to reduce the yields of rice slightly in Tanzania by 0.1 % by 2050 (CCAFS, 2019). According to this analysis, the areas under rice production is likely to increase by 2 % by 2050, but this may be irrespective of climate change (Figure 3-19).

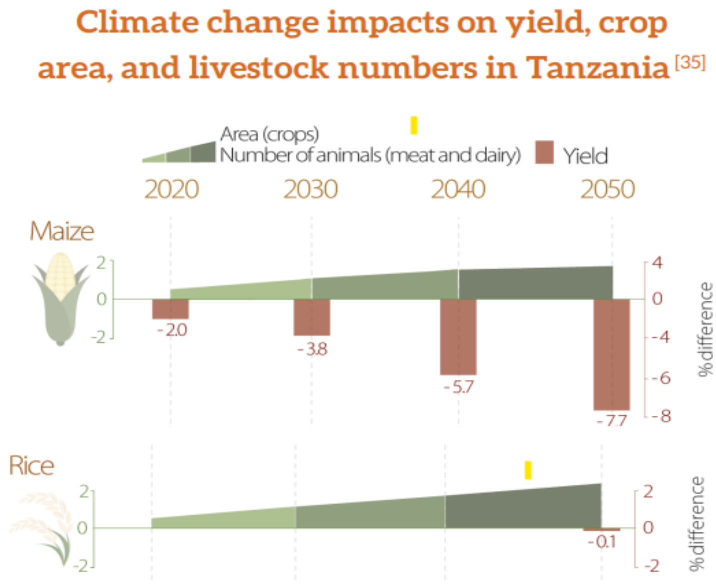


Figure 3-20 - Projected changes in crop yields and crop area for maize and rice in Tanzania, with climate change impacts (CCAFS, 2019)

According to (AGRICA, 2021) **yield projections for millet, sorghum, rice, groundnuts, and cassava are anticipated to benefit from the impacts of climate change**. Specifically, under the extreme scenarios, it is projected that by 2080, crop yields will surge 18% for rice compared to the levels observed in the year 2000. These encouraging outcomes are attributed to the CO_2 fertilization effect, which promotes plant growth (Figure 3-20).

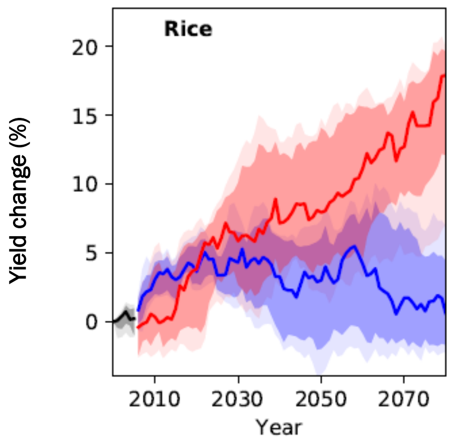


Figure 3-21 - Projections of crop yield changes for Rice in Tanzania for different GHG emissions scenarios relative to year 2000 (AGRICA, 2021)

Note to readers: Published literature is scarce on the climate impacts on post-harvest stages of the rice value chain (in Tanzania 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 Tanzania indicates that the most significant **hazards** are temperature (increases in average temperature, as well as increases in the number of extremely hot days where temperatures breach the 35°C threshold), heavy or intense precipitation (extreme volumes of rainfall in a single day or single days exceeding 20 mm), flooding (pluvial and fluvial), urban and coastal, and wildfires. To a slightly lesser degree, landslides, heat waves and cyclones also pose a threat.

Tanzanian 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 **rainfall variability, heavy or intense rainfall (excessive and erratic or prolonged rains); flooding; drought; and high temperatures. They also expressed concerns about the threats of strong winds.**

Specifically, stakeholders in Dar-es-Salaam and Morogoro identified the three most important climate change related hazards, corresponding to the three value chain stages RE-GAIN is concerned with, as shown in Table 3-4

Table 3-4 - Top three climate change hazards identified for Tanzania'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
Dar-es-Salaam	Heavy, excessive, or erratic rainfall (damages crops); Drought; High temperatures (extreme heat); Strong winds	Heavy, excessive, or erratic rainfall (damages crops); Drought; High temperatures (extreme heat); Strong winds	Rainfall variability (erratic and linked to flooding) High temperatures (extreme heat, leading to conditions for growth of fungus, mould, aflatoxin, pests)
Morogoro	Drought (causing premature harvest and reduction in size); Rainfall variability (including erratic or prolonged rainfall); Flooding and waterlogging of fields.	Rainfall variability (including erratic or prolonged rainfall); Flooding; Rising temperatures (extreme heat): Pest and aflatoxin contamination.	Rainfall variability (including erratic or prolonged rainfall); Flooding; Rising temperatures (extreme heat)

A range of factors create **vulnerability** in the maize value chain, including a very high percentage of rural population (dependent on agriculture), very low levels of irrigation and the high reliance on rainfed agriculture increasing food insecurity, and high levels of poverty and unemployment leading to high levels of undernourishment (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).

Stakeholders in Dar-es-Salaam and Morogoro added further granularity and insights to the understanding of vulnerability in the maize value chain, indicating that principal drivers of vulnerability in Tanzania's maize value chain – at harvest and during post-harvest stages – are: **the lack of or limited access to efficient harvesting and post-harvest technology, equipment, facilities, and infrastructure; limited or poor knowledge of optimal techniques and practices; reliance on outdated traditional approaches (rather than mechanization); lack of or limited access to climate information services; lack of or limited market information; as well as poverty and food insecurity.**

Specifically, stakeholders in Sar-es-Salaam and Morogoro 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 shown in

Table 3-5.

Table 3-5- Top three climate change vulnerability factors identified for Tanzania'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
Dar-es-Salaam	Lack of/limited access to technology, equipment, facilities, infrastructure. Reliance on outdated technologies and tools (traditional methods,	Lack of/limited access to technology, equipment, facilities, infrastructure (especially storage); Lack of/limited access to knowledge and skills (including on	Lack of/limited access to technology, equipment, facilities, infrastructure (especially roads); Lack of/limited access to knowledge and skills about

	rather than mechanization); Lack of/limited access to climate information services.	packaging); Lack of/limited access to climate information services.	quality-control and packaging; Lack of/limited access to markets and market information
Morogoro	Lack of/limited access to knowledge and skills; Food insecurity and poverty; Lack of / poor access to climate information services.	Lack of/limited access to knowledge and skills, especially on drying; Lack of/limited access to technology, equipment, facilities, infrastructure (especially drying) Lack of / poor access to climate information services.	Substandard or damaged technology, equipment, facilities, infrastructure (especially roads); Lack of/limited access to knowledge and skills; Lack of/limited access to markets and market information.

In terms of **exposure**, the key factor is the share of cropland area under maize considering the total area is projected to decrease towards the end of the century. Overall, in our comparative climate change risk assessment, quantitatively the risk level of the maize value chain in Tanzania scored: 37.33 out of 125 (Table 4-2), putting it at rank **3** of the 14 crop value chains similarly assessed.

Table 3-6 - 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

Crop losses during pre-harvest drying in the field can be attributed to wildlife, birds, and rodents. In severe instances, as much as 32% of maize-on-cobs may be lost to birds, monkeys, and other rodents before harvest, along with qualitative spoilage due to mould and fungi (and the mycotoxin such as aflatoxin contamination resulting from mould), particularly prevalent in moist conditions. Comparable qualitative losses occur due to mycotoxin / aflatoxin contamination of maize and cassava in Tanzania (Abass, et al., 2013).

Post-harvest losses stem from a variety of factors, including the perishable nature of crops, mechanical harm, prolonged exposure to unfavourable environmental conditions such as high temperatures, humidity, and rain, as well as contamination by spoilage-causing fungi and bacteria (Abass, et al., 2013). Additionally, losses can result from intrusion by birds, rodents, insects, and other pests, along with improper handling, storage, and processing practices (World Bank, 2011). These losses may be compounded by inadequate infrastructure, harvesting techniques, post-harvest processes, distribution systems, and marketing strategies. In sub-Saharan nations, an estimated 50% of fruits and vegetables, 40% of roots and tubers, and 20% of cereals perish before they reach the market (Johnson, Nyomora, & Lyimo, 2020). Particularly in East Africa, post-harvest losses are prominent in cereal crops like maize, rice, sorghum, groundnuts, pulses, cassava, and sweet potatoes. For instance, in Tanzania, research indicates that annually, 15-40% of cereal crops are lost.

The duration required for complete drying grains varies significantly depending on weather and atmospheric conditions (ACF, 2014). If grains become overly dry, they can become brittle and prone to cracking during threshing, hulling, or milling (estimates indicate that in 2023, 1.3% of the maize crop's dryweight volume was lost in threshing and shelling (APHLIS, African Post Harvest Loss Information System, n.d.). Harvesting before proper drying can result in incomplete threshing. Moreover, if grains are threshed while still too damp and then promptly stored or piled up, they become highly vulnerable to attack by microorganisms, thus reducing their shelf life.

Temperature and moisture levels are pivotal factors in maize grain storage. Elevated temperatures, for instance, can prompt changes in the chemical composition of grains, affecting lipids, carbohydrates, and proteins (Coradi, Maldaner, Everton Lutz, Dai, & Teodoro, 2020). Higher temperatures and humidity hasten grain deterioration, whereas lower levels of these variables preserve the viability and vigour of maize seeds (Rahmawati & Aqil, 2016). Notably, the quality of harvested seeds, including their initial moisture content upon harvest, significantly influences post-harvest quality and degradation levels. Managing climatic conditions during maize storage is complex due to the interaction between temperature and moisture. For example, while temperature speeds up grain moisture reduction, it also exacerbates deterioration. Additionally, moisture accumulation from lower temperatures leading to condensation during storage further diminishes grain quality (Coradi, Maldaner, Everton Lutz, Dai, & Teodoro, 2020).

Furthermore, extreme weather events during storage can inflict physical harm on storage infrastructure and result in the loss of stored grains, such as water infiltration into storage silos or grains being swept away by floodwaters and landslides (Figure 3-21). Unfortunately, farmers do not have adequate information on proper crop harvesting and handling methods, resulting in significant damage by insect pests during storage and marketing (Abass, et al., 2013).

In Tanzania, the maize weevil *Sitophilus zeamais* Motshulsky causes significant damage to stored maize. Of recent, the effects of climate change have been noted to amplify the losses as they affect the effectiveness of most of the commonly used Post-Harvest Technologies in harvesting and drying, pest & disease management, and storage (Republic of Tanzania, 2019).

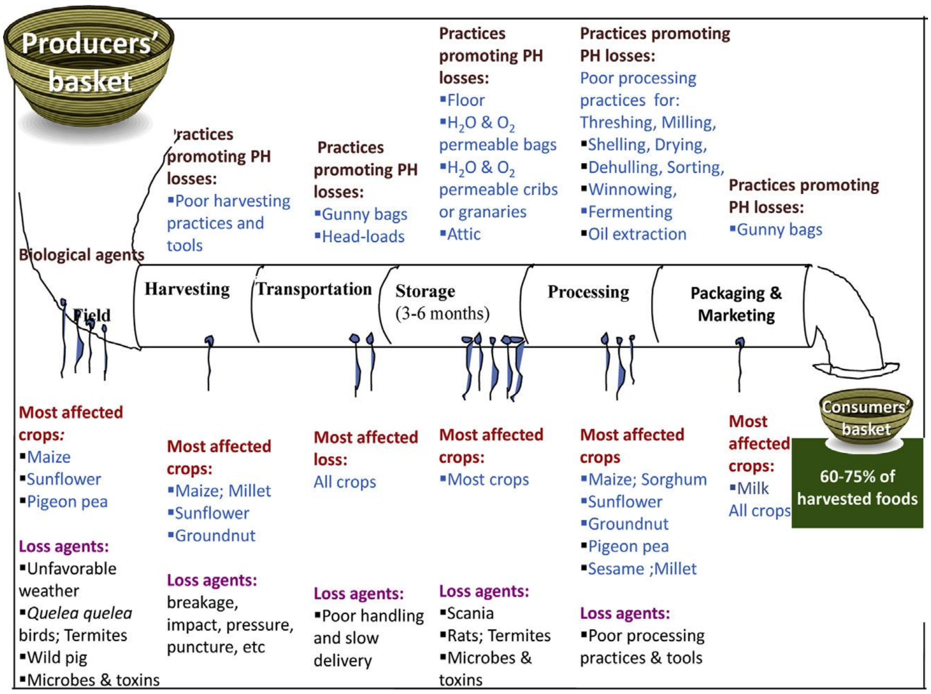


Figure 3-22 - post-harvest loss characteristics in the maize-based system (Abass, et al., 2013)

The effects of temperature, moisture, and extreme weather events on post-harvest processes such as processing, transportation, and distribution to markets (both wholesale and retail) are primarily indirect. These effects manifest through acute (rapid-onset) and chronic (gradual-onset) damage to machinery and equipment (e.g., weathering, rusting, decay, and other weather-related wear and tear of assets), transportation infrastructure (e.g., damage to roads, railways, and bridges such as melting and buckling of roads or rail tracks, warping of bridge joints), 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 Tanzania 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 17.9 % of the maize harvest in Tanzania was lost as dry-weight loss based on decadal data from 2013 through 2022 (APHLIS, African Post Harvest Loss Information System, n.d.). Of the various post-harvest value-chain stages (per APHIS, 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 average volume of maize losses occurred in Tanzania (in decreasing order over the decade) are:

1. **Harvesting and field drying** – an average annual loss of 6.4% of the crop
2. **Household level storage** – an average annual loss of 5.2% of the crop
3. **Further drying** – an average annual loss of 4% of the crop.

Collectively, these three phases account for approximately 87% of the total losses within the post-harvest maize value chain in Tanzania on an annual basis. Climatic factors play a significant role in each of these stages, as temperature, moisture, humidity, and the presence of pests and plant diseases (which are sensitive to temperature) contribute to damage to the harvested maize.

Climate change is expected to worsen these factors, with rising temperatures, increasingly erratic and intense rainfall, and a heightened risk of floods in Tanzania. Consequently, these stages of the maize value chain are particularly vulnerable to climate change and should therefore be given priority for adaptation measures aimed at reducing losses.

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 harvesting and field drying and household storage, it is fair to surmise that the areas in Tanzania where maize is farmed are the dominant geographical locations for these losses, at these stages. Based on the map of maize growing areas in Tanzania (Figure 3-22) (Republic of Tanzania, 2021), the district of **Ruvuma** had the highest maize production (498 685 tonnes; 7.7 %), followed by **Manyara** (469 037 tonnes; 7.2 %) and **Tanga** (429 788 tonnes; 6.6 %), and it follows that these three should be prioritized for climate-responsive, risk-reduction interventions.

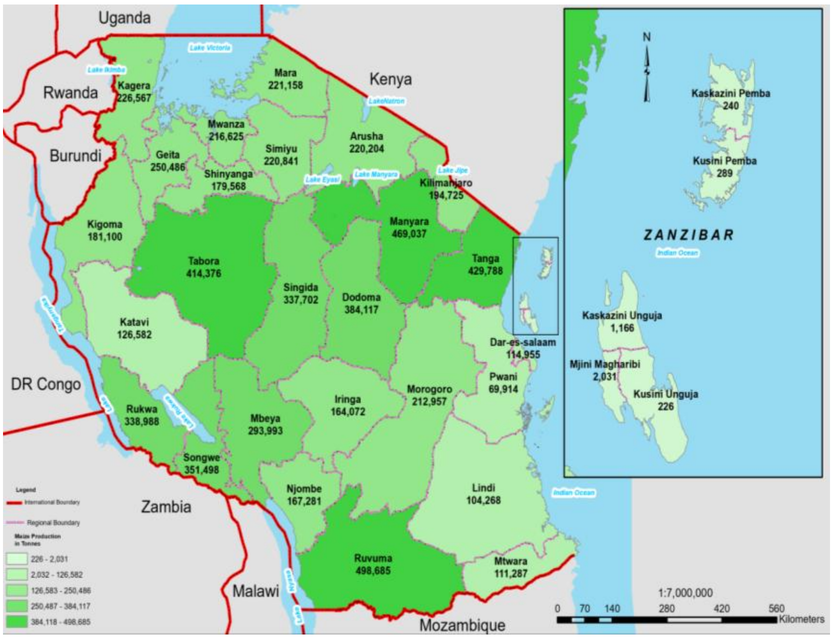


Figure 3-23 - Tanzania: Maize Production by District (The United Republic of Tanzania, 2021)

Stakeholder workshops in Tanzania 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 suggests that the priority target areas (regions) that should be the focus of RE-GAIN's post-harvest loss-reduction climate change solutions are listed below.

Table 3-7 - Prioritised Regions and Climate Risks

Region	Prioritized Climate Change Risks
Manyara	Drought, Landslides, Floods
Tabora	Drought, Prolonged Rainfall Events
Kigoma	Prolonged Rainfall
Katavi	Floods
Rukwa	Strong Winds, Drought
Mbeya	Floods, Drought
Iringa	Floods, Drought
Njombe	High Rainfall Variability
Morogoro	Floods In Kilosa And Mvomero Districts

3.5.2 Rice

Our analysis of climate change risks to the rice value chain in Tanzania indicates that the most significant **hazards** are temperature (increases in average temperature, as well as increases in the number of extremely hot days where temperatures breach the 35°C threshold), heavy or intense precipitation (extreme volumes of rainfall in a single day or single days exceeding 20 mm), flooding (pluvial and fluvial), urban and coastal, and wildfires. To a slightly lesser degree, landslides, heat waves and cyclones also pose a threat.

Tanzanian stakeholders at the national and local levels affirmed that for the rice value chain, climate hazards that pose the most substantial risk at harvest and during the post-harvest stages are **rainfall variability, heavy or intense rainfall (excessive and erratic or prolonged rains); flooding; and high temperatures. They also expressed concerns about the threats of strong winds, and about moisture levels (leading to spoilage and growth of mould, prevalence of pests, etc.).**

Specifically, stakeholders in Dar-es-Salaam and Morogoro identified the three most important climate change related hazards, corresponding to the three value chain stages RE-GAIN is concerned with, as follows (Table 3-8):

Table 3-8 - Top three climate change hazards identified for Tanzania's rice 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
Dar-es-Salaam	Flooding (inundating fields and causing crop damage); Heavy, prolonged, or erratic rainfall (delaying harvesting, damaging the grain); Strong winds (damaging the crop).	Heavy, excessive, prolonged, or erratic rainfall (damages crops); Flooding; High temperatures (extreme heat).	Flooding (causing damage to processing facilities, roads, and transport infrastructure); High temperatures (extreme heat, leading to spoilage of grains and growth of mould, aflatoxin, pests).
Morogoro	Rainfall variability (including erratic or prolonged rainfall, making timing difficult to predict); Flooding (causing water damage).	Rainfall variability (including erratic or prolonged rainfall); Rising temperatures (extreme heat), resulting in more moisture: Pest and aflatoxin contamination.	Rainfall variability (including erratic or prolonged rainfall); Flooding; Rising temperatures (extreme heat)

A range of factors create **vulnerability** in the rice value chain, including a very high percentage of rural population (dependent on agriculture), very low levels of irrigation and the high reliance on rainfed agriculture increasing food insecurity, and moderate levels of poverty and unemployment leading to high levels of undernourishment (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).

Stakeholders in Dar-es-Salaam and Morogoro added further granularity and insights to the understanding of vulnerability in the rice value chain, indicating that principal drivers of vulnerability in Tanzania's rice value chain – at harvest and during post-harvest stages – are: **the lack of or limited access to efficient harvesting and post-harvest technology, equipment, facilities, and infrastructure; limited or poor knowledge of optimal techniques and practices (especially drying and storage); reliance on outdated traditional approaches (rather than mechanization); lack of or limited access to climate information services; the lack of or limited market information; as well as poverty and food insecurity.**

Specifically, stakeholders in Sar-es-Salaam and Morogoro identified the three most important vulnerability factors that make the rice value chain susceptible to climate change risks, corresponding to RE-GAIN's three value chain stages, as demonstrated in Table 3-9.

Table 3-9- Top three climate change vulnerability factors identified for Tanzania's rice 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
Dar-es-Salaam	Lack of/limited access to technology, equipment, facilities, infrastructure. Reliance on outdated technologies and tools (traditional methods, rather than mechanization); Lack of/limited access to climate information services.	Lack of/limited access to technology, equipment, facilities, infrastructure (especially storage); Lack of/limited access to knowledge and skills (including on drying and storage and handling); Lack of/limited access to climate information services.	Lack of/limited access to technology, equipment, facilities, infrastructure (especially roads). Lack of/limited access to knowledge and skills about quality-control and logistics; Lack of/limited access to markets and market information.
Morogoro	Lack of/limited access to knowledge and skills; Food insecurity and poverty; Lack of / poor access to climate information services.	Lack of/limited access to knowledge and skills, especially on drying; Lack of/limited access to technology, equipment, facilities, infrastructure (especially drying); Limited knowledge of and exposure to moisture control.	Substandard or damaged technology, equipment, facilities, infrastructure (especially roads); Lack of/limited access to knowledge and skills; Lack of/limited access to markets and market information.

In terms of **exposure**, one key factor that reduces the exposure of the rice value chain (relative to maize in Tanzania) is the much smaller fraction of cropland in the country that currently is dedicated to rice cultivation (low).

Overall, in our comparative climate change risk assessment, quantitatively the risk level of the rice value chain in Tanzania scored: 17.77 out of 125 (Table 3-10) putting it at rank **12** of the 14 crop value chains similarly assessed.

Table 3-10 - 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

There is limited available literature about post-harvest losses in the rice value chain in Tanzania (Ndingeng, 2021). Evidence from scholarly studies suggests that the primary processing stage, which involves threshing the paddy, drying, and storing, primarily occurs at the production site, typically under labour-intensive often rudimentary conditions. Post-harvest losses are notably significant, with up to 50% of the initial grain being lost due to various factors (FAO, 2015a). In Sub-Saharan Africa, paddy rice production in 2018 amounted to approximately 26.5 million tonnes, harvested from a total area of 11.95 million hectares. However, a significant portion of this production failed to reach the consumer due to post-harvest losses, which can be categorized into quantitative (weight) and qualitative (value) losses.

Quantitative post-harvest losses in grains are estimated at 17%. Table 3-11 from the National Post-Harvest Loss Strategy for Tanzania shows the net rice production (2012-2016) as 1 780 000 tonnes. Out of this, a total of 190 000 tonnes were lost, amounting to a value of 276 million TZS (Republic of Tanzania, 2019). According to (Ndingeng, 2021), the most substantial recorded loss is quantitative loss before and during harvesting, followed by qualitative loss throughout the entire value chain, quantitative loss during milling, parboiling, and threshing, in that sequence, with the lowest being quantitative loss during drying. About 47.6 % of the total post-harvest losses demonstrates losses under extreme conditions of inadequate on-farm and post-harvest practices, high temperature and humidity.

Table 3-11 - Average annual economic value loss for major food crops due to post-harvest loss 2012-2016 (Source: (Republic of Tanzania, 2019)

Crop	Average (000' tonnes)		Average monetary value TZS million (000')	
	Production	Loss	Value retained	Value lost
Maize	6 046	937	3 920	604
Rice	1 780	190	2 580	276
Sorghum	793	99	767	95

According to data from the African Post Harvest Loss Information System (APHLIS), an estimated 11.7% of the rice harvested in Tanzania was lost as dry-weight loss based on the average decadal data from 2013 through 2022 (APHLIS, African Post Harvest Loss Information System, n.d.). Of the various post-harvest value-chain stages (per APHIS, 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 average volume of maize losses occurred in Tanzania (in decreasing order over the decade) are:

1. **Harvesting and field drying** – an average annual loss of 4.4% of the crop;
2. **Threshing and shelling** – an annual loss of 3.1% of the crop;
3. **Winnowing** – an annual loss of 2.5% of the crop.

Collectively, these three phases account for approximately 85 % of the total losses within the post-harvest rice value chain in Tanzania on an annual basis. Climatic factors play a significant role in each of these stages, as temperature, moisture, humidity, and the presence of pests and plant diseases (which are sensitive to temperature) contribute to damage to the harvested rice. With climate change projected to exacerbate these factors, through rising temperatures, more erratic and heavy rainfall events, and through the growing risk of floods in Tanzania, ***these stages of the rice value chain are most at risk from climate change, and thus should be prioritized for adaptation (loss-reduction) responses.***

Considering that these stages, where the majority of post-harvest losses occur, are primarily associated with on-farm activities like harvesting, threshing, shelling, and winnowing, it's reasonable to assume that the regions in Tanzania where rice cultivation is prevalent are the primary geographical areas experiencing these losses. Referring to the Figure 3-24of rice-growing regions in Tanzania (USDA, 2024), districts such as **Morogoro** (contributing to 15% of rice production in 2017), **Mbeya** (10%), and **Pwani** (8%) could be targeted for interventions aimed at reducing risks associated with climate change.

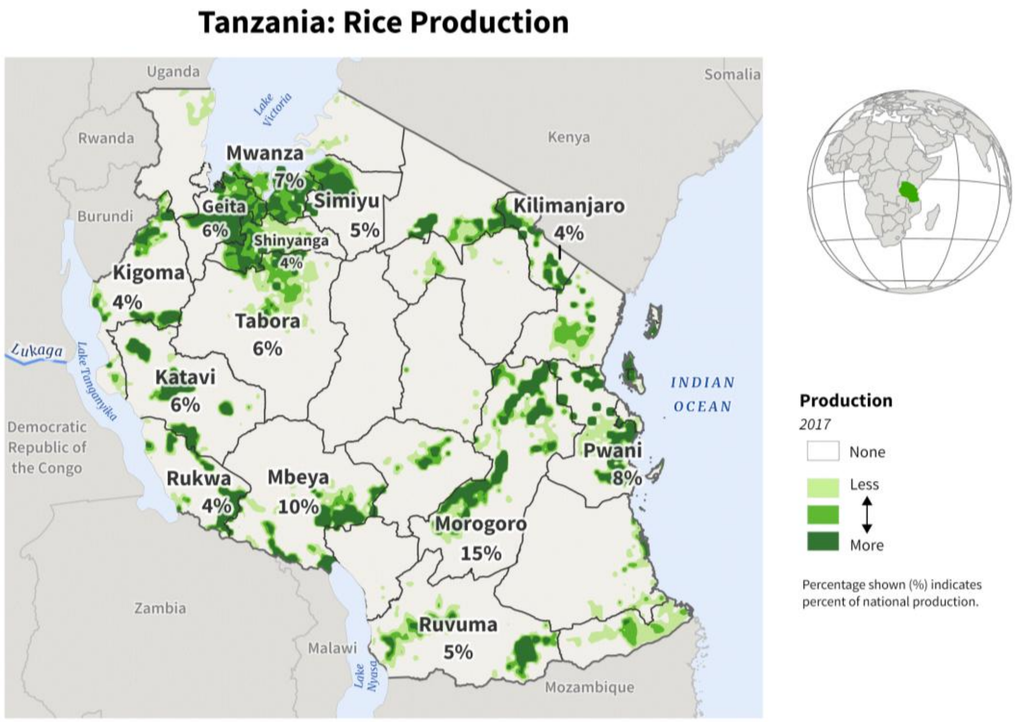


Figure 3-24 – Tanzania Rice Production by District, 2017 (USDA, FAS)

Stakeholder workshops in Tanzania 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 rice value chain, particularly during harvest and post-harvest stages. Insights and guidance from stakeholders suggest that the priority target areas (provinces) that should be the focus of RE-GAIN's post-harvest loss-reduction climate change solutions are listed in Table 3-12.

Table 3-12 - Prioritised Regions and Climate Risks for Rice Production

Region	Prioritized Climate Change Risks
Manyara	Drought, Landslides, Floods
Tabora	Drought, Prolonged Rainfall Events
Kigoma	Prolonged Rainfall
Katavi	Floods
Rukwa	Strong Winds, Drought
Mbeya	Floods, Drought
Iringa	Floods, Drought
Njombe	High Rainfall Variability
Morogoro	Floods in Kilosa and Mvomero Districts
Ruvuma	Flood and Drought

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 **hazard 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 Rice in Tanzania are presented in Table 3-13.

Table 3-13- Summary Climate Change Hazard Risk Table for Tanzania 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, Transport, and Logistics

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*
RICE	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*

Key:

High	
Medium	
Low	

4 Climate analysis - Mitigation

4.1 COUNTRY AND SECTORAL CLIMATE CHANGE EMISSIONS BASELINE

4.1.1 National emissions

Tanzania presented its National Greenhouse Gas Inventory (GHGI) in their Second National Communication (United Republic of Tanzania, 2014) **to the United Nations Framework Convention on Climate Change (UNFCCC).** Agriculture and land-use change and forestry are the largest emitting sectors at ~62 million tonnes CO_2e and ~71 million tonnes CO_2e as of 2021, respectively (Figure 4-1) (Climate Watch, n.d.). While Tanzania's national emissions have grown steadily in the last few decades, it still contributes only 0.41% of global emissions as of 2022 (Jones, et al., 2024).

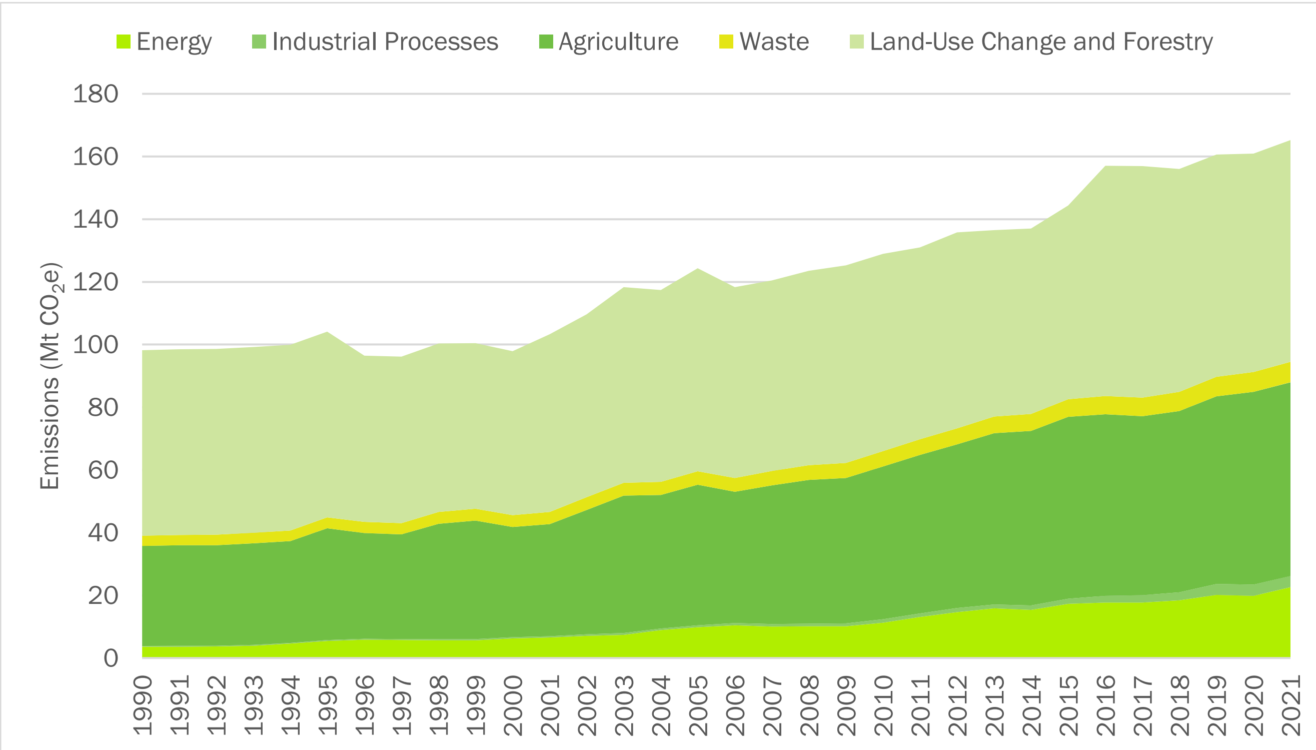


Figure 4-1 - Emissions (all GHG, $MtCO_2e$) across all sectors (total including LUCF) for Tanzania (Climate Watch, n.d.)

4.1.1.1 Land use change

By using available land use change datasets, we can ascertain that a loss of forest cover occurred in Tanzania between 1960 and 2019, with forest loss occurring over up to ~5%[2] of the land area in AGRA's target regions (Table 4-1). Cropland expanded by up to ~2% of these areas in that period (fig xx). Where deforestation occurred between 2001 and 2020, the dominant land uses which replaced forest cover were small- and large-scale agriculture, pastures, other tree cover and plantation forests (Table 4-1) (Masolele, et al., 2024).

[2] Calculated using zonal statistics in QGIS from HILDA+ data layers

Table 4-1 - Frequency (%) of land use types replacing forest where forest cover was lost between 2001 and 2020 in Tanzania (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
Kilimanjaro	24.40%	1.30%	<1%	17.20%	<1%	2.20%	50.60%	<1%	<1%	2.30%	<1%	<1%	<1%	<1%	<1%
Manyara	31.80%	34.50%	<1%	25.40%	<1%	6.10%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	1.00%
Arusha	18.40%	9.40%	<1%	43.70%	<1%	14.50%	10.00%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	1.60%
Kagera	4.40%	1.00%	4.10%	74.20%	<1%	10.70%	<1%	4.20%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
Mbeya	4.60%	6.50%	<1%	37.20%	<1%	37.80%	11.40%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
Singida	10.50%	40.90%	1.40%	45.60%	<1%	1.20%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
Iringa	4.00%	3.40%	<1%	70.50%	<1%	4.70%	11.70%	<1%	1.20%	<1%	<1%	<1%	<1%	2.50%	<1%
Ruvuma	1.60%	3.90%	<1%	77.60%	<1%	12.50%	<1%	<1%	1.40%	<1%	<1%	<1%	2.20%	<1%	<1%
Morogoro	5.20%	4.10%	<1%	64.70%	<1%	22.70%	<1%	<1%	<1%	<1%	<1%	<1%	2.00%	<1%	<1%
Rukwa	8.30%	6.40%	<1%	69.00%	<1%	13.70%	<1%	<1%	<1%	1.50%	<1%	<1%	<1%	<1%	<1%
Kigoma	9.60%	1.90%	<1%	76.50%	<1%	8.40%	<1%	1.50%	<1%	1.10%	<1%	<1%	<1%	<1%	<1%
Dodoma	12.50%	28.70%	<1%	53.70%	<1%	3.30%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
Zanzibar South & Central	3.40%	18.80%	7.90%	34.00%	<1%	14.50%	<1%	1.10%	<1%	1.40%	<1%	2.80%	14.40%	1.20%	<1%
North Pemba	5.90%	<1%	20.30%	63.40%	<1%	<1%	<1%	7.00%	<1%	1.40%	<1%	<1%	<1%	<1%	<1%
Zanzibar North	17.80%	11.60%	10.50%	43.50%	<1%	3.20%	<1%	3.80%	<1%	1.40%	<1%	<1%	4.20%	2.80%	<1%
Zanzibar Urban/ West	2.70%	<1%	10.00%	17.30%	<1%	<1%	<1%	66.40%	<1%	1.80%	<1%	<1%	1.80%	<1%	<1%
South Pemba	1.00%	<1%	37.80%	54.50%	<1%	<1%	<1%	1.40%	<1%	5.40%	<1%	<1%	<1%	<1%	<1%
Katavi	1.60%	2.90%	<1%	65.30%	<1%	28.60%	<1%	1.00%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
Njombe	10.20%	3.10%	<1%	65.50%	<1%	4.20%	11.60%	<1%	1.10%	<1%	<1%	<1%	1.90%	<1%	<1%
Shinyanga	4.80%	4.10%	<1%	85.40%	<1%	5.10%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%

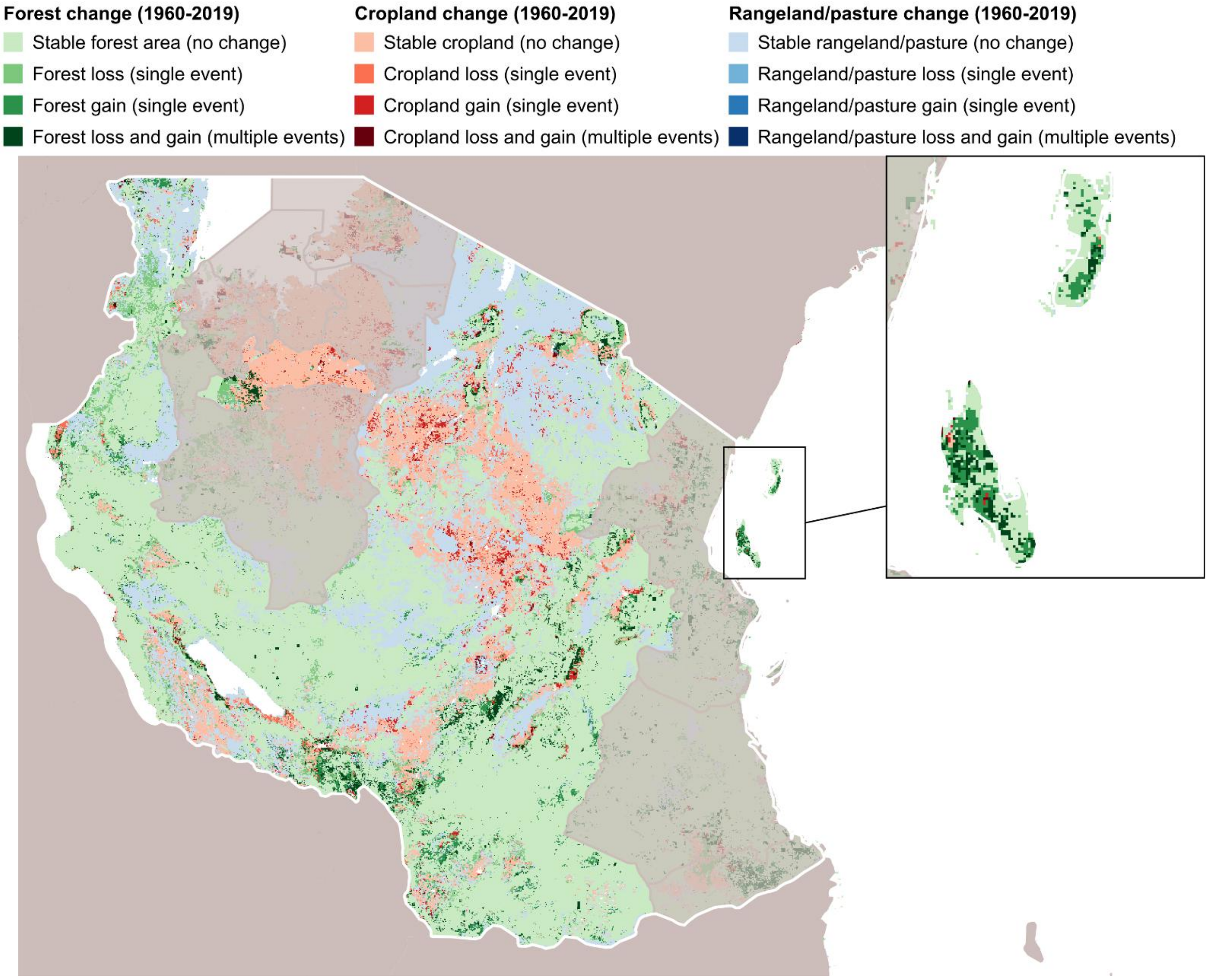


Figure 4-2 - Change in cover for land use categories forest, rangeland/pasture and cropland in AGRA target regions across Tanzania between 1960 and 2019 (HILDA+)

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 rice (Figure 4-3) (Poore & Nemecek, 2019). Losses account for a significant proportion of emissions (Figure 4-3), particularly in smallholder value chains.

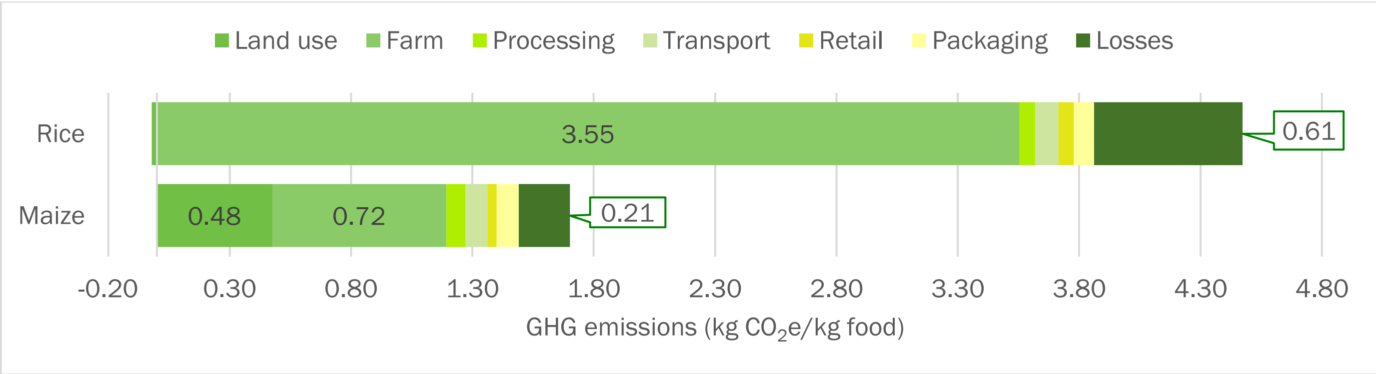


Figure 4-3 - Average GHG emissions (kg CO2e/kg food) for agricultural commodities across value chains (Poore & Nemecek, 2019)

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.

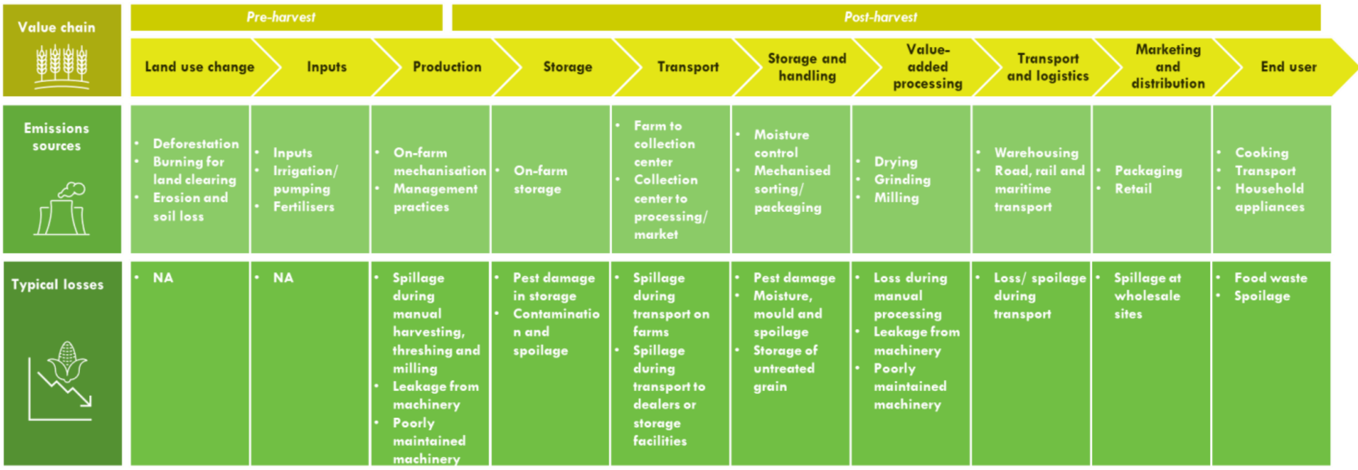


Figure 4-4 - Typical sources of emissions and food losses across agricultural value chains (Report Authors Analysis)

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, 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. Table 4-2 lists calculated emissions associated with food loss for commodity groups in Tanzania (Kipkirui et al., 2023).

Table 4-2 - Emissions (Tonnes CO_2e) associated with food loss for cereals, pulses and oil crops (Kipkirui et al., 2023)

Country	Cereals	Pulses	Oil crops
Tanzania	2 118 290	5 760	551 600

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 processing practices, as well as spoilage from pests and mould during storage

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

Value chain stage	Losses (%)	Cause(s)	Reference
Harvesting, field drying	6.4%	N/A	(APHLIS, African Post Harvest Loss Information System, 2024) (Abass, et al., 2013)
Threshing/ shelling	1.3%	Manual processing practices, breakage, puncture, compression, rupture, dent bruises, or spillages	
Winnowing	N/A	N/A	
Drying	4.0%	N/A	
Transport to farm	2.4%	Transportation of the crops by headloads, bicycles and other means results in spillage	
On-farm storage	5.2%	Infestation by grain borers and other pests, storage using different types of bags	
Transport to market	N/A	N/A	

4.2.2.2 Rice

On-farm post-harvest losses in the rice value chain occur largely as a result of inefficient harvesting and processing practices (Table 4). The largest reported losses occur during harvesting and drying, estimated at 4.4% of total production (Table 4-4). This will be further discussed on chapter 5.

Table 4-4. Extent of post-harvest food loss and the main causes for rice in Tanzania

Value chain stage	Losses (%)	Cause(s)	Notes on loss values	Reference
Harvesting, field drying	4.4%	N/A	Values for losses (%) during the drying stage were not available from APHILIS for the target country. The FAO FLWD provides values for losses during drying for other West African countries (Benin, Ghana and Sierra Leone). An average of these loss values has been used as a proxy.	(APHLIS, African Post Harvest Loss Information System, 2024)
Threshing/ shelling	3.1%	N/A		
Winnowing	2.5%	N/A		
Drying	2.8%	N/A		
Transport to farm	1.3%	N/A		
On-farm storage	1.0%	N/A		
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 Tanzania could amount to 851 645 tCO_2e for maize and 807 651 tCO_2e for rice, based on smallholder production values (Figure 4-5, Table 4-5).

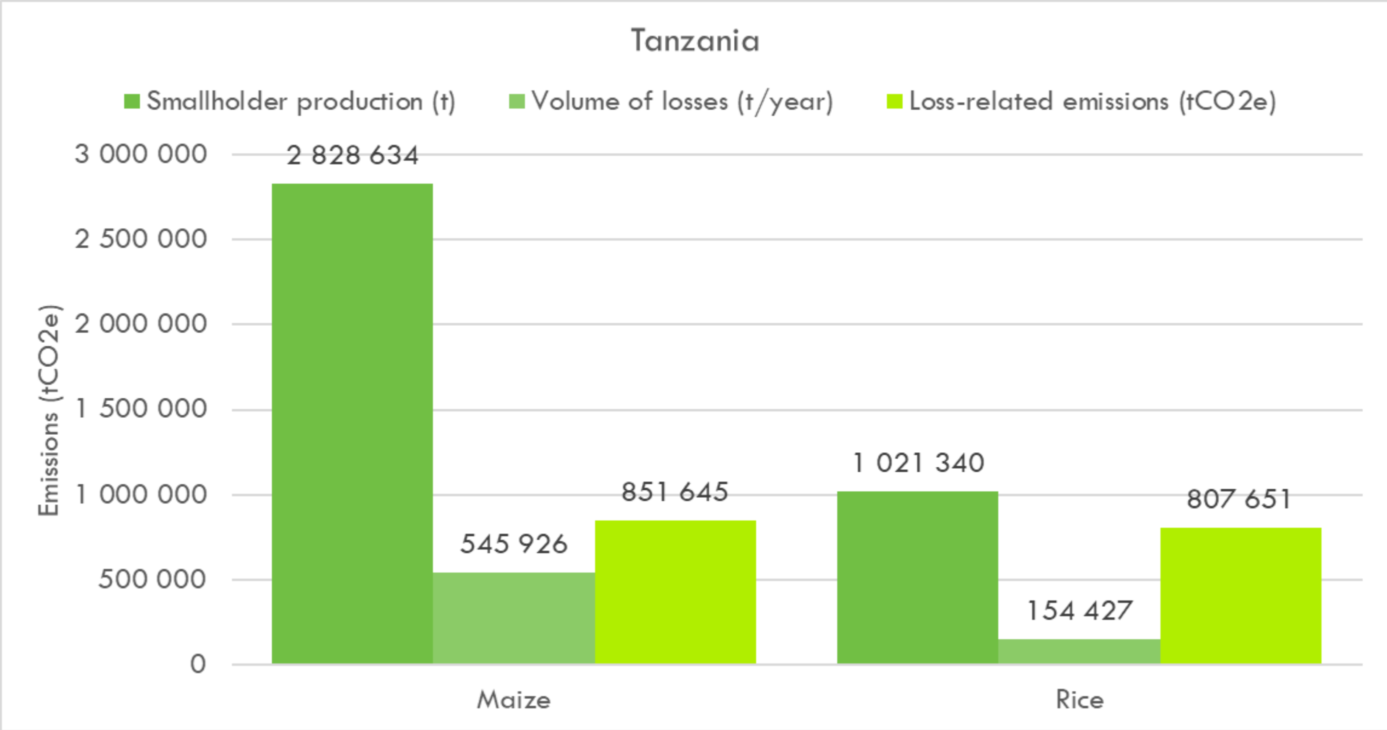


Figure 4-5 - Estimated losses across agricultural value chains for key commodities

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 4-5 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, Reay, higgins, & Bomberg, 2016) and have been used in several studies to estimate emissions.

Table 4-5 - Estimated emissions (t CO_2e/t food) calculated using total maximum losses per commodity, total national annual smallholder production (tonnes) and emissions factors for food loss emissions published by (Porter, Reay, higgins, & Bomberg, 2016)

Country	Crop	Smallholder production (t)	Loss rate (%)	Volume of losses (t/year)	Loss-related emissions (tCO2e)
Tanzania	Maize	2 828 634	19%	545 926	851 645
	Rice	1 021 340	15%	154 427	807 651
Total		**3 849 974**	**34%**	**700 353**	**1 659 296**

4.3 COUNTRY AND SECTORAL CLIMATE CHANGE EMISSIONS PROJECTIONS

The GHG inventory developed by Tanzania provides projected emissions to 2030 for key sectors under business-as-usual (BAU) and alternative scenarios, which are also used as part of the Nationally Determined Contributions (NDCs). The BAU emissions projections for Tanzania as stated in the (The United Republic of Tanzania, 2021) **are provided below (Figure 4-6, see also Figure 4-1 above**). Emissions from agricultural soils are projected to increase slightly between 2020 and 2030 under the BAU emissions scenario by 2030 (Figure 4-6).

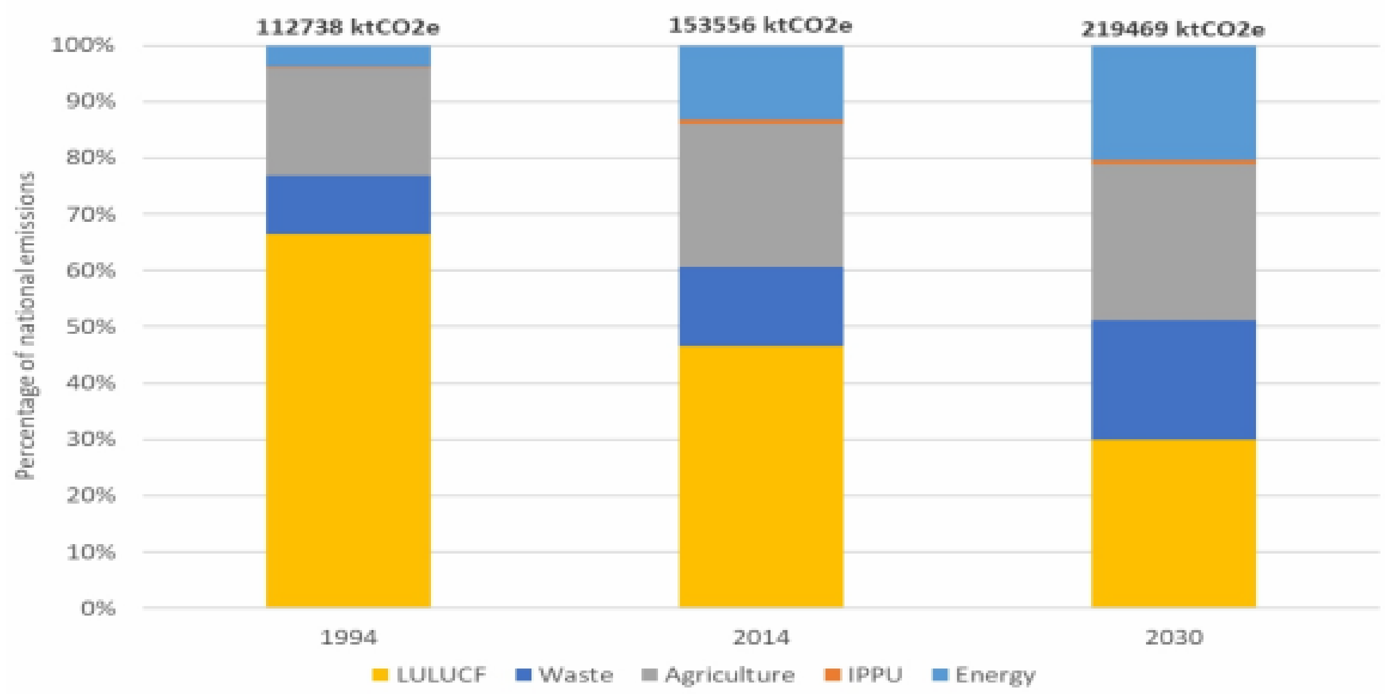


Figure 4-6 - Projected emissions across key sectors in Tanzania (The United Republic of Tanzania, 2021)

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).

Globally, crop losses along the maize and rice 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.

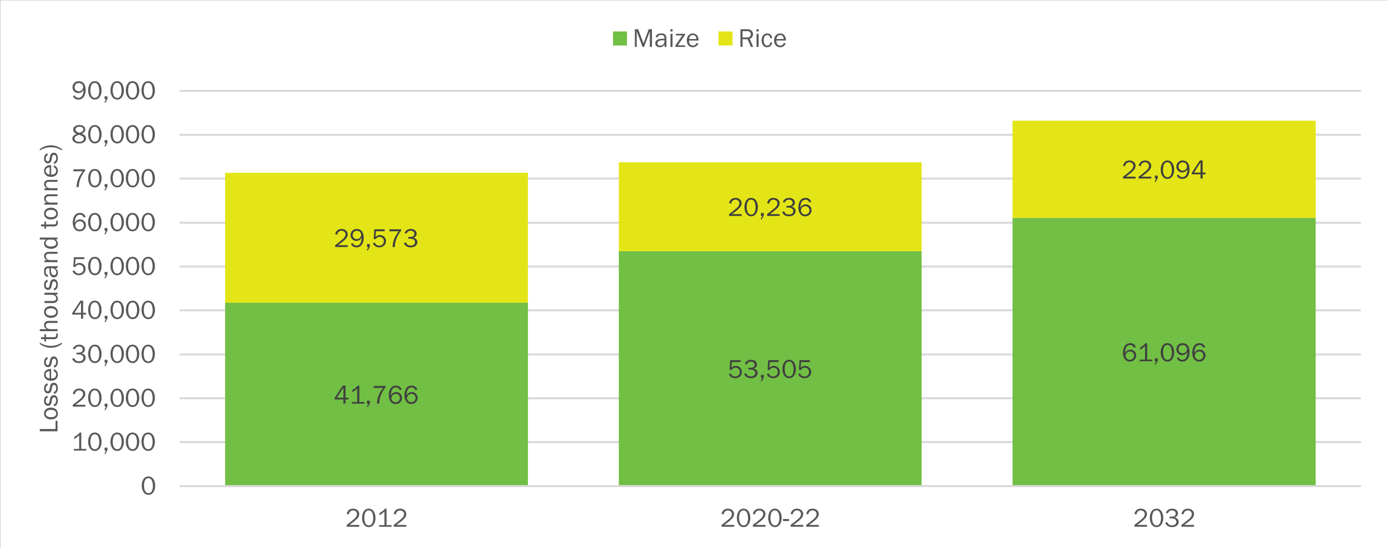


Figure 4-7 - Projected losses across global agricultural value chains for key commodities towards 2032 (OECD & FAO, 2023b)

By using available estimates of losses as presented in Table 4-5 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 4-6 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 4-5 and its sources, the OECED & FAO (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 4-6 - Estimated emissions (t CO_2e) for the year 2032 calculated using projected losses per commodity, total smallholder annual production (tonnes) and emissions factors for food loss emissions published by (Porter, Reay, higgins, & Bomberg, 2016)

Country	Crop	Projected production 2032 (t)	Projected losses 2032 (t/year)	Projected loss-related emissions 2032 (tCO2e)
Tanzania	Maize	3 427 111	661 432	1 031 835
	Rice	1 179 390	178 324	932 633
Total		**4 606 501**	**839 756**	**1 964 468**

Without intervention, emissions related to post-harvest losses on smallholder farms are expected to increase by between ~15% and ~21% for rice and maize, respectively (

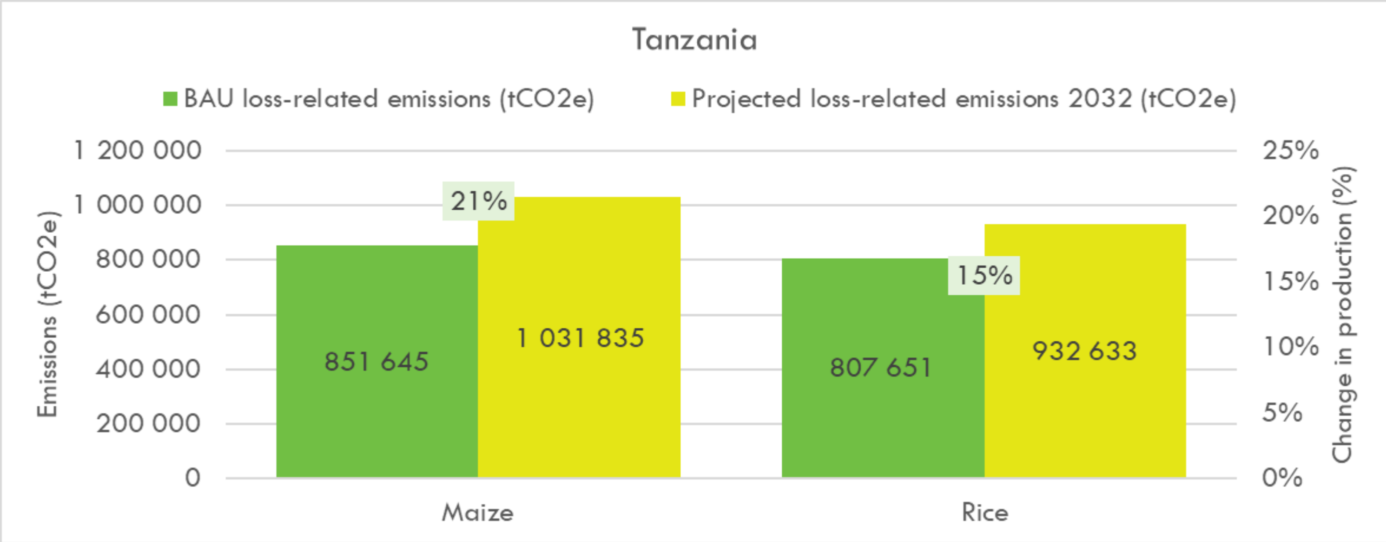


Figure 4-8 - Estimated emissions from post-harvest losses in 2022 and 2032 for key crops across target countries, percentage values indicate projected increase in emissions

). For Tanzania, this could amount to 1 031 835 tCO_2e for maize and 932 633 tCO_2e for rice by 2032 (Table 4-6). This presents the minimum expected losses as climate change is likely to exacerbate these numbers.

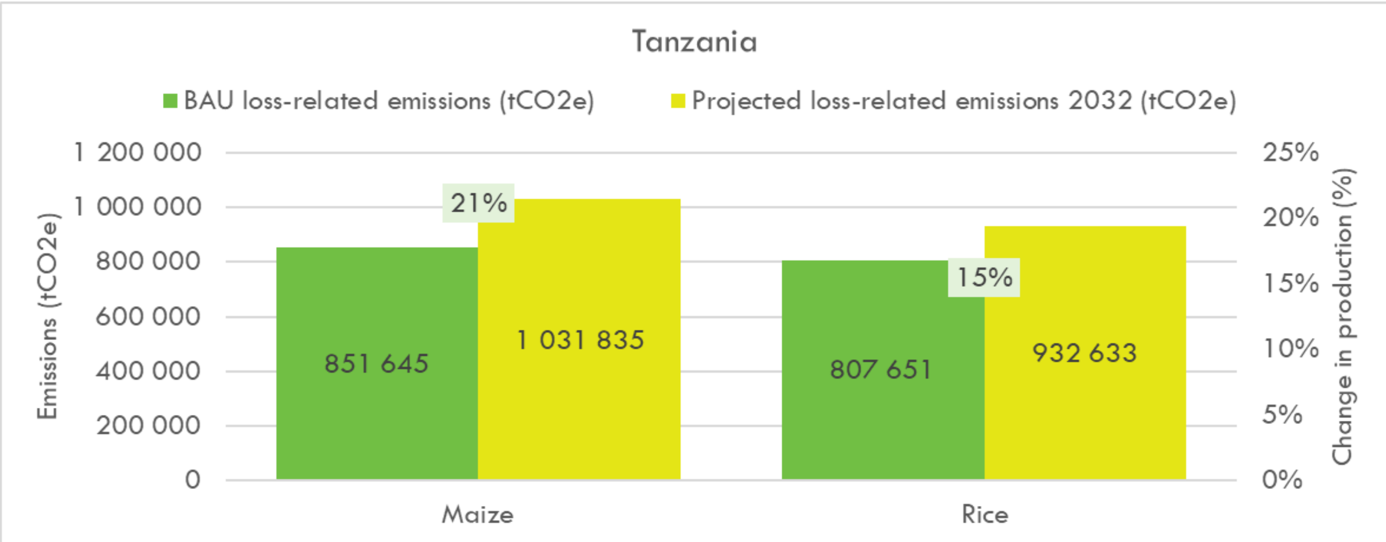


Figure 4-8 - Estimated emissions from post-harvest losses in 2022 and 2032 for key crops across target countries, percentage values indicate projected increase in emissions

5 Design of Food Loss Reduction Solutions

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

5.1.1 Maize

Maize holds primary importance as Tanzania's staple food crop, cultivated across more than 45% of arable land and contributing nearly 50% to rural household incomes, averaging around 100 USD per maize-producing household in 2018 (Barreiro-Hurle, 2012). Most maize production in Tanzania occurs under low-input rain-fed conditions (Baijukya, 2020), serving both as a subsistence crop and a source of income. Typical farming practices include basic equipment, recycled seeds, minimal agrochemical use, and low levels of weeding.

The distribution of maize production spans various agricultural zones and regions in Tanzania, adapted to agro-ecological conditions ranging from sea level to 2 400 meters, with optimal growth zones situated between 500-1 500 meters. The Southern Highlands and Lake Regions account for the largest maize-growing areas, followed by other regions such as the Eastern, Northern, Western, Southern, and Central, as highlighted on Figure 5-1 (Mtaki B. S., 2023).

Despite favourable growing conditions, maize yields in Tanzania are relatively low, averaging about 1.5 metric tonnes per hectare. A significant portion, between 65% and 80%, is consumed within producing households, with only 20% to 35% entering commercial channels. Maize constitutes approximately 16% of national household food expenditures, with substantial regional variations (FAO, 2015b).

Small-scale farmers contribute to more than 80% of Tanzania's total maize production. According to Tanzania's National Sample Census of Agriculture Atlas 2019/20, maize produced by smallholder farmers across the country accounted for 6 504 725 tonnes (with 99% of it produced in Mainland Tanzania). Ruvuma region had the highest maize production (7.5%), followed by Manyara (7.2%) and Tanga (6.6%), while the lowest maize production was reported in Pwani region (The United Republic of Tanzania, 2021).

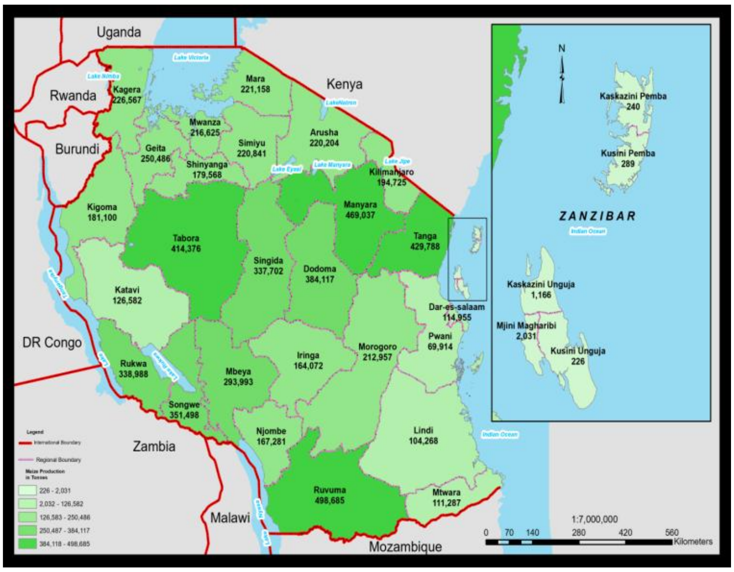


Figure 5-1 - Strategic regions of Tanzania in terms of maize production The United Republic of Tanzania, 2021)

Maize is primarily grown for home consumption, but it is also a cash crop sold through four recognized marketing channels: (i) Small-scale farmers who sell to local traders and millers mainly in the rural areas and nearby cities; (ii) Medium-sized grain traders and millers who serve rural and urban centres; (iii) A small number of well-established, large-scale millers and traders based in Dar es Salaam, operating in both national and regional markets; and (iv) Institutional buyers including The National Food Reserve Agency (NFRA), the World Food Program (WFP), the armed forces, hospitals and schools (FAO, 2015b). Tanzania's maize domestic market has many buyers and processors between the farm gate and the consumer. Each intermediary takes a margin, which reduces overall financial efficiency.

Maize in Tanzania can be majorly affected by desert locust invasion, excessive rainfall, and high postharvest losses (Mtaki B. S., 2023). According to FAOSTAT, over the last 30 years (1992-2022), maize cultivation areas in Tanzania have been slowly increasing (Figure 5-2) and doubled by 2022, starting from 1 908 163 ha in 1992 and resulting in 4 million ha in 2022. Production volumes have been also steadily growing (FAOSTAT, 2022).

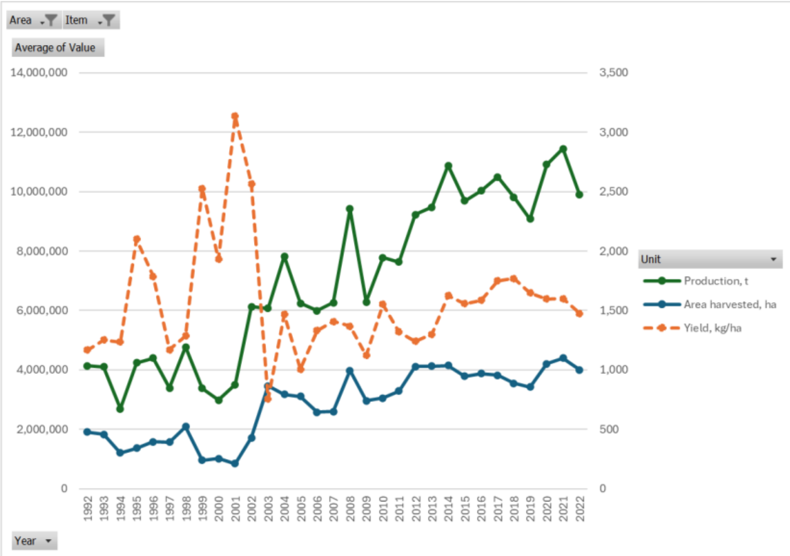


Figure 5-2 - Maize production, harvest area and annual yields in Tanzania, 1992-2022 (FAOSTAT, 2022)

According to FAOSTAT, over the last 10 years (2011-2021), Tanzania has been successful in producing enough maize to satisfy its domestic needs and consumption (Table 5-1, Figure 5-1), and even export part of the production abroad.

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

Year	Production ('000t)	Domestic supply quantity ('000t)	Export quantity ('000t)	Food supply quantity (kg/capita/yr)	Losses ('000t)
2011	4 341	4 033	18	56.81	533
2012	5 104	4 380	243	60.13	634
2013	5 356	4 615	92	61.45	665
2014	6 737	4 731	376	60.23	831
2015	5 903	4 674	62	59.32	728
2016	6 149	4 804	78	58.92	758
2017	6 681	5 240	26	62.08	824
2018	6 273	4 940	201	56.69	774
2019	5 652	5 275	178	58.65	704
2020	6 711	5 944	113	65.99	829
2021	7 039	6 370	492	69.16	866

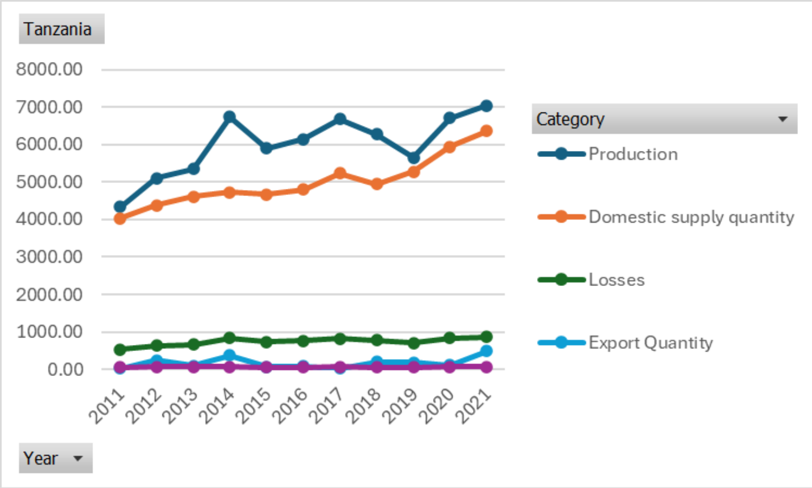


Figure 5-3 - Maize production, domestic supply, export quantities and losses in Tanzania, 1000 t, 2011-2021 (FAOSTAT, 2022)

In terms of maize cultivation, simple hand hoes, farm-recycled seeds, little use of chemical fertilizers or agrochemicals and minimal weeding is the usual technological package.

According to Maziku, P. (Determinants for Post-Harvest Losses in Maize Production for Small Holder Farmers in Tanzania, 2019)**, factors influencing maize post-harvest losses among farmers in Tanzania include education level, family size, maize production quantity, market experience, type of storage facilities, adverse weather conditions, distance to markets, and livestock numbers**. Insufficient storage facilities and transportation methods were identified as the primary causes of losses, accounting for up to 15%. Therefore, enhancing education and providing better marketing information to farmers could empower them to adopt new technologies. Additionally, upgrading storage facilities and using modern post-harvest handling tools like hermetic storage and combined harvesters could significantly reduce maize post-harvest losses.

The majority of maize sold is transported to local collection points where traders gather it for sale in local, regional, and urban markets. Some maize is also sold to processors and grain traders who then export it. There are a few large roller mills in operation, that produce high-quality flour, but they are underutilized. Small-scale hammer mills are predominantly used across Tanzania to process maize into inexpensive and lower-quality flour. However, the economic aspects of these mills are not transparent, and any profit tends to come from large-scale trading volumes, without clear tracking of final product destinations (Maziku P. , 2019).

Inadequate and substandard grain storage poses a challenge to effective maize marketing in Tanzania. Farmers may lose as much as 30% of their harvest stored on-farm, which encourages them to sell shortly after harvesting, despite the lower prices available at that time (Maziku P. , 2019).

In terms of specific volumes of postharvest food losses in the maize value chain in Tanzania, there is data available from the APHLIS database, as well as FAO Food Loss and Waste Database. Maize food loss data is presented in Table 5-2 below. Those numbers vary slightly, as FAO uses in many cases different forecasting and economic modelling techniques to evaluate those specific stage losses.

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

Value chain stage	APHLIS database, 2022	FAO Food Loss and Waste Database, 2021
Harvesting/ field drying	6.40%	Average 5.31% (4.20 – 6.42%)
Further drying	4.00%	4.00%
Threshing and Shelling	1.30%	1.32%
Transport from field	2.40%	2.36%
Household-level storage	5.20%	5.16%
Transport to market	-	Average 0.80% (0.20 – 1.40%)
Market storage	-	Average 5.20% (2.60 – 7.80%)
Overall	19.30%	24.15%

As per Table 5-2, the most critical value chain stage in terms of food losses is harvesting, storage (including both farm and market), drying and transport.

General overview of the maize value chain in Tanzania, covering key stages, processes, stakeholders, climate data, and potential solutions to reduce food losses are summarized in the Table 5-3.

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

FSC Stage/ process	Processes	% losses (APHLIS)	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	6.40%	Quantitative losses, rodent and pest attacks of the stooks, increased humidity/ moisture of crops and fungi development	Farmers	Heat stress for workers/farmers and animals, rains and winds	Capacity building on harvesting techniques and machinery, capacity building and training on drying
Transportation to the farm	Transport from the field to the farm, carrying by hand or by using various vehicles	2.40%	Quantitative losses	Farmers	Rains, winds	Awareness raising/ capacity building on the best transportation techniques
Post-harvest processes (on-farm)						
Threshing/shelling	Manual or mechanical shelling, using manual and mechanical shellers	1.30%	Mechanical damage	Farmers	Rains, winds, temperature	Capacity building on threshing techniques and machinery
Drying	Additional drying using cribs, tarpaulins, and similar solutions	4.00%	Mold, insects, rodents, livestock foraging	Farmers	Rains, winds	Plastic sheets and tarpaulins, rectangular cribs, moisture meters
On-farm storage	Storage in silos, bags or baskets	5.20%	Mold, insects, rodents	Farmers	Rains, winds, heat/ high temperatures	Metal and plastic silos, plastic and hermetic bags, Insecticides/ fumigation, storage structures
Primary processing	Grinding, hulling, pounding, milling, using manual, partially mechanised or fully mechanised small-scale and industrial mills	Not reported	Spillage, contamination with foreign materials	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	Not Reported	Spillage	Aggregators/ collectors and traders		Plastic hermetic bags; non-hermetic polypropylene bags
Grading and packing	Sorting, pre-cleaning, re-packaging and packaging	Not Reported	Spillage, qualitative losses	Collectors and traders		Plastic hermetic bags; non-hermetic polypropylene bags
Storage	In bulk and/or in bags	Not Reported	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 the snack and brewing industry, etc.	Not Reported		Secondary processors		

5.1.2 Rice

Rice ranks second in importance to maize as a food crop in Tanzania. Spanning over 1 million hectares, rice cultivation yields 2.2 million tonnes annually, positioning Tanzania as the leading rice producer in the region. Recognized by the Tanzanian government as a crucial sector for agricultural advancement, rice offers significant potential to enhance food security and income for numerous rural households with land holdings ranging from 0.5 to 3 hectares. Approximately 18% of farming households engage in rice cultivation, and it is more extensively marketed compared to maize (Busungu, 2023). The proportion of marketed rice stands at about 42% of total production, whereas for maize, it is 28%, highlighting its greater commercialization relative to maize.

Rice serves as a staple in both urban and rural settings, and it carries connotations of higher social status (Mtaki B. S., 2023). Dar es Salaam stands out as the primary destination market, responsible for approximately 60% of the nation's rice consumption. Dar es Salaam boasts the largest urban population and overall population in Tanzania, followed by Mwanza (Figure 5-4).

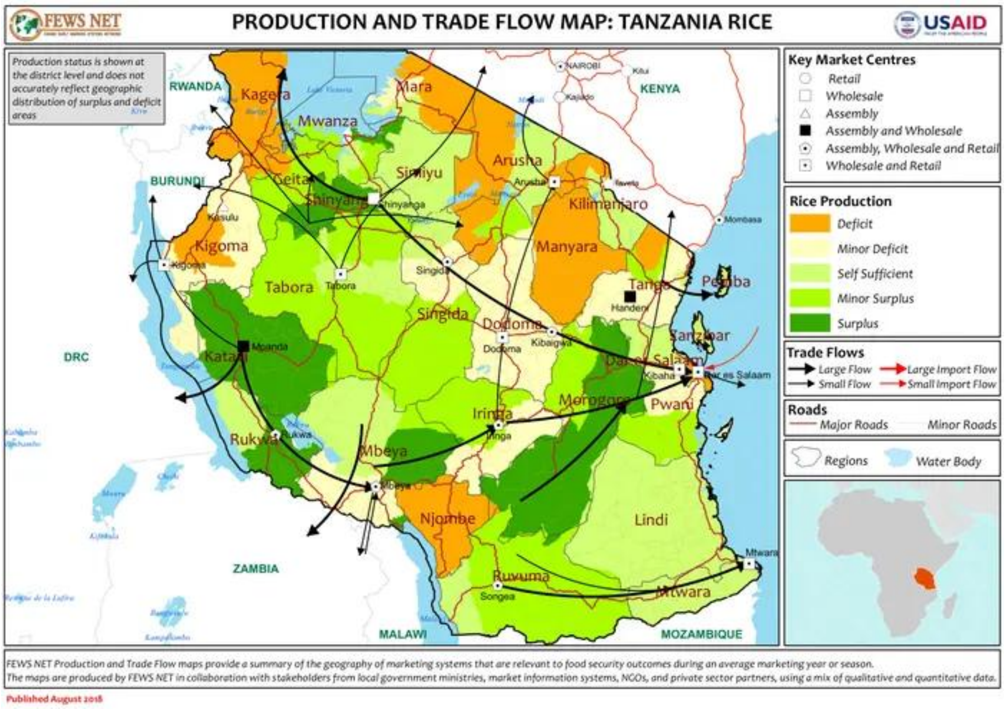


Figure 5-4 - Key production areas and trade flow map of rice in Tanzania in 2018

Despite Tanzania's status as one of the leading rice producers in Africa, its rice productivity remains among the lowest globally, ranging from 0.71 tonnes/ha to 3.31 tonnes/ha, well below the global benchmark of 4.5 tonnes/ha (Busungu, 2023). Rice cultivation in Tanzania predominantly relies on rainfed agriculture, with irrigation systems largely dependent on diverting rainwater to rice fields, thereby making them susceptible to insufficient rainfall. Additionally, farmers often leave fields fallow or switch to alternative crops during adverse weather conditions.

In Tanzania, rice is grown across three primary ecosystems: rain-fed lowland, upland, and irrigated systems. Large-scale rice farmers constitute a small proportion, accounting for less than 10%, while the majority—approximately 90%—are small-scale farmers (Busungu, 2023). Most large-scale producers opt for irrigation due to their economies of scale and substantial investments, resulting in an estimated 5% of rice being cultivated under irrigation systems. Small-scale farmers, who cannot afford such investments, predominantly cultivate rice under rain-fed lowland conditions, comprising about 85% of production, with the remaining 10% in upland ecosystems.

The Government of Tanzania even developed the National Rice Development Strategy (NRDS II 2019-2030) with an aim to address various challenges faced by the stakeholders in the rice value chain and offering various opportunities for increased

production and productivity. These challenges include high costs of production (seed, fertilizers, chemicals, machinery, labour); lack of access to these inputs; lack of credit facilities; erratic weather and water supply; high harvest and post-harvest losses; poor infrastructure in neighbouring countries and low rice value addition; among others. The interventions include the development and dissemination of improved production technologies, introduction of high yielding rice varieties, along the value chain, improved knowledge and skills on harvest and postharvest handling and value addition in rice and rice by-products.

Global warming and climate changes are anticipated to cause a wide-range effect to world food production systems and food security in Tanzania. Rice is one of the crops likely to be severely impacted due to its sensitivity to photoperiod and vulnerability to environmental changes such as salinity, drought, and emerging pests and diseases. This impact is already evident in Tanzania, where in 2021, low rainfall led to a reduction in the area under rice cultivation to 955 729 hectares (Busungu, 2023). During periods of low rainfall or drought, some farmers shift to cultivating other crops like sorghum, millet, and cassava, which are more drought resistant. Enhancing the resilience of rice farmers and maintaining the growth trajectory of rice production in Tanzania, despite the challenges posed by climate change, global warming, and globalization, is crucial for the development of the rice sub-sector.

Tanzania's rice production and productivity have been increasing steadily year after year. More farmers are entering rice cultivation hence the area under rice cultivation has increased from 306 570 hectares in 1992 to 1 351 200 hectares in 2021 (Figure 5-5).

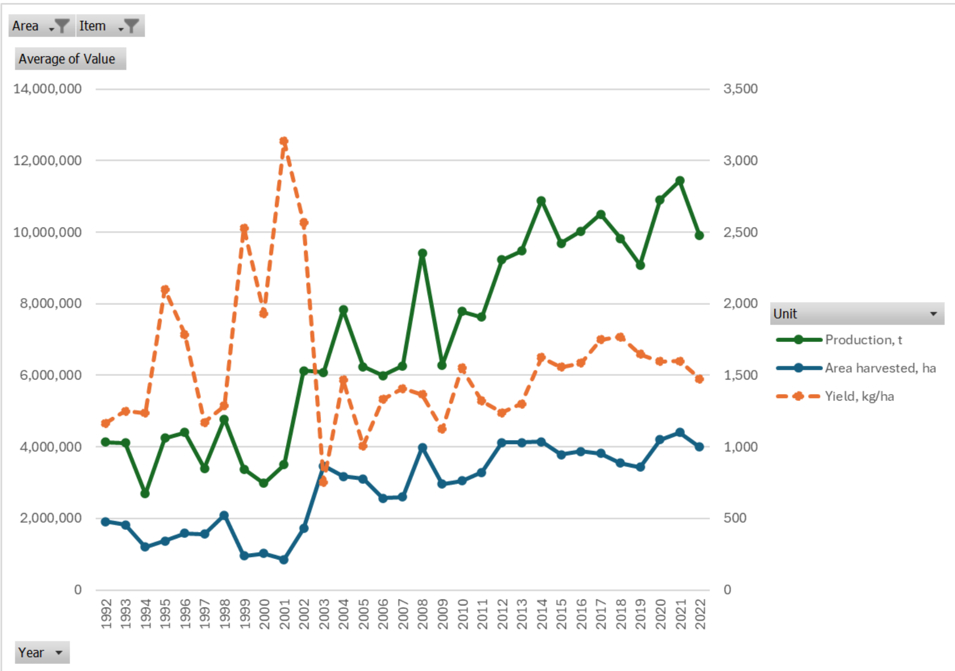


Figure 5-5 - Tanzania's rice production, harvested area and annual yields, 1992 – 2022 (FAOSTAT, 2022)

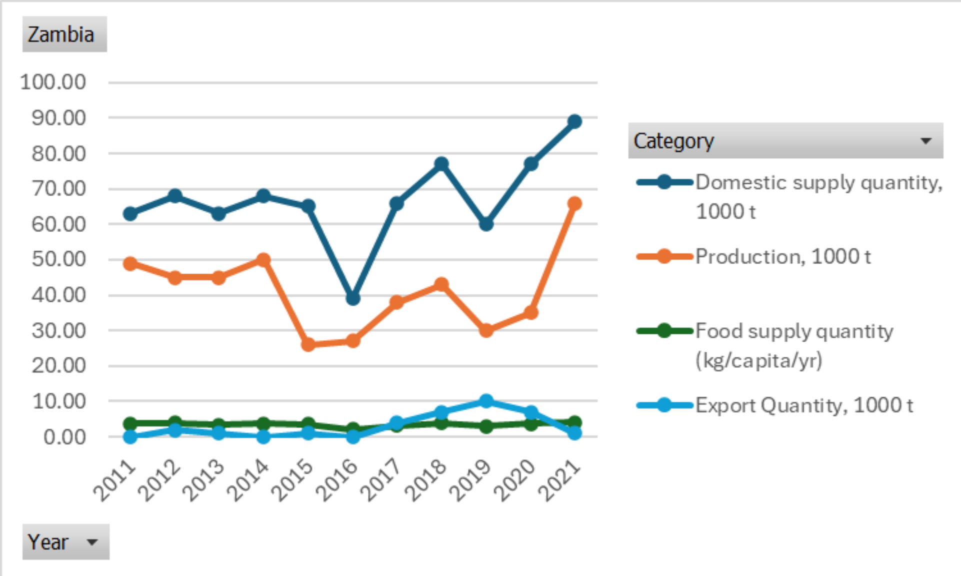


Figure 5-6 - Tanzania's rice domestic supply, production, per-capita consumption and export quantities, 2011-2021 (FAOSTAT, 2022)

Around 75% of rice producers in the region are smallholder farmers who generally cultivate between 0.5 and 2 hectares of rice fields, primarily for household consumption. These farmers face significant risks of substantial harvest losses due to unreliable weather patterns, posing a threat to their food security. This risk is exacerbated in a region where climate change is causing weather patterns to become increasingly unpredictable (Ministerie van Landbouw, Natuur en Voedselkwaliteit, n.d.).

In Tanzania, small-scale farmers typically yield approximately 1.5 tonnes of rice per hectare, which is lower than the average across Africa by one tonne and three tonnes lower than the Asian average. On-farm studies indicate that farmers can lose up to half of their harvest from the time of cutting rice to its sale or consumption, primarily due to traditional practices in cutting, drying, threshing, bagging, and storing rice. Therefore, supporting small-scale rice farmers in enhancing their production methods is critical (Ministry of Agriculture, United Republic of Tanzania, 2019).

In terms of specific volumes of postharvest food losses in the rice value chain in Tanzania, there is data available from the APHLIS database, as well as FAO Food Loss and Waste Database. The relevant estimates presented in Table 5-4 below.

Table 5-4- Comparison of Rice food losses in the different stages of the value chain in different studies

Value chain stage	APHLIS database, 2022	FAO Food Loss and Waste Database, 2021
Harvesting	4.4%	4.4%
Further drying	4%	-
Threshing and Shelling	3.1%	3.14%
Winnowing	2.5%	2.50%
Transport from field	1.3%	1.25%
Household-level storage	1.0%	0.97%
Processing (milling)	-	3.50%
Transport to market	-	-
Market storage	-	-
Overall:	**12.3%**	**15.76%**

As seen above, the most critical rice value chain stage in terms of food losses is harvesting, threshing and shelling, winnowing, and transport from the field, as well as FAO additionally identified processing (milling) as a critical loss point (CLP).

General overview of the rice value chain in Tanzania, covering key stages, processes, stakeholders, climate data, and potential solutions to reduce food losses are summarized in Table 5-5.

Table 5-5 - Overview of Rice food losses in Tanzania in the different steps in the value chain, relevant parameters, and suggested solutions

FSC Stage/ process	Processes	% Losses (APHLIS, African Post Harvest Loss Information System)	Cause of losses	Affected stakeholders	Climate aspects	Suggested solutions
Harvesting						
Reaping (cutting)	Manual cutting of mature panicles and straw above ground using sickles and knives, or mechanically with threshers or combine harvesters	4.4%	Quantitative losses, increased humidity/ moisture of crops, shattering if the grain is too dry	Farmers	Heat stress for workers/farmers and animals, rains and winds	Capacity building on harvesting techniques and machinery, capacity building and training on drying
Threshing	Separating the paddy grain from the non-grain material. Can be manual or mechanical, using manual and mechanical threshers	3.1%	Mechanical damage, spillage, grain damage, incomplete threshing and cracking	Farmers	Rains, winds, temperature	Capacity building on threshing techniques and machinery
Winnowing and cleaning	Removing immature, unfilled and non-grain materials	2.5%	Quantitative losses because of the removal of broken grains	Farmers	Rains, heat/ high temperatures	Capacity building on winnowing and cleaning techniques
Hauling	Transportation of the cut crop to the farm	1.3%	Quantitative losses	Farmers	Rains, winds	Awareness raising/ capacity building on the best transportation techniques
Post harvest processes (on-farm)						
Drying	Drying outdoors using tarpaulins, and similar solutions		Spoilage, fungal damage, discoloration, smell, livestock foraging and breakage because of animal stamping	Farmers	Rains, winds	Plastic sheets and tarpaulins, rectangular cribs, moisture meters
On-farm storage	Storage in silos, bags or baskets	1.0%	Mold, insects, rodents	Farmers	Rains, winds, heat/ high temperatures	Metal and plastic silos, plastic and hermetic bags, Insecticides/ fumigation, storage structures
Primary processing (milling)	Milling using manual, partially mechanised or fully mechanised small-scale and industrial mills	3.5%	Spillage, contamination with foreign materials	Millers	-	Training on milling technologies and machinery
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	Not Reported	Spillage	Aggregators/ collectors and traders		Plastic hermetic bags; non-hermetic polypropylene bags
Grading and packing	Sorting, pre-cleaning, re-packaging and packaging	Not Reported	Spillage, qualitative losses	Collectors and traders		Plastic hermetic bags; non-hermetic polypropylene bags
Storage	In bulk and/or in bags	Not Reported	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 flour, products for the snack and brewing industry, etc.	Not Reported	Spillage, qualitative losses	Secondary processors		

5.2 SHORT-LIST OF FOOD LOSS REDUCTION SOLUTIONS (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 Tanzania. RE-GAIN Programme aims to increase awareness of smallholder farmers in Tanzania 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 Tanzania 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 Tanzania. The proposed FL-RS in those subchapters have been short-listed considering the specific context of Tanzania 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 5-6.

Table 5-6 - Indicative Awareness Raising and Capacity Building elements of RE-GAIN Programme in Tanzania

	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 Fl-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 Tanzania, 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 Tanzania, 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 Tanzania.

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 5-7 below.

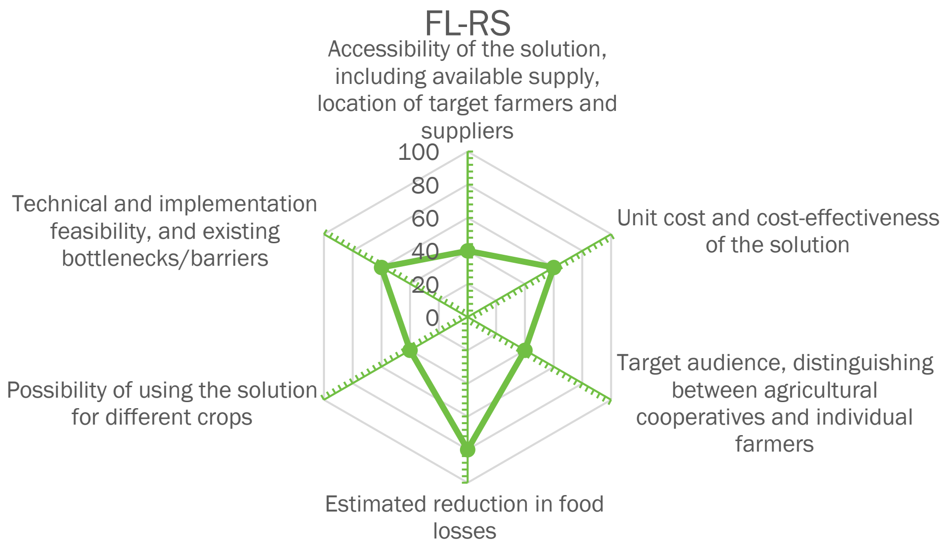


Figure 5-7 - FL-RS evaluation matrix

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 5-8.

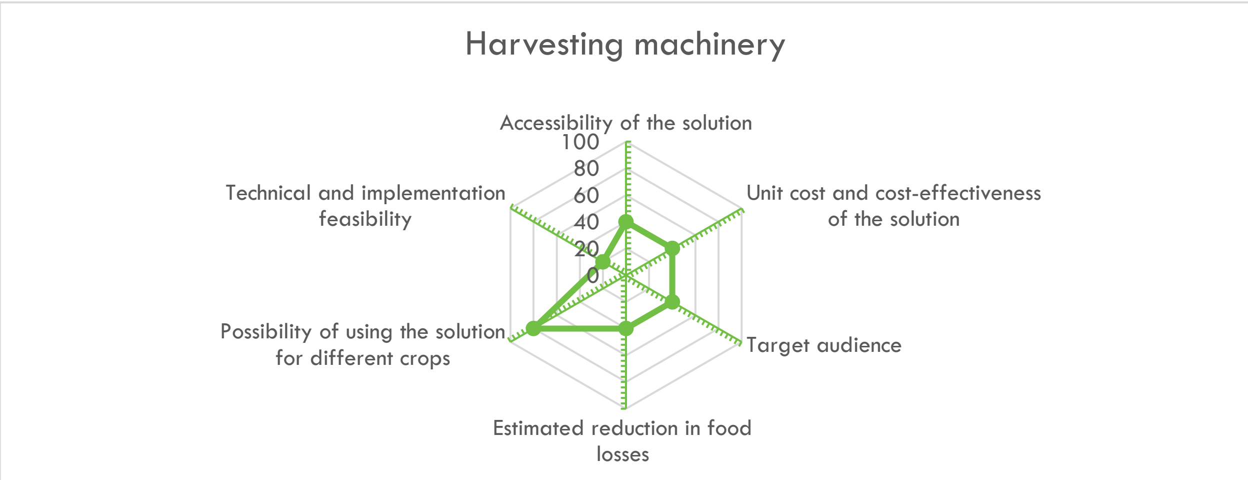


Figure 5-8 - FL-RS evaluation for harvesting machinery

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 5-9.

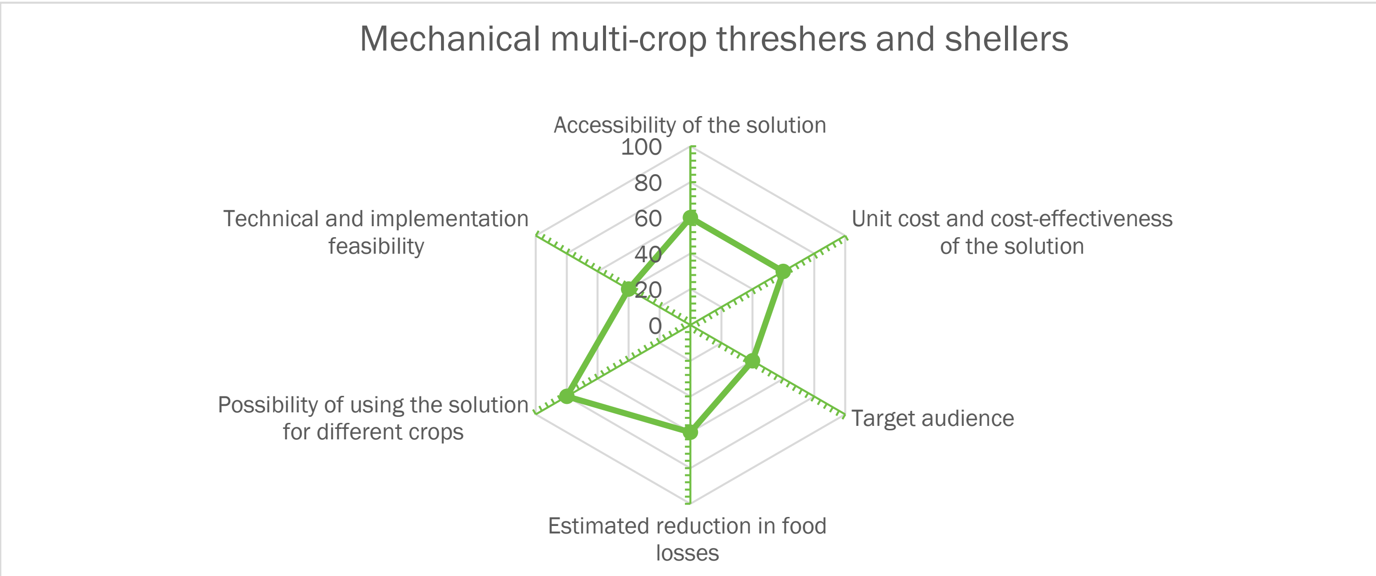


Figure 5-9 - FL-RS evaluation for mechanical multi-crop threshers and shellers

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 5-10.

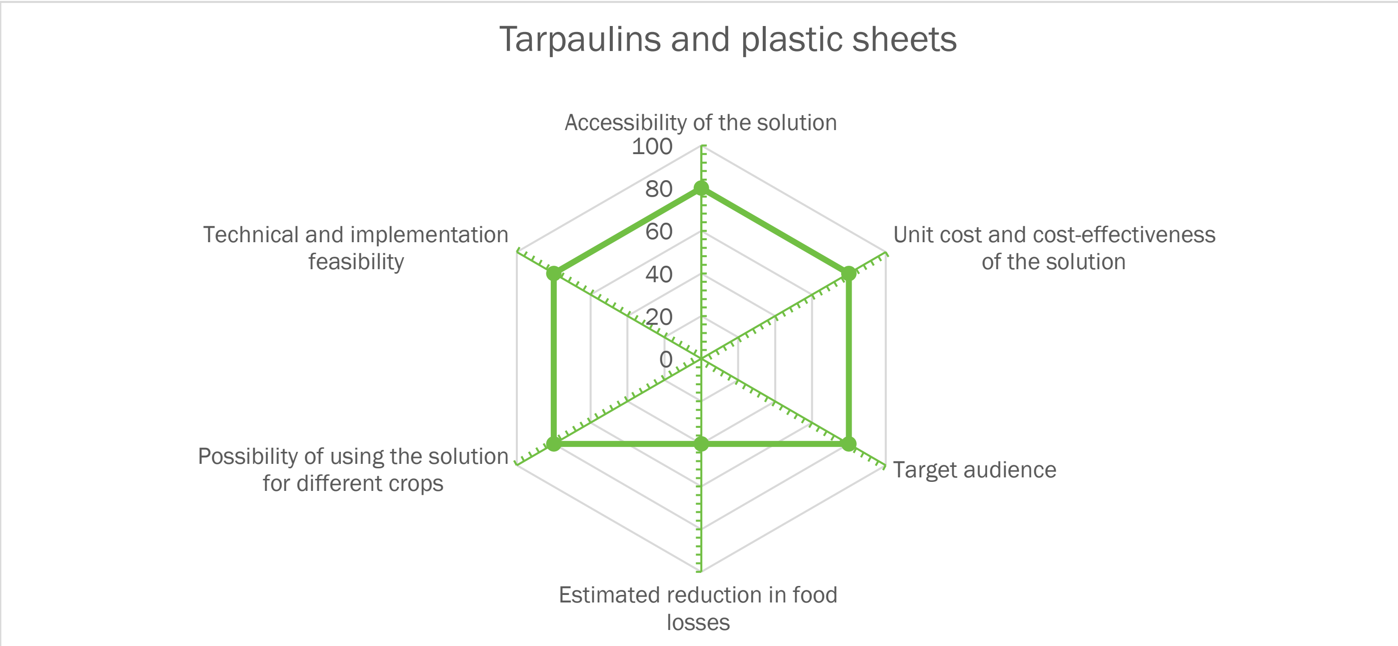


Figure 5-10 - FL-RS evaluation for tarpaulins and plastic sheets

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 5-11.

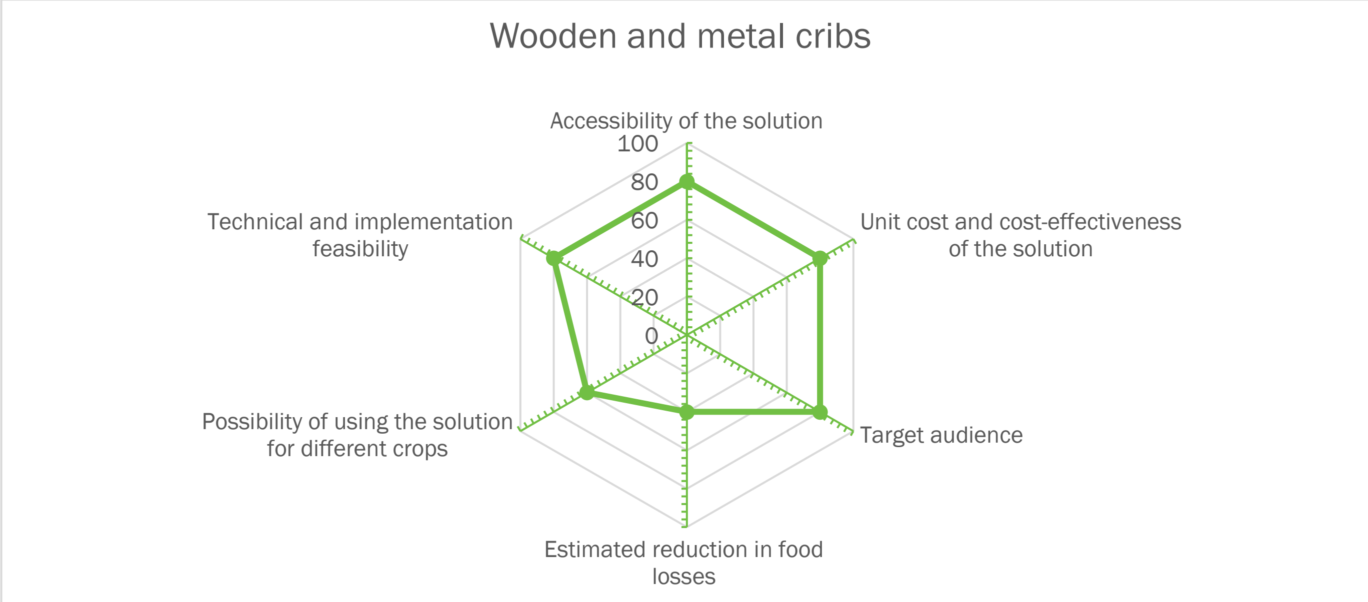


Figure 5-11 - FL-RS evaluation for wooden and metal cribs

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 5-12.

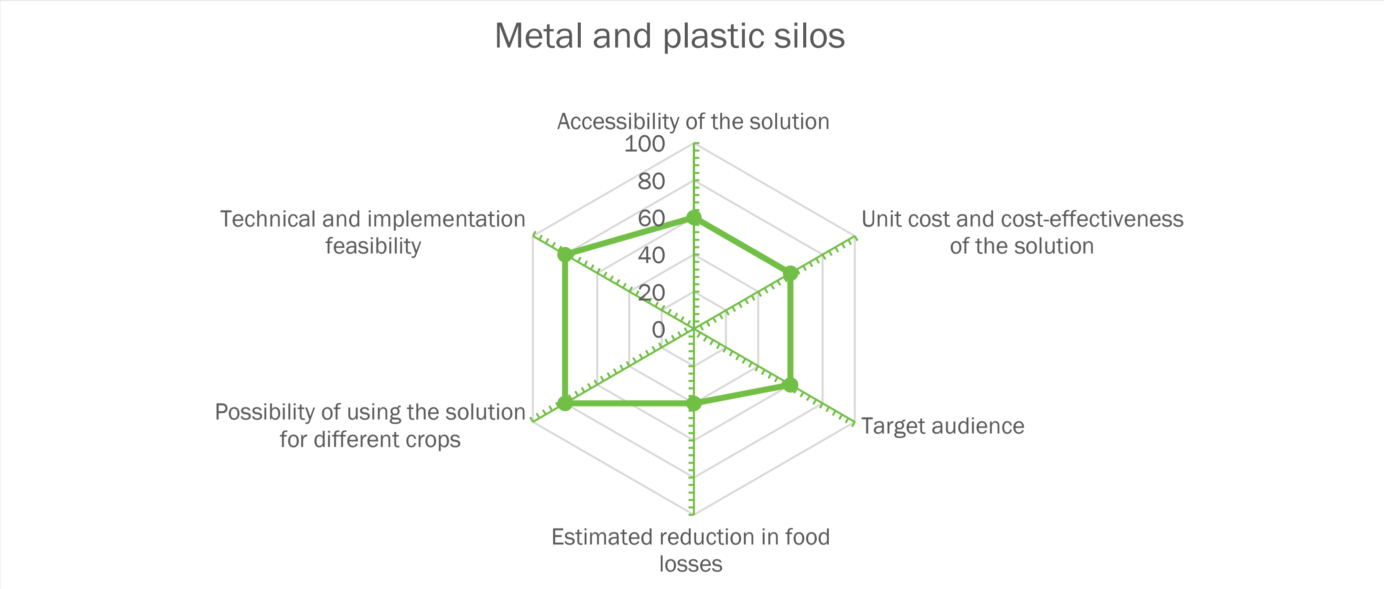


Figure 5-12 - FL-RS evaluation for metal and plastic silos

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 5-13.

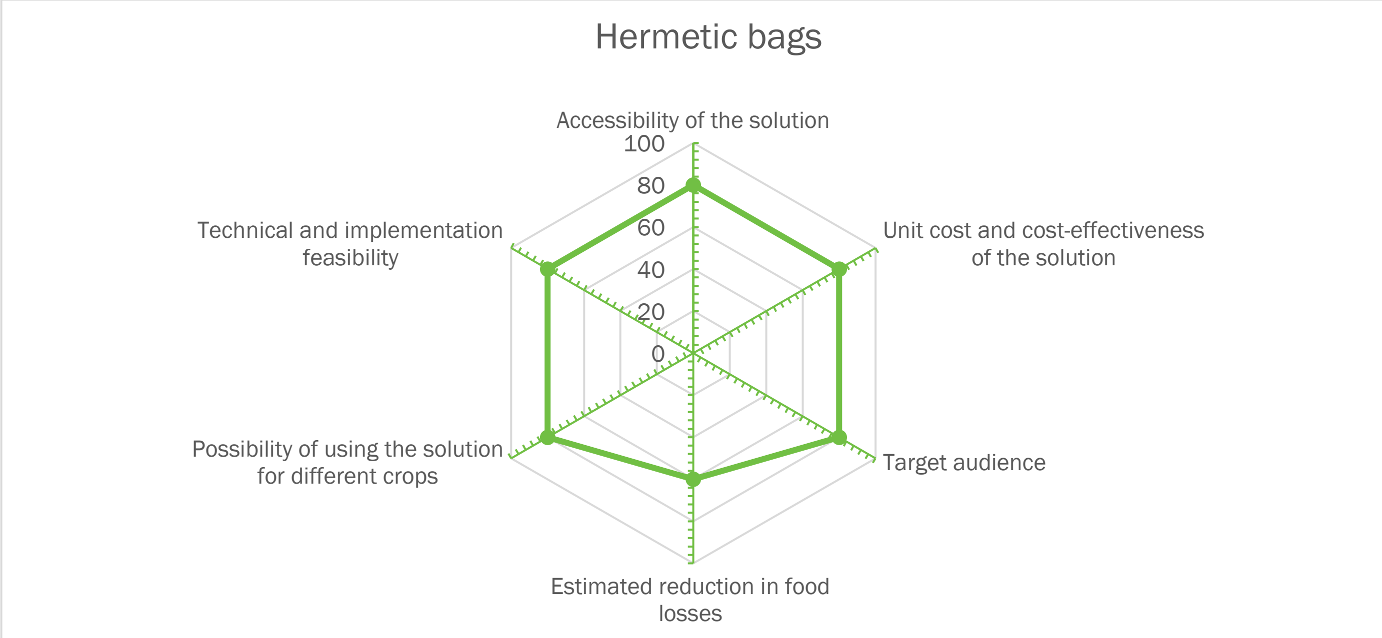


Figure 5-13 - FL-RS evaluation for hermetic bags

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 5-14.

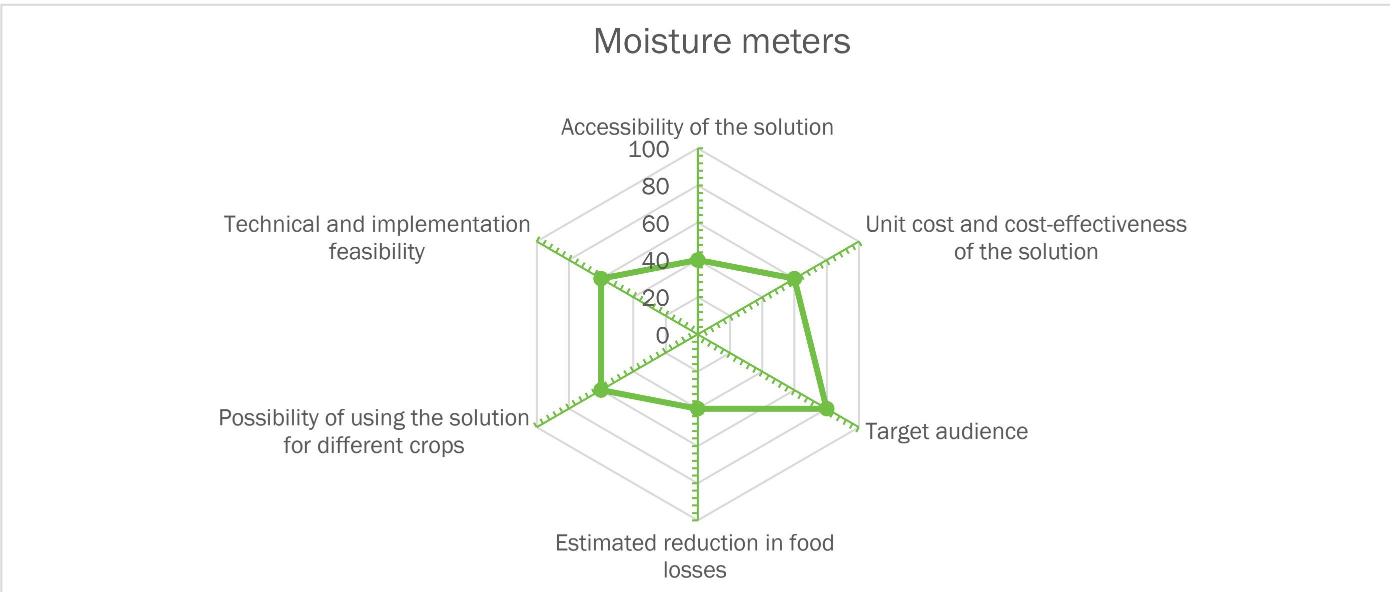


Figure 5-14 - FL-RS evaluation for moisture meters

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 5-15.

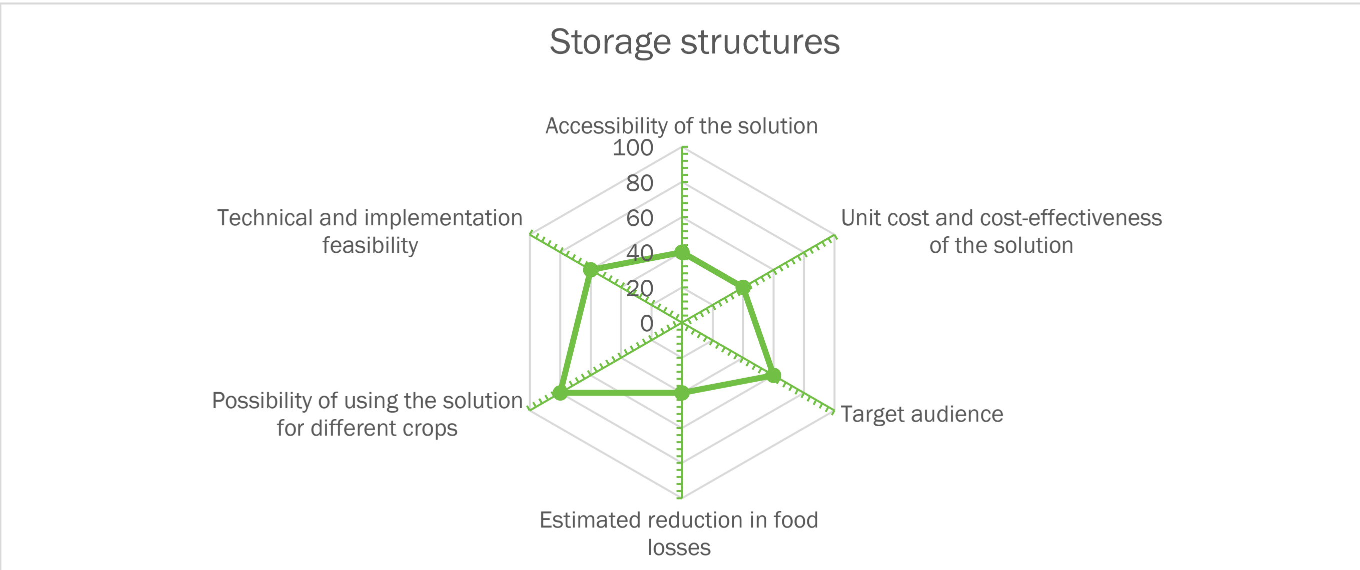


Figure 5-15 - FL-RS evaluation for storage structures

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, 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 A. B., 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 5-16.

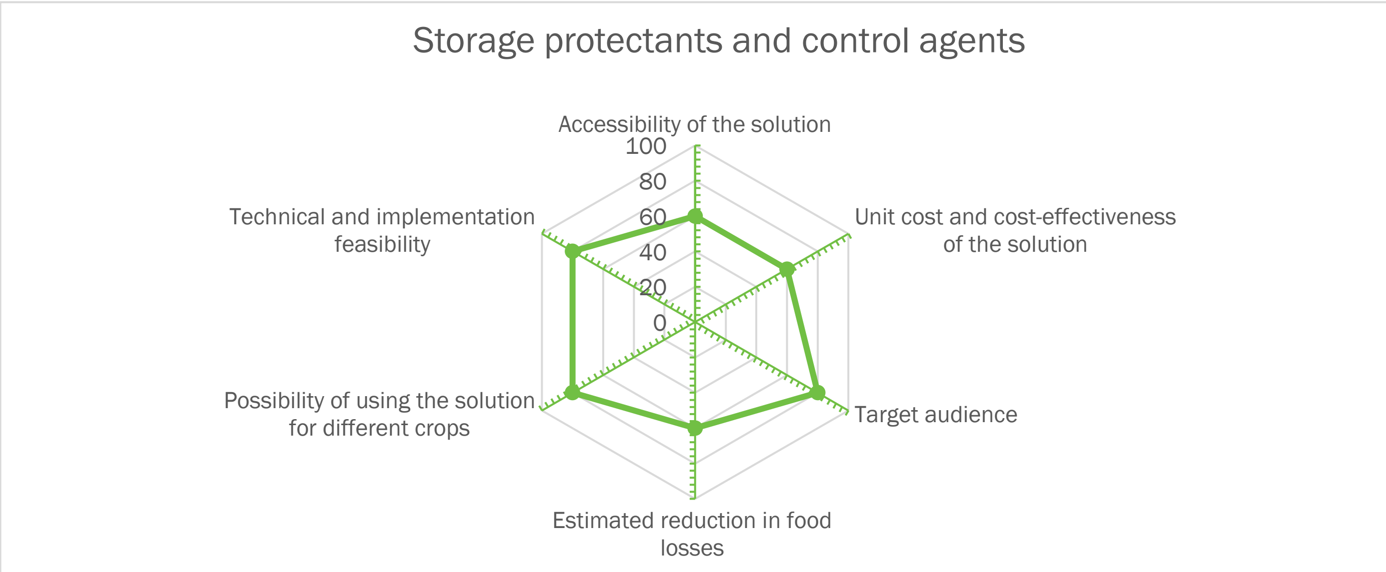


Figure 5-16 - FL-RS evaluation for storage protectants and control agents

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 5-17.

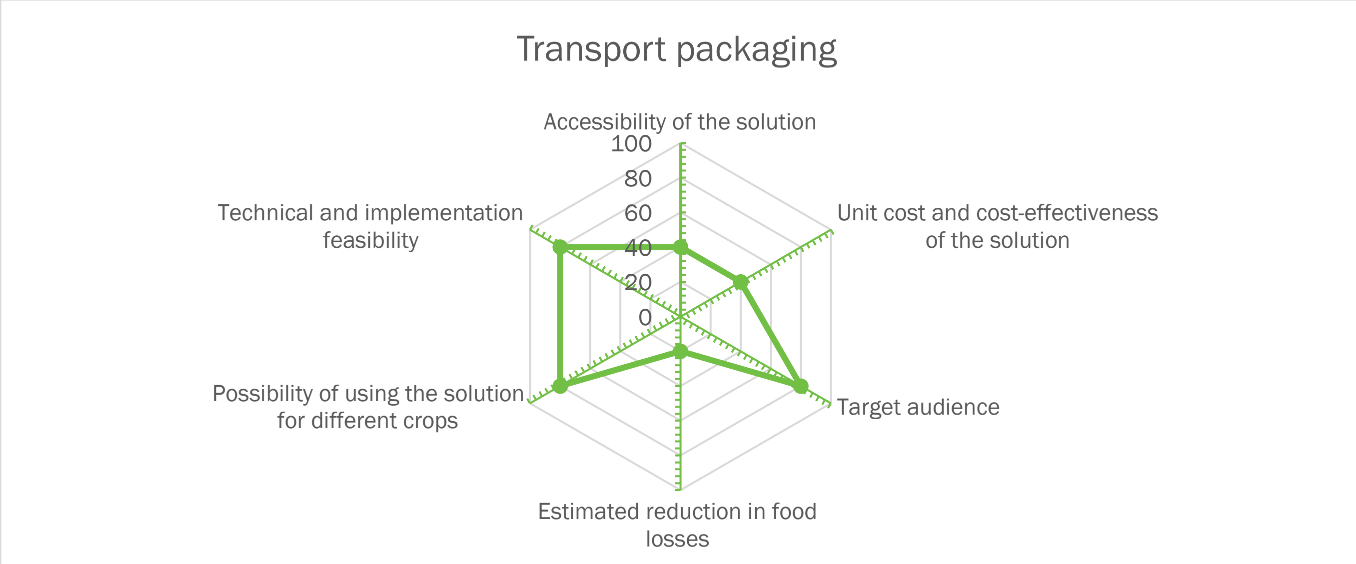


Figure 5-17 - FL-RS evaluation for transport packaging

Summary of the above-mentioned reduction in postharvest losses attributed to those 10 key physical FL-RS are presented in the Table 5-7.

Table 5-7 - 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, 2011); (Abass A. B., 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 rice 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 rice and maize value chains

In terms of climate risks in Tanzania, both maize and rice are highly vulnerable and susceptible to overall increase in temperatures and extremely hot days, water scarcity/droughts, heavy rains and floods as identified in Table 3-13. This vulnerability can lead to reduced harvests and postharvest losses due to spoilage, emphasizing the importance of precise harvesting timing, postharvest crop management and processing, 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 rice and maize value chains is presented in Table 5-8 and Table 5-9 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 5-8 - Evaluation of the potential solutions in addressing key climate hazards in Tanzania for the maize value chain

Solutions	Climate hazards			Average rate
	Average high temperatures and hot days over 35°C	Heavy rains (days with rainfall > 20mm, large 1-day rains and large 5-day rains) and river and /or urban floods	Water scarcity/ droughts	
Harvesting machinery	4	2	4	3.33
Mechanical multi-crop threshers and shellers	4	4	4	4.00
Tarpaulins and plastic sheets	4	2	4	3.33
Wooden and metal cribs	4	2	3	3.00
Metal and plastic silos	4	5	3	4.00
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	2	2.33

Table 5-9 - Evaluation of the potential solutions in addressing key climate hazards in Tanzania for rice value chain

Solutions	Climate hazards			Average rate
	Average high temperatures and hot days over 35°C	Heavy rains (days with rainfall > 20mm, large 1-day rains and large 5-day rains) and river and /or urban floods	Water scarcity/ droughts	
Harvesting machinery	4	4	4	4.00
Mechanical multi-crop threshers and shellers	4	4	4	4.00
Tarpaulins and plastic sheets	4	2	3	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	2	3	2	2.33
Storage structures	4	4	4	4.00
Storage protectants and control agents	3	3	2	2.67
Transport packaging	2	1	2	1.67

Based on the Table 5-8 and Table 5-9 , the FL-RS with the highest average scoring are listed below in the order of importance:

Metal and plastic silos (4.33 points for rice and 4.00 points for maize)

- Hermetic bags (4.00 points for both rice and maize)
- Mechanical multi-crop threshers and shellers (4.00 points for both maize and rice)

- Storage structures (4.00 points for both maize and rice)
- Harvesting machinery (4.00 points for rice and 3.33 points for maize)
- Tarpaulins and plastic sheets (3.33 points for maize and 3.00 points for rice)
- Moisture meters (3.33 points for maize and 2.33 points for rice)

Baseline research findings, detailed in subchapter 5.1 and supported by the outcomes of discussions with stakeholders, have identified harvesting, threshing and shelling and on-farm storage of rice and maize as critical loss factors. For rice, additional stages such as milling, winnowing, and cleaning are also significant contributors to postharvest losses. To address these issues and reduce those postharvest losses, it is essential to promote the widespread adoption of agricultural machinery, including multi-crop harvesters and mechanical threshers and shellers within rural communities. These machines can significantly reduce labour costs and minimize both the quantity and quality of physical crop losses.

Furthermore, pest and rodent infestations are major contributors to postharvest losses in the maize and rice value chains in Tanzania. These problems are often worsened by high temperatures and inadequate storage facilities and techniques. Therefore, it is crucial to provide durable, well-ventilated, or hermetic dry storage facilities. Effective storage solutions should include both on-farm storage and larger wholesale or communal storage options to protect crops from these 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 in Tanzania, 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 Tanzania are presented in Table 5-10 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 5-10 - Estimation of the costs of the top 10 FL-RS in Tanzania ((JiJi Tanzania, 2024)

Solutions	Estimated cost of the solution in US dollars	Scoring
Harvesting machinery	n/a	1
Mechanical multi-crop threshers and shellers	Around 4 000	2
Moisture meters	75 - 120	3
Metal and plastic silos	Est. 100 - 200	3
Wooden and metal cribs	Est. 50 - 200	3
Storage structures	n/a	3
Tarpaulins and plastic sheets	Around 30	4
Transport packaging	2 - 20	4
Storage protectants and control agents	2-20	4
Hermetic bags	Around 2	5

Smallholder farmers in Tanzania, as in many other African countries, often depend on low-technology and low-cost solutions that align with their existing practices and resources. These solutions, characterized by their simplicity and ease of maintenance, are essential for the sustainability of small-scale farming operations and postharvest food losses reduction. The adoption and effective utilization of such technologies are contingent upon the farmers' familiarity and comfort with the tools provided. Recognizing this, it becomes imperative to focus on enhancing the farmers' knowledge and operational capacity. This necessitates a structured approach to capacity-building and awareness-raising, integral to Component 1 of the RE-GAIN Programme. Capacity-building activities aim to equip farmers with the necessary skills to integrate new technologies into their farming practices. Concurrently, awareness-raising initiatives will focus on highlighting the benefits and practical applications of these technologies, fostering a conducive environment for their adoption. This dual approach will ensure that the technological solutions provided are not only accessible but also effectively employed, thereby enhancing agricultural productivity and sustainability.

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 Tanzania 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, quality low-technology solutions are scarce for harvesting, drying, and storing maize and rice 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 Tanzania during the baseline assessments (Chapters 3 and 4), and the first round of stakeholder engagement on national and local levels, major losses in both maize and rice value chains are observed on the harvesting, and post-harvest handling and storage stages.

During the first round of stakeholder consultations in Tanzania, participants of local and national workshops shortlisted the top three solutions, that would be relevant for both maize and rice 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 5-11.

Table 5-11 - Top solutions for maize and rice production, resilience against climate risks, and impact potential for smallholder farmers in Tanzania

Relevance for maize production	Relevance for rice production	Relevance to build resilience against climate risks	Impact potential for smallholder farmers
Harvesting machinery	Harvesting machinery	Storage structures	Harvesting machinery
Mechanical multi-crop threshers and shellers	Mechanical multi-crop threshers and shellers	Mechanical multi-crop threshers and shellers	Mechanical multi-crop threshers and shellers
Metal and plastic silos	Tarpaulins and plastic sheets	Metal and plastic silos	Tarpaulins and plastic sheets
Hermetic bags	Hermetic bags	Hermetic bags	Hermetic bags
Wooden and metal cribs	Wooden and metal cribs	Moisture meters	Wooden and metal cribs

As we can see from the Table, mechanical multi-crop threshers and shellers, as well as hermetic bags, were listed in all four categories, and therefore are of primary importance for postharvest food loss reduction in Tanzania. Harvesting machinery, and wooden and metal cribs were also identified as crucial FL-RS by consulted stakeholders.

For the final evaluation provided in the Table 5-12, 1 point was given for a single mention of the solution. Solutions that were not included, scored 0 points.

5.3.4 Final evaluation

Taking into consideration all the above-mentioned factors, and considering the major climate risks for Tanzania specified in the previous chapters, the physical FL-RS for Tanzania with the highest potential to reduce postharvest food losses are highlighted in Table 5-12 below:

Table 5-12 - Final evaluation of the shortlisted physical FL-RS in Tanzania

Solutions	Climate risks		Costs of the solutions	Best solutions in the local context	Final score
	Maize	Rice			
Harvesting machinery	3.33	4.00	1	3	11.33
Mechanical multi-crop threshers and shellers	4.00	4.00	2	4	14.00
Tarpaulins and plastic sheets	3.33	3.00	3	2	11.33
Wooden and metal cribs	3.00	2.00	3	3	11.00
Metal and plastic silos	4.00	4.33	3	2	13.33
Hermetic bags	4.00	4.00	5	4	17.00
Moisture meters	3.33	2.33	3	1	9.67
Storage structures	4.00	4.00	3	1	12.00

Storage protectants and control agents	2.67	2.67	4	0	9.33
Transport packaging	2.33	1.67	4	0	8.00

Based on the evaluation results, the list of shortlisted solutions for Tanzania includes the following physical FL-RS, in order of their importance: hermetic bags, mechanical multi-crop threshers and shellers, metal and plastic silos, harvesting machinery, tarpaulins and plastic sheets, storage structures, moisture meters, and storage protectants and control agents.

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 Tanzania, each 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 5-13.

Table 5-13 - Results of the shortlisted FL-RS evaluation in Tanzania

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
Harvesting machinery	High efficiency and the ability to cover extensive areas within a short timeframe. These machines are cost-effective, capable of processing multiple crops, easy to operate, and beneficial for commercial farming	High cost, and the requirement for experienced personnel to operate them. Maintenance costs are significant, and the machinery can cause soil compaction during wet seasons. Moreover, while they are suitable for large-scale farming, they are not ideal for small-scale operations	High capital investment required, maintenance and operational costs, and limited applicability to smallholder farming	Harvesting machinery can be either procured by communities or farmer associations or rented out. Multi-crop harvesters were often referred as the most effective solutions in minimizing crop damage and ensuring a higher quality yield
Mechanical multi-crop threshers and shellers	Simplify agricultural work, save time, and enhance efficiency. They are durable, mobile, and affordable, making them suitable for both smallholder and commercial farming. These machines reduce post-harvest losses and are easy to operate	Their operation depends on expensive power sources such as generators or electricity, and maintenance costs can be high. Additionally, their utility is limited throughout the year, and they may not be efficient for handling large quantities of crops	High cost of conventional fuels, the inaccessibility of fuel in some areas, and the machines being potentially expensive for vulnerable communities	Help in maintaining the quality of rice and maize by minimizing damage during processing. Using solar-powered threshers and shellers was identified as a priority
Tarpaulins and plastic sheets	Cost-effective, multipurpose, and easy to use, making them ideal for drying crops, especially at the family level. They are affordable and helpful for small-scale farming	Expose produce to various weather conditions, leading to potential contamination and damage by birds and rodents. They are unreliable during rain and require a large flat area for use	Susceptibility to human activities, the need for a mindset change, and their unsuitability for large-scale production	Provide affordable and effective means for drying and protecting crops from moisture. They are easy to use and widely accessible, making them ideal for smallholder farmers.
Wooden and metal cribs	Simple to construct using local materials and technology, making them suitable for remote areas. They are easy to use and based on traditional knowledge	Lack concrete foundations, making them susceptible to pest infestation, rain, and rodent damage. Wood and metal retain oxygen, providing a conducive environment for fungus and rodents	Lack of proper know-how, availability of construction materials in remote areas, and potential pest and rodent infestations	Familiar for farmers, helps to protect crops against floods and heavy rains, and ensures good ventilation of harvest, but in some cases prone to theft
Metal and plastic silos	Offer durability, pest prevention, and simple technology for grain storage. They maintain quality and are suitable for small quantities	Low storage capacity, are not mobile, and are not suitable for large-scale communal storage	High initial investment costs, inaccessibility to rural areas, and suitability limited to small-scale storage	They are essential for maintaining the quality and quantity of stored maize and rice, especially during periods of surplus production. They offer robust

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
				protection against fluctuating weather conditions, are durable and provide long-term storage solutions that can benefit farmers over multiple seasons
Hermetic bags	Affordable, durable, and easily accessible. They require low maintenance and minimize the need for pesticides when properly used	May be costly for some smallholder farmers and are not suitable for large-scale harvesting. Low-quality bags can easily rupture and are not environmentally friendly	Eco-friendliness, affordability, inaccessibility in remote areas, and limitations for small-scale farmers	Hermetic bags were referred to as particularly effective in creating an airtight environment that prevents pest infestation. Farmers require improved knowledge of the use and maintenance of hermetic bags
Moisture meters	Precise/ ensure accurate moisture content measurement, and simple to use. They ensure that crops are stored under optimal conditions, enhancing resilience against climate-induced quality degradation.	Require personnel with certain skills to utilize the tool. Availability and affordability for small scale farmers are limited	Expensive, and calibrating and repairing them might be challenging	Moisture meters are crucial for monitoring the moisture content of stored crops, preventing spoilage and fungal growth.
Storage structures	Simple, easy to use, and appropriate for both small- and large-scale farmers. They offer relevant grain storage solutions and can be constructed using local materials	Requires significant space, might be costly for some farmers, and exposes produce to climatic conditions	Lack of capital, challenges in operationalization, and the availability of local materials	Improved storage facilities, such as communal silos and advanced storage structures, are described as very effective in protecting crops from adverse weather and pests. These facilities enhance the overall storage capacity and efficiency, contributing to food security and economic stability
Storage protectants and control agents	Effective when properly managed, keeping the harvest safe for extended periods, and easy to apply	Produce needs thorough washing before use, which is often neglected, leading to potential health implications such as cancer	High costs, accessibility issues, and challenges in proper handling	Stakeholders raised the importance of using biological/ organic agents to ensure food safety

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 5-14:

Table 5-14 Prioritized physical FL-RS for Tanzania

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

Regarding the feasibility of implementing harvesting machinery as a prioritized solution in Tanzania, considering the substantial costs and technical requirements associated with the utilization and maintenance of such equipment, we suggest engaging through the development of partnerships with existing agricultural service providers in these countries as the most effective strategy. AGRA team in Tanzania will facilitate the creation of demand and awareness about the advantages of harvesting machinery, particularly in terms of mitigating food losses during harvest induced by climate hazards, through consortia with key relevant partners. This strategy will ensure both direct and indirect engagement with the target farmers.

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***: harvesting machinery, 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.

Considering the above mentioned points, we recommend the FL-RS adaptation strategy for Tanzania to be deployed as basket of option as bespoke combinations such as harvesting machinery, 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.

Taking into consideration the shortlisted solutions for Tanzania, as well as their potential to reduce postharvest losses and existing barriers, Table 5-15 provides a brief overview of the proposed solutions' delivery mechanism for Tanzania.

Table 5-15 - Proposed delivery mechanism for shortlisted physical FL-RS in Tanzania

Solution	Estimated reduction in PHL, % (Table 5-1)	Barriers to solution implementation	Proposed delivery mechanisms
Harvesting machinery	10-15%	• High capital investment • High maintenance and operational costs • Limited applicability to smallholder farming	• Training and capacity building on operating and maintaining multi-crop harvesters
Mechanical multi-crop threshers and shellers	10-30%	• Expensive for vulnerable communities • High cost of conventional fuels • Inaccessibility of fuel in some areas	• Improved access to solutions through a subsidy scheme • Capacity building (training of trainers) on managing and maintaining the machinery
Tarpaulins and plastic sheets	10-20%	• Lack of knowledge of proper use and maintenance • Limited use for large-scale production	• Improved access to solutions through a subsidy scheme • Training and capacity building on the appropriate use of tarpaulins and plastic sheets
Metal and plastic silos	10-50%	• High initial investment costs • Limited availability in rural areas • Primarily suitable for small-scale storage	• Improved access to solutions through a subsidy scheme • Training and capacity building on the appropriate use of silos
Hermetic bags	20-30%	• Use of non-recycled/single use plastics • Affordability • Limited availability in remote rural areas • Limitations for small-scale farmers	• Improved access to solutions through a subsidy scheme • Training and capacity building on the appropriate use of hermetic bags
Moisture meters	Up to 25%	• Availability and affordability • Require technical skills for the right application, calibration, maintenance and repair	• Improved access to solutions through a subsidy scheme • Training and capacity building on the appropriate use of moisture meters
Storage structures	Up to 15%	• Lack of capital • Challenges in operating and maintaining those structures • Limited availability of local materials for construction	• 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 • Accessibility issues • Challenges in proper handling	• Improved access to solutions through a subsidy scheme • Capacity building (training of trainers) on the best practices in using those 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 Tanzania, 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 5-16:

Table 5-16 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 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	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) • Facilitate access to finance for FL-RS providers through innovative de-risking schemes	Output 2.1. Business development support for the improved provision of FL-RS on local markets
	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.
- *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).

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[3] Vice presidents, relevant business line or programme directors/heads, Lead of PMU , Head of MEL
[4] Which fall under the same legal entity as the PSAA Applicant

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.

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 5-17: Country PSC Representatives

Country	PSC Representatives
Tanzania	• Vice President Office (PS/NDA) • Ministry of Agric (PS/Postharvest and Marketing Unit/Food Security) • Ministry Industry and Trade (PS/Dept of Trade/TANTRADE) • Agric Council of Tanzania

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.

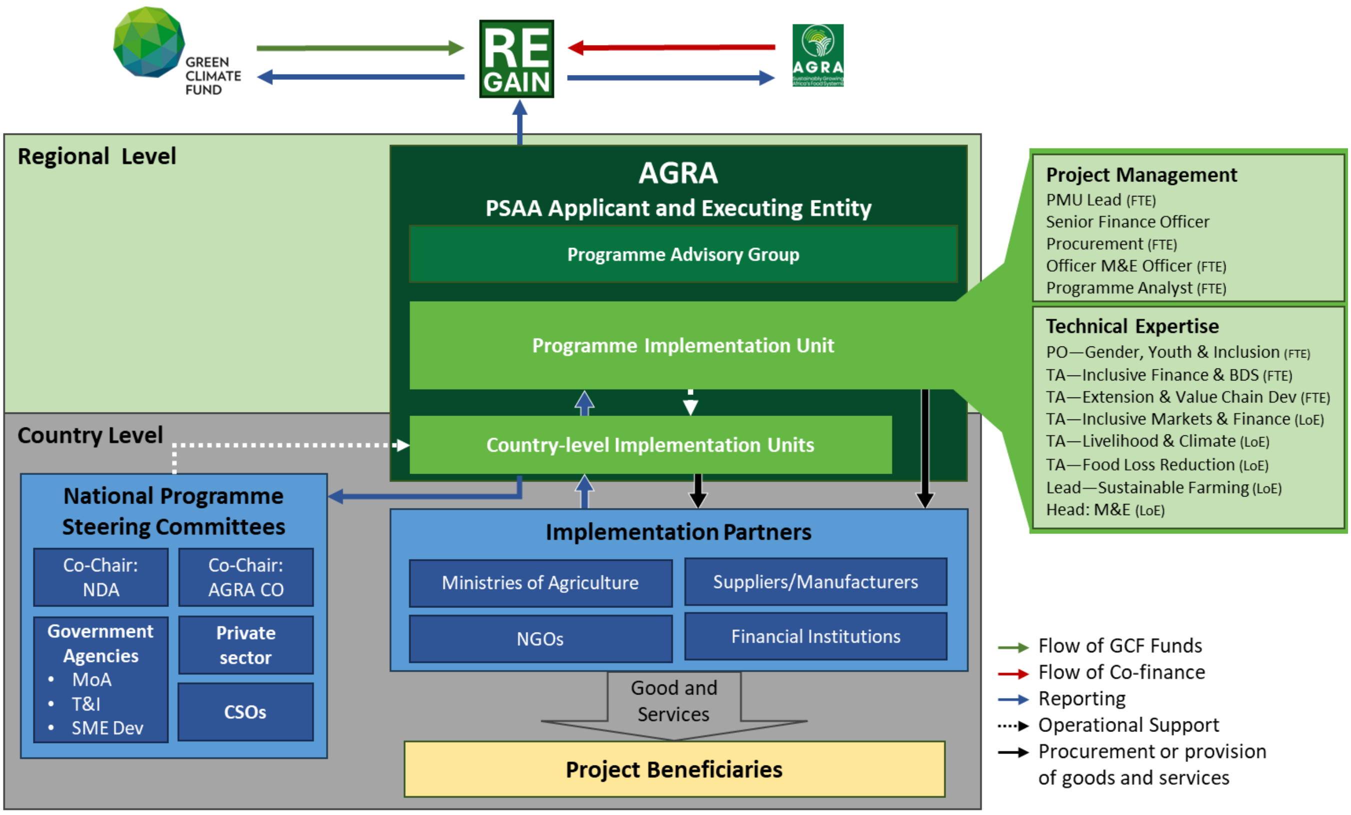

Figure 5-18 Implementation Arrangements for the RE-GAIN Programme

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 AND SUPPLY OF THE PRIORITISED FL-RS

The agricultural sector in Tanzania faces significant challenges in managing food loss, which occurs at various stages from harvesting to storage. The demand for food loss reduction solutions, including harvesting machinery, mechanical multi-crop threshers and shellers, tarpaulins, hermetic bags, silos, moisture meters, and storage structures, has been increasing as awareness grows about the economic and nutritional losses associated with post-harvest inefficiencies.

Despite the increasing demand for these solutions in the market, the demand and supply of agricultural machinery and other post-harvest food loss reduction technologies among smallholder farmers in Tanzania 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 Tanzania, 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.

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

Addressing these barriers requires concerted efforts from the government, private sector, and international development partners to enhance local production, improve distribution, provide financial support, and increase awareness and training among farmers. Subsidies and financial incentives could make these technologies more affordable, while educational campaigns and extension services can raise awareness and improve farmers' capacity to utilize these tools effectively. Strengthening supply chains and improving infrastructure would also enhance the availability and accessibility of food loss reduction solutions, ultimately contributing to the reduction of post-harvest losses and improvement of food security in Tanzania.

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

The demand for FL-RS in Tanzania highlights the critical need for affordable and high-quality solutions to enhance agricultural productivity and reduce post-harvest losses.

The demand for **harvesting machinery** in Tanzania is multifaceted and driven by several key factors. Firstly, the agricultural sector in Tanzania is characterized by a high reliance on manual labour, which is not only time-consuming but also inefficient and prone to significant losses. This reliance is particularly problematic during peak harvesting seasons when labour shortages can lead to delays, resulting in substantial post-harvest losses. Consequently, there is a growing recognition of the need for mechanized solutions to enhance efficiency and productivity. The increasing demand for harvesting machinery is also influenced by the agricultural modernization and commercialization. Progressive smallholder farmers are leading the way in adopting harvesting machinery to improve their operations. These farmers recognize that mechanization can lead to higher yields, reduced labour costs, and improved crop quality.

However, several barriers impede the widespread adoption of harvesting machinery. The primary challenge is the high cost of machinery, which is beyond the reach of many smallholder farmers who form the backbone of Tanzania's agricultural sector. The initial investment required for purchasing machinery is substantial, and many farmers lack access to affordable financing options. Even when credit is available, the terms are often unfavourable, with high-interest rates and short repayment periods. Another significant barrier is the limited availability of harvesting machinery within the country. The market is heavily reliant on imports, which are subject to high import duties and taxes, further inflating the costs. Moreover, imported machinery may not always be suitable for the local farming conditions, leading to issues with efficiency and durability. The lack of local manufacturing and assembly facilities means that farmers have limited choices and often have to settle for machinery that is not ideally suited to their needs. Furthermore, there is a scarcity of technical expertise and support services for maintaining and repairing harvesting machinery. The lack of after-sales service and technical support can lead to frequent breakdowns and reduced machinery lifespan, discouraging farmers from investing in mechanization.

To address these challenges, there is a need for a multi-pronged approach. Improving access to affordable financing is crucial, and this can be achieved through innovative financial products tailored to the needs of farmers, such as machinery leasing and hire purchase schemes. Encouraging local manufacturing and assembly of harvesting machinery can also help reduce costs and ensure that equipment is better suited to local conditions. Moreover, strengthening distribution networks and providing training programs for farmers and technicians can enhance the adoption and effective use of harvesting machinery.

The demand for **mechanical multi-crop threshers and shellers** in Tanzania is significant, driven by the need to improve post-harvest processing efficiency and reduce labour costs. Traditional manual threshing and shelling methods are labour-intensive, time-consuming, and often result in considerable losses due to improper handling and inefficiencies. Besides that, multi-crop threshers and shellers provide the versatility needed to handle a range of crops, making them highly sought after. Moreover, the push towards agricultural commercialization and value addition has further amplified the demand for these machines. Mechanical threshers and shellers help in achieving uniformity and reducing contamination, thus enhancing the quality of the final product and increasing its market value.

However, several barriers hinder the widespread adoption of mechanical multi-crop threshers and shellers in Tanzania. The primary obstacle is the high cost of these machines, which is prohibitive for many smallholder farmers. Access to affordable credit and financing options remains limited, further constraining their ability to invest in such equipment. Additionally, the supply of mechanical multi-crop threshers and shellers is insufficient to meet the growing demand. The market relies heavily on imported machines, which are subject to high import duties, taxes, and logistical challenges. Furthermore, imported machines may not always be designed to handle the specific needs of Tanzanian crops and farming conditions, leading to suboptimal performance and frequent breakdowns. Local manufacturing and assembly of these machines are limited, which exacerbates the supply constraints. There is a need to develop local production capacities to ensure that threshers and shellers are affordable, accessible, and tailored to local requirements. Enhancing local manufacturing would also create employment opportunities and stimulate the local economy. Another significant barrier is the lack of technical knowledge and skills among farmers and operators regarding the use and maintenance of mechanical threshers and shellers. Many farmers are unfamiliar with the operation and upkeep of such machinery, leading to improper use, frequent malfunctions, and reduced machine lifespan. This situation is compounded by inadequate access to technical support services and spare parts, particularly in rural areas.

To address these challenges, a comprehensive approach is required. Improving access to affordable financing options is critical. Financial institutions and development organizations can play a pivotal role by offering tailored loan products, subsidies, and grant schemes to facilitate the purchase of threshers and shellers. Encouraging public-private partnerships can also help in developing local manufacturing capacities, reducing dependency on imports, and ensuring that machines are suited to local conditions. Moreover, investing in training and capacity-building programs is essential to equip farmers and operators with the necessary skills to use and maintain mechanical threshers and shellers effectively. Establishing robust distribution networks and technical support services can further enhance the adoption and sustained use of these machines.

The demand for **tarpaulins and plastic sheets** in Tanzania's agricultural sector is driven by the critical need to reduce post-harvest losses, particularly during the drying and temporary storage phases. These materials provide an affordable and practical solution for smallholder farmers to protect their crops from moisture, pests, and other environmental factors that can lead to significant losses. Demand for tarpaulins and plastic sheets is particularly high among smallholder farmers who are seeking cost-effective solutions to improve their post-harvest practices. These materials are relatively inexpensive compared to other post-harvest technologies, making them accessible to a larger number of farmers. Additionally, they are lightweight, portable, and easy to use, which further enhances their appeal.

Despite the high demand, several barriers hinder the widespread adoption and effective use of tarpaulins and plastic sheets. One major challenge is the availability of high-quality products. The market is often flooded with low-quality tarpaulins that do not provide adequate protection and have a shorter lifespan, but still being sold as high-quality products. They can tear easily and offer limited resistance to UV rays and other environmental factors, reducing their effectiveness and leading to frequent replacements. The supply chain for tarpaulins and plastic sheets is also underdeveloped. Distribution networks are often inadequate, especially in remote and rural areas where many smallholder farmers reside. This makes it difficult for farmers to access these materials when needed. Affordability remains another significant barrier, particularly for the poorest farmers. While tarpaulins and plastic sheets are cheaper than many other post-harvest technologies, the upfront cost of buying enough tarpaulins for the season can still be prohibitive for those with limited financial resources. Access to credit and financing options specifically tailored for purchasing such materials is limited, making it difficult for farmers to invest in them.

To address these challenges, a multi-faceted approach is necessary. Enhancing the quality and availability of tarpaulins and plastic sheets is essential. This can be achieved by promoting local manufacturing and ensuring that products meet certain quality standards. Improving distribution networks is another crucial step. Establishing partnerships with agricultural cooperatives, NGOs, and private sector actors can help create more efficient supply chains and ensure that materials reach farmers in remote areas. Additionally, providing targeted subsidies or voucher programs can make tarpaulins more affordable for smallholder farmers.

Hermetic bags have seen a surge in demand in Tanzania, driven by the critical need to address post-harvest losses and improve the storage of grains and other crops. These bags are particularly beneficial for smallholder farmers who need affordable and effective storage solutions. However, several challenges hinder the widespread adoption of hermetic bags in Tanzania. One of the primary barriers is the cost. Although hermetic bags are a cost-effective solution in the long run, their initial purchase price can be relatively high for smallholder farmers, who make up the majority of the farming population. Many of these farmers operate on tight budgets and may not have the financial capacity to invest in hermetic bags without external support. Quality assurance is another critical issue. The market for hermetic bags in Tanzania is not well-regulated, leading to the presence of counterfeit and substandard products. These inferior bags may not provide the airtight seal required to prevent pest infestations and moisture ingress, thus failing to deliver the expected benefits. Ensuring that farmers have access to genuine, high-quality hermetic bags is essential for building trust and encouraging widespread adoption. Another significant barrier is the lack of awareness and understanding of the benefits and proper use of hermetic bags. Many farmers continue to rely on traditional storage methods simply because they are unaware of better alternatives or do not fully understand how hermetic bags work. Distribution challenges also play a crucial role in limiting access to hermetic bags. The supply chains for these bags are often underdeveloped, particularly in remote and rural areas where they are needed most. Additionally, there is a lack of local manufacturing capacity, which means that many hermetic bags must be imported, further increasing costs and limiting availability.

To address these challenges, improving access to affordable financing options is crucial. Financial institutions and development organizations can play a pivotal role by offering tailored loan products, subsidies, or grant schemes to facilitate the purchase of hermetic bags. Strengthening distribution networks is also essential to ensure that hermetic bags are available to farmers in all regions, particularly in remote areas. Besides that, quality control measures need to be implemented to ensure that only genuine, high-quality hermetic bags are available in the market. This can be achieved through regulation, certification, and regular market inspections.

The demand for **metal and plastic silos** in Tanzania is moderate. Despite the clear benefits and rising demand, the use of silos is still limited, with high initial costs being a significant barrier. Metal silos, in particular, require significant capital investment for construction and purchase, which can be prohibitive for many smallholder farmers. Although plastic silos are generally less expensive, they still represent a considerable financial outlay for farmers with limited resources. Access to affordable credit and financing options specifically designed for purchasing silos is often lacking, further constraining their ability to invest in these solutions. The supply chain for metal and plastic silos also faces significant limitations. Local manufacturing capacity for these silos is limited, leading to a reliance on imports. Additionally, the distribution networks for these storage solutions are underdeveloped, particularly in remote and rural areas where many farmers operate. The lack of technical knowledge and skills among farmers regarding the construction, maintenance, and proper use of metal and plastic silos also poses a barrier to adoption.

Moisture meters are getting more popular in Tanzania because of the several factors. Firstly, the prevalence of post-harvest losses due to improper drying methods is a significant issue. Traditional methods of moisture assessment, such as visual inspection or tactile methods, are often inaccurate and lead to either under-drying or over-drying. Under-drying leaves crops susceptible to mould growth and pest infestations, while over-drying can result in weight loss and reduced market value. The shift towards agricultural modernization and the adoption of better post-harvest practices have also fuelled the demand for moisture meters. As farmers become more aware of the importance of proper drying and storage, they increasingly recognize the value of having reliable tools to manage these processes. However, most moisture meters are imported, making them expensive and limiting their distribution. Besides that, many farmers are unfamiliar with these devices and may not fully understand how to use them effectively, which can lead to scepticism about the value of investing in moisture meters.

Extension services and educational programs are often limited, leaving a gap in the necessary training and support for farmers.

There is a high demand for **improved storage structures** to reduce post-harvest losses and enable farmers to store crops longer to achieve better prices. The establishment of these structures is growing, supported by various development programs and cooperatives. However, challenges such as securing funding, land, and proper management structures limit their effectiveness. Organizational capacity and governance issues also need to be addressed to ensure these communal facilities are used efficiently and equitably. Enhanced access to affordable storage solutions and management training would significantly benefit smallholder farmers in Tanzania.

Demand for **storage protectants and control agents** in Tanzania is strong and growing, driven by the need to reduce post-harvest losses and improve the overall quality of stored crops. However, challenges such as affordability, distribution, and the presence of counterfeit products need to be addressed to fully realize the market's potential. Besides that, not all the farmers are aware about the right use and dosage of those protectants, and express interest in increased presence of biological/organic protectants on the market.

6.2 MARKET OF SUPPLIERS AND MANUFACTURERS OF FL-RS

The current market situation for food loss reduction solutions in Tanzania involves a diverse range of suppliers, manufacturers, and importers, each playing a critical role in addressing post-harvest challenges. The landscape is characterized by a mix of local production and significant reliance on imported technologies, with varying degrees of accessibility and affordability impacting their widespread adoption.

Harvesting Machinery: Local production of harvesting machinery in Tanzania is minimal, with most machinery being imported. Companies such as Poly Run Enterprise Co Ltd, Imara Tech, Farming and Engineering Services (FES), Tractors Tanzania, Intermech Engineering Ltd, as well as John Deere Tanzania, AGCO Corporation, and Massey Ferguson, represented by local dealers, are key players in supplying harvesting machinery. Their production volumes and types of machinery differ between companies. More information on the location, average prices of the solutions, and whether those are locally produced or imported, are provided in the Appendix 9.

Threshers and Shellers: In Tanzania, there are a few local manufacturers assembling/producing these machines, such as Poly Run Enterprise Co Ltd, Imara Tech, and Intermech Engineering Limited. However, the market largely depends on imported machinery from countries like China, India, and Brazil. Importers and distributors such of various sizes are key players in bringing these technologies into the country.

Tarpaulins and Plastic Sheets: The market for these products in Tanzania includes both local manufacturers and importers. Local companies like AgroZ and Pee Pee Tanzania Limited (PPTL Co Ltd) produce various plastic products, including tarpaulins and sheets. Additionally, imports from countries such as China and India supplement local production. Retailers and wholesalers play a significant role in distributing these products across urban and rural areas, although quality and durability remain concerns for many farmers.

Hermetic Bags: Local companies like AgroZ (A to Z) and Pee Pee Tanzania Limited produce hermetic bags that cater to the needs of smallholder farmers. International organizations, such as the Purdue Improved Crop Storage (PICS) project, also support the distribution of these bags. Importers complement local production by bringing in products from neighbouring countries and further afield.

Metal and Plastic Silos: In Tanzania, local production is limited, with a few manufacturers like Intermech Engineering Limited and the SIDO involved in producing these silos. However, the majority of silos are imported from countries such as India, China, and Kenya. Importers and distributors such as Balton Tanzania and TechnoServe play a crucial role in ensuring these silos are available to Tanzanian farmers.

Moisture Meters: The market for moisture meters in Tanzania is primarily driven by imports, with few local manufacturers like Cotex Industries Limited producing these specialized devices. Companies such as Agricom Africa Ltd and Agrimech Africa Ltd are prominent suppliers, importing moisture meters from countries like Germany, the United States, and China.

Communal Storage Structures: The development of these structures in Tanzania often involves a combination of imported materials, local construction companies and international aid organizations. Local firms such as Nandra Engineering and Construction and BQ Contractors are frequently engaged in building these facilities. UN and other international development organizations also play a significant role in funding and facilitating the construction of communal storage.

Storage protectants and control agents: Tanzania's market for those FL-RS is dynamic, with a strong presence of both local manufacturers and international importers. The majority of crop protectants and control agents used in Tanzania are imported, with a wide range of international companies such as Bayer Crop Science, Syngenta, BASF, and Corteva Agriscience being active in the Tanzanian market through local distributors. They are further being distributed by local local agrodealers.

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 Tanzania

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 Tanzania, given the importance of agricultural financing for the development and sustainability of the sector in the country. These initiatives encompass a variety of interventions and have had varying degrees of success and impact.

Overall, the most common interventions for supporting farmers in acquiring necessary agricultural inputs and equipment in Tanzania include subsidies, tax exemptions, loans, cooperative societies, and the warehouse receipt system. These interventions facilitate various physical solutions for farmers, including threshers, agricultural equipment and storage facilities.

The entities responsible for setting up these interventions include the government, non-governmental organizations (NGOs), international organizations like the United Nations (UN), farmers, and collaborations between the private and government sectors. Government bodies, NGOs, and the UN often initiate these programs, with government agencies directly providing financial solutions. Cooperative groups formed by farmers pool resources, and collaborations between private entities and the government also play a significant role.

Development banks, such as the Tanzania Agricultural Development Bank (TADB), provide various financial products, including seasonal loans, investment loans, and guarantee schemes. Regional development banks also support regional agricultural projects through loans and credit facilities.

In addition to these institutional sources, government programs and schemes offer vital support. Examples include the Agricultural Inputs Trust Fund (AGITF), which provides loans for purchasing agricultural inputs, and the National Agriculture and Food Corporation (NAFCO), which finances large-scale agricultural projects. The Tanzania Social Action Fund (TASAF) also contributes by funding community-based agricultural initiatives.

Subsidies, known as Ruzuku, provide financial support to reduce the cost of agricultural inputs and machinery. Tax exemptions lower costs by exempting taxes on agricultural equipment and inputs. Loans offer favourable terms for purchasing necessary equipment and inputs. Cooperative societies are formed to provide collective financial and material support. The warehouse receipt system allows stored produce to be used as collateral to secure loans for agricultural purchases.

The functioning of these interventions involves several mechanisms. Subsidies and tax exemptions reduce the overall cost of agricultural inputs and machinery for farmers. The omission of value-make tax (VAT) on agricultural products makes them more affordable. Soft loans with low-interest rates make it easier for farmers to finance their operations. Financial solutions are extended to both individual farmers and cooperative groups, increasing access. Innovative collateral solutions, such as using stored produce, make securing loans more flexible.

As a result of these interventions, farmers reported an increase in agricultural production due to enhanced access to machinery and inputs. The cost of agricultural machinery has been reduced, making it more affordable for farmers. Improved storage solutions and market access have led to increased profitability in farming. However, some interventions have experienced limited success due to various challenges.

Among those government – led initiatives implemented in Tanzania in the recent years, there are:

1. **Green Financing Programme**: Provided various physical solutions, such as threshers, and involved entities like the government, NGOs, UN, RIKOLTO & CRDB, and SIDO. Currently in the pilot stage, it provides credit facilities for machines and funds, showing impacts primarily at the SME level.
2. **SIDO**: Focuses on the fabrication of threshing machines, issuing loans, and post-harvest technologies. This ongoing initiative has positively impacted farmers by providing credit facilities and subsidized prices for post-harvest technologies.
3. **Guarantees Scheme to Farmers' Organizations**: Led by local government authorities, this programme helps farmers access machinery and inputs by outsourcing through microfinance.
4. **Formation and Institutionalization of Community Serving Schemes and Lending Schemes**: Managed by government programs and NGOs, these schemes rely on member contributions to facilitate low-interest loans for farmers.

Commercial bank loans are a significant source of agricultural financing in Tanzania, offering short-term, medium-term, and long-term loans. Short-term loans are typically utilized for purchasing seeds, fertilizers, and other inputs, while medium-term loans are used for acquiring equipment and machinery. Long-term loans, on the other hand, are essential for infrastructure development such as storage facilities.

Microfinance institutions (MFIs) play a vital role in providing financial services to smallholder farmers in Tanzania. They offer small-scale loans for purchasing tools and small equipment. Savings and Credit Cooperative Societies (SACCOS) also contribute significantly by providing member loans based on individual savings and shares. These cooperatives often offer agricultural-specific loans tailored to farming activities and agribusiness ventures.

Non-governmental organizations (NGOs) and donor agencies offer grants and subsidies for specific agricultural projects and capacity-building initiatives, often accompanied by technical assistance, training, and advisory services. International grants from organizations like the FAO and the World Bank support specific agricultural development projects, further enhancing the sector's growth and sustainability.

These international organizations and their initiatives play a crucial role in providing microcredit to farmers in Tanzania, supporting agricultural development, and improving the livelihoods of rural communities.

Farm to Market Alliance: Involves promotion and financing of threshers and other inputs, managed by WFP and AGRA. It operates through microfinance outsourcing and member contributions, facilitating access to credit and low-interest loans for farmers.

As for the financing schemes and initiatives, managed by the NGOs and private sector in Tanzania, the following were highlighted by the stakeholders during the consultations:

1. **LULU SACCOS**: Provides threshers and other inputs through farmers' organizations, offering credit facilities and easy access to low-interest loans.
2. **ADHH Project**: Provides threshers and inputs, supported by various organizations. It has shown positive impacts by subsidizing prices for post-harvest technologies.

Despite these initiatives, several barriers prevent broader adoption. There is a lack of adequate information dissemination, leaving many farmers unaware of available financial solutions. Even when information is available, it is often insufficient or not well communicated. Many smallholder farmers lack the necessary collateral to secure loans. Climate change introduces additional risks and uncertainties, discouraging investment in agriculture. There is also a general lack of awareness, as well as insufficient policies and guidelines to support these financial initiatives.

These initiatives have collectively contributed to reducing the costs of agricultural solutions in Tanzania. However, agricultural sector in Tanzania still needs specific financing products tailored to meet the diverse needs of farmers. To remove financial barriers in Tanzania's agricultural sector, several strategic actions could be implemented, including:

- Enhancing training on finance accessibility and management
- Promoting common user facilities, such as community equipment and resources,
- Reducing high interest rates imposed on agricultural financing agencies.
- Creating awareness among farmers about available agricultural financial solutions can enable them to make informed decisions.

6.3.3 Suppliers of financial products and services

The agricultural sector in Tanzania benefits from a variety of financial products and services provided by several key institutions, including:

1. Tanzania Agricultural Development Bank (TADB).
2. Financial Sector Deepening Trust (FSDT): FSDT works to increase financial inclusion in Tanzania, focusing on developing alternative credit scoring models for farmers. These models use diverse data sources to improve credit access for underserved populations, including women and youth smallholder farmers. FSDT collaborates with financial service providers to create products that cater to the needs of the agricultural sector.
3. Commercial Banks and Microfinance Institutions: Various banks and microfinance institutions in Tanzania, such as CRDB Bank and NMB Bank, provide specialized financial products for the agricultural sector. These products include loans for purchasing equipment, working capital, and financing agri-processing plants.
4. Agricultural Cooperatives and SACCOs: Cooperative societies and Savings and Credit Cooperative Organizations (SACCOs) offer financial services tailored to the needs of their members. They provide collective financial and material support, making it easier for smallholder farmers to access loans and other resources.

Cooperation with those major financing institutions is crucial for the success of RE-GAIN programme. In Tanzania, AGRA has already discussed collaboration opportunities, and signed Letters of Interest (LoI) with several financial institutions such as NMB and TCB. that intend to increase their agricultural portfolio using clear loan targets, as part of RE-GAIN's overarching strategy.

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 Tanzania as potential partners for the RE-GAIN programme:

Table 6-1 Potential financial partner institutions considered for RE-GAIN programme in Tanzania

Financial partner	Overview
NMB Bank	NMB Bank in Tanzania is a significant player in agricultural finance, offering a range of financial products and services tailored to the needs of the agricultural sector. The bank's initiatives aim to support farmers by providing them with the necessary financial resources to enhance their productivity and contribute to the national economy
Tanzania Commercial Bank (TCB)	TCB offers a range of financial products and services aimed at supporting the agricultural sector in Tanzania. These services are designed to cater to smallholder farmers, SMEs, and larger agribusinesses involved in various stages of the agricultural value chain, including primary production, processing, and distribution.
Tanzania Agricultural Development Bank (TADB)	TADB is a state-owned development finance institution established to provide affordable credit facilities for the agricultural sector. Its Integrated Value Chain Financing Model (IVCF) supports various nodes of the agricultural value chain. TADB offers short, medium, and long-term loans aimed at transforming agriculture from subsistence to commercial farming.

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 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.

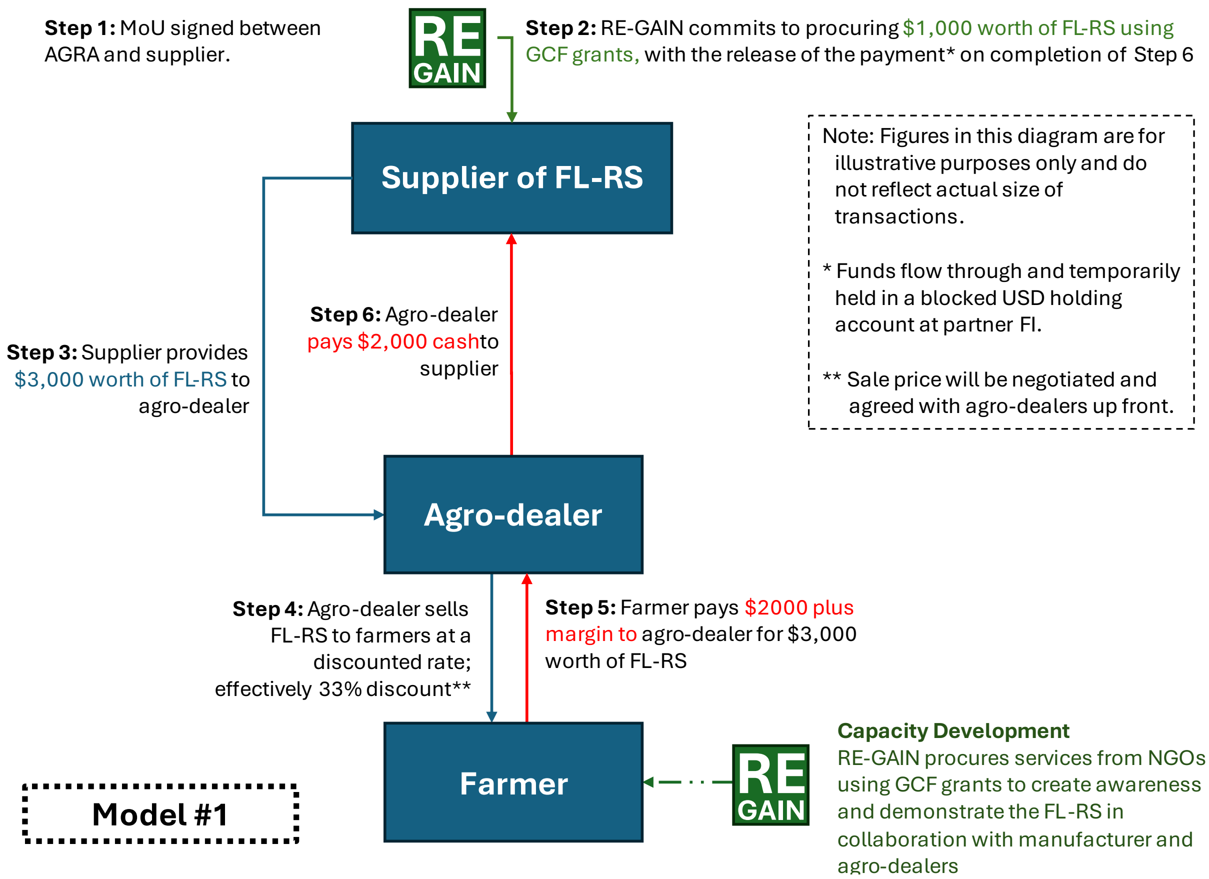

Figure 6-1 Model 1 for RE-GAIN Programme

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 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.

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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 higher 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 higher value FL-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

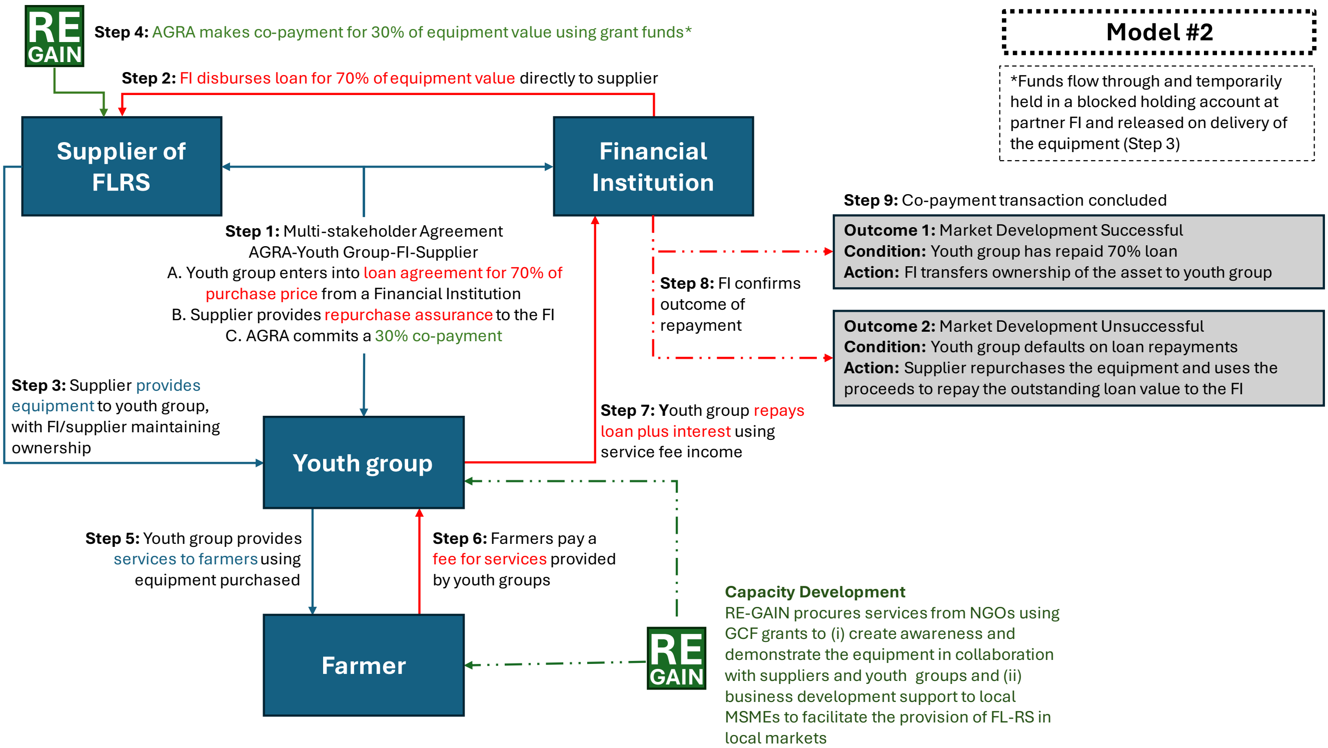

Figure 6-2, with detailed descriptions of each step in the following text. While RE-GAIN will facilitate the establishment of the entire process, its active involvement beyond Step 4, with ownership of Steps 5-9 transitioning to the three partners: youth groups, suppliers, and financial institutions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

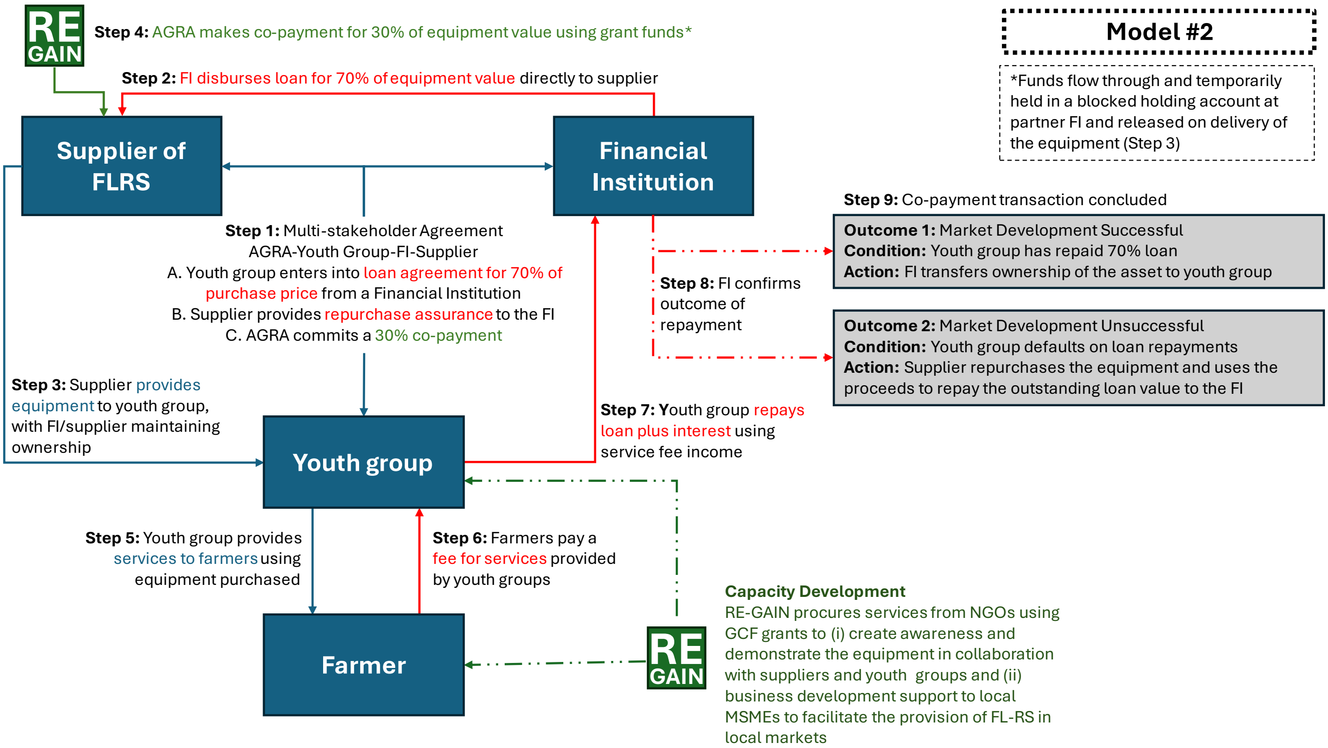

Figure 6-2 Model 2 for RE-GAIN programme

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, AGRA commits 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 a Tanzania 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 Tanzania. 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 awareness campaign and capacity building programmes in Tanzania

Organization	Description
Agriwezesha	Agriwezesha works closely with small-holder farmers to enhance agricultural productivity through education, training, and market linkage. Their mission is to boost productivity while conserving the environment using modern farming techniques. They also provide free consultations and practical training sessions
Sustainable Agriculture Tanzania (SAT)	SAT focuses on promoting agroecological practices that improve soil fertility, prevent soil erosion, and increase crop yields while protecting the environment. They provide training and support to farmers through their Farmer Training Centre and various projects aimed at sustainable agriculture and entrepreneurship
Sustainability in Action (SiA)	SiA focuses on community empowerment, supporting special groups such as women, youth, and persons with disabilities. They implement various programs in agriculture, environment management, and community development. SiA also offers consultation services and training to enhance agricultural practices
SANREM AFRICA-Tanzania	SANREM Africa works with rural communities using action research and extension methods to support sustainable livelihoods. They collaborate with international NGOs and organizations to deliver training on climate-smart agriculture and other sustainable farming practices
Tanzania Farmers Association (TFA)	TFA is a member-based organization that represents the interests of farmers across Tanzania. It provides support in areas such as input supply, market access, and advocacy for better agricultural policies.
Tanzania Federation of Cooperatives (TFC)	TFC supports the cooperative movement in Tanzania, helping farmers to organize into cooperatives for better bargaining power, access to inputs, and market linkage. They play a significant role in improving the economic conditions of smallholder farmers through collective action.

These organizations play a critical role in advancing Tanzania'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 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. At least 3 years of management accounts preferably audited;
- 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 of 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 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; Registration as a sole trader, partnership, franchise, cooperative, or limited liability company in good order with the local tax authorities

- 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 Tanzania:

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. • **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.	A supportive policy environment that enables the successful implementation of 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 Tanzanian 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 Tanzania 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 Tanzania, with significant losses within the harvest and post-harvest stages for key crops in the country; rice and maize. 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 Tanzania. 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 Tanzania by addressing the key barriers identified during this phased study, as described in the image below:

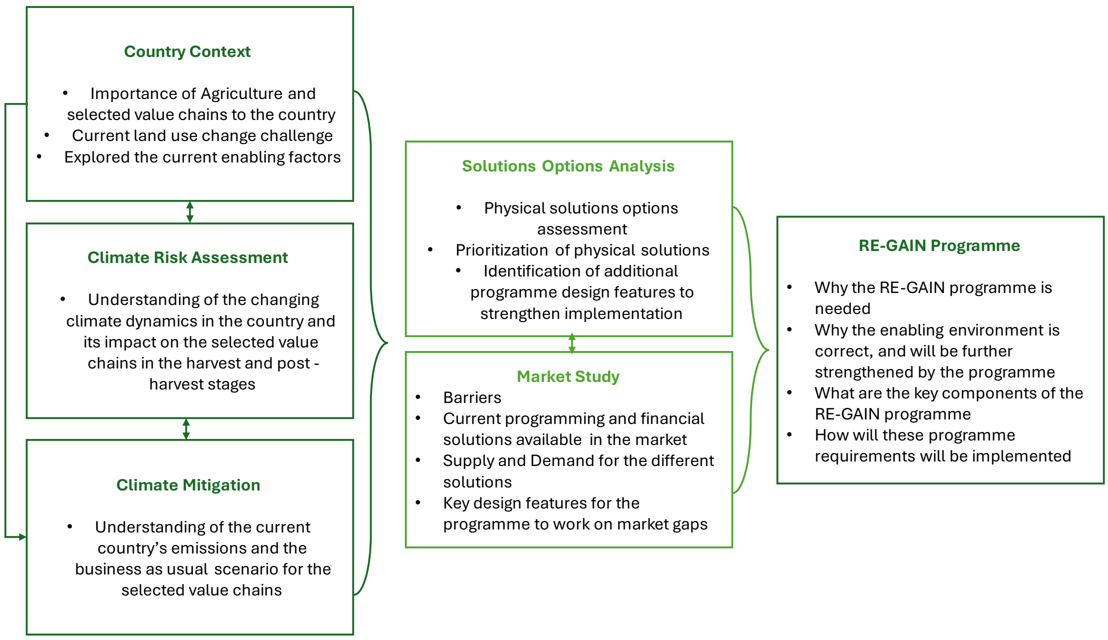

Figure 7-1 Content Summary of Feasibility Study for the RE-GAIN programme

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 rice value chains within the Tanzanian 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. Tanzania 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 Tanzania 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 Tanzania 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 Tanzanian 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 Tanzania, and highlighted the lack of a unified initiative that can respond to these growing challenges and support Tanzania's mitigation initiatives. RE-GAIN offers a solution by reducing food losses across the rice and maize 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 Tanzania. Over time, this programme will become self-sustaining, significantly improving the resilience and sustainability of the country's agricultural sector.

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