ANNEX 2

Burkina Faso

Rice and Cowpea

Version 4

2024

RE-GAIN: Scaling Solutions for Food Loss in Africa

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ACRONYMS

APHLIS	African Post-Harvest Loss Information System
BAU	Business as Usual
CATALI.5°T	Concerted Action to Accelerate Local I.5° Technologies
CGIAR	Consultative Group on International Agricultural Research
CMIP	Coupled Model Intercomparison Project
FAO	Food and Agriculture Organisation of the United Nations
FL-RS	Food Loss Reduction Solutions
GCF	Green Climate Fund
GDP	Gross Domestic Product
GFDRR	Global Facility for Disaster Reduction and Recovery
GHG	Greenhouse Gas
GHGI	Greenhouse Gas Inventory
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
HILDA+	Historic Land Dynamics Assessment
HDPE	High-density Polyethylene
IFAD	International Fund for Agricultural Development
IGREENFIN I	Inclusive Green Financing Initiative

IPCC	Intergovernmental Panel on Climate Change
LDC	Least Developed Countries
LUCF	Land-Use Change and Forestry
MSME	Micro, Small, and Medium Enterprises
NDA	National Designated Authority
NDC	Nationally Determined Contributions
OAPH	Agropastoral and Fisheries Offensive
PA-SD	Action Plan for Stabilisation and Development
PICS	Purdue Improved Crop Storage
PNA	National Climate Change Adaptation Plan
PNDD	National Sustainable Development Policy
PNDES	National Economic and Social Development Plan
PS-PASP	Agro-sylvo-pastoral Production Sectoral Policy
RCP	Representative Concentration Pathways
SIL	Soybean Innovation Lab
SnCF Global	Global Subnational Climate Fund
SSA	Sub-Saharan Africa
SSP	Shared Socioeconomic Pathway
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
USDA	United States Department of Agriculture

Executive Summary

Africa's food insecurity challenge has been exacerbated by climate change, with the FAO estimating that post-harvest losses in agriculture contribute to between 30% and 50% of the continent's total food loss (FAO, 2011)**.** Post-harvest food loss, which refers to the reduction in quantity and quality of crops once harvested, occurs during various stages, including handling, storage, processing, and transportation. The impacts of these losses include reduced food availability, economic losses for farmers, and increased food insecurity. Climate change exacerbates these issues with rising temperatures, erratic rainfall, and extreme weather events contributing to increased spoilage, pest infestations, and mould growth, further intensifying global food losses. In Burkina Faso, rice and cowpea, two crucial crops, experience significant post-harvest losses, with rice reaching up to 13.9% (APHLIS, 2022) and cowpea up to 35% (FAO, IFAD, WFP, 2021). These losses severely affect the country's food security and economic stability. The frequent occurrence of droughts, floods, and extreme heat events exacerbates these losses, endangering the livelihoods of over 80% of the population that relies on agriculture, and posing a serious threat to the nation's overall food security and economic well-being (World Bank, 2011) (World Bank, 2011).

Given the significant role of agriculture in Burkina Faso's economy and the increasing threats posed by climate change, it is essential to manage post-harvest food losses in rice and cowpea production to maintain socio-economic stability. Agriculture forms the backbone of Burkina Faso's economy, contributing 32% to the GDP (Republic of Burkina Faso, 2021) and providing employment for approximately 80% of the population (World Bank, 2011). Smallholder farmers, who manage the majority of the agricultural land, predominantly grow rice and cowpea, among other crops. Rice, a staple food, is crucial for domestic consumption and food security, while cowpea serves as an important legume used for both human consumption and animal feed, also benefiting soil fertility through nitrogen fixation. Agricultural activities in Burkina Faso are mainly concentrated in the Sahelian and Sudanian regions (World Bank, 2011), characterized by the rainy season from June to September, the dry season from October to May, and a brief cold season from December to February (Republic of Burkina Faso, 2022; World Bank, 2021). Addressing the impacts of climate change and implementing effective mitigation and adaptation strategies in crop production and post-harvest processes are critical for ensuring the country's socio-economic resilience.

Efforts to bolster climate change adaptation, mitigation, and reduce post-harvest food losses in Burkina Faso are underpinned by national policies and programmatic interventions, yet these efforts must be significantly intensified to ensure robust food security. Burkina Faso has implemented several national policy frameworks to address climate change adaptation, mitigation, and post-harvest food loss management. Key policies include the National Sustainable Development Policy (PNDD), which aims to reduce post-harvest losses through improved storage, processing, and distribution techniques. Additionally, the National Economic and Social Development Plan II (PNDES II) focuses on enhancing the handling and storage of agricultural products to mitigate losses. The Action Plan for Stabilisation and Development (PA-SD) further operationalizes these strategies, emphasizing resilient agricultural practices and investment in rural infrastructure. The National Climate Change Adaptation Plan (PNA) underscores adaptive agricultural methods and access to climate information, while the National Agricultural Investment Program provides strategic guidance to reduce post-harvest losses. These policies predominantly target agricultural regions across Burkina Faso, with a focus on rural areas where smallholder farming is prevalent. Furthermore, Burkina Faso has engaged with the Green Climate Fund (GCF) on multiple initiatives aimed at enhancing climate resilience. Significant GCF projects include the Concerted Action to Accelerate Local I.5° Technologies (CATALI.5°T) Initiative, the Inclusive Green Financing Initiative (IGREENFIN I), and the Africa Integrated Climate Risk Management Programme, all of which support climate-resilient agricultural practices and enhance the capacity of local farmers.

While these policies and initiatives provide a strong framework for climate adaptation and mitigation, there are gaps in their implementation. Specifically, there is a need for more targeted interventions that directly address the unique challenges faced by smallholder farmers in post-harvest stages. Additionally, access to modern technologies and infrastructure, as well as enhanced market information and financial services, remains limited. Addressing these gaps is crucial for the effective management of post-harvest food losses and the overall resilience of Burkina Faso's agricultural sector.

A comprehensive understanding of the climate risks facing Burkina Faso's agricultural sector is crucial to determine effective climate adaptation measures. Burkina Faso faces significant climate risks, including increasing temperatures, variable rainfall patterns, and a rise in the frequency and intensity of extreme weather events such as droughts and floods. These risks predominantly affect the Sahelian and Sudanian regions, with areas like the Centre-Est, Hauts-Bassins, Boucle du Mouhoun, and Cascades being particularly vulnerable. The impacts of these climate risks include reduced agricultural productivity, increased pest infestations, and post-harvest losses, leading to heightened food insecurity and economic instability. Historically, Burkina Faso has experienced shifts in rainfall patterns and rising temperatures over the past decades. Projections indicate that these trends will continue, with scenarios under SSP2-4.5 and SSP5-8.5 predicting further increases in temperature and more erratic rainfall. Average mean surface temperatures are expected to rise by 1.5°C to 2°C under SSP2-4.5 and by 2.5°C to 3.5°C under SSP5-8.5 by 2050 compared to the historic baseline (1950-2014). The number of hot days with temperatures exceeding 35°C is projected to increase significantly, from 152 days historically to 199 days under SSP2-4.5 and 211 days under SSP5-8.5 by 2040. Additionally, the frequency of heavy rainfall events is anticipated to rise, with the number of days experiencing more than 20 mm of rainfall increasing from 1.85 days historically to approximately 2.4 days under SSP2-4.5 and 3.96 days under RCP 8.5 (World Bank Climate Change Portal, 2024). These changes will likely exacerbate existing vulnerabilities in the agricultural sector, highlighting the necessity for robust adaptation and mitigation measures.

Addressing the prevalence of these climate risks necessitates the application of adaptation measures to minimize post-harvest food losses. For rice, increasing temperatures and erratic rainfall patterns result in decreased yields and higher post-harvest losses. This trend is evident with rising temperatures and irregular rainfall patterns observed from 2010 to 2020. Such climate trends have significantly impacted yields, leading to a total yield loss of 7% to 21% (Kima, Traore, Wang, & Chung, 2014). Projections indicate that rice yields will continue to decline under future climate scenarios, further exacerbated by heavy rainfall and flooding. These reduced yields will negatively affect food security and economic stability, as lower yields translate to diminished food availability and increased prices. Therefore, implementing adaptation measures to stabilize rice yield and mitigate post-harvest losses due to drought and variable rainfall is crucial for maintaining the value chain.

Similarly, cowpea is severely affected by climate change, with excessive soil moisture and high temperatures impacting yields and increasing food losses during storage. For instance, the heightened humidity and temperature fluctuations have led to more frequent occurrences of mould and fungi during storage. Cowpea yields are projected to decrease by 16.2% under the SSP2-4.5 scenario and by 27% under the SSP5-8.5 scenario by 2080 due to climate change impacts such as excessive rainfall and prolonged droughts (World Bank Climate Change Portal, 2024). These climate impacts on cowpea will result in reduced yield and quality, leading to increased post-harvest losses and economic difficulties for farmers. Therefore, adaptation measures for the cultivation and processing of cowpea are essential to mitigate the adverse effects of climate change on production.

Mitigation efforts, in conjunction with adaptation measures, are essential to reduce the negative effects of climate change on Burkina Faso's agricultural sector. Burkina Faso has undergone significant land use changes, primarily driven by agricultural expansion, which has led to considerable deforestation. The country has lost substantial areas of savanna,

woodlands, and forests as agricultural land expanded by approximately 42% between 1960 and 2019. The continued conversion of natural landscapes to agriculture remains a pressing environmental challenge, threatening the sustainability of these ecosystems (Masolele et al., 2024).

Furthermore, Burkina Faso's emissions trajectory is concerning, with agriculture and land use changes contributing to approximately 24 million tonnes CO_2e each, as of 2021 (Climate Watch Data, 2024). The GHG inventory projects a substantial increase in emissions by 2030 under business-as-usual (BAU) scenarios, with agricultural emissions expected to rise to 12.2 $MtCO_2e$ by 2030 (Republic of Burkina Faso, 2022). Emissions from agricultural sources, such as rice and cowpea production, along with those associated with land use change and forestry (LUCF) sector, are anticipated to increase, highlighting the critical need for mitigation measures. Mitigating these emissions is crucial in the response to climate change.

Food losses account for a significant proportion of Burkina Faso's emissions, particularly in the agricultural value chains. The emissions associated with food loss across the agricultural value chains considered by the RE-GAIN programme **could amount to 281,372 tCO_2e for rice and 11,782 tCO_2e for cowpea**, based on smallholder production values (Porter et al., 2016). Without intervention, emissions related to post-harvest losses on smallholder farms in Burkina Faso are expected to increase by between 13% and 17% by 2032. Therefore, minimizing post-harvest food losses is essential to reduce emissions and support climate change mitigation efforts.

To address the significant impact of climate risks on Burkina Faso's agricultural sector, it is vital to apply adaptation measures that reduce post-harvest food losses. Most post-harvest losses contributing to agricultural emissions and necessitating adaptation measures occur during harvesting, drying, threshing, and storage processes. On-farm post-harvest losses in the rice value chain, which account for approximately 13.9% (APHLIS, 2022), occur mainly due to inefficient harvesting and drying practices. For cowpea, on-farm post-harvest losses can be as high as 12% (FAO, PAM, FIDA, 2019), primarily due to inadequate harvesting practices and poor storage conditions. Non-climate factors, such as labour shortages during peak seasons and lack of access to efficient processing equipment, also contribute significantly to food losses in Burkina Faso. Increased temperatures, erratic rainfall, and humidity due to climate change worsen the already high post-harvest losses of rice and cowpea by promoting pest infestations and spoilage, further threatening food security. Mitigation and adaptation through effective post-harvest food loss management are crucial to combat these exacerbated losses.

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

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

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

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

This feasibility study showcases how climate change is likely to exacerbate food losses, and addressing post-harvest food losses in Burkina Faso's rice and cowpea 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 Burkina Faso. 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,

Value Chain Components	Climate Risk Issues	Risk Management Interventions
		groundwater recharge); introduce demand-side 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.

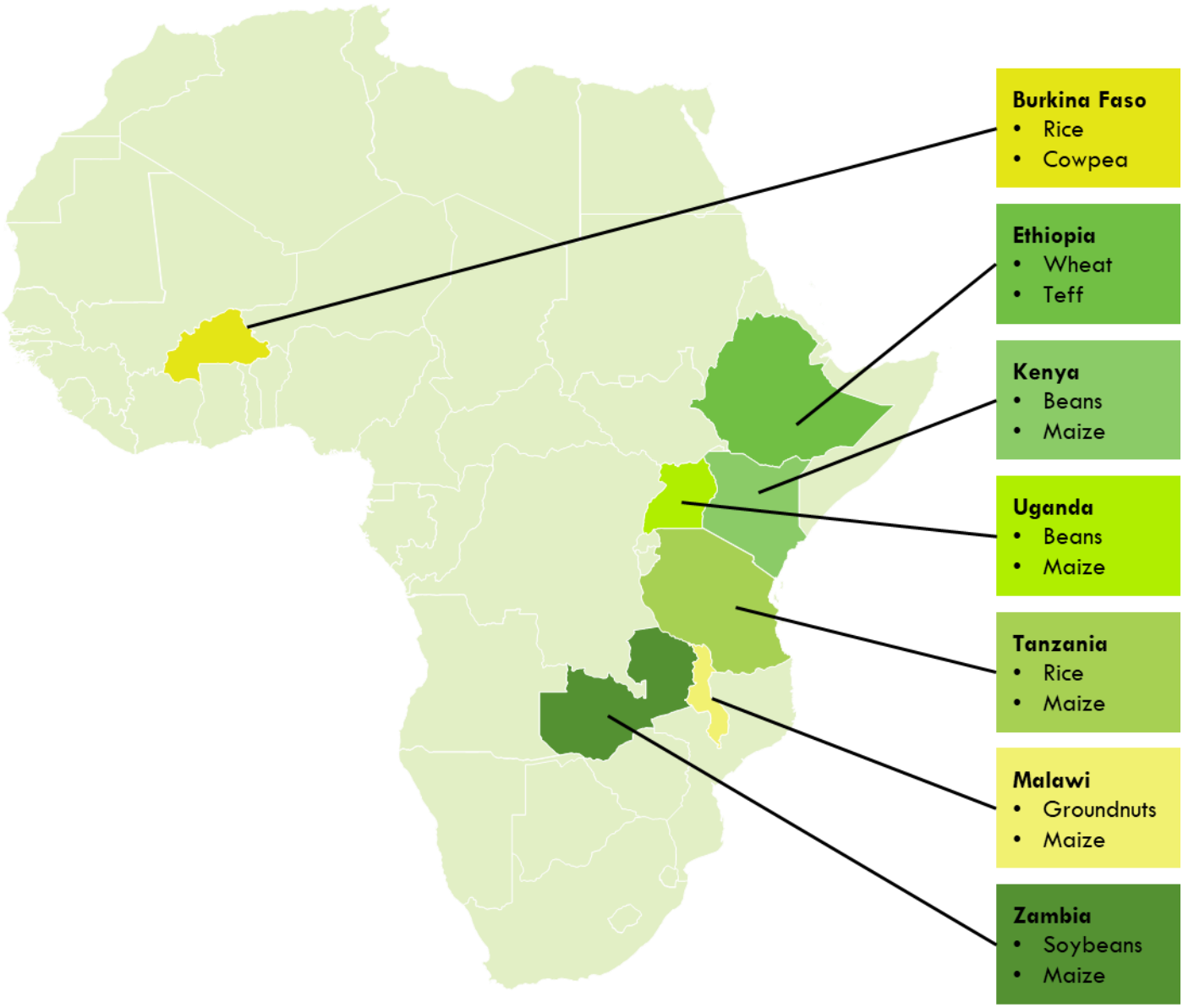


Figure 1-1 Focus Geographies for AGRA (2023-2027)

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

Burkina Faso's agricultural sector contributes an average of 32% to the Gross Domestic Product (GDP) (Republic of Burkina Faso, 2021) **and serves as the primary source of income for around 80% of the country's working population, including youth** (World Bank, 2011). Despite its significant socio-economic role, the sector remains dominated by small-scale subsistence farming with limited market orientation. While advancements in agriculture have reduced the threat of recurring famine, more than 3.5 million people, roughly 20% of the population, are food insecure (USAID, 2015).

Agriculture in Burkina Faso is characterised by low crop productivity. Sorghum, millet, and maize, the major staple food crops, are cultivated on about 80% of the arable land, with cowpeas and horticulture also expanding (IFAD, 2019). Increases in crop production have primarily been driven by extensification rather than intensification. Agriculture is predominantly rain-fed and consists of small family farms ranging from 1.5 to 12 hectares per household. These small parcels of land often lack necessary inputs such as irrigation, fertiliser, and efficient agronomic practices, hindering improvements in living standards. Women constitute over half of the agricultural workforce and produce more than two-thirds of the country's food (Global Yield Gap Atlas, 2023).

Burkina Faso faces challenges from low and variable rainfall, droughts, floods, strong winds, heatwaves, land degradation, deforestation, and desertification. Soils are generally fragile and infertile, especially in the northern Sahelian regions, though the southern and central savannah regions have slightly more fertile soils (World Bank, 2011). Soil degradation is exacerbated by poor agricultural practices, including low organic matter supply, inappropriate chemical inputs, and minimal soil cover. Climate change further worsens these conditions with increasingly frequent heavy rainfall and extreme weather events (Nyamekye, 2018).

The main challenges for the sector include low crop and livestock productivity, weak market linkages, inadequate non-financial and financial services, high agricultural risk due to harsh climate conditions, and persistent land insecurity, particularly for youth and women (GIZ, 2023). Processing and marketing constraints include high energy and equipment costs and difficult access to production areas. Agriculture in the country remains labour-intensive and lacks adequate mechanisation, improved varieties, agricultural inputs, and networks. Most farmers practice direct planting to manage rainfall unpredictability, poor soil quality, insufficient labour availability, and lack of appropriate ploughing equipment. At harvest, crop residues are often removed for use as feed, fuel, or building materials; alternatively, they are grazed by livestock or burned (Global Yield Gap Atlas, 2023).

In conclusion, while Burkina Faso's agricultural sector is a crucial component of the economy and a primary source of livelihood for the majority of its population, it faces ongoing challenges from climate variability, low productivity, and inadequate infrastructure. Strategic interventions and adaptive practices are essential to enhance the sector’s contribution to the economy and food security, ensuring sustainable development and resilience against climate change.

2.2 TRENDS OF LAND USE CHANGE

Burkina Faso's land area accounts for 273 600 km^2, including a large area of arable land, estimated at 90 000 km^2, of which only 46% is in use for agriculture (FAOSTAT, 2022). Burkina Faso has two large agro-ecological zones: the Sahelian zone in the North, where pastoralism and agro-pastoralism predominate, and the Sudanian zone with most of the cultivable land (USAID, 2016).

Agricultural land is 40% of the total land area, and irrigated cropland is only 0.5%. Forests cover 25% of the land, with an average deforestation rate of 0.3% (USAID, 2016). Agricultural activities are a major driver of deforestation in the country, with conversion to cropland being a significant cause. Burkina Faso has experienced a significant loss of savannah, woodlands, and forests, primarily due to agricultural expansion to support both rural and urban populations (Knauer, Gessner, Fensholt, Forkour, & Kuenzer, 2017).

Between 1960 and 2019, forest cover in Burkina Faso decreased with a 3% forest loss in AGRA's target regions. During this period, cropland expanded by approximately 42%. Deforestation that occurred between 2001 and 2020 primarily resulted in the land being converted to large and small-scale agriculture, pasture, settlements, cashew plantations, and other land uses (Masolele et al., 2024).

2.3 NATIONAL AND SECTORAL POLICY LANDSCAPE

Burkina Faso has developed several national policy frameworks to address climate change, carbon emissions, and post-harvest food losses.

The National Sustainable Development Policy (PNDD) is central to these efforts (Government of Burkina Faso, 2013). It envisions Burkina Faso as an emerging nation by 2050. This policy integrates various sectoral strategies and development plans to uplift living standards, particularly for the poorest populations. A key focus of the PNDD is reducing post-harvest losses through improved storage, processing, and distribution techniques. By advocating for modern storage facilities and farmer training, the PNDD aims to minimise losses, thereby enhancing food security and promoting sustainable agricultural practices. Complementing the PNDD, the National Economic and Social Development Plan II (PNDES II) 2021-2025 emphasises the restoration of security and peace, strengthening national resilience, and transforming the economy for inclusive and sustainable growth (Government of Burkina faso, 2021). A critical aspect of this plan is improving the handling, storage, and processing of agricultural products to reduce post-harvest losses. More recently, the Action Plan for Stabilisation and Development (PA-SD) has been published to operationalise the PNDES II and follows the same structure (Government of Burkina Faso, 2023). The PA-SD outlines comprehensive strategies to support and enhance agriculture, focusing on sustainability, resilience, and equitable resource distribution. Notably, by 2030, the PA-SD aims to double the productivity and incomes of small-scale food producers, especially women, indigenous people, family farmers, pastoralists, and fishermen. The PA-SD focuses on implementing resilient agricultural practices, preserving genetic diversity of crops and livestock, and plans to increase investment in agricultural infrastructure in rural areas.

The National Climate Change Adaptation Plan (PNA) addresses the need for resilience in agricultural systems amid climate variability and change (Ministry of Environment and Fisheries, 2015). This plan underscores adaptive agricultural practices and sustainable methods to secure food and nutritional needs. It highlights the importance of access to climate information

and early warning systems, enabling farmers to make informed decisions. The PNA also focuses on capacity building and training programs to disseminate knowledge on climate-smart practices and research and development to support resilient technologies.

Further reinforcing these efforts, the National Agricultural Investment Program provides strategic guidance to the agricultural sector, aiming to reduce post-harvest losses and improve food security by addressing aflatoxin-triggered losses, among other issues (Government of Burkina Faso, 2009). In line with this, the National Strategy for the Development of Agricultural Entrepreneurship by 2025 envisions a modern and efficient agricultural sector. This strategy focuses on reducing post-harvest losses through improved storage facilities, processing techniques, and investments in modern infrastructure and training for farmers (Ministry of Agriculture and Irrigation, 2012). The Agricultural Value Chain Development Strategy 2019-2023 aims to develop efficient agricultural value chains that contribute to food security and poverty reduction (Ministry of Agricultuire and Hydrological development, 2019). This strategy focuses on increasing productivity and reducing harvest and post-harvest losses through disseminating conservation technologies, building capacity on good practices, and constructing storage facilities.

The Agro-sylvo-pastoral Production Sectoral Policy 2018-2027 (PS-PASP) aims to create a productive, market-oriented sector that ensures food security and generates decent jobs through sustainable production and consumption patterns (Ministry of Agriculture and Irrigation, 2018). It emphasizes reducing harvest and post-harvest losses by improving storage and processing facilities and investing in infrastructure and farmer training. The Agropastoral and Fisheries Offensive 2023-2025 (OAPH) aligns with the goals of the PS-PASP by concentrating on boosting agricultural productivity, enhancing the competitiveness of the agro-sylvo-pastoral, halieutic, and faunal sectors, and promoting sustainable management of natural resources.

Finally, Burkina Faso's revised its Nationally Determined Contribution for the period 2021–2025 sets ambitious targets for reducing greenhouse gas emissions and adapting to climate change (Government of Burkina Faso, 2021). Central to these objectives is the promotion of regenerative agriculture and food systems, which are crucial for both mitigating emissions and enhancing the resilience of natural and human systems to climate impacts.

2.4 LEGAL AND REGULATORY LANDSCAPE

Our initial research did not identify any specific laws or regulations associated with climate change and agriculture.

2.5 GCF COUNTRY PROGRAMME DETAILS

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

Burkina Faso has engaged with the Green Climate Fund (GCF) on multiple fronts, implementing 12 projects with a total GCF financing of USD 135.3 million. These initiatives address various aspects of climate resilience and sustainable development, reflecting the nation's commitment to mitigating climate impacts and fostering sustainable agricultural practices. Among these, four country-level readiness activities have been approved, with a budget of USD 5.2 million, of which USD 2.2 million has been disbursed (Green Climate Fund, 2024).

Table 2-1 - GCF Portfolio in Burkina Faso (Green Climate Fund, 2024)

Project code	Focus	Geographical scope	Project title
FP211	Cross-cutting	Africa (16 countries)	Hardest-to-Reach
FP198	Mitigation	Latin America and the Caribbean, Africa (16 countries)	Concerted Action To Accelerate Local I.5° Technologies (CATALI.5°T) Initiative – Latin America and West Africa
FP183	Cross-cutting	Africa (13 countries)	Inclusive Green Financing Initiative (IGREENFIN I): Greening Agricultural Banks & the Financial Sector to Foster Climate Resilient, Low Emission Smallholder Agriculture in the Great Green Wall countries - Phase I
FP178	Mitigation	Africa (Burkina Faso, Niger, Mali, Chad, Mauritania)	Desert to Power G5 Sahel Facility
FP162	Cross-cutting	Africa (Burkina Faso, Gambia, Mauritania, Senegal, Chad, Mali, Niger)	The Africa Integrated Climate Risk Management Programme: Building the resilience of smallholder farmers to climate change impacts in 7 Sahelian Countries of the Great Green Wall
FP152	Mitigation	Eastern Europe, Latin America and the Caribbean, Africa, Asia–Pacific (42 countries)	Global Subnational Climate Fund (SnCF Global) – Equity
FP151	Mitigation	Eastern Europe, Latin America and the Caribbean, Africa, Asia–Pacific (42 countries)	Global Subnational Climate Fund (SnCF Global) – Technical Assistance Facility
FP105	Mitigation	Benin, Guinea-Bissau, Niger, Burkina Faso, Mali, Togo	Banque Ouest Africaine de Développement Climate Finance Facility to Scale Up Solar Energy Investments in Francophone West Africa LDCs
FP095	Cross-cutting	Latin America and the Caribbean, Africa (17 countries)	Transforming Financial Systems for Climate
FP093	Mitigation	Burkina Faso	Yeleen Rural Electrification Project in Burkina Faso
FP092	Cross-cutting	Africa (Benin, Cameroon, Cote d'Ivoire, Mali, Nigeria, Burkina Faso, Chad, Guinea, Niger)	Programme for integrated development and adaptation to climate change in the Niger Basin
FP074	Adaptation	Burkina Faso	Africa Hydromet Program – Strengthening Climate Resilience in Sub-Saharan Africa: Burkina Faso Country

Several key projects focus specifically on the agricultural sector, aiming to enhance resilience and reduce vulnerabilities to climate change. For instance, the **Concerted Action To Accelerate Local I.5° Technologies (CATALI.5°T) Initiative (FP198),** running from 2022 to 2029, aims to support climate start-ups and small enterprises in West Africa and Latin America. By fostering an enabling environment and providing capacity building, this initiative seeks to bridge the gap between the current capabilities of climate ventures and the requirements for accessing venture capitalist finance. This support is crucial for demonstrating the market feasibility of innovative, low-emission technologies and business models.

The Inclusive Green Financing Initiative (IGREENFIN I) (FP183), part of the Great Green Wall initiative, is another pivotal project running from 2022 to 2030. It targets the reversal of land degradation and the enhancement of climate resilience in 13 countries, including Burkina Faso. IGREENFIN I supports local farmers, cooperatives, and small enterprises in implementing climate-resilient and low-emission agriculture and agroforestry practices by providing access to credit and technical assistance. This initiative aims to create coherence and complementarity in climate actions across the region.

Addressing the specific vulnerabilities of the Sahel region, the Africa Integrated Climate Risk Management Programme (FP162), operational from 2021 to 2029, focuses on building and scaling up the resilience of smallholder farmers in seven

least developed countries (LDCs). This programme emphasises capacity building and institutional development in integrated climate risk management, aiming to improve access to agricultural insurance and enhance climate weather information services. By strengthening adaptive capacities, the programme seeks to safeguard livelihoods and food security in the face of increasing climate variability.

The Programme for Integrated Development and Adaptation to Climate Change in the Niger Basin (FP092) targets the Niger Basin, one of Africa's most climate-vulnerable regions. With a focus on sustainable natural resource management, this six-year programme addresses drivers of ecosystem fragility and social vulnerability. It includes measures to reduce silting of the Niger River, improve natural resource management, and enhance population resilience through comprehensive climate adaptation and mitigation actions.

Finally, the Africa Hydromet Program (FP074), running from 2018 to 2025, aims to strengthen climate resilience in Burkina Faso by enhancing climate information systems. Given the country's vulnerability to weather-related hazards such as floods and droughts, this project focuses on optimising the supply and demand of climate information. Improved climate information is expected to bolster rural livelihoods, increase food security, and reduce vulnerability to weather-related disasters.

3 Climate analysis - Adaptation

3.1 COUNTRY CLIMATE CHANGE BASELINE

Burkina Faso is a landlocked country located in West Africa in the Sahel region (Republic of Burkina Faso, 2022)**.** The country is divided into three climate zones based on the Köppen Geiger climate classification system from north to south: the northern Sahelian zone, where rainfall is less than 600 millimetres per year (mm/year), the Sudano-Sahelian region on a savannah plateau (Mossi Plateau) with slightly cooler temperatures and rainfall from 600-900 mm/year, and a more humid Sudanian zone in the south with rainfall between 900-1200 mm/year (World Bank, 2021). The dry season is from October to May, and the rainy season is between June and September (Republic of Burkina Faso, 2022). Dry easterly winds (the harmattans) that bring hot air to Burkina Faso from March to May influence the dry season (World Bank, 2021).

The Sahel region has been identified as one of the most vulnerable regions in the world to climate change (The World Bank, 2022). Historical trends (based on observations between 1961 and 2018) suggest that climate change has already influenced an increase in average temperatures. The main observed trends over this period include (Republic of Burkina Faso, 2022):

- Temperature increases in the three climatic zones of approximately 0.2°C per decade in Dori and 0.3°C per decade in Ouagadougou and Bobo-Dioulasso;
- Increase in the number of days (+11 additional days a year) and nights (+15 additional nights a year) considered "hot";
- Wetter conditions have been recorded through increases in annual precipitation, maximum 1-day and 5-day indices, and extremely wet days;
- The length of dry spells has decreased slightly in the eastern half of the country, while in the western half, there is a slight increase in the length of dry spells.

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

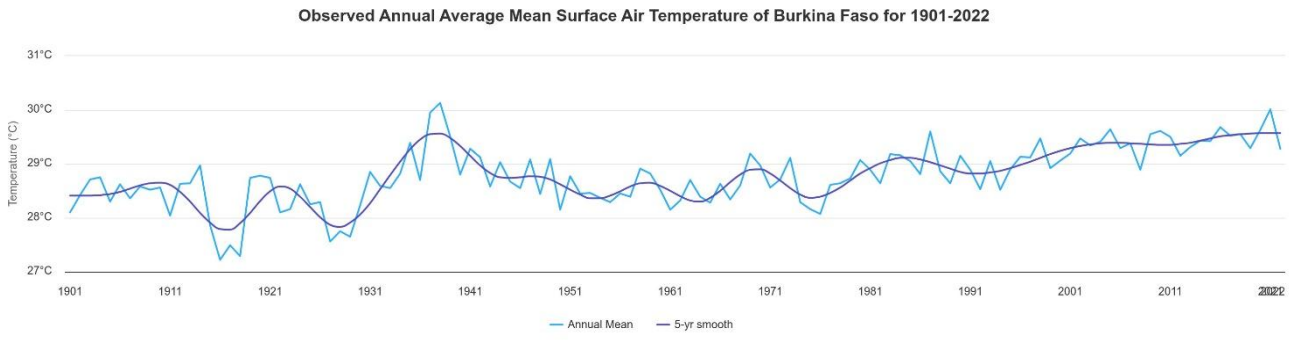


Figure 3-1 - Observed annual average mean surface air temperature of Burkina Faso, 1901 - 2022 (World Bank Climate Change Portal, 2024)

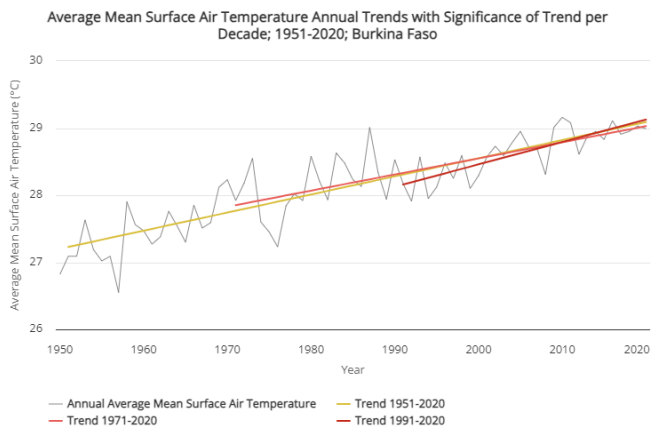


Figure 3-2 - Average mean surface air temperature annual trends with significance of trend per decade, 1951 - 2020, Burkina Faso (World Bank Climate Change Portal, 2024)

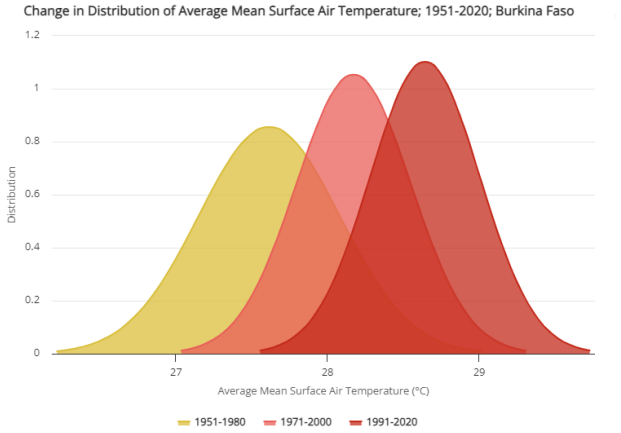


Figure 3-3 - Change in distribution of average mean surface air temperature, 1951-2020, Burkina Faso (World Bank Climate Change Portal, 2024)

Some studies indicate that there is an increase in aridity and less rainfall overall (The World Bank, n.d.)**.** According to the official submission of the Government of Burkina Faso to the United Nations Framework Convention on Climate Change (UNFCCC), rainfall is increasing in Burkina Faso, which can be observed by the isohyets shifting north, as shown in Figure 3-4 (Republic of Burkina Faso, 2022). Burkina Faso's rainfall patterns are becoming more erratic and alternating between wet and dry years, as shown in Figure 3-5 (International Bank for Reconstruction and Development, World Bank, 2020).

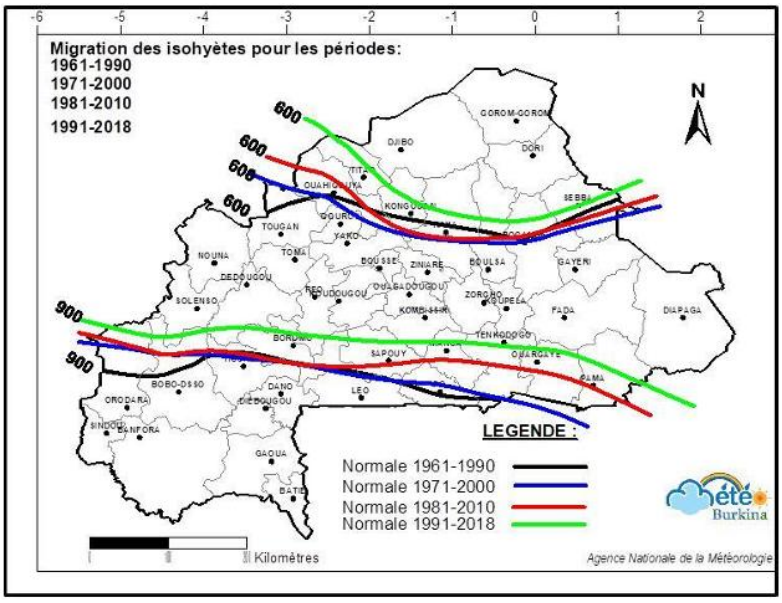


Figure 3-4 - Migration of Isohyets in Burkina Faso (1961-2018) (Republic of Burkina Faso, 2022)

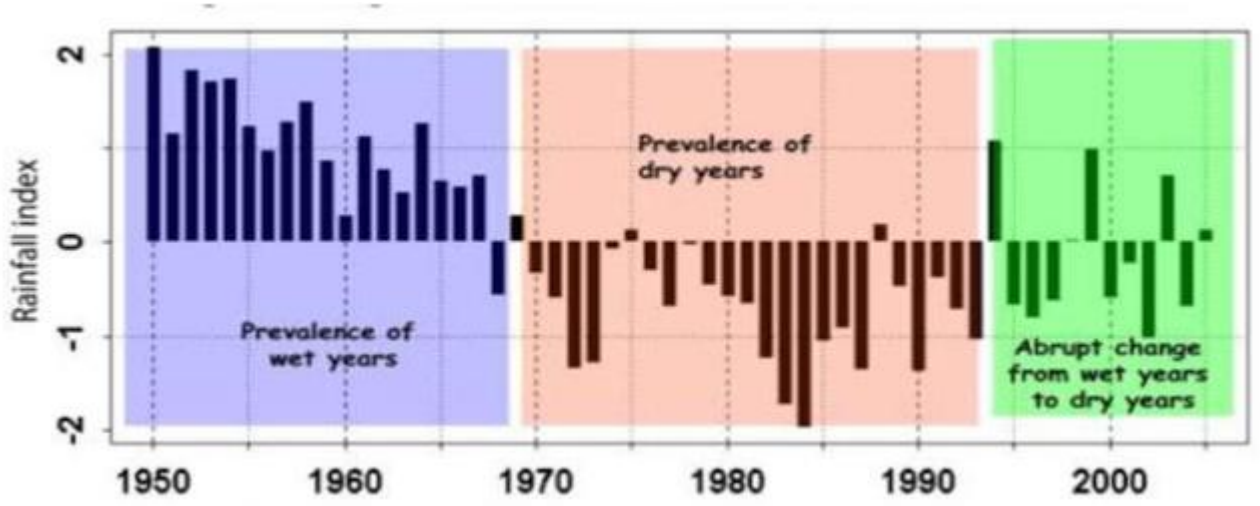


Figure 3-5 - Rainfall Trends in Burkina Faso (1950-2005) (International Bank for Reconstruction and Development, World Bank, 2020)

Burkina Faso 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 Burkina Faso as 112th out of 180 countries (Eckstein, Künzel, & Schäfer, 2022). According to the European Union's INFORM climate risk index, Burkina Faso's baseline risk level comprises an above-average vulnerability to climate-related hazards (7.4 out of 10) and a high lack of coping capacity (6.5 out of 10) (European Commission, n.d.).

Key climatic hazards in Burkina Faso are droughts, floods, and sandstorms (Republic of Burkina Faso, 2021). The Republic of Burkina Faso does not maintain a database of extreme climatic events but notes that climatic conditions have deteriorated since the 1970s (Republic of Burkina Faso, 2021). Severe droughts in 1973-1974 and 1983-1984 resulted in losses of livestock and crops that resulted in famine and population migration to the more humid south, east, and west regions of the country (Republic of Burkina Faso, 2021).

According to the World Bank, between 1980 and 2020, Burkina Faso experienced 22 major flooding events and eight severe droughts (World Bank, 2021). In the Sahel region, an average of 248 000 people per year have been affected by floods since 2000, and droughts have affected more than 20 million people between 2016 and 2020 (The World Bank, 2022).

3.2 AGRICULTURE SECTOR CLIMATE CHANGE BASELINE

Agriculture contributes significantly to Burkina Faso's economy, with the sector contributing an estimated 32.46% to GDP between 2005 and 2015, including 17.79% from plant production, 11.20% from animal production, and 3.46% from forestry and fishing (Republic of Burkina Faso, 2021). The sector is highly vulnerable to climate change, given the extremely high reliance on rainfed agriculture which accounts for 99..5% of cultivation (German Federal Ministry for Economic Cooperation and Development, 2021a), and the dominance of small-holder farmers (with agriculture employing 80.9% of the population in 2010 (Institut national de la statistique et de la démographie, 2022)), who typically are under-resourced and under-capacitated to cope with shocks and stressors. Shallow sandy soils that are poor in nutrients in northern Burkina Faso are more susceptible to drying, erosion, and flooding (German Federal Ministry for Economic Cooperation and Development, 2021a).

Rice is a staple crop in Burkina Faso that accounts for 10% of cereal production and 5% of cultivated area for cereals (Institut national de la statistique et de la démographie, 2022). Burkina Faso imports significant quantities of rice presenting an

opportunity for local production to substitute these imports. Rice is sensitive to changes in temperatures and rainfall. A 2014 study in Burkina Faso found that increasing temperatures and decreasing precipitation has had a negative impact on rice production, with losses ranging from 7% to 21% (Kima, Traore, Wang, & Chung, 2014).

The IPCC's synthesis of global literature on observed climate change impacts on major crops indicates that rice yields in Western Africa have displayed negative trends under a steadily warming climate, as captured in Figure 3-6.

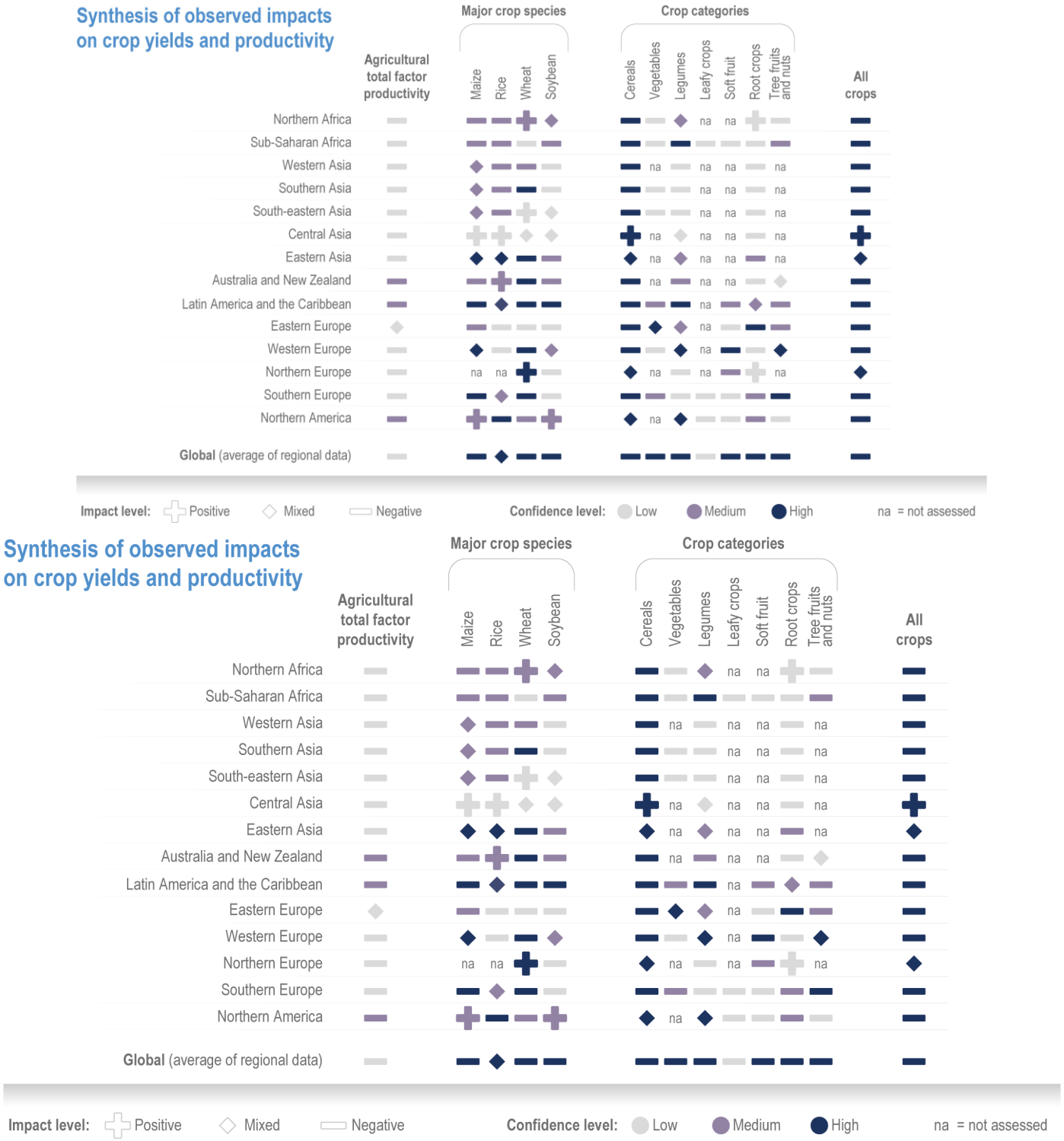


Figure 3-6 - Synthesis of literature on observed impacts of climate change on productivity by crop type and region (IPCC, 2021)

Flooding can have significant impacts on rice production and even cause entire crop failure, leading to food insecurity, as described in a recent case study in Burkina Faso (Müller, Ouédraogo, Schwarz, Sandra Barteit, & Sauerborn, 2023). Droughts can also have moderate effects on rice production (Sawadogo, 2022) and decreases in rice yields of up to 65% have been observed in sub-Saharan Africa (Ndindeng, et al., 2023).

Cowpea is an important legume in Burkina Faso with the largest production and cultivated area outside of cereal crops (Institut national de la statistique et de la démographie, 2022). More recently, cowpea has also become an important cash crop for urban markets and export (FAO, WFP, IFAD, 2019) as Burkina Faso is the third-largest producer of cowpea in the world (USAID, 2016). Both droughts and excessive soil moisture content due to heavy rainfalls have been shown to have negative impacts on cowpea production in West Africa (Lizumi, et al., 2024).

3.3 COUNTRY CLIMATE CHANGE FUTURE

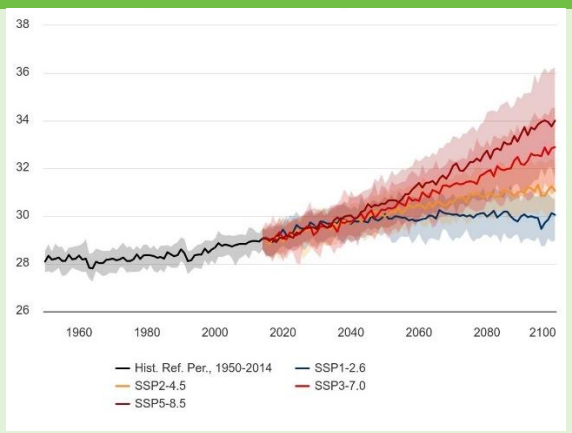
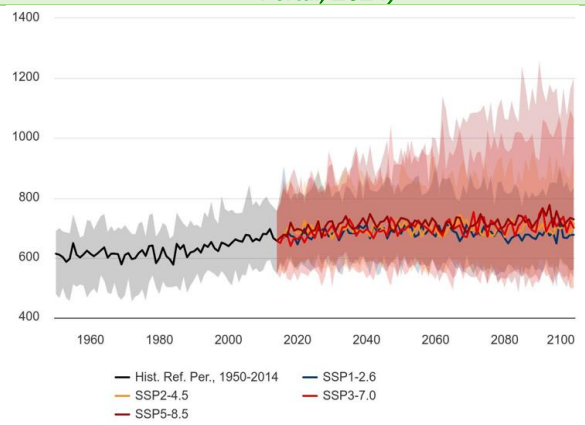
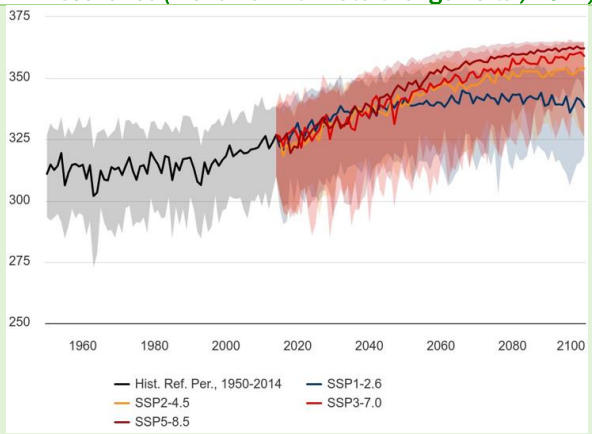
For the analysis of future climate risk to the two crops of interest, Cowpea and Rice, our assessment looks at the 2040-time horizon (a timescale relevant to RE-GAIN's programmatic interventions). To identify future climate conditions that would (i) signal the major climate-driven threats that could 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:

(1) SSP2-4.5 (the intermediate, middle-of-the-road future likely if the current emissions trajectory is followed, with moderate radiative forcing); and
(2) SSP5-8.5 (an extreme future with the highest range of warming this century, likely if no action whatsoever is taken to lower emissions and the world follows a fossil fuel-dominated pathway) (Hausfather, 2019).

We undertook a quantitative component of the climate risk assessment (see Excel Annex, workbook "Burkina Faso") 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 Burkina Faso, focused on post-harvest stages of the crop value chain.

Table 3-1: Principal Climatic Variables (World Bank Climate Change Portal, 2024)

Variable Name	In-Country Context Description	Additional information
Average Mean Surface Temperature	Across all future climate scenarios, average mean surface temperature in Burkina Faso 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 **moderate**.	 *Figure 3-7 - Projected average mean surface temperature under multiple future scenarios (World Bank Climate Change Portal, 2024)*
Mean Precipitation	Across all future climate scenarios, mean precipitation is projected to increase, relative to the historic baseline (reference period 1950-2014). 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 high**.	 *Figure 3-8 - Projected mean precipitation under multiple future scenarios (World Bank Climate Change Portal, 2024)*
Number of Hot Days over 35°C	Across all future climate scenarios, the average number of hot days with temperatures rising over 35°C displays a rising trend. 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, on average, 152 such days in the year, projections of potentially 199 (SSP 2-4.5) or even 211 (SSP 5-8.5) such days in 2040 is a notable percentage change. Thus, in our assessment, we found that the estimated change in the number of hot days over 35°C is **very high**.	 *Figure 3-9 - Projected change in number of hot days with temperature over 35°C, under multiple future scenarios (World Bank Climate Change Portal, 2024)*

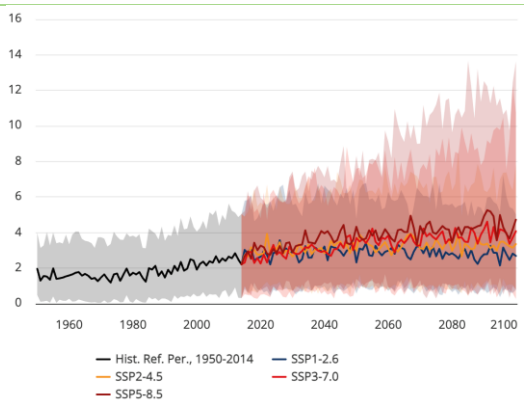
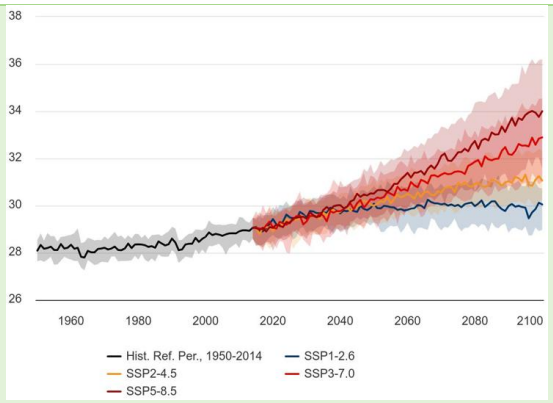
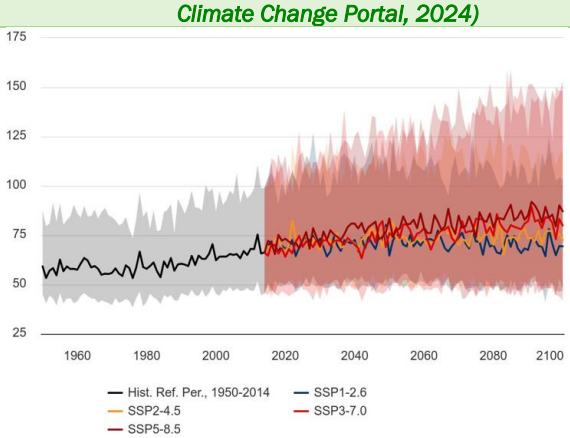
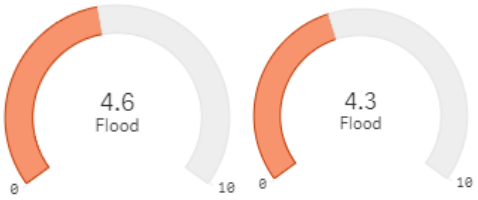
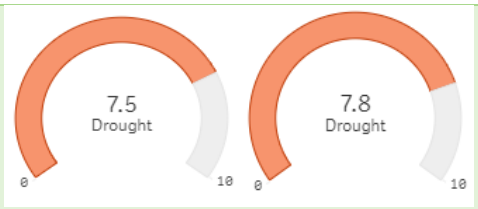
Number of days with rainfall > 20 mm	Across all future climate scenarios, the average number of days with rainfall greater than 20mm displays a rising trend (except SSP1-2.6). The rise is more pronounced towards the end of the century, but even in 2040, the number of such days increases markedly from the historic baseline (reference period 1950-2014). Given that in the past, there were, on average, 1.85 such days in the year, projections of potentially ~2.4 (SSP 2-4.5) or even ~3.96cs (SSP 5-8.5) such days in 2040 is a notable percentage change. Thus, in our assessment, **we found that the estimated change in the number of days with precipitation >20 mm is very high**.	 *Figure 3-10 - Projected change in the number of days with rainfall greater than 20 mm, under multiple future scenarios (World Bank Climate Change Portal, 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) is projected to increase, relative to the historic baseline (reference period 1950-2014). 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 3-11 - Projected change in average largest single-day precipitation, under multiple future scenarios (World Bank Climate Change Portal, 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 a high degree of variability in climate projections relative to the historical 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 **very high** (with an increasing signal).	 *Figure 3-12 - Projected change in average largest five-day precipitation, under multiple future scenarios (World Bank Climate Change Portal, 2024)*

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

Variable Name	In-Country Context Description	Additional Information
Extreme Heat/Heatwaves	Burkina Faso's future extreme heat risk due to climate change is regarded as **high**. This implies that "prolonged exposure to extreme heat, resulting in heat stress, is expected to occur at least once in the next five years." (GFDRR, n.d.). [Note: the INFORM climate risk index does not provide data for extreme heat/heatwaves.]	N/A

Floods	Burkina Faso'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 ten years" (GFDRR, n.d.). According to the INFORM Climate Change Risk Index, Burkina Faso's baseline risk of flooding (on a 0-10 scale) is 3.9 as of 2022. However, under the SSP2-4.5 scenario for mid-century (2050), this rises to 4.6, and under the SSP5-8.5 scenario, this rises to 4.3 for the same period (European Commission, n.d.).	 *Figure 3-13 - Burkina Faso's future flood risk in 2050 under SSP2-4.5 and SSP5-8.5, on a scale of 10 (INFORM Climate Risk Index, 2024)*
Wildfire	Burkina Faso's future wildfire risk due to climate change (and other factors) is regarded as **high**. This suggests that "there is greater than a 50% chance of encountering weather that could support a significant wildfire that is likely to result in both life and property loss in any given year." (GFDRR, n.d.). [Note: the INFORM climate risk index does not provide data for wildfires.]	
Landslides	Burkina Faso's future landslide (or landslip) risk due to climate change (and other factors) is regarded as **very low**. 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 rare hazard phenomenon." (GFDRR, n.d.). [Note: the INFORM climate risk index does not provide data for landslides.]	
Water Scarcity / Drought	Burkina Faso's future water scarcity risk due to climate change (and other factors) is regarded as **high**. This means that "droughts are expected to occur on average every five years." (GFDRR, n.d.) According to the INFORM Climate Change Risk Index, Burkina Faso's baseline risk of drought (on a 0-10 scale) is 6.2 as of 2022. However, under the SSP2-4.5 scenario for mid-century (2050), this rises to 7.5, and under the SSP5-8.5 scenario, this rises to 7.8 for the same period (European Commission, n.d.).	 *Figure 3-14- Burkina Faso's future drought risk in 2050 under SSP2-4.5 and SSP5-8.5, on a scale of 10 (INFORM Climate Risk Index, 2024)*
Cyclones	Not applicable.	
Coastal Flooding	Not applicable (no coastal region).	
Sea Level Rise	Not applicable (inland country without an oceanic coastline).	

3.4 THE FUTURE OF CROP AGRICULTURE UNDER CLIMATE CHANGE

One study suggests that yields of both cowpeas and rice in Burkina Faso have the potential to increase due to climate change (German Federal Ministry for Economic Cooperation and Development, 2021a). Under Representative Concentration Pathways (RCP) 6.0, 2080 yields are projected to increase by 16.2% for cowpeas and 27.0% for rice relative to 2000 yields (German Federal Ministry for Economic Cooperation and Development, 2021a). This may be due to the metabolic pathways of these C3 plants, which may benefit more from the CO_2 fertilisation effect (German Federal Ministry for Economic Cooperation and Development, 2021a).

3.4.1 Cowpea

Cowpea is a reasonably resilient crop that can tolerate high temperatures and drought conditions (Jackai, Dingha, & Worku, 2018). Although cowpeas are relatively resilient to climate change (The World Bank, n.d.), the area suitable for cowpea production in Burkina Faso will decrease under future climate scenarios according to crop models (German Federal Ministry for Economic Cooperation and Development, 2021b). This is due to the northerly shifting of the isohyets since cowpeas are generally grown in the northern regions of Mouhoun, Nord, and Centre Nord (USAID, 2016).

Some studies indicate that cowpea yields in West Africa may decrease due to excessive soil moisture content (Lizumi, et al., 2024). [2]

3.4.2 Rice

Climate change may cause the disruption of growing season calendars and shorten the cropping season (Adaptation Fund, 2021). Studies show the potential for climate change to have both positive and negative impacts on rice production in sub-Saharan Africa, and there is significant geographic variability in these findings (Terdoo & Feola, 2016). Smallholders are expected to experience more negative effects of climate change on rice production due to their limited adaptive capacity (Terdoo & Feola, 2016).[3]

3.5 RISK ASSESSMENT FOR POST-HARVEST VALUE CHAIN STAGES

3.5.1 Cowpea

Our analysis of climate change risks to the cowpea value chain in Burkina Faso indicates that the most significant **hazards** are increases in the number of extremely hot days where temperatures breach the 35 °C threshold, water scarcity, heavy or intense precipitation (extreme volumes of rainfall in a single day or five-day period), flooding (pluvial and fluvial), and wildfires.

[2] Note to readers: Published literature is scarce on the climate impacts on post-harvest stages of the cowpea value chain (in Burkina Faso and globally).

[3] *Note to readers: Published literature on the climate impacts on post-harvest stages of the rice value chain (in Burkina Faso and globally) is scarce.*

Burkina Faso stakeholders at the national and local levels affirmed that for the cowpea value chain, climate hazards that pose the most substantial risk at harvest and during the post-harvest stages are **heavy or intense rainfall (excessive and variable or erratic), flooding, and high temperatures (extreme heat).** Wildfires were also highlighted as a threat.

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

Table 3-3 - Top three climate change hazards identified for Burkina Faso's cowpea 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
Ouagadougou	Flooding Excessive, erratic, or highly variable rainfall High temperatures / extreme heat	Flooding Excessive, erratic, or highly variable rainfall High temperatures / extreme heat	Flooding Excessive, erratic, or highly variable rainfall High temperatures / extreme heat
Bobo Dioulasso	High temperatures / extreme heat; Excessive, erratic, or highly variable rainfall Flooding	High temperatures / extreme heat Excessive, erratic, or highly variable rainfall Flooding	High temperatures / extreme heat Excessive, erratic, or highly variable rainfall Flooding

A range of factors create **vulnerability** in the cowpea 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, and high levels of poverty, illiteracy, and unemployment (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 cowpea value chain in particular).

Stakeholders in Ouagadougou and Bobo Dioulasso added further granularity and insights to the understanding of vulnerability in the cowpea value chain, indicating that principal drivers of vulnerability in Burkina Faso's cowpea value chain – at harvest and during post-harvest stages – are: **a lack of access to appropriate technology and equipment and facilities (such as adequate drying and storage facilities and other post-harvest infrastructure); lack of necessary knowledge and skills; poor or limited access to market information; and limited or poor access to climate information services.**

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

Stakeholder Workshop Location	Harvesting Processes	Post-Harvest Handling and Storage	Processing, Transport, and Logistics
Ouagadougou	Lack of/limited access to technology, equipment, facilities, and infrastructure (especially drying) Lack of/limited access to knowledge and skills Lack of / poor early warning systems and climate information	Lack of/limited access to technology, equipment, facilities, infrastructure (especially storage and packaging) Lack of/limited access to knowledge and skills Lack of / poor early warning systems and climate information	Lack of/limited access to technology, equipment, facilities, and infrastructure Lack of/limited access to knowledge and skills Lack of / limited access to market information
Bobo Dioulasso	Lack of/limited access to technology, equipment, facilities, and infrastructure (especially threshing) Lack of/limited access to knowledge and skills; Prevalence of pests and vermin	Lack of/limited access to technology, equipment, facilities, and infrastructure (especially drying/removing moisture) Lack of/limited access to knowledge and skills Prevalence of pests and vermin	Lack of/limited access to technology, equipment, facilities, and infrastructure (especially transport) Lack of/limited access to knowledge and skills Lack of / limited access to market information

In terms of **exposure**, one key factor that reduces the exposure of the cowpea value chain (relative to other crops in Burkina Faso) is the smaller fraction of cropland in the country that currently is dedicated to cowpea cultivation (low, compared to the land used for staple crops).

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

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

Quantitatively, the risk level of the cowpea value chain in Burkina Faso scored: 33.923 out of 125, putting it at rank **5** of the 14 crop value chains similarly assessed.

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

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

For the storage of cowpeas, temperature and moisture are critical variables. Managing climatic factors during cowpea storage is also complicated by the interplay between temperature and moisture. For instance, temperature accelerates the reduction in cowpea moisture but nevertheless increases deterioration. Extreme weather events during storage can, of course, cause physical damage to storage infrastructure and cause loss of stored cowpeas (e.g., through infiltration of storage silos with water or the washing away of stored cowpeas in floodwaters and landslides, etc.). Additionally, losses due to moulds and fungi can also be exacerbated by climatic conditions which can reduce the efficacy of the drying stage and result in the development of moulds and fungi during storage.

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

While direct attribution of climate change to post-harvest losses of cowpea in Burkina Faso 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.

Estimates of harvest losses are 8.7% to 12%, where losses are due to non-collection of pods, rot, or termite attacks (FAO, WFP, IFAD, 2019). Critical post-harvest loss points for cowpeas in Burkina Faso are during drying, threshing/winnowing (1.1%), and **storage** (20% to 35%). Transport losses are low and estimated at 0.3% (FAO, WFP, IFAD, 2019). Intermittent rains during

the harvest season due to climate change may pose difficulties for crop drying and may increase the risk of toxins from fungi (Sugri, Abubakari, Owusu, & Bidzakin, 2021). The **biggest post-harvest losses occur during storage,** where cowpeas can be damaged by insects (USAID, 2016). Cowpea losses in Burkina Faso are estimated at 47 500 tonnes per year in the Northern Region, equivalent to USD 26 million (FAO, WFP, IFAD, 2019).

In both drying and storage, **climatic factors are highly relevant**, given the manner in which temperature, moisture, and humidity, and the prevalence of pests and plant diseases (themselves temperature-sensitive) cause damage to the harvested cowpeas.

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

Since storage is where the largest share of post-harvest losses happens, it is fair to surmise that the areas in Burkina Faso that act as key storage hubs are the dominant geographical locations for these losses. Based on the map of cowpea growing areas in Burkina Faso (Figure 3-15) (FEWS NET, USAID, 2017), the provinces of Houet, Kadiogo, and Kourritenga are key storage hubs. Other notable provinces include Bam, Boulkiemdè, Ganzourgou, Gourma, Houet, Kadiogo, Kourritenga, Passorè, Sanguiè, Sanmatenga, Sourou, Yatenga, and Zondoma and may be prioritised for climate-responsive, risk-reduction interventions.

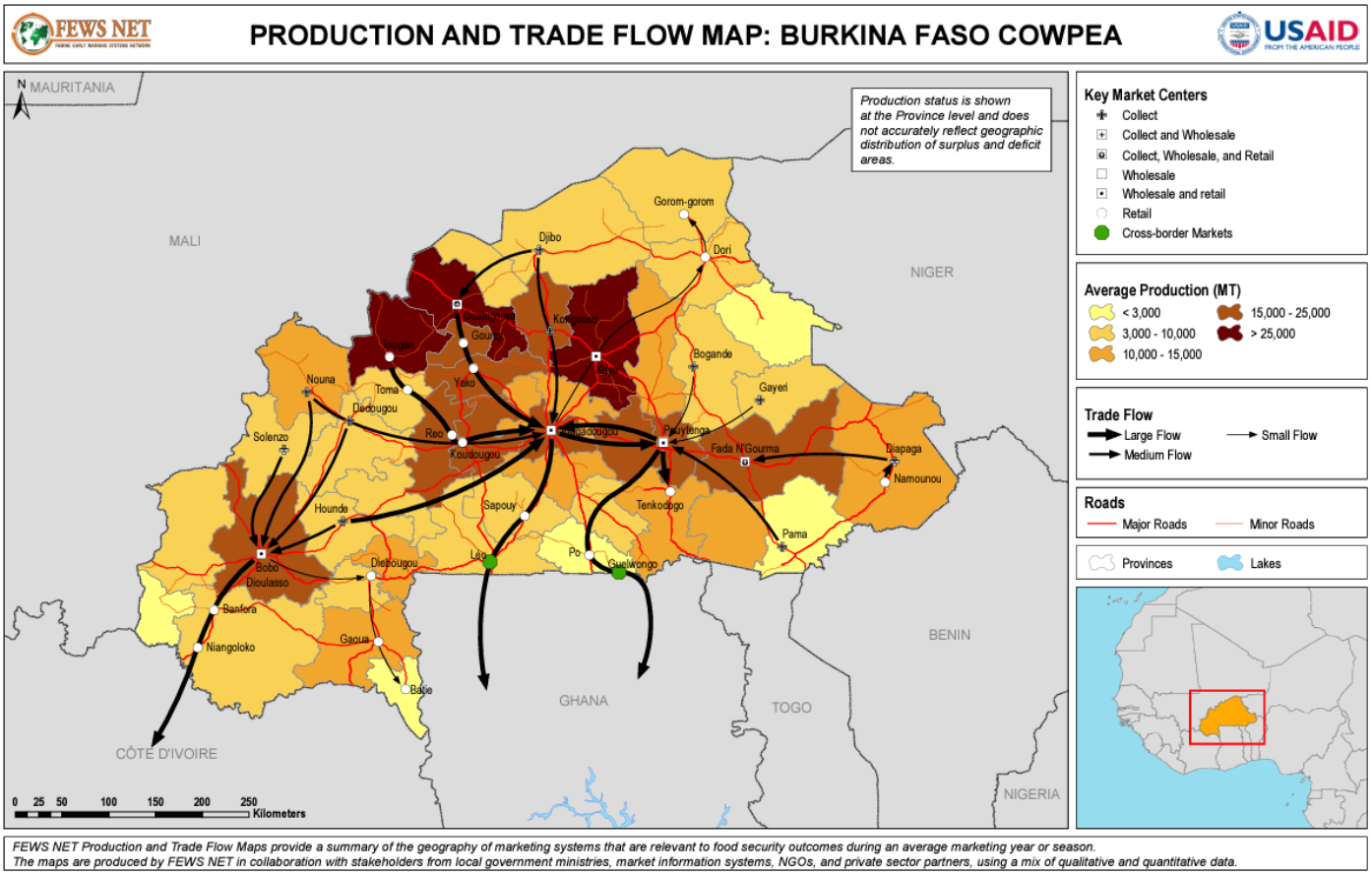


Figure 3-15 – Burkina Faso: Cowpea Production and Trade Flow Map (FEWS NET, USAID, 2017)

Stakeholder workshops in Burkina Faso 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 cowpea value chain, particularly during harvest and post-harvest stages. Insights and guidance from stakeholders suggest that the priority target areas that should be the focus of RE-GAIN's post-harvest loss-reduction climate change solutions are in western Burkina Faso, and these include:

- Boucle de Mouhoun,
- Cascades,
- Centre Ouest,
- Hauts Basins,
- Sud Ouest.

3.5.2 Rice

Our analysis of climate change risks to the rice value chain in Burkina Faso indicates that the most significant **hazard**s are increases in the number of extremely hot days where temperatures breach the 35 °C threshold, water scarcity, heavy or intense precipitation (extreme volumes of rainfall in a single day or five-day period), flooding (pluvial and fluvial), and wildfires.

Burkina Faso 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 **heavy or intense rainfall (excessive and variable or erratic), flooding, and high temperatures (extreme heat).** Wildfires were also highlighted as a threat.

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

Table 3-6 - Top three climate change hazards identified for Burkina Faso'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
Ouagadougou	Flooding Excessive, erratic, or highly variable rainfall High temperatures/extreme heat	Flooding Excessive, erratic, or highly variable rainfall High temperatures/extreme heat	Flooding Excessive, erratic, or highly variable rainfall High temperatures/extreme heat
Bobo Dioulasso	High temperatures/extreme heat Excessive, erratic, or highly variable rainfall Flooding	High temperatures/extreme heat Excessive, erratic, or highly variable rainfall Flooding	High temperatures/extreme heat Excessive, erratic, or highly variable rainfall Flooding

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, and high levels of poverty, illiteracy, and unemployment (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 cowpea value chain in particular).

Stakeholders in Ouagadougou and Bobo Dioulasso added further granularity and insights to the understanding of vulnerability in the rice value chain, indicating that the principal drivers of vulnerability in Burkina Faso's rice value chain – at harvest and during post-harvest stages – are: **a lack of access to appropriate technology and equipment and facilities (such as adequate drying and storage facilities and other post-harvest infrastructure); lack of necessary knowledge and skills; poor or limited access to market information; and limited or poor access to climate information services.**

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

Table 3-7 - Top three climate change vulnerability factors identified for Burkina Faso'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
Ouagadougou	Lack of/limited access to technology, equipment, facilities, and infrastructure (especially drying) Lack of/limited access to knowledge and skills; Lack of / poor early warning systems and climate information;	Lack of/limited access to technology, equipment, facilities, infrastructure (especially storage and packaging) Lack of/limited access to knowledge and skills Lack of/poor early warning systems and climate information	Lack of/limited access to technology, equipment, facilities, and infrastructure Lack of/limited access to knowledge and skills Lack of/limited access to market information
Bobo Dioulasso	Lack of/limited access to technology, equipment, facilities, and infrastructure (especially threshing) Lack of/limited access to knowledge and skills Prevalence of pests and vermin	Lack of/limited access to technology, equipment, facilities, and infrastructure (especially sorting and drying) Lack of/limited access to knowledge and skills Prevalence of pests and vermin	Lack of/limited access to technology, equipment, facilities, and infrastructure (especially transport) Lack of/limited access to knowledge and skills Lack of/limited access to market information

In terms of **exposure**, one key factor that reduces the exposure of the rice value chain (relative to other crops in Burkina Faso) is the smaller fraction of cropland in the country that currently is dedicated to rice cultivation (low, compared to the land used for other staple crops).

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

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

Quantitatively, the risk level of the rice value chain in Burkina Faso scored: 22.231out of 125, putting it at rank **11** of the 14 crop value chains similarly assessed.

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

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

Environmental factors such as temperature and humidity have a considerable impact on post-harvest losses. Temperature fluctuations from daytime highs to cooler night temperatures cause expansion and contraction of the grains, resulting in grain fissures (Ndindeng, et al., 2023). Repeated wetting and drying of grains post-harvest can also cause fissures (Ndindeng, et al., 2023). These fissures increase the likelihood of grain breakage during milling, reducing grain size (Ndindeng, et al., 2023).

Storage losses result from insects (Baoua, Amadou, Bakoye, Baributsa, & Murdock) and fungi (Ndindeng, et al., 2023) both of which can be impacted by temperature and humidity. Extreme weather events during storage can, of course, cause physical damage to storage infrastructure and cause loss of stored grains (e.g., through the infiltration of storage silos with water or the washing away of stored grains in floodwaters and landslides, etc.).

While direct attribution of climate change to post-harvest losses of rice in Burkina Faso 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 13.9% of the rice harvest in Burkina Faso was lost as dry-weight loss in 2022 (APHLIS, 2022). Based on data from 2013 through 2022, of the various post-harvest value-chain stages (per APHLIS, these are: harvesting/field drying; further drying; threshing and shelling; winnowing; transport from field; household level storage; transport to market; and market storage), the four stages where the largest volume of rice losses occurred in Burkina Faso (in decreasing order) are:

1. **Harvesting and field drying** – an average annual loss of 4.4% of the crop;
2. **Threshing and shelling** – an average annual loss of 3.1 of the crop;
3. **Market storage** – an average annual loss of 2.7% of the crop; and
4. **Winnowing** – an average annual loss of 2.5% of the crop.

Together, these four stages represent an average annual loss of 12.7% of the total losses in the post-harvest rice value chain in Burkina Faso (APHLIS, 2022).

In each of these three stages, climatic factors are relevant, given the manner in which temperature, moisture and humidity, and the prevalence of pests and plant diseases (themselves temperature-sensitive) cause 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 and heatwaves in Burkina Faso, **these stages of the rice value chain are most at risk from climate change, and thus should be prioritized for adaptation (loss-reduction) responses.**

Since the majority of these stages (where the largest share of post-harvest losses happens) of the rice value chain are still largely linked to on-farm activities such as harvesting and field drying, threshing and shelling, and winnowing, it is fair to surmise that the areas in Burkina Faso where rice is farmed are the dominant geographical locations for these losses, at these stages. Based on data about rice production in different parts of Burkina Faso, the areas to be prioritized are Centre-Est (17% of Burkina Faso's rice production in 2021), Haut-Bassins (17%), Boucle du Mouhoun (15%), and Cascades (15%) (USDA FAS, n.d.).

Stakeholder workshops in Burkina Faso 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 that should be the focus of RE-GAIN's post-harvest loss-reduction climate change solutions are in western Burkina Faso, and these include:

- Boucle de Mouhoun,
- Cascades,
- Centre Ouest,
- Hauts Basins,
- Sud Ouest.

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 rice and cowpeas in Burkina Faso is presented in

Table 3-9.

Table 3-9 - Summary Climate Change Hazard Risk Table for Burkina Faso 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
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	N/A	N/A	N/A
	Wildfire			
	Landslides			
	Cyclones	N/A	N/A	N/A
	Sea Level Rise	N/A	N/A	N/A
	OVERALL RISK LEVEL	*HIGH*	*HIGH*	*MODERATE*
COWPEAS	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	N/A	N/A	N/A
	Wildfire			
	Landslides			
	Cyclones	N/A	N/A	N/A
	Sea Level Rise	N/A	N/A	N/A
	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

Burkina Faso presented its National Greenhouse Gas Inventory (GHGI) in their Third National Communication (Republic of Burkina Faso, 2022) to the UNFCCC, as well as their First Biennial Update Report (Republic of Burkina Faso, 2021). Agriculture and land-use change and forestry (LUCF) are the sectors with the largest contributions to Burkina Faso's emissions with each sector contributing ~24 million tonnes CO_2e as of 2021 (Climate Watch Data, 2024). While Burkina Faso's national emissions have grown steadily in the last few decades, it still contributes only 0.016% of global emissions (Jones et al., 2024).

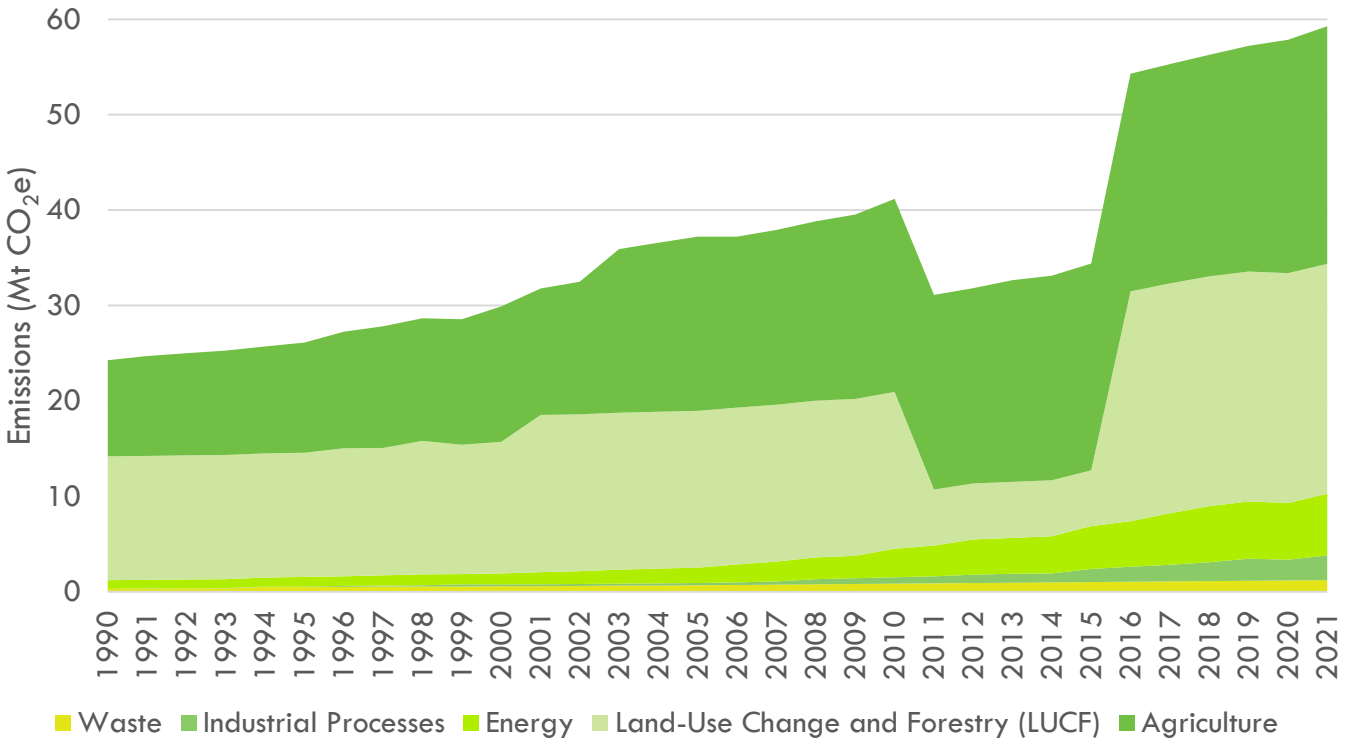


Figure 4-1 - Emissions (all GHG, $MtCO_2e$) across all sectors (total including LUCF) for Burkina Faso (Climate Watch Data, 2024)

4.1.2 Land use change

By using available land use change datasets, we can ascertain that forest cover has remained relatively stable in Burkina Faso between 1960 and 2019, with forest loss occurring over ~3% (HILDA+, 2024) of the land area in AGRA's target regions (Figure 4-1). Cropland expanded over ~42% of the area in that period (Figure 4-2). Where deforestation occurred between 2001 and 2020, the most common land uses which replaced forest cover were large and small-scale agriculture, pasture, settlements, cashew plantations and other land use types (Table 4-1 - Frequency (%) of land use types replacing forest where forest cover was lost between 2001 and 2020 in Burkina Faso Table 4-1) (Masolele et al., 2024).

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

	Large-Scale Cropland	Pasture	Mining	Small-Scale Cropland	Roads	Other Land with Tree Cover/ Regrowth	Coffee	Settlement	Water	Cashew
Boucle Du Mouhoun	26.8%	29.4%	<1%	40.0%	<1%	2.0%		<1%	<1%	
Cascades	27.6%	4.4%	<1%	43.2%		14.8%	<1%	2.9%	<1%	7.0%

	Large-Scale Cropland	Pasture	Mining	Small-Scale Cropland	Roads	Other Land with Tree Cover/ Regrowth	Coffee	Settlement	Water	Cashew
Centre-Est	50.0%	41.7%	2.1%	6.3%				<1%	<1%	
Centre-Ouest	5.8%	43.2%	<1%	48.5%		2.2%		<1%	<1%	
Hauts-Bassins	26.0%	15.6%	<1%	49.4%		7.9%		<1%	<1%	<1%
Sud-Ouest	38.1%	1.6%	<1%	47.4%		6.2%		2.2%	<1%	4.4%

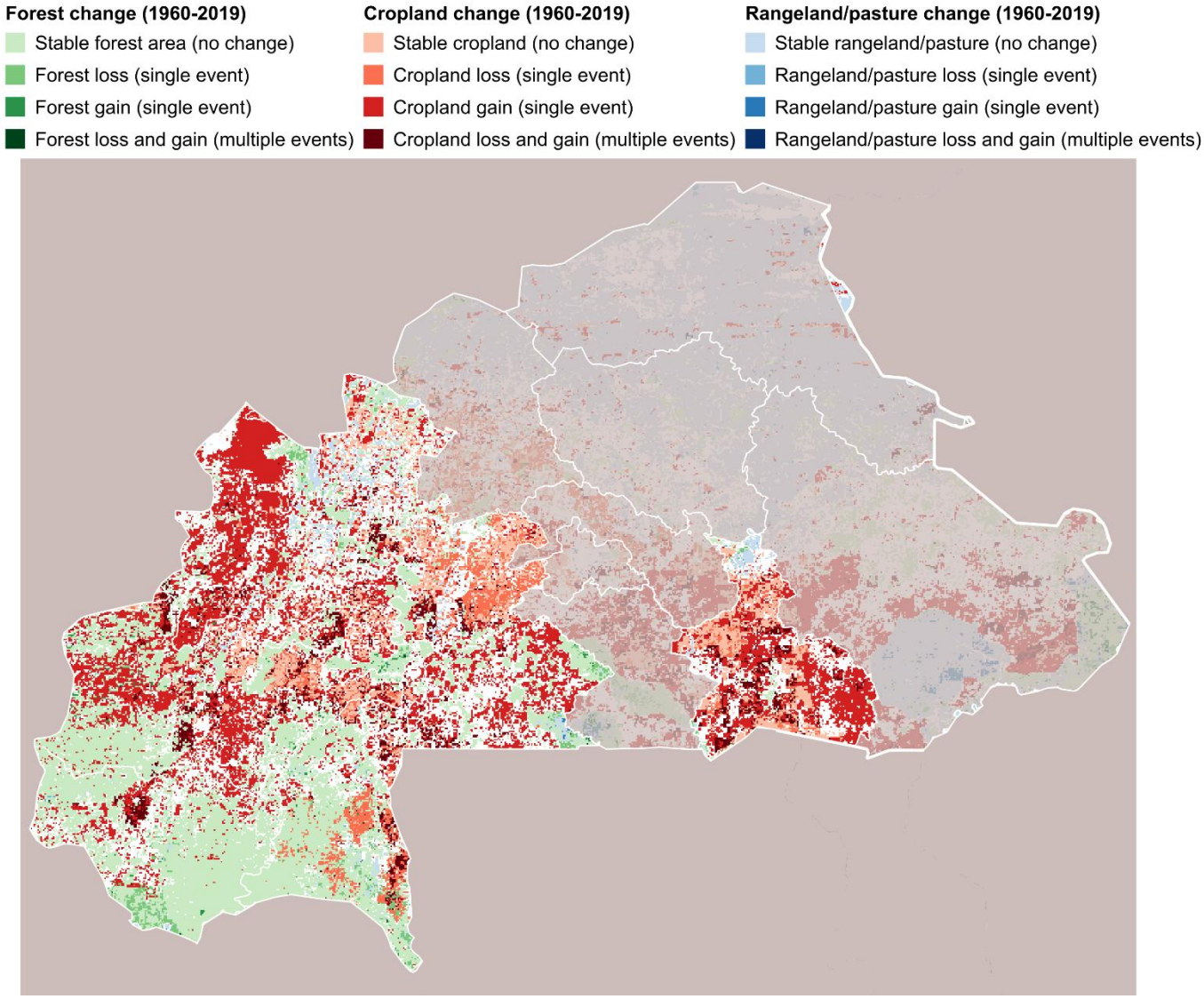


Figure 4-2 - Change in cover for land use categories forest, rangeland/pasture and cropland in AGRA target regions across in Burkina Faso between 1960 and 2019 (HILDA+, 2024)

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, rice, wheat, peas, soy and groundnuts (Poore & Nemecek, 2018). Farm activities account for the bulk of emissions for rice and peas, which are used here as indicative values for cowpeas (Figure 4-3). Losses account for a significant proportion of emissions (Figure 4-3) particularly in smallholder value chains.

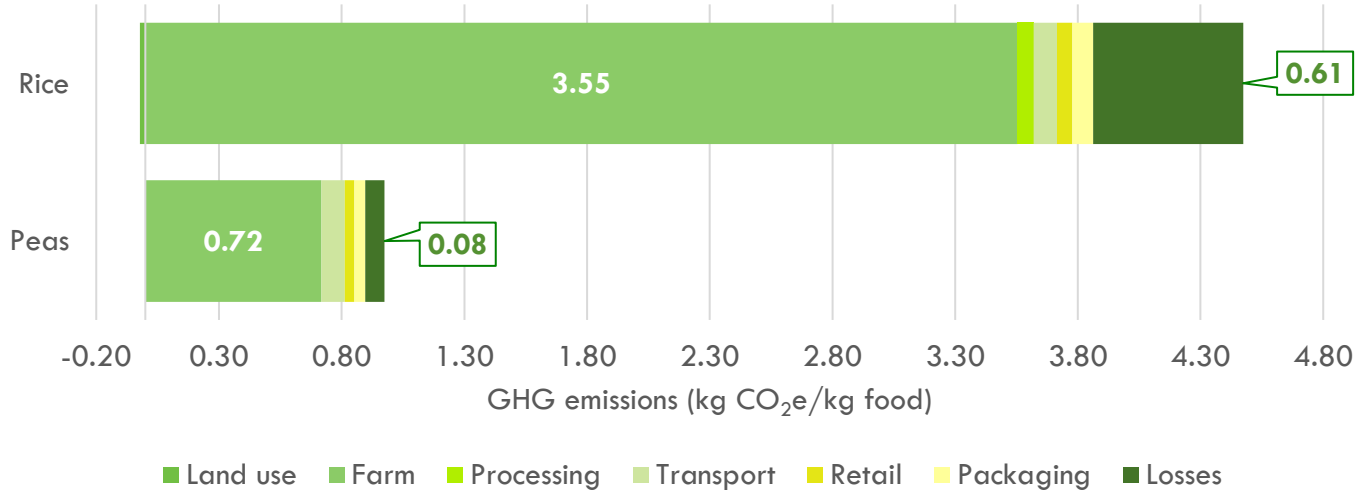


Figure 4-3 - Average GHG emissions (kgCO_2e/kg food) for agricultural commodities across value chains (Poore & Nemecek, 2018)

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.

Value chain	Pre-harvest				Post-harvest					
	Land use change	Inputs	Production	Storage	Transport	Storage and handling	Value-added processing	Transport and logistics	Marketing and distribution	End user
Emissions sources	• Deforestation • Burning for land clearing • Erosion and soil loss	• Inputs • Irrigation/ pumping • Fertilisers	• On-farm mechanisation • Management practices	• On-farm storage	• Farm to collection center • Collection center to processing/ market	• Moisture control • Mechanised sorting/ packaging	• Drying • Grinding • Milling	• Warehousing • Road, rail and maritime transport	• Packaging • Retail	• Cooking • Transport • Household appliances
Typical losses	• NA	• NA	• Spillage during manual harvesting, threshing and milling • Leakage from machinery • Poorly maintained machinery	• Pest damage in storage • Contamination and spoilage	• Spillage during transport on farms • Spillage during transport to dealers or storage facilities	• Pest damage • Moisture, mould and spoilage • Storage of untreated grain	• Loss during manual processing • Leakage from machinery • Poorly maintained machinery	• Loss/ spoilage during transport	• Spillage at wholesale sites	• Food waste • Spoilage

Figure 4-4 - Typical sources of emissions and food losses across agricultural value chains (Report Author's 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 and affect household food security. To compensate for post-harvest losses, farmers are likely to expand their agricultural lands, resulting in the 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 also the waste of the natural resources associated with its production, such as land and water. The inefficient use of natural resources can have its own environmental footprint, with carbon emissions associated with food loss being among them.

The emissions associated with food loss across agricultural value chains considered by the RE-GAIN Programme could amount to 281 372 tCO_2e for rice and 11 782 tCO_2e for cowpea in Burkina Faso, based on smallholder production values (Figure 4-5, Table 4-2).

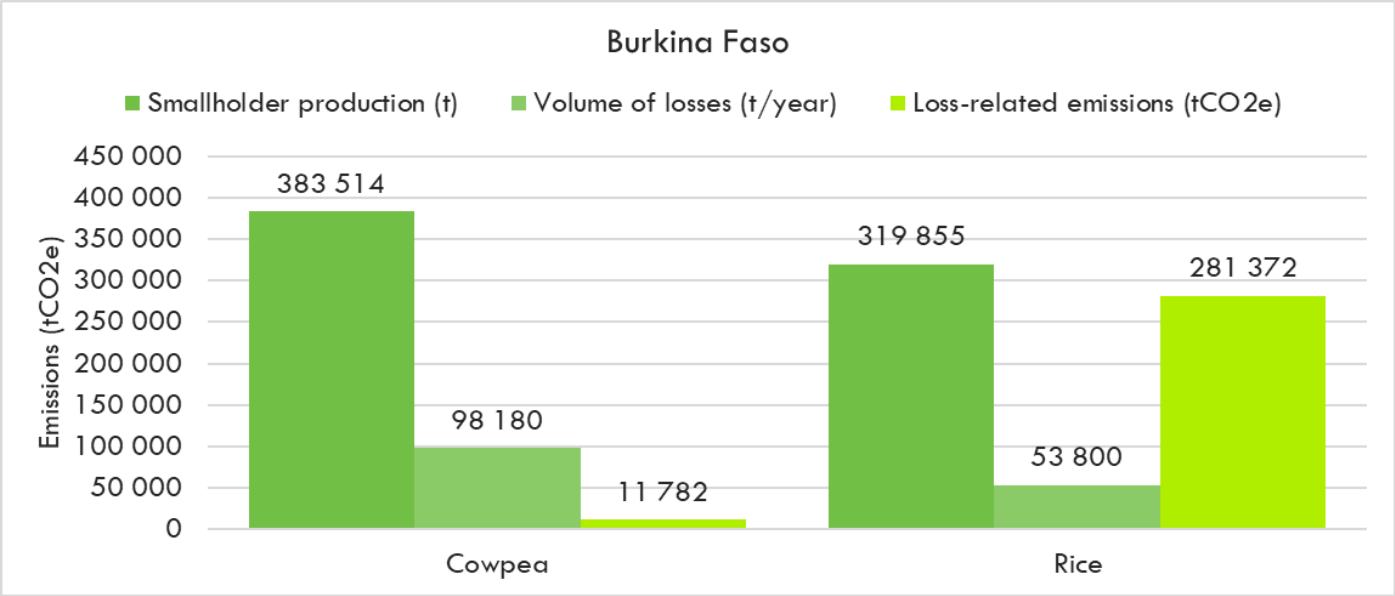


Figure 4-5 - Estimated losses across agricultural value chains for key commodities

A note on the calculation methodology: Using the total maximum losses possible under the loss scenarios presented in Table 4-3 and Table 4-4, a possible total loss (%) per commodity can be calculated, as presented in Table 4-2 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 unavailable, the national production statistics were adjusted to represent the percentage of smallholders in the relevant value chain. The emissions factors used were published in (Porter et al., 2016) and have been used in several studies to estimate emissions.

Table 4-2 - Estimated emissions (tCO_2e/t food) calculated using total maximum losses per commodity, total national annual smallholder production (tonnes) and emissions factors for food loss emissions (Porter et al., 2016)

Country	Crop	Smallholder production (t)	Loss rate (%)	Volume of losses (t/year)	Loss-related emissions (tCO2e)
Burkina Faso	Cowpea	383 514	26%	98 180	11 782
	Rice	319 855	17%	53 800	281 372
Total		**703 369**	**42%**	**151 979**	**293 154**

On-farm post-harvest losses in the rice value chain occur largely as a result of inefficient harvesting and process practices (Table 4-3). The largest reported losses occur during harvesting and drying, estimated at 4.4% of total production (Table 4-3). This will be further discussed in Chapter 5.

Table 4-3 - Extent of post-harvest food loss and the main causes for rice in Burkina Faso (APHLIS, 2022)

Value chain stage	Losses (%)	Cause(s)	Notes on loss values	Reference
Harvesting, field drying	4.4%	Inappropriate practices, such as early/delayed harvesting due to labour shortages	Values for losses (%) during the drying stage were not available from APHILIS for the target country.	(APHLIS, 2024); FAO, IFAD & WFP (2021);

Threshing/shelling	3.1%	Inappropriate use and/or maintenance of equipment	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.	(FAO Food loss and waste database, 2024)
Winnowing	2.5%	N/A		
Drying	2.8%	N/A		
On-farm storage	2.7%	Insect attacks due to inappropriate storage facilities and lack of storage management skills		
Transport to market	1.3%	Poor quality and rough handling of bags and poor vehicle conditions		

On-farm post-harvest losses in the cowpea value chain occur largely as a result of inefficient harvesting practices and poor storage practices, with the largest reported losses occurring during these stages, estimated at up to 12% and 8% of total production, respectively (Table 4-4). This will be further discussed in Chapter 5.

Table 4-4 - Extent of post-harvest food loss and the main causes for cowpeas in Burkina Faso (FAO, PAM, FIDA, 2019)

Value chain stage	Losses (%)	Cause(s)	Notes on loss values	Reference
Harvesting, field drying	12.0%	Inefficient harvesting practices limit labour availability when crop maturation overlaps with cereal crops	Values for losses during value chain stages were not available from either APHILIS or the FAO Food Loss and Waste Database. Values for the following value stages were derived from FAO, PAM & FIDA (2019): Harvesting/field drying, threshing/shelling, transport to farm and on-farm storage. Values for losses during drying were derived from estimates available for Uganda from the FAO Food Loss and Waste Database, which has been assumed to be a reasonable estimate in this case.	(APHLIS, 2024); FAO, PAM & FIDA (2019); FAO, IFAD & WFP (2021); (FAO Food loss and waste database, 2024)
Threshing/shelling	3.5%	Spillage, breakage, lack of access to mechanised threshing		
Winnowing	N/A	N/A		
Drying	1.8%	N/A		
Transport to farm	0.3%	N/A		
On-farm storage	8.0%	Insect damage, damp storage conditions, mould		
Transport to market	N/A	N/A		

4.3 COUNTRY AND SECTORAL CLIMATE CHANGE EMISSIONS PROJECTIONS

The GHG inventory developed by Burkina Faso 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 Burkina Faso, as stated in the Third National Communication of 2022 (Republic of Burkina Faso, 2022) are provided below (Figure 4-6). Emissions in the agricultural sector under the BAU emissions scenario are projected to rise between 2020 and 2030, reaching 12.2 $MtCO_2e$ by 2030 (Figure 4-6).

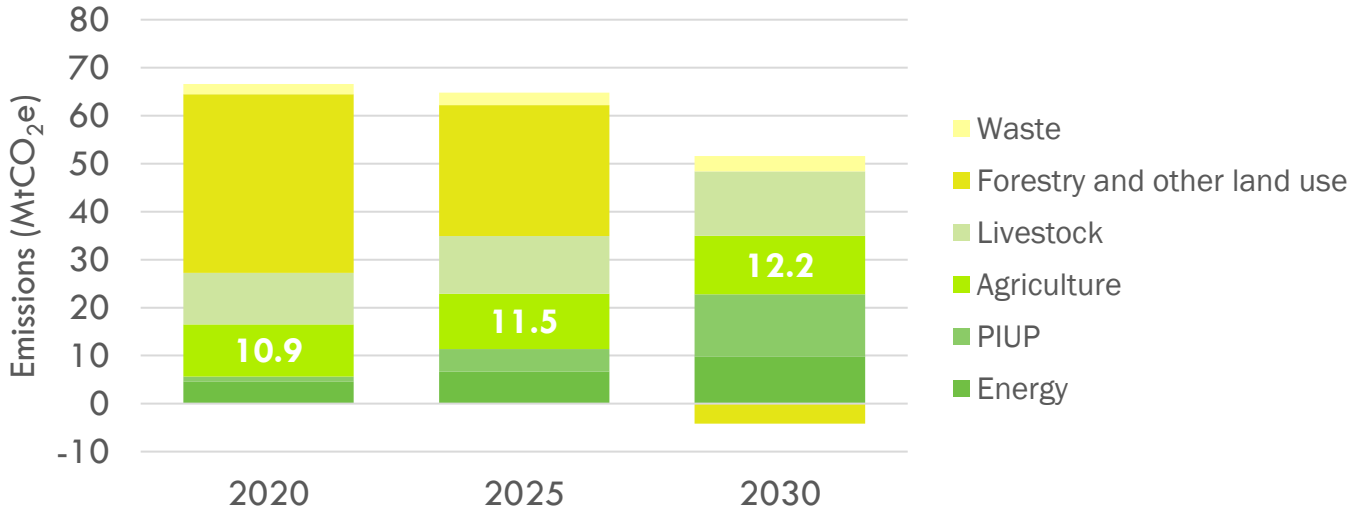


Figure 4-6 - Projected emissions across key sectors in Burkina Faso (Republic of Burkina Faso, 2022)

4.4 CROP VALUE CHAINS CLIMATE CHANGE EMISSIONS PROJECTIONS

The OECD-FAO Agricultural Outlook 2023–2032 (OECD & FAO, 2023) 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, 2023).

The gap between production and demand concerns 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, 2023). 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, 2023).

Globally, crop losses along the rice and pulses value chains are estimated to increase by 2032, compared to the 2020–2022 period (Figure 4-7 - Projected losses across global agricultural value chains for key commodities towards 2032 Figure 4-7). Without significant intervention, losses will undermine regional efforts to improve food security.

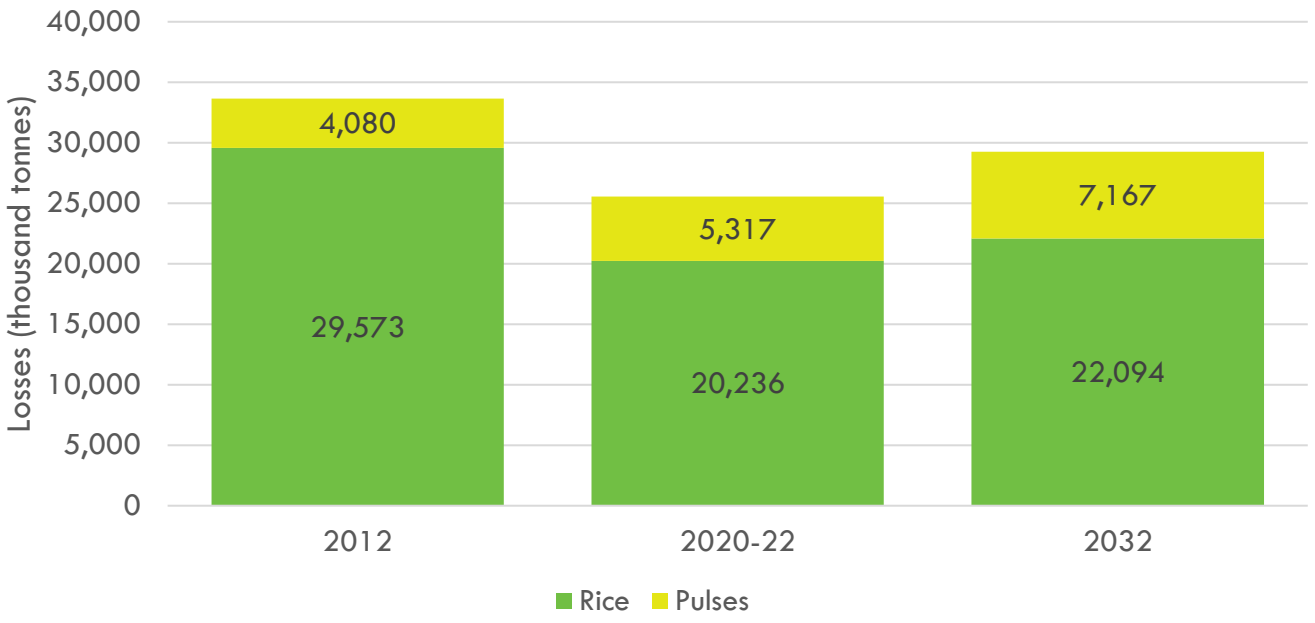


Figure 4-7 - Projected losses across global agricultural value chains for key commodities towards 2032 (OECD & FAO, 2023)

By using available estimates of losses as presented in Table 4-2 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, 2023) to calculate potential post-harvest losses and associated emissions for 2032. In Table 4-5 below, projected emissions from post-harvest losses for the year 2032 are presented. These are an underestimation as they do not consider the impacts of climate change on either yields or post-harvest losses. Changing rainfall regimes and increasing temperatures, as well as the associated, predicted increases in the occurrence and severity of droughts and floods, are likely to have negative impacts on smallholder agricultural production if no adaptation actions are undertaken.

A note on the calculation methodology: The OECD-FAO Agricultural Outlook (OECD & FAO, 2023) provides projected estimates of changes in production, yields and harvested area for key commodity groups across SSA. By using the data available from Table 4-2 and its sources, the OECD & FAO (2023) projections were used to calculate estimates for the production of the crops in the target countries. These values assume that loss estimates remain unchanged by both adaptation interventions and climate change impacts.

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

Country	Crop	Projected production 2032 (t)	Projected losses 2032 (t/year)	Projected loss-related emissions 2032 (tCO2e)
Burkina Faso	Cowpea	464 185	118 831	14 260
	Rice	369 352	62 125	324 914
Total		**833 537**	**180 956**	**339 173**

Without intervention, emissions related to post-harvest losses on smallholder farms in Burkina Faso are expected to increase by between ~13% and ~17% by 2032 (Figure 4-8). **For Burkina Faso, this could amount to 324 914 tCO_2e for rice and 14 260 tCO_2e for cowpea by 2032 (Table 4-5).** This presents the minimum expected losses as climate change is likely to exacerbate these numbers.

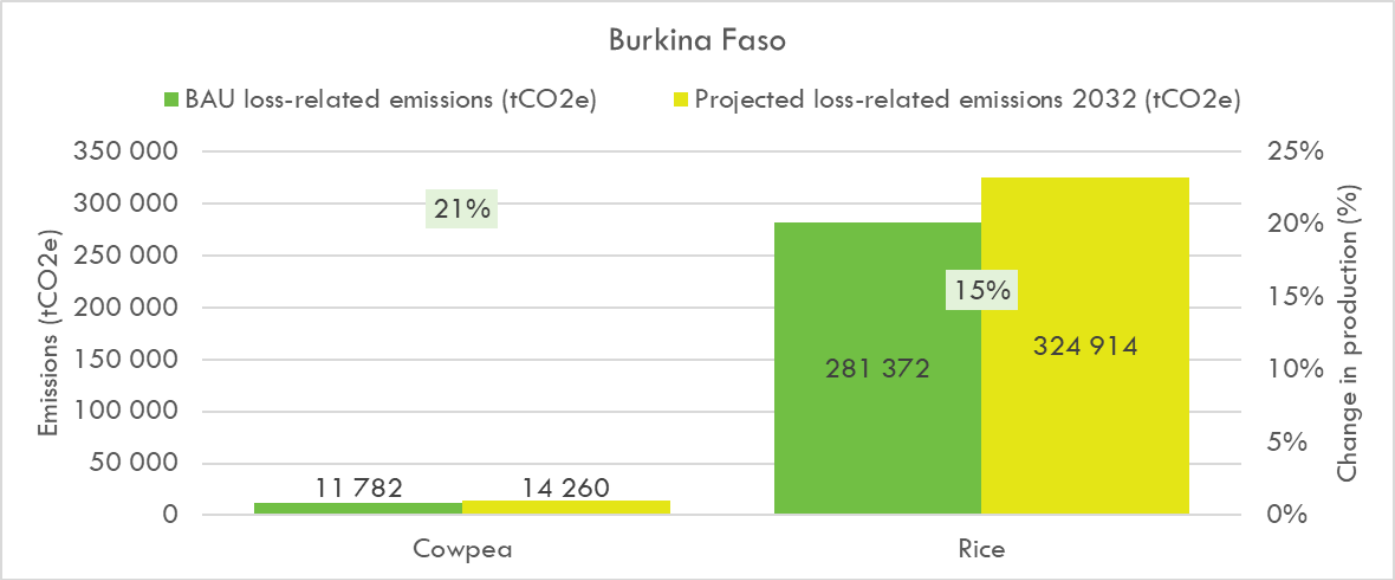


Figure 4-8 - Estimated emissions from post-harvest losses in 2022 and 2032 for key crops in Burkina Faso, percentage values indicate projected increase in emissions (OECD & FAO, 2023)

5 Design of Food Loss Reduction Solutions

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

5.1.1 Rice

Over the past decade, rice has become a staple in Burkinabè households, increasing pressure on local production and prompting significant government investment to boost output. Currently the fourth most-produced cereal in Burkina Faso—following sorghum, millet, and maize—rice production has surged due to urbanization and population growth (Laudien R, 2022). National demand for rice is projected to reach 1.5 million tonnes by 2025, underscoring the urgent need to enhance local production. Despite having substantial potential for rice cultivation, with approximately 500 000 hectares of lowlands and over 233 500 hectares of irrigable land available, only a small fraction of this land is currently developed (Knauer, Gessner, Fensholt, Forkour, & Kuenzer, 2017).

The Centre-East region, contributing about 20% of the national rice production and housing 29% of the processing capacity, operates at just 30% capacity. This underutilisation is due to supply shortages, lack of equipment, worker scarcity, and financial mistrust. In 2016, the region produced 59 000 tonnes of paddy on 24 000 hectares, highlighting both the challenges and the potential for growth in Burkina Faso's rice sector (Rikolto, 2024).

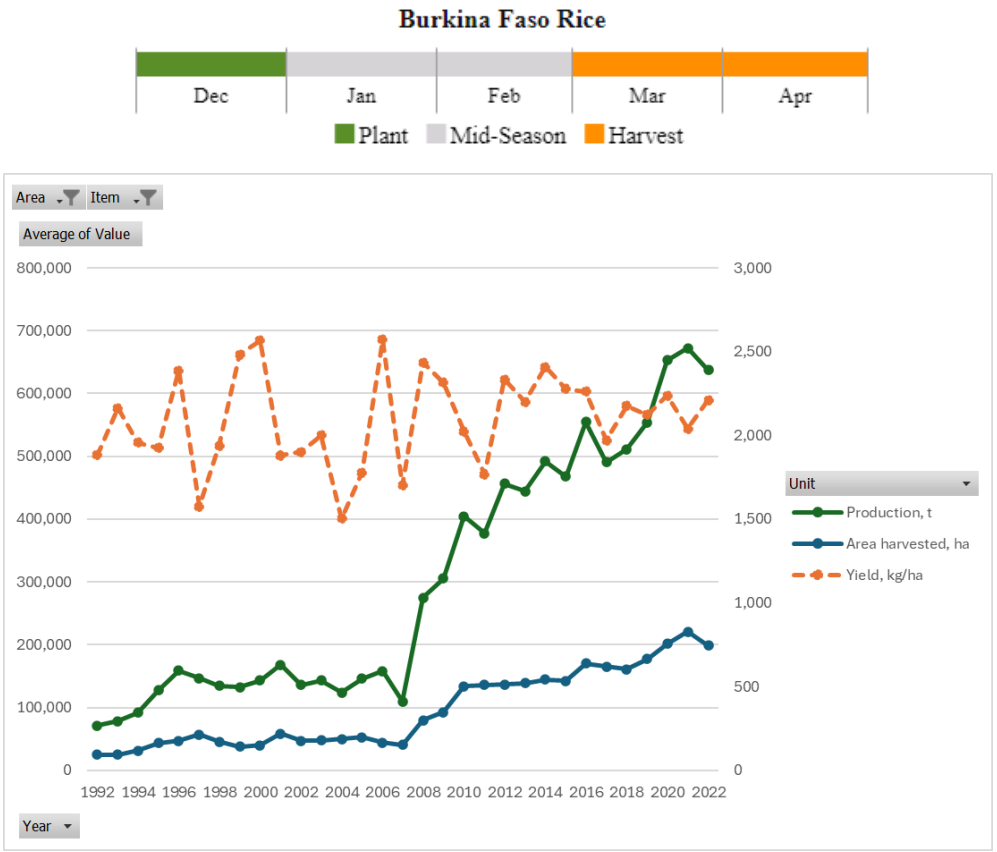


Figure 5-1 Rice production, harvested area, and annual yields in Burkina Faso, 1992 – 2022 (FAOSTAT, 2022)

Rice consumption in Burkina Faso increased by almost 300 000 tonnes between 2015 and 2022, reaching nearly 1 million tonnes annually, with per capita consumption exceeding 60 kg. Despite this, local production covers only 47% of demand,

necessitating substantial imports. Milled rice imports nearly doubled from 350 000 tons in 2015/2016 to 600 000 tonnes in 2022/2023, making Burkina Faso the 6th largest importer in the region (FAOSTAT, 2022).

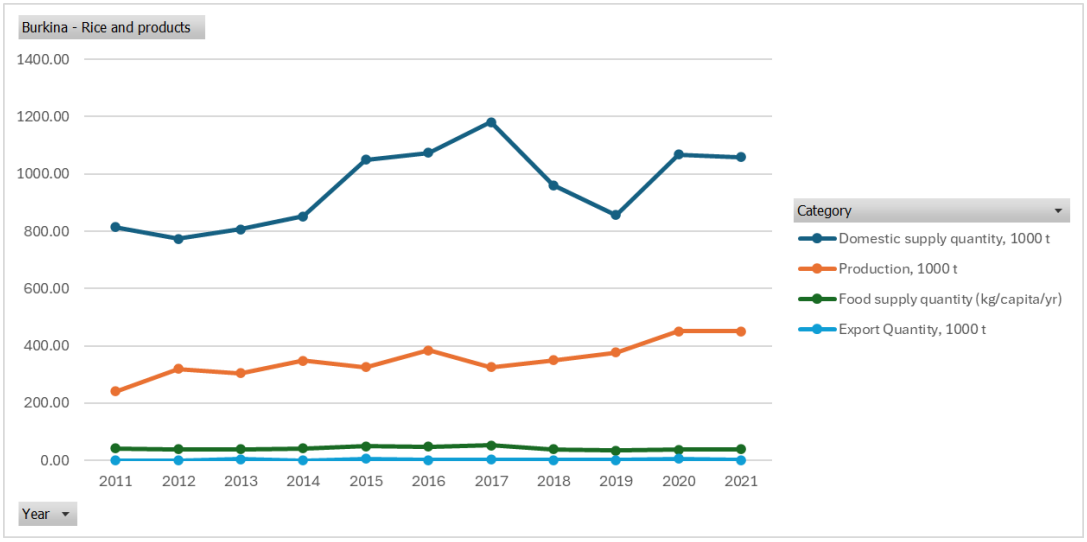


Figure 5-2 Rice per capita consumption, domestic supply quantity, export and production in Burkina Faso, 2011-2022 (FAOSTAT, 2022)

Rice cultivation in Burkina Faso is primarily managed by smallholders who face limited access to agricultural inputs, modern equipment, and innovative technologies. Despite achieving an average annual production growth rate of 14% from 2005-2016, significant challenges persist in climate change adaptation, mechanisation, technical capacity building, and securing land tenure (Coalition for African Rice Development, 2021) .

Harvesting in Burkina Faso typically spans a 3–4-month period following planting, with smallholder farmers using traditional methods involving manual labour. After harvesting, rice undergoes several post-harvest processing stages to transform paddy rice into edible white rice. Threshing separates rice grains from stalks, followed by drying to reduce moisture content and prevent spoilage (Kalimba, 2020). Cleaning removes impurities like dirt and stones through manual winnowing or mechanical cleaners. Milling removes husks and bran layers to produce white rice, with larger processing units using advanced equipment. Polishing, which enhances appearance and texture, may follow milling but is less common in small-scale operations. The final stages involve sorting and grading the rice by size and quality, with higher-quality rice commanding higher prices in the market. Effective storage practices are critical in managing post-harvest handling to ensure that rice remains safe and maintains its high quality until it reaches consumers. Traditional storage methods such as granaries and sacks are common but prone to pest infestations and moisture damage, compromising the rice's quality. Improved storage solutions like hermetic bags and metal silos are being promoted to enhance the longevity and quality of stored rice (Gervâncio Covele, 2020).

Postharvest rice losses in Burkina Faso are influenced by several factors that affect the quality and quantity of rice available for consumption and sale. Many smallholder farmers rely on manual labour for harvesting, which can be inefficient and result in significant grain losses. Manual methods are slower and less precise, leading to more rice left in the fields or damaged during collection. Improper drying of rice grains can lead to spoilage and mould growth. Farmers often dry rice in the open air, exposed to variable weather conditions. Inconsistent drying can result in uneven moisture content, making the rice more susceptible to fungal contamination and pest infestations (USAID, 2015).

Traditional threshing methods, such as beating rice bundles against hard surfaces, can result in high levels of grain breakage and loss. Although more efficient, mechanical threshers are not widely available or accessible to all farmers. Inadequate cleaning processes can leave impurities such as stones, dirt, and chaff mixed with the rice grains. This not only reduces the quality of the rice but also increases the likelihood of spoilage during storage. Many small-scale farmers use local milling machines that are less efficient and cause significant grain breakage and loss (Hauer, 2022). Advanced milling equipment,

which can improve the yield and quality of rice, is often beyond the financial reach of many farmers. Traditional storage methods, such as using granaries and sacks, are prone to pest infestations and moisture damage. These methods do not provide adequate protection against insects, rodents, and adverse weather conditions, leading to substantial postharvest losses (Manandhar, Milindi, & Shah, 2018).

Rice stored using traditional methods is vulnerable to pests, including insects and rodents, which can cause significant damage and losses. Without adequate pest management and control measures, stored rice is highly susceptible to contamination and degradation. Many farmers lack access to modern postharvest technologies and practices that could help reduce losses,this includes mechanical dryers, advanced threshers, and improved storage solutions like hermetic bags and metal silos. Farmers often lack the necessary training and knowledge on best practices for postharvest handling. This includes understanding the importance of proper drying, cleaning, sorting, and storage techniques to minimise losses. Many smallholder farmers face financial limitations that prevent them from investing in better postharvest equipment and storage facilities. Without adequate financial resources, farmers continue to rely on traditional, less efficient methods that contribute to higher postharvest losses (Manandhar, Milindi, & Shah, 2018).

Addressing these challenges is crucial for reducing postharvest losses and improving the overall efficiency of Burkina Faso's rice value chain. As of 2022, the country reported estimated post-harvest losses of 33 373 tonnes (13.9%), with the highest loss in the Hauts-Bassins region. These losses occurred primarily during harvesting, field drying, threshing and shelling, market storage, and winnowing (APHLIS, 2022).

Table 5-1 Comparison of Rice food losses in Burkina Faso in the different stages of the value chain in different studies (APHLIS, 2022)

Value chain stage	APHLIS database, 2022	FAO food loss and waste database, 2021
Harvesting	4.4%	4.4%
Further drying	-	-
Threshing and Shelling	3.1%	3.14%
Winnowing	2.5%	2.50%
Transport from field	1.3%	1.25%
Household-level storage	0.2%	0.14 – 0.30%
Processing (milling)	-	3.50%
Transport to market	1.0%	1.0%
Market storage	2.7%	-
Overall:	**13.9%**	**15.18%**

Table 5-2 presents a general overview of the rice value chain in Burkina Faso, covering key stages, processes, stakeholders, climate data, and potential solutions to reduce food losses.

Table 5-2 Overview of rice food losses in Burkina Faso in the different steps in the value chain, relevant parameters, and suggested solutions (APHLIS, 2022)

FSC stage/ process	Processes	% losses	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
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
Winnowing and cleaning	Removing immature, unfilled and non-grain materials	2.5%	Quantitative losses because of 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)						
On-farm storage	Storage in silos, bags or baskets	0.2%	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		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		Spillage	Aggregators/ collectors and traders		Plastic hermetic bags; non-hermetic polypropylene bags
Transport to market		1.0%				

FSC stage/ process	Processes	% losses	Cause of losses	Affected stakeholders	Climate aspects	Suggested solutions
Storage	In bulk and/or in bags	2.7%	Spillage, qualitative losses	Storage companies, warehouses		Plastic hermetic bags, non-hermetic polypropylene bags. Insecticides/ fumigation
Wholesale	Packaging, storage, transportation to the sale points (markets, supermarkets)		Spillage, qualitative losses	Traders		
Secondary processing	Further processing into flour, products for snack and brewing industry, etc.		Spillage, qualitative losses	Secondary processors		

5.1.2 Cowpea

Cowpea, also known as niébé, is a crucial crop in Burkina Faso, cultivated for both domestic consumption and commercial purposes. It plays an essential role in the diets of both rural and urban populations and enjoys high foreign demand, making it a strategic crop for the country. Over the past decade, cowpea production in Burkina Faso has increased, though it fluctuates due to seasonal agro-climatic conditions and market incentives (Famine Early Warning Systems Network, 2017). Production is highly dependent on climatic conditions, which significantly affect yield. According to FAOSTAT, Cowpea production volumes and harvested areas vary significantly from year to year, but yields have remained stable for the last 15-20 years (FAOSTAT, 2022).

Large stocks of cowpeas are found in regions such as Centre-Nord, Nord, Boucle du Mouhoun, Plateau Central, Sahel, and Hauts Bassins (Figure 3-15). However, inadequate knowledge of conservation methods and a lack of storage infrastructure force farmers to sell their crops immediately after harvest at low prices, leading to price volatility due to the perishable nature of cowpeas (Röhrig, et al., 2021).

Cowpea consumption patterns vary by location: in rural areas, they are primarily consumed during preparation, planting, and harvesting seasons, as well as during periods of intensive physical labour; most consumption, however, occurs in urban and mining areas, with exports mainly directed to coastal regional markets (Famine Early Warning Systems Network, 2017). A small portion of the production is exported to neighbouring countries like Ghana and Côte d'Ivoire; many rural households sell cowpeas to these international markets at high prices to purchase cereals for personal consumption. Per capita consumption in Burkina Faso averages 12.75 kg per person per year. They are commonly used in low-cost restaurants and informal eateries, providing affordable meals for urban workers (Famine Early Warning Systems Network, 2017).

Burkina Faso recognised the importance of cowpea in its agricultural development plans by formulating an Action Plan for Cowpea Development in 2003. This plan primarily targets small farmers, with 68% of Burkinabé cowpea growers at the time producing less than three 100-kg bags each, while the remainder produced no more than 10 bags (one metric tonne). Starting with the 2010-2011 production and marketing year, Burkina Faso included cowpea in its 5-year national agricultural development program, the Projet d'Amélioration de la Productivité Agricole et de la Sécurité Alimentaire (PAPSA) (USAID, 2016).

The cowpea supply chain in Burkina Faso can be divided into two main types. The first type is the classic supply chain, organised around wholesale traders who collect cowpeas to supply the national market or for export. The second type is managed by agricultural producer organisations or development associations. In the classic supply chain, cowpeas are produced by many farmers, often organised into groups or unions. Farm sizes range from 0.25 hectares, mainly for women, to 2-3 hectares. Farmers typically sell about half of their production to meet household needs, such as education and health, either at local markets or from their homes (USAID, 2016).

Commercialisation includes collectors, wholesalers, semi-wholesalers, and retailers organised around a wholesaler's network. Most traders in this chain are men. Wholesalers are exclusively men, while women make up 30% of semi-wholesalers, 37.8% of collectors, and 47.4% of retailers (FAO, WFP, IFAD , 2019). Both men and women participate in cowpea farming in Burkina Faso, though men typically manage larger fields. Women often cultivate their own small plots and play a crucial role in harvesting, cutting plants in the fields, and threshing beans from the shells during initial processing.

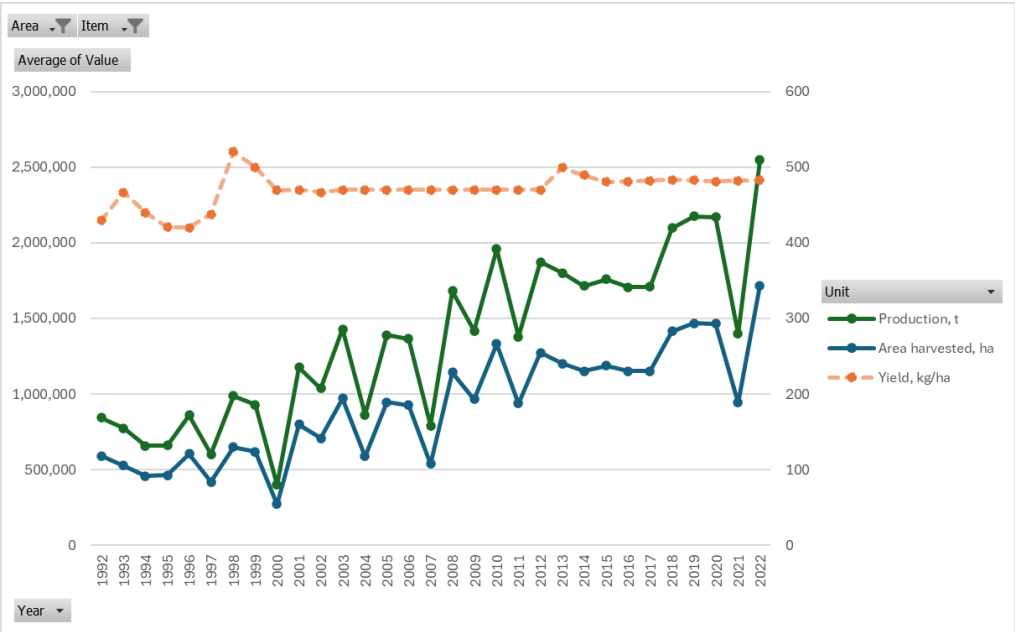


Figure 5-3 Cowpeas production, harvested area and yields in Burkina Faso, 1992-2022 (FAOSTAT, 2022)

Cowpea thrives with minimal water, making it ideal for the Sahel region and Burkina Faso. Cowpeas enhance soil fertility by fixing nitrogen, benefiting crop rotation with millet and sorghum. The yield varies between monocropping and intercropping systems, with cowpeas and millet complementing each other in nutrient management and water conservation. Harvesting typically involves manual labour and occurs 75 to 120 days after planting, depending on the variety and climate. Farmers either pull the entire plant or cut the pods by hand, a labour-intensive process carried out two or three times based on pod maturity. Women primarily handle this task, using various containers to collect and transport the pods home for drying. Post-harvest, cowpeas are spread out to dry further, reducing moisture to prevent mould growth and spoilage. Drying is usually done on terraces or cleaned spaces, often directly on the ground due to limited access to tarpaulins. Proper drying is crucial to prevent post-harvest losses from fungal infections (FAO, PAM, FIDA, 2019).

Once dried, the cowpea pods are threshed manually by beating with sticks or using simple mechanical threshers, followed by winnowing to remove chaff and debris. Threshing and winnowing are performed by both men and women, with women handling smaller quantities using mortars. Cleaning the beans to remove impurities like stones, dirt, and damaged beans is done manually or with mechanical cleaners. Proper storage is essential to maintain cowpea quality and prevent post-harvest losses. Traditional methods include using granaries, sacks, or pots, while improved solutions like hermetic bags and metal silos are being promoted to address pest infestations and moisture control challenges (FAO, PAM, FIDA, 2019).

During the harvest period, which spans from October to January, household members, especially women, face a heavy workload as most rain-fed crops mature simultaneously (Famine Early Warning Systems Network, 2017). This prioritisation of certain activities can lead to the neglect of others. Harvesting cowpeas intercropped with millet or sorghum is particularly labour-intensive, requiring the search for cowpea pods on the ground between cereal stalks, significantly reducing efficiency and leading to high loss rates estimated at 16% in sampled households. The staggered maturation of cowpea pods necessitates at least three manual passes through the fields, resulting in major losses due to uncollected pods, grain rot, and termite attacks. These losses are exacerbated by the heavy workload of women, who have limited access to and control over cowpea income.

Proper storage of cowpeas is crucial to maintain their quality and prevent post-harvest losses. Traditional methods include using granaries, sacks, pots, metal silos, triple-layer bags, plastic containers, and woven PP sacks. However, these methods often fall short in protecting against pest infestations, particularly from weevils and other insects, as well as against moisture and temperature variations (Famine Early Warning Systems Network, 2017). To address these issues, improved storage solutions are being promoted. Hermetic storage bags, which are airtight and prevent pest entry, have proven effective in maintaining the quality of stored cowpeas. Additionally, metal silos and plastic containers with tight-fitting lids are also used to protect the beans from pests and environmental factors. These improved methods offer better protection and help reduce post-harvest losses (FAO, PAM, FIDA, 2019).

Cowpea marketing channels in Burkina Faso are largely controlled by the same actors involved in cereal marketing, including collection, assembly, and distribution markets. The main sources of supply are domestic production by Burkinabe farmers, collectors, semi-wholesalers, and retailers. Minimal processing occurs, with cowpeas commonly used in dishes like boiled cowpeas, rice, and couscous. Over the past 5-7 years, the role of storage has evolved, particularly for farmers, who historically sold their cowpeas immediately post-harvest to avoid weevil damage, thus missing potential price increases (FAO, PAM, FIDA, 2019). Commercial processing is limited to restaurant meals and baby foods, with 92.6% of household cowpea processing done by women. Women's groups and entrepreneurs also make products like fritters, gonré, and cakes, sold along urban roadsides and at events (CILSS, 2015).

Threshing and winnowing losses occur due to scattered and unrecovered grains, broken grains from excessive force, unopened pods, and grains that women cannot separate from straw dust during winnowing. Lack of tarps to contain the grains and inadequate drying facilities further contribute to losses, estimated at 2% during the threshing and cleaning phases (FAO, PAM, FIDA, 2019). The heavy workload of women impacts both quantitative and qualitative losses, as time constraints limit the application of best practices known to reduce losses. Grain scattering and breakage during pounding and the second winnowing due to fatigue also contribute to losses.

During storage, the main cause of cowpea deterioration is infestation by bruchids, which begins in the fields and lowers commercial quality. Over several months, this can lead to a total loss of both commercial and food quality. Traditionally, traders used extensive insecticide to avoid insect damage while storing cowpeas, but research has shown that hermetic (airtight) containers are effective for cowpea storage (FAO, PAM, FIDA, 2019).

The transfer of cowpea sacks between collectors and wholesalers, or between wholesalers and their clients, is influenced by several factors that can cause losses. These factors include the poor condition or low quality of packaging, improper handling during loading and unloading, the condition of transport vehicles, and road conditions. Farmer organisations and associations generally use new or good-condition sacks for cowpea transfer. However, collectors often use worn-out sacks with holes, leading to grain spillage during transport. Some traders add 1 to 2 kg of product to compensate for weight loss. The available market sacks are often of poor quality, even when new, and are not UV-treated, causing deterioration when exposed to the sun. Despite this, handlers often load and unload sacks carelessly, further damaging them and making them more prone to tearing during the transfer process. Cowpea sacks are transported using various truck capacities, but the poor state of vehicle bodies can also damage the sacks, resulting in grain loss. Some organisations use tarpaulins over the vehicle body to protect sacks and recover spilt grains along the seams. Road conditions significantly impact grain loss during transfer. Paved roads cause fewer jolts and, therefore, fewer losses compared to poor-quality roads. In extreme cases, vehicle overturns can result in substantial grain losses (FAO, PAM, FIDA, 2019).

According to (FAO, WFP, IFAD , 2019), the critical points of loss in the cowpea supply chains occur during several key operations. These include harvesting (due to late rains and uncollected pods), drying (late rains slowing the drying process and causing mould), manual threshing/pounding (resulting in broken grains), and storage at the producer level (due to bruchid infestations). Table 5-3 presents a general overview of the cowpea value chain in Burkina Faso, covering key stages, processes, stakeholders, climate data, and potential solutions to reduce food losses.

Table 5-3 Overview of cowpea food losses in Burkina Faso in the different steps in the value chain, relevant parameters, and suggested solutions (FAO, PAM, FIDA, 2019)

FSC Stage/ process	Processes	% losses	Cause of losses	Affected stakeholders	Climate aspects	Suggested solutions
Harvesting						
Harvesting	Beans are collected from the field and uprooted as whole plants	12%	Immature grains, spillage, failure to collect pods from the fields, grain rot, and termite attacks	Farmers	Heat stress for workers/farmers and animals, increased humidity/ moisture Rains, winds	Capacity-building training on harvesting techniques and harvesting tools Capacity building on drying
Threshing/shelling	Manual or mechanical threshing, using manual and mechanical tools	1.1%	Mechanical damage, scattered and broken grains	Farmers	Rains, winds, temperature	Capacity building on threshing techniques or using mechanical threshers
Winnowing	Separating the beans from the chaff and other debris		Spillage	Farmers	Winds, rains	Capacity building on winnowing techniques
Transport from the field	In bulk, using different types of available transport	0.3%	Spillage, mechanical damage	Farmers	Rains, winds	Using trucks and other types of vehicles
Post harvest processes (on-farm)						
Drying	Drying of the threshed beans using tarpaulins, dryers, and similar solutions	Not Reported	Insects, rodents, contamination	Farmers	Rains, winds, temperature	Improved access to tarpaulins and plastic sheets
Packing, grading	Sorting, pre-cleaning and packaging	Not Reported	Spillage	Farmers		Improved packaging techniques and bags
On-farm storage	Storage in bags, silos, or baskets	3.3 to 8%	Humidity/ mould, rodents, continued infestation by bruchids	Farmers	Heat/ high temperatures; rains/floods, humidity	Metal and plastic silos, sheds, plastic and hermetic bags, baskets and cribs, solid brick bins, Insecticides/ fumigation
Transport, logistics, further processing						
Collection from farm	Aggregating, transportation to collection centres/ aggregation depots using vans and trucks of various capacity	Not Reported	Spillage	Aggregators/ collectors and traders		
Storage	In bags	Not Reported	Spillage, mould, pests and rodents	Storage companies, warehouses		

FSC Stage/ process	Processes	% losses	Cause of losses	Affected stakeholders	Climate aspects	Suggested solutions
Wholesale	Packaging, transportation to the sale points (markets, supermarkets)	Not Reported	Spillage, mould, pests and rodents	Traders		
Retail	Sales of cowpeas and their products in small and big markets and supermarkets	Not Reported	Spillage, mould, pests	Retailers		

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 Burkina Faso. RE-GAIN Programme aims to increase awareness of smallholder farmers in Burkina Faso 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 Burkina Faso 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 Burkina Faso. The proposed FL-RS in those subchapters have been short-listed considering the specific context of Burkina Faso 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 5-4.

Table 5-4 - Indicative Awareness Raising and Capacity Building elements of RE-GAIN Programme in Burkina Faso

	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.

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

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

Development of education materials will be implemented by AGRA national teams involved in the project, based on the most crucial topics identified for Burkina Faso, 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 Burkina Faso, 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 Burkina Faso.

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 5-4* below.

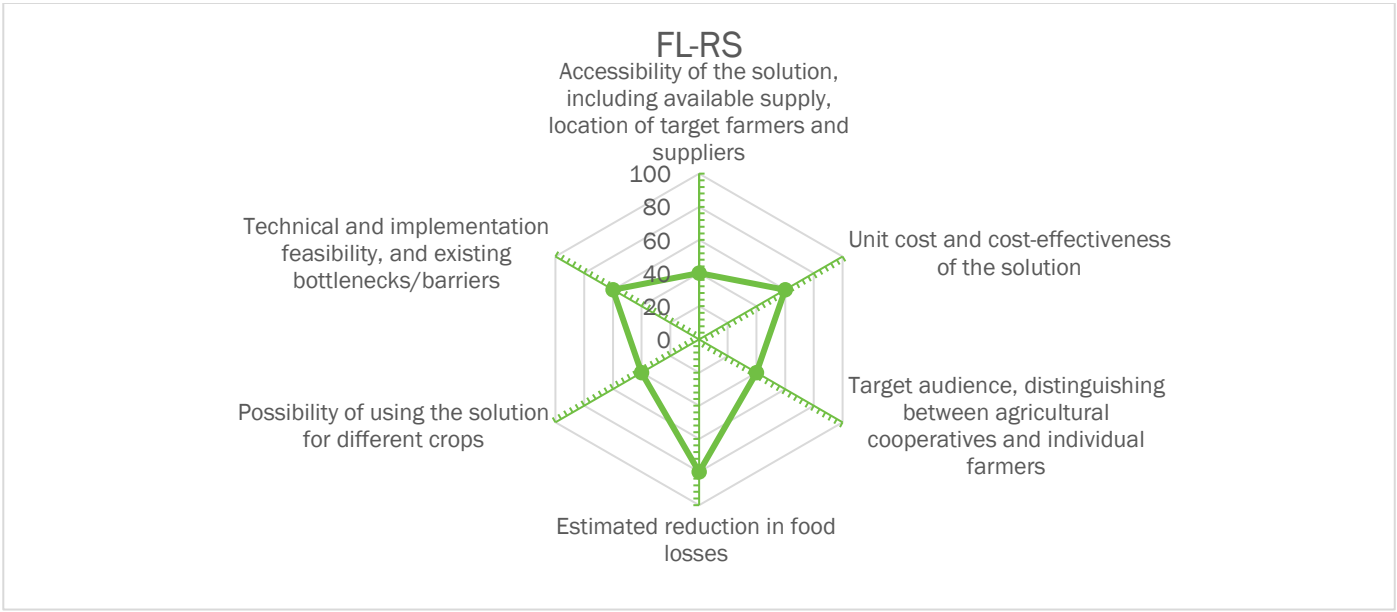


Figure 5-4 - FL-RS evaluation matrix

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 C. M.-Z., 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 S. H., 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 5-4.

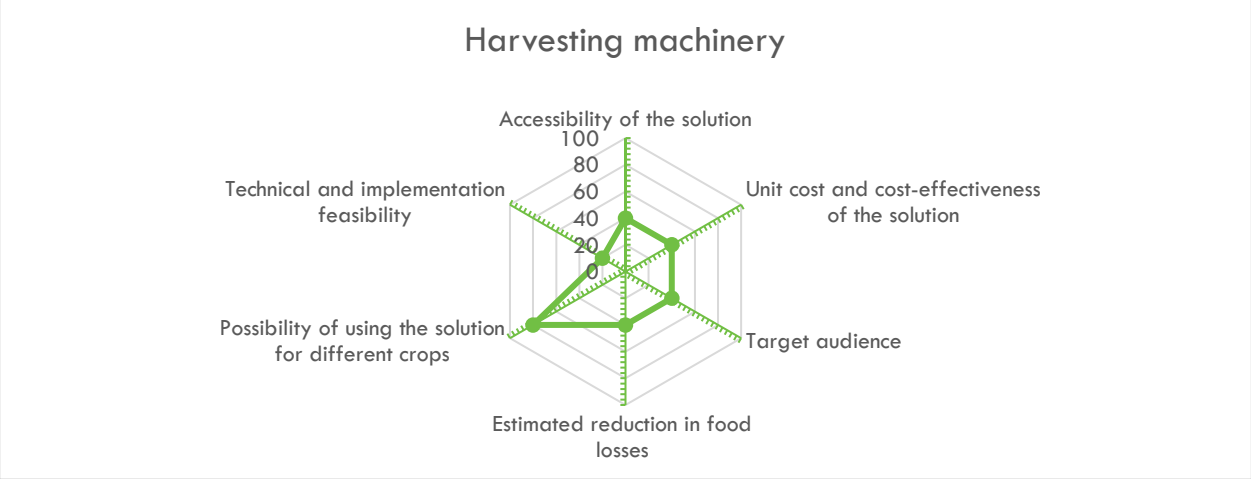


Figure 5-5 - FL-RS evaluation for harvesting machinery

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 S. &., 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 S. &., 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 M. &., 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 M. &., 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 M. &., 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 5-6.

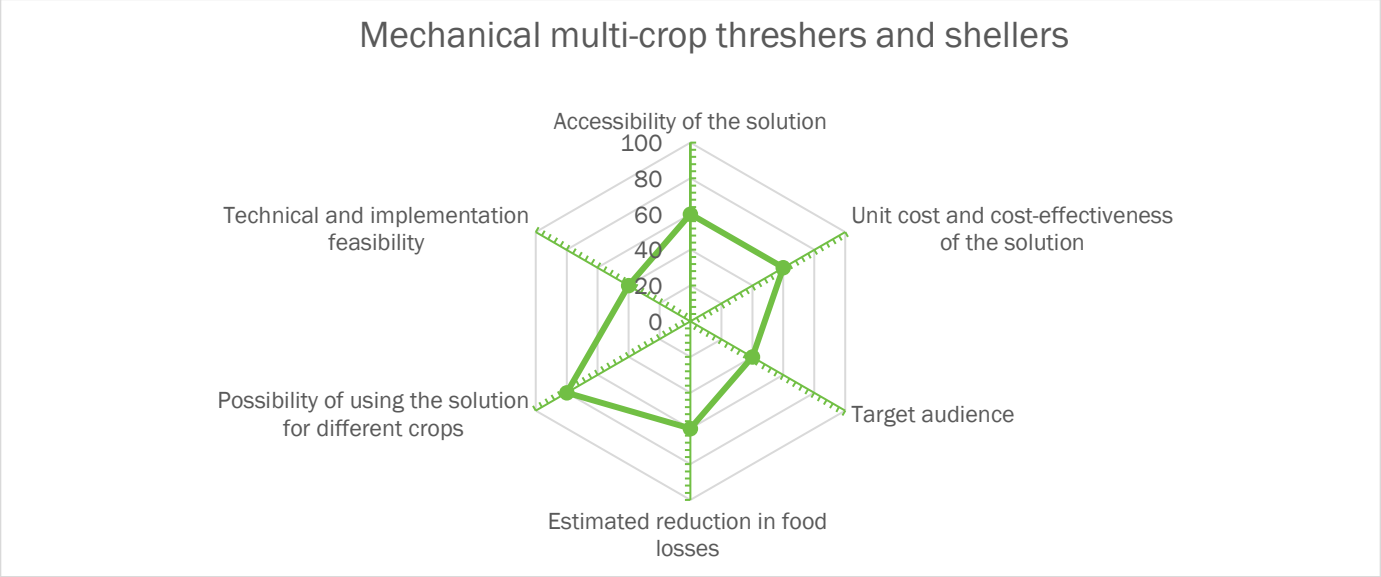


Figure 5-6 - FL-RS evaluation for mechanical multi-crop threshers and shellers

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 R. J., 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 H. M., 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 H. M., 2015). The use of these drying methods often results in higher quality produce, which can command better market prices (Kader A. A., 2005).

The evaluation of tarpaulins and plastic sheets is provided in Figure 5-7.

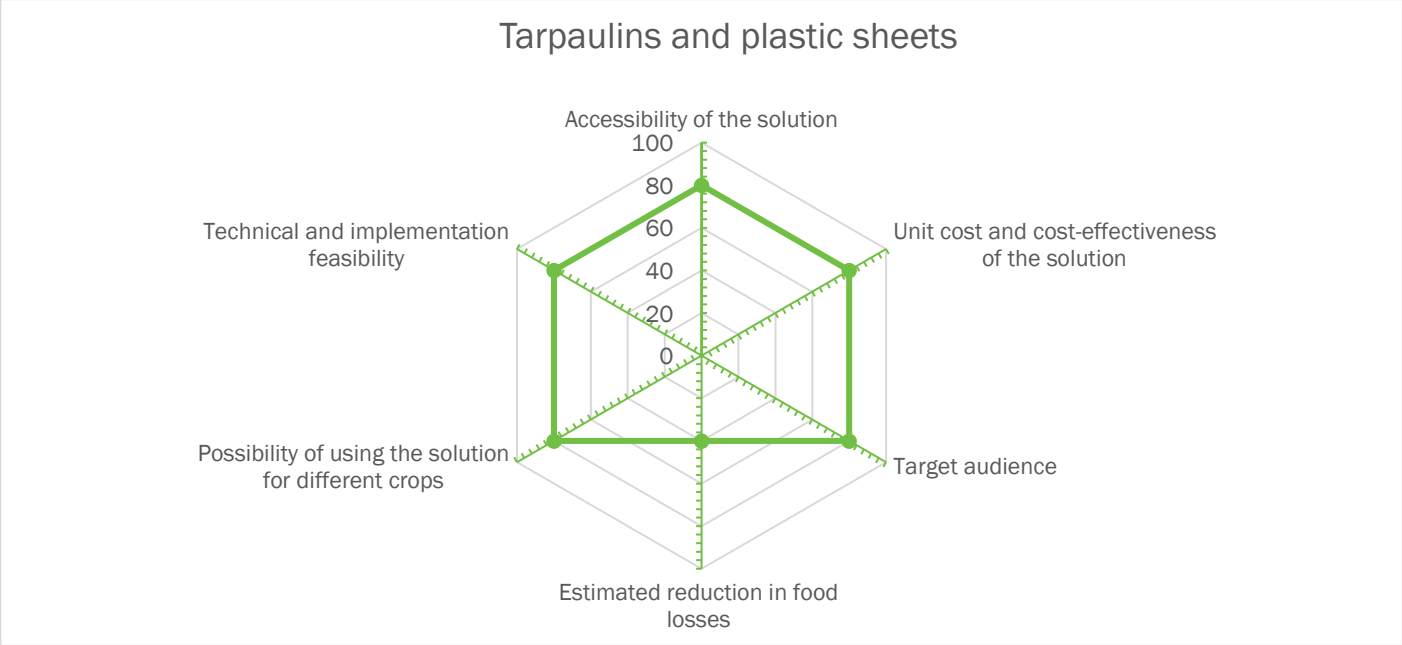


Figure 5-7 - FL-RS evaluation for tarpaulins and plastic sheets

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 5-8.

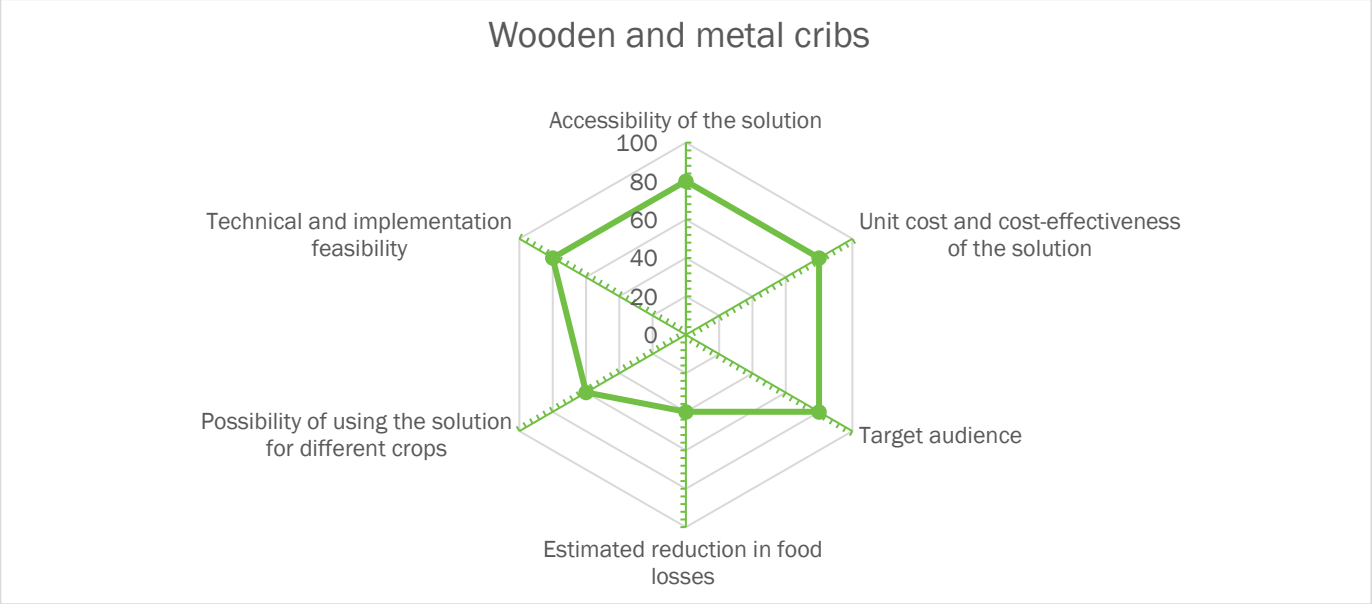


Figure 5-8 - FL-RS evaluation for wooden and metal cribs

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 5-9.

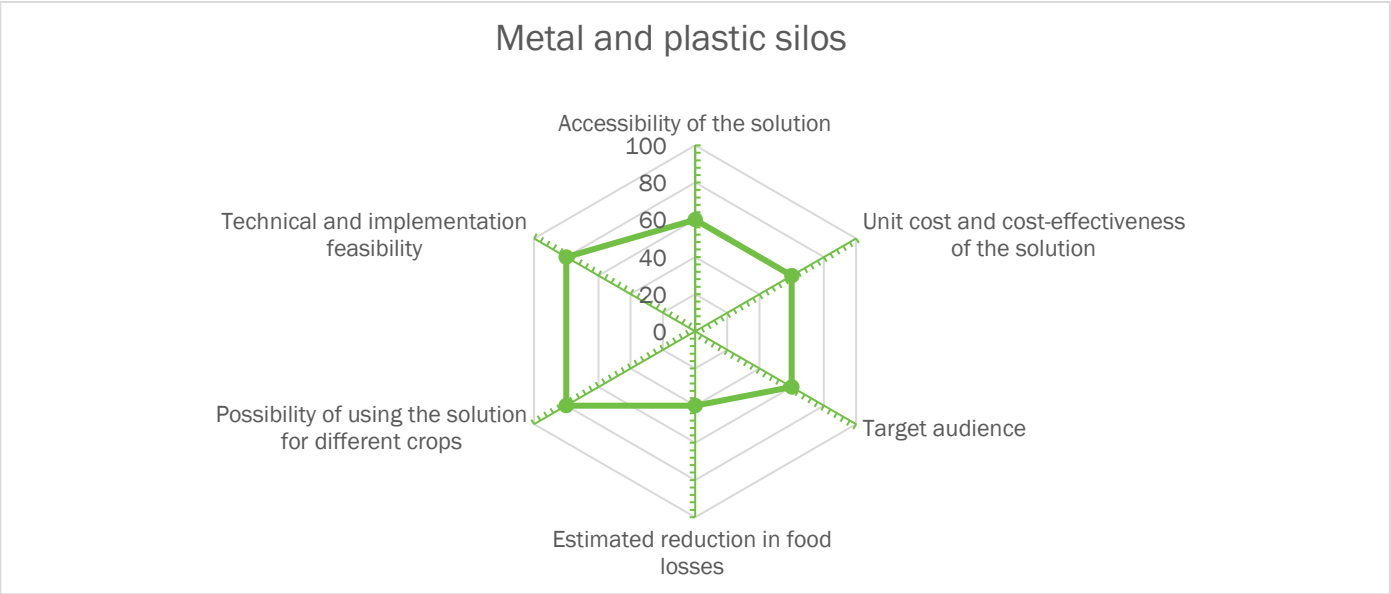


Figure 5-9 - FL-RS evaluation for metal and plastic silos

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 5-10.

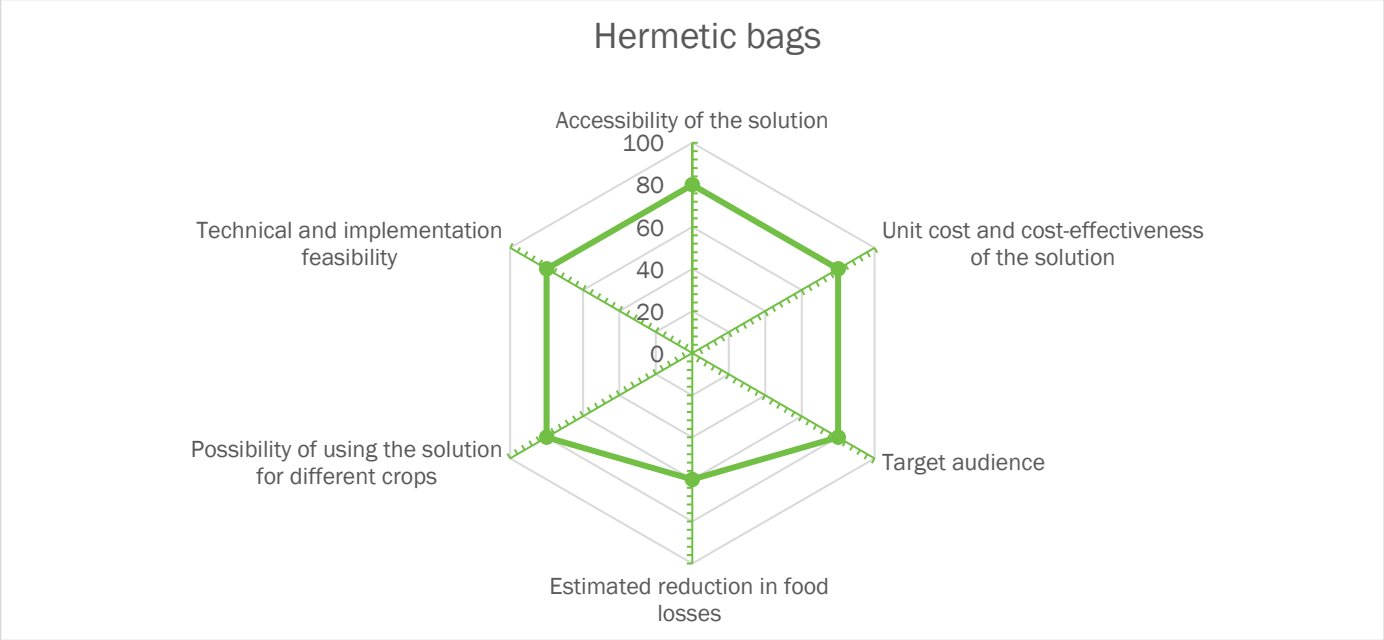


Figure 5-10 - FL-RS evaluation for hermetic bags

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 5-11.

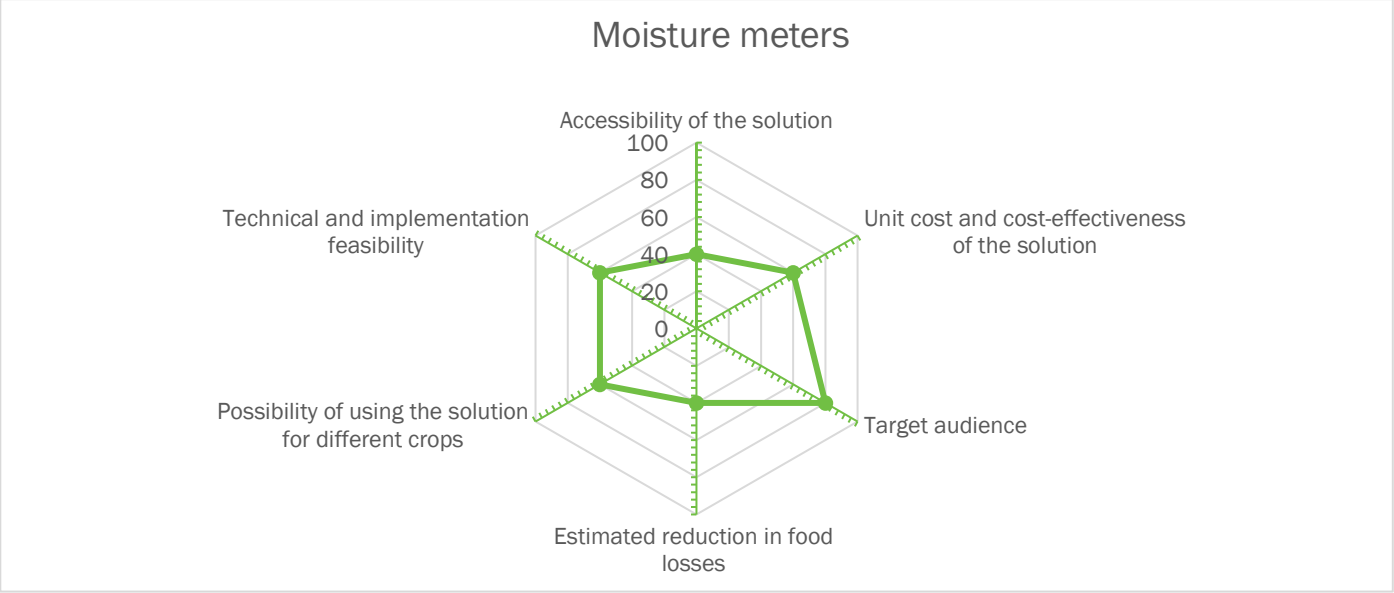


Figure 5-11 - FL-RS evaluation for moisture meters

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 5-12.

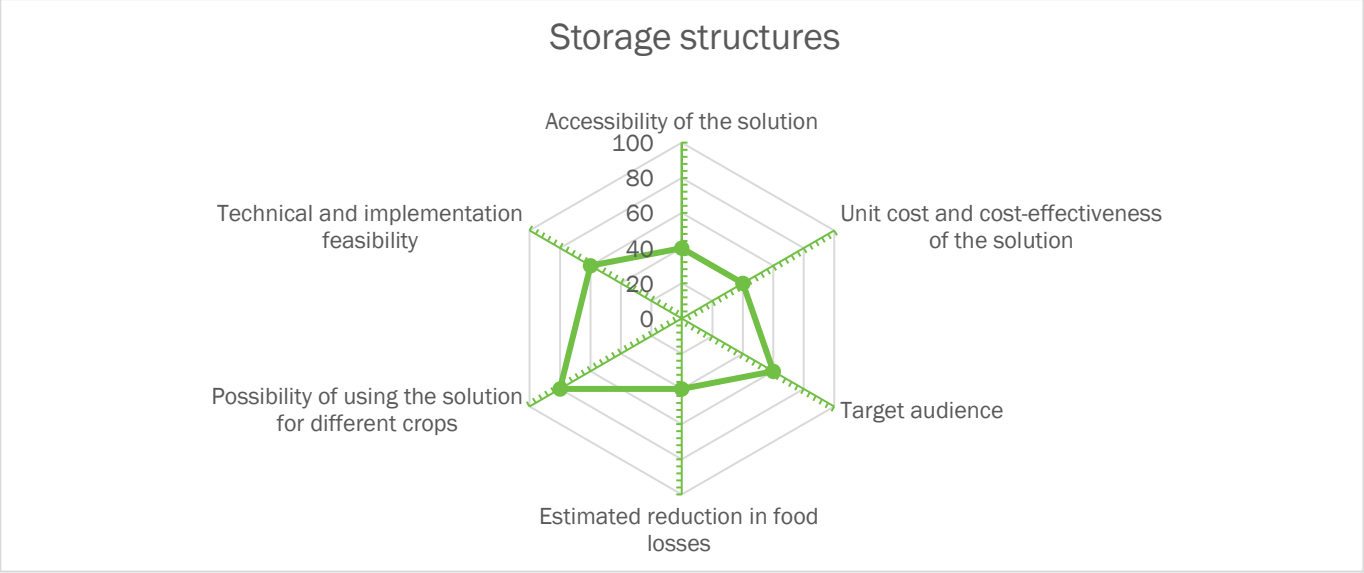


Figure 5-12 - FL-RS evaluation for storage structures

5.2.3.9 Storage protectants and control agents

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

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

The evaluation of storage protectants and control agents is provided in Figure 5-13.

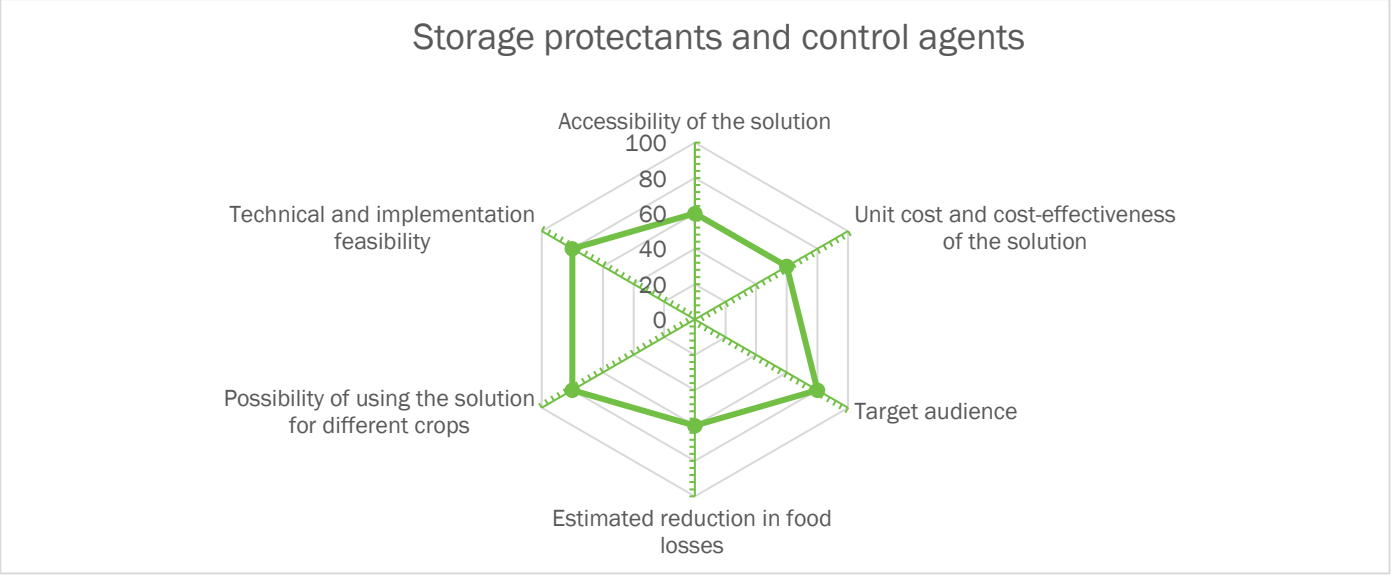


Figure 5-13 - FL-RS evaluation for storage protectants and control agents

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 H. M., 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 5-14.

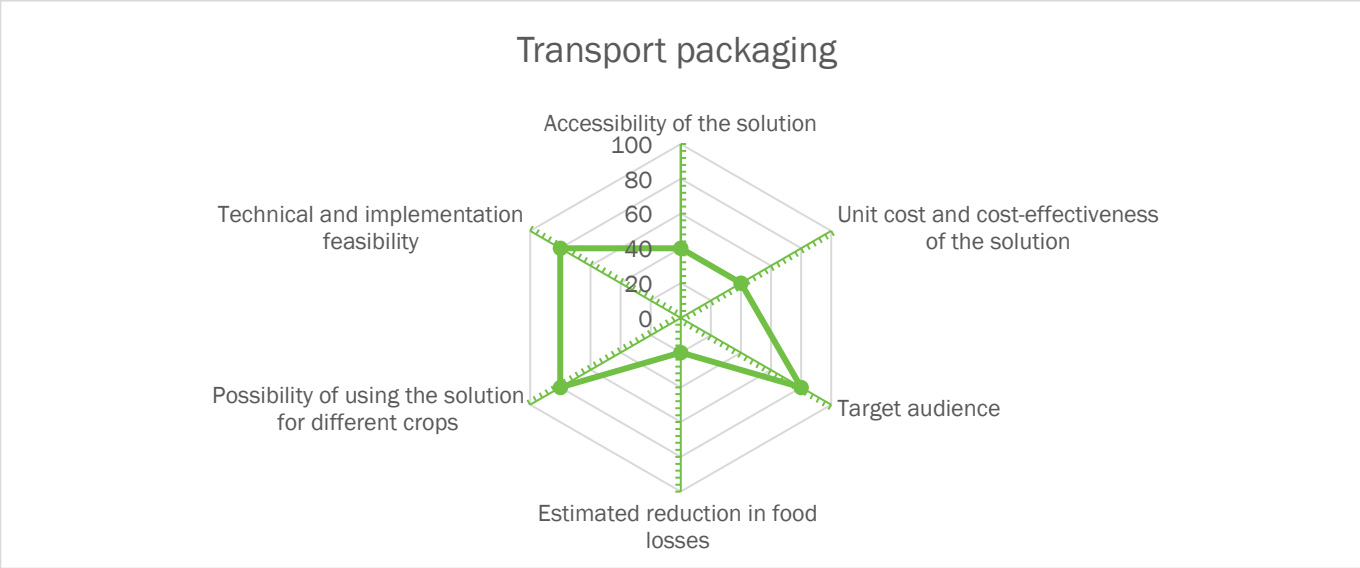


Figure 5-14 - FL-RS evaluation for transport packaging

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

Table 5-5 - 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 C. M.-Z., 2023); (Muhammad Yasin, 2019); (Aparna Kumari, 2023); (Mathanker S. H., 2014)
Mechanical multi-crop threshers and shellers	**10-30%** *Sources:* (Amponsah S. &., 2017); (FarmBiz Africa, 2020); (Getachew M. &., 2022); (Soybean Innovation Lab, 2016)
Tarpaulins and plastic sheets	**10-20%** *Sources:* (Hodges R. J., 2011); (Grolleaud, 2002); (Affognon H. M., 2015); (Kitinoja L. S., 2011)
Wooden and metal cribs	**30-50%** *Sources:* (Julius, 2021); (FAO, 2011); (Tadele Tefera, 2011)
Metal and plastic silos	**10-50%** *Sources :* (Njoroge, 2019); (De Groote H. K., 2013)
Hermetic and other plastic bags	**20-30%** *Sources:* (Williams, 2017); (De Groote H. K., 2012); (Koskei, 2020)
Moisture meters	**Up to 25%** *Sources:* (Hossain, 2016); (Koskei, 2020)
Storage structures	**Up to 15%** *Sources:* (Befikadu, 2014); (FAO, 2014); (Ansah, 2018)
Storage protectants and control agents	**30-40%** *Sources:* (Tefera T. M., 2011); (Abass, 2014)
Transport packaging	**10-15%** *Sources:* (Affognon, Mutungi, Sanginga, & Borgemeister, 2015); (Adejumo, 2007)

5.3 DEFINITION OF FEASIBILITY AND PRIORITISATION CRITERIA FOR FOOD LOSS REDUCTION SOLUTIONS (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 cowpeas
- 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 cowpeas value chains

In terms of climate risks in Burkina Faso, both rice and cowpeas are highly vulnerable and susceptible to overall increase in temperatures, extremely hot days, and heavy rains and floods as identified in Table 3-8. This vulnerability can lead to reduced harvests and postharvest losses due to both qualitative and quantitative losses, emphasizing the importance of selecting right harvesting timing, as well as proper postharvest crop management including 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 cowpeas value chains is presented in Table 5-6 and Table 5-7 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 5-6 – Evaluation of the potential solutions in addressing key climate hazards in Burkina Faso for Cowpeas value chain

Solutions	Climate hazards			Average rate
	Extreme heat and heatwaves, and hot days over 35°C	Heavy rains (days with rainfall > 20mm, large 1-day rains and large 5-day rains)	River and/or urban floods	
Harvesting machinery	4	2	3	3.00
Mechanical multi-crop threshers and shellers	4	4	4	4.00
Tarpaulins and plastic sheets	4	2	2	2.67
Wooden and metal cribs	4	2	2	2.67
Metal and plastic silos	4	5	4	4.33
Hermetic bags	4	4	4	4.00
Moisture meters	4	4	3	3.67
Storage structures	4	4	4	4.00
Storage protectants and control agents	4	2	2	2.67
Transport packaging	4	1	1	2.00

Table 5-7 - Evaluation of the potential solutions in addressing key climate hazards in Burkina Faso for Rice value chain

Solutions	Climate hazards			Average rate
	Extreme heat and heatwaves, and hot days over 35°C	Heavy rains (days with rainfall > 20mm, large 1-day rains and large 5-day rains)	River and/or urban floods	
Harvesting machinery	4	4	3	3.67
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	3	2.67
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 5-6 and Table 5-7, the FL-RS with the highest average scoring is listed below in the order of importance:

- Metal and plastic silos (4.33 points for both rice and cowpeas)
- Mechanical multi-crop threshers and shellers (4.00 points for both cowpeas and rice)
- Hermetic bags (4.00 points for both rice and cowpeas)
- Storage structures (4.00 points for both cowpeas and rice)
- Harvesting machinery (4.00 points for rice and 3.33 points for cowpeas)
- Moisture meters (3.67 points for cowpeas and 2.67 points for rice)

Tarpaulins and plastic sheets (2.67 points for cowpeas and 3.00 points for rice)

Baseline research findings, detailed in subchapter 5.1 and supported by the outcomes of discussions with stakeholders in Burkina Faso have identified harvesting, threshing and shelling and on-farm storage of rice and cowpeas 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 rice and cowpea value chains in Burkina Faso. 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 Burkina Faso, 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 Burkina Faso are presented in the Table 5-8 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 5-8– Estimation of the costs of the top 10 FL-RS in Burkina Faso

Solutions	Estimated cost of the solution in US dollars	Scoring
Harvesting machinery	Est. 10 000	1
Mechanical multi-crop threshers and shellers	Est. 7 500	2
Moisture meters	Est. 75 - 120	3
Metal and plastic silos	Est. 50 - 200	3
Wooden and metal cribs	Est. 50 - 200	3
Storage structures	Est. 20 - 200	3
Tarpaulins and plastic sheets	Est. 50 - 90	4
Transport packaging	Est. 2 - 20	4
Storage protectants and control agents	Est. 10 - 20	4
Hermetic bags	1.5 - 2	5

Source: (CoinAfrique, 2024)

Smallholder farmers in Burkina Faso, 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 loss 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 Burkina Faso include the limited financial capacity of smallholder farmers to invest in mechanized high-tech solutions, coupled with restricted access to credit and bank loans. Additionally, there is a scarcity of quality low-technology solutions for harvesting, drying, and storing cowpeas 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 Burkina Faso during the baseline assessments (Chapters 3 and 4), and the first round of stakeholder engagement on national and local levels, major losses in both cowpeas and rice value chains are observed on the harvesting, and post-harvest handling and storage stages.

During the first round of stakeholder consultations in Burkina Faso, participants of local and national workshops shortlisted top three solutions, that would be relevant for both rice and cowpeas 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 5-9.

Table 5-9 – Top solutions for rice and cowpeas production, resilience against climate risks, and impact potential for smallholder farmers in Burkina Faso

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

As we can see from Table 5-9, tarpaulins and plastic sheets, as well as hermetic bags, and mechanical multi-crop threshers and shellers were the most frequently mentioned, and therefore are of primary importance for postharvest food losses reduction in Burkina Faso. Harvesting machinery, moisture meters, storage structures, as well as storage protectants and control agents were also identified as crucial FL-RS by consulted stakeholders.

For the final evaluation provided in the Table 5-10, 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 Burkina Faso specified in the previous chapters, the physical FL-RS for Burkina Faso with the highest potential to reduce postharvest food losses is highlighted in Table 5-10 below:

Table 5-10 – Final evaluation of the shortlisted physical FL-RS in Burkina Faso

Solutions	Climate risks		Costs of the solutions	Best solutions in the local context	Final score
	Rice	Cowpeas			
Harvesting machinery	3.67	3.00	1	2	9.67
Mechanical multi-crop threshers and shellers	4.00	4.00	2	3	13.00
Tarpaulins and plastic sheets	3.00	2.67	3	3	11.67
Wooden and metal cribs	2.00	2.67	3	1	8.67
Metal and plastic silos	4.33	4.33	3	1	12.66
Hermetic bags	4.00	4.00	5	3	16.00
Moisture meters	2.67	3.67	3	3	12.34
Storage structures	4.00	4.00	3	2	13.00

Storage protectants and control agents	2.67	2.67	4	2	11.34
Transport packaging	1.67	2.00	4	0	7.67

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

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

Based on the results of stakeholder engagements in Burkina Faso, each out of shortlisted physical solutions were evaluated, including key strategic points such as the advantages and disadvantages of each solution, and key barriers for their use particularly in the context of smallholder farmers. The results of the evaluation are provided in the Table 5-11.

Table 5-11 – Results of the shortlisted FL-RS evaluation in Burkina Faso

Solution	Strategic advantages of the solution	Key disadvantages of the solution	key barriers for solution implementation	Additional points based on the baseline research results and discussions with stakeholders
Mechanical Multi-Crop Threshers and Shellers	Effective in reducing labour costs and time, and they can be used by farmers of all scales, from small to large. They improve the quality and quantity of harvests, are easy to use, and reduce harvesting losses	High cost and limited accessibility due to price are significant disadvantages.	High energy consumption and maintenance requirements	They are not affordable for small farmers due to their high costs, making them accessible primarily to large farmers and producers
Tarpaulins and plastic sheets	Accessible, affordable, and easy to use, making them practical for drying harvests and preventing crop contamination with stones and sand	Not suitable for drying large volumes of crops, pose hygienic risks, and leave harvests exposed to foraging animals	Limited accessibility, variable quality, and limited durability of these materials	Adequate use of tarpaulins requires additional capacity building for farmers, including trainings on the selection of tarpaulins, their use and maintenance
Metal and plastic silos	Offer large storage capacity, protecting cereals from pests and insects. They are effective for long-term storage and conservation of crops, ensuring better quality and isolation	Inaccessible to small producers due to high prices, and do not allow to store several agricultural products simultaneously due to the risk of mixing	High costs, limited storage capacity, and difficulty adapting for small producers	Metal silos often referred as prone to overheating during the heatwaves, and prone to rusting during heavy rains and floods
Hermetic bags	Effective for storing cowpeas and adaptable for different crops, including transportation of rice and cowpeas. They are practical, reasonably priced, and accessible	Can be expensive for small farmers, and their availability can be limited. The bags' durability and quality can also be an issue	Affordability, limited availability, and the variable durability of the bags	Farmers in some cases are not fully aware about the proper use and maintenance of hermetic bags
Moisture meters	Help check the humidity level of crops quickly, aiding farmers in storing crops and making informed decisions. They are easy to use, effective, and practical	Not durable and should be adopted only in cases of high crop humidity	Limited availability, high costs, and the need for proper understanding and utilization	Moisture meters require training on their use, and often referred as highly technological
Storage structures	Offer significant storage capacity, particularly beneficial for aggregators, and improve harvest conservation. They are	Expensive and not easily adoptable in certain contexts	High sustaining costs, scarcity of construction materials, and the overall expense of these structures	For reducing postharvest losses during storage, storage structures are needed on both household/farm and community levels

Solution	Strategic advantages of the solution	Key disadvantages of the solution	key barriers for solution implementation	Additional points based on the baseline research results and discussions with stakeholders
	effective for storing large volumes of produce			
Storage protectants and control agents	Effective, easy to apply, affordable, and practical for local production	Can be hazardous to human health and the environment, leading to contamination of food products and pollution risks	High pollution risks and health concerns associated with the use of chemical products	Many stakeholders raised the importance of using biological/ natural pesticides and fungicides

This assessment 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 the 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 in Burkina Faso, 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. 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 are presented in Table 5-12:

Table 5-12 Prioritized physical FL-RS for Burkina Faso

Solutions	Level of priority
Harvesting machinery	low
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	high
Communal storage structures	high
Storage protectants and control agents	medium
Transport packaging	low

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

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

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

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

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

Taking into consideration the shortlisted solutions for Burkina Faso, as well as their potential in reducing postharvest losses and existing barriers, Table 5-13 provides a brief overview of the proposed solutions' delivery mechanism for Burkina Faso.

Table 5-13 – Proposed delivery mechanism for shortlisted physical FL-RS in Burkina Faso

Solution	Estimated reduction in PHL, % (Table 5-1)	Barriers to solution implementation	Proposed delivery mechanisms
Mechanical Multi-Crop Threshers and Shellers	10-30%	• High energy consumption and maintenance requirements	• Improved access through subsidy scheme • Capacity building (training of trainers) on managing and maintaining the machinery
Tarpaulins and Plastic Sheets	10-20%	• Limited accessibility • variable quality • limited durability	• Improved access through subsidy scheme • Training and capacity building on the appropriate use of tarpaulins and plastic sheets
Metal and plastic silos	10-50%	• High costs • limited storage capacity • difficulty adapting for small producers	• Improved access through subsidy scheme • Training and capacity building on the appropriate use of silos
Hermetic Bags	20-30%	• Affordability • limited availability • variable durability	• Improved access through subsidy scheme • Training and capacity building on the appropriate use of hermetic bags
Moisture meters	Up to 25%	• Limited availability • high costs • need for proper understanding and utilization	• Improved access through subsidy scheme • Capacity building (training of trainers) on the use and maintenance of moisture meters
Storage Structures	Up to 15%	• High sustaining costs • scarcity of construction materials	• Improved access through subsidy scheme

Solution	Estimated reduction in PHL, % (Table 5-1)	Barriers to solution implementation	Proposed delivery mechanisms
		• Overall high cost of these structures	• Capacity building (training of trainers) on the best practices in using storage structures
Storage protectants and control agents	30 – 40%	• High pollution risks and health concerns associated with the use of chemical products	• Improved access through subsidy scheme • Capacity building (training of trainers) on the best practices in using storage protectants

For the successful implementation of RE-GAIN programme, it is also critical to consider additional aspects and factors, such as improved access to finance for women and youth groups, traditional roles of both genders in the agricultural sector in Burkina Faso, 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 5-14:

Table 5-14 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**	**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
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**	**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

Identified risks, needs and barriers	Activity sets	Outputs
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		
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[4] 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

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

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[5] and will be comprised of country-office staff. The CIUs will be responsible for managing day-to-day operations in each country, reporting directly to the PIU, as well as providing regular reports to the relevant Project Steering Committee (see below).

Programme Steering Committee

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

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

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 5-15: Country PSC Representatives

Country	PSC Representatives
Burkina Faso	• The General Directorate of Rural Economy Promotion (DGPER) – Ministry of Agriculture • The General Directorate of Studies and Statistics (DGESS) – Ministry of Agriculture • The National Designated Authority – Prime Ministry Office

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.

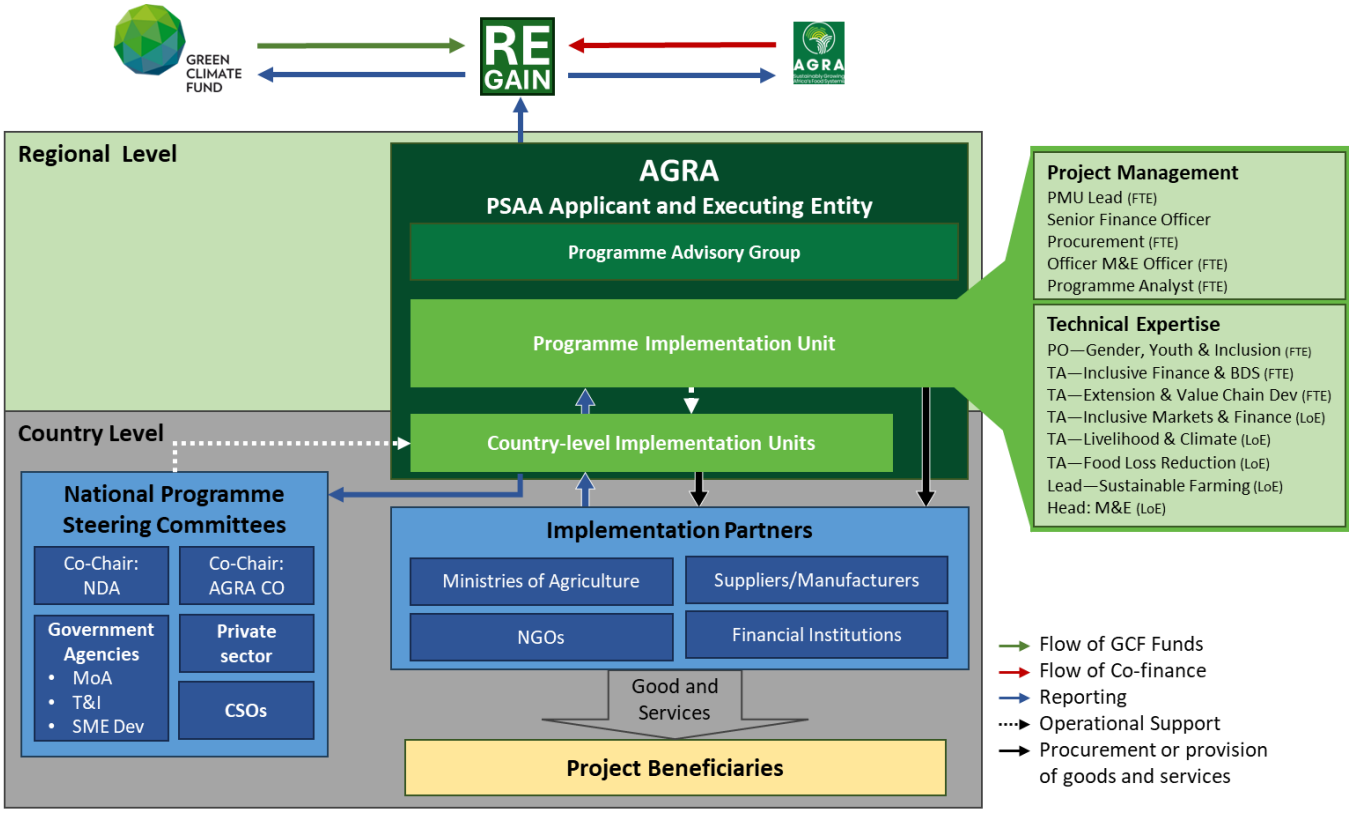


Figure 5-15 Implementation Arrangements for the RE-GAIN Programme

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 demand and supply of agricultural machinery and other post-harvest food loss reduction technologies among smallholder farmers in Burkina Faso 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 Burkina Faso, including:

a) Lack of information and awareness about the importance of food losses and available postharvest technologies;
b) Lack of appropriate knowledge and skills within the farming community that hinders the adoption of modern agricultural techniques and more efficient resources management;
c) Low literacy levels among women farmers which hinders their full participation in awareness and training activities, inhibiting their adopting improved agricultural activities, including FL-RS;
d) High cost of some of the FL-RS, such as threshes/shellers, silos, moisture meters and even hermitic bags making them unaffordable;
e) Poor market linkages and market and product information asymmetries which hamper farmers' ability to connect effectively with suppliers;
f) Limited supply of affordable finance due to high interest rates, short loan periods, or lack of access to collateral, limits farmer's access to loans for investing in FL-RS;
g) Unstable market prices add another layer of uncertainty, making it difficult for farmers to plan and invest in their operations confidently.

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

6.1.1 Demand for specific FL-RS

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

The demand for **mechanical multi-crop threshers and shellers** in Burkina Faso is high, particularly among smallholder farmers who seek to reduce labour costs and increase efficiency. Farmers are overall well aware about the efficiency and benefits of using threshers and shellers, and prefer solar-powered machinery, as it also reduces the maintenance costs, and reduces

environmental pollution. However, the supply of threshers is constrained by financial limitations and the availability of suitable machinery. Imported threshers are often expensive, and local production is limited, creating a gap between demand and supply.

The demand for **tarpaulins and plastic sheets** in Burkina Faso's agricultural sector is substantial, as they are seen as a cost-effective solution for reducing post-harvest losses during drying and storage stages. Despite their affordability, the supply chain for tarpaulins faces logistical challenges, including distribution to remote areas and ensuring consistent quality. Local markets do offer tarpaulins, but they often fall short of the durability and standards required for effective food loss prevention.

Adoption of **hermetic bags and silos** in Burkina Faso is growing, driven by increased awareness and training programs. The demand for hermetic bags is particularly high due to their ease of use and relative affordability. Silos, while highly effective, are more expensive and require substantial initial investment. The supply of hermetic bags has improved with local manufacturing initiatives, but the distribution network needs strengthening. Silos, on the other hand, are less accessible due to their higher costs and the need for skilled installation.

Moisture meters play a vital role in ensuring that grains are adequately dried before storage, thus preventing mold and spoilage. The demand for these devices is increasing as farmers become more aware of their benefits. However, the supply is limited by the availability of affordable and reliable meters. Imported moisture meters are often beyond the financial reach of smallholder farmers, and local alternatives are scarce.

Storage structures and storage protectants are integral to safeguarding stored produce from environmental and biological threats. The demand for improved storage solutions is high, given the inadequacies of traditional storage methods. Modern storage structures, such as improved granaries and warehouses, are sought after but are limited by high construction costs and maintenance requirements. Storage protectants, including chemical treatments and natural alternatives, are in demand to control pests. The supply of these protectants is generally sufficient, though their safe and effective use requires better training and regulation.

6.2 MARKET OF SUPPLIERS AND MANUFACTURERS OF FL-RS

The current market situation for FI-RS in Burkina Faso includes a range of suppliers, manufacturers, and importers. Market landscape is characterized by a mix of local production and significant reliance on imported technologies, with varying degrees of accessibility and affordability.

Mechanical multi-crop threshers and shellers are primarily available in Burkina Faso through a mix of local manufacturers and international importers. Local manufacturing of threshers remains limited, with a few small-scale workshops such as ACIEAA and SC Design producing basic models that often lack the durability and efficiency of imported machines. Importers, mainly from China, India, and Europe, dominate the market by providing higher-quality threshers, albeit at a higher cost. The high price of imported threshers limits their accessibility to smallholder farmers, who constitute the majority of Burkina Faso's agricultural sector. More information on the companies' location, average prices of the solutions, production/supply capacities, and whether those are locally produced or imported, are provided in the Appendix 9.

Tarpaulins and plastic sheets are widely available in local markets in Burkina Faso, predominantly supplied by local and regional manufacturers. Companies such as GTESF, SIELE International Sarl, and SOLDEV, among others, supply tarpaulins

in various sizes and qualities, catering to different farmer needs. However, the quality of locally produced tarpaulins often varies, with many not meeting the durability standards required for effective crop protection. Importers from neighbouring countries supplement the supply but face logistical challenges that can lead to inconsistent availability.

Hermetic bags and silos are increasingly gaining attention in Burkina Faso due to their effectiveness in preserving grain quality. Local manufacturers, such as GTESF, SIELE International, TEC Services, BOUTAPA Sarl, SOLDEV and others have begun supplying hermetic bags, supported by initiatives from agricultural development organizations and NGOs. These efforts have helped to stabilize the supply and reduce costs. Major international suppliers, such as GrainPro and PICS (Purdue Improved Crop Storage) bags, are also present in the market, offering high-quality options at higher prices. The supply of silos, however, is more dependent on imports from countries like India and China, as local production is minimal. The higher costs and the technical complexity of silos further restrict their widespread adoption.

Moisture meters are mostly imported to Burkina Faso due to the lack of local manufacturing capabilities. Suppliers from Europe and Asia dominate this market segment, providing a range of moisture meters that vary in price and sophistication. The high cost of these imported devices limits their use primarily to larger, commercially oriented farms and agricultural cooperatives, while smaller farmers often continue to rely on less precise traditional methods. Among the main suppliers of moisture meters in Burkina Faso, there are companies such as Complexe Services COSER, Mansa International, GTESF, and others.

Storage structures, including modern granaries and warehouses, are often constructed by local builders using locally sourced materials. However, the market for advanced storage solutions is limited by the high cost and technical expertise required. Companies specializing in agricultural infrastructure, often based in urban centers like Ouagadougou, undertake these projects, frequently in collaboration with international donors and development agencies. Importers play a smaller role in this segment, primarily providing materials and components not readily available locally.

Storage protectants, such as chemical treatments and natural alternatives, are widely available through local agricultural supply stores and cooperatives. These products are often supplied by both local manufacturers and international agrochemical companies. Key players in the market include Mansa International, SOLDEV, Bioprotect, Prophyma SA-Groupe Savana, Saphyto, and others. The market is well-served, but issues related to the correct and safe use of these protectants persist, requiring better training and regulation.

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 Burkina Faso

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 Burkina Faso. These initiatives encompass a variety of interventions and have had varying degrees of success and impact.

Governmental initiatives

In Burkina Faso, there are several governmental initiatives aimed at enhancing agricultural productivity and financial accessibility, including improved access to FL-RS. The Fonds de Développement Agricole (FDA) is one such initiative, providing loans and grants to farmers for purchasing equipment, and other farming needs. Banque Agricole du Faso (BAF), a specialized agricultural bank, offers loans and credit facilities specifically tailored to the requirements of smallholder farmers. Additionally, the government implements subsidy programs to reduce the cost of agricultural inputs, making them more affordable for these farmers.

Development Projects

Some of the development projects in Burkina Faso focus on supporting smallholder farmers through financial and technical assistance. For example, the Agricultural Value Chains Support Project (PAPFA) (2017-2024), funded by the International Fund for Agricultural Development (IFAD), aims to improve the productivity and income of smallholder farmers by providing training and financial support.

Funding by NGOs

Non-governmental organizations (NGOs) play a crucial role in supporting smallholder farmers in Burkina Faso. For example, Oxfam, through various projects, provides grants, microloans, and technical assistance to help improve agricultural practices and market access. Heifer International contributes by providing livestock, training, and small grants aimed at improving the livelihoods of smallholder farmers.

Microfinance Institutions

Microfinance institutions (MFIs) in Burkina Faso offer essential financial services to smallholder farmers. Institutions like MicroCred and ACEP Burkina provide microloans to farmers to finance agricultural inputs and equipment. Additionally, the Union des Caisses d'Epargne et de Crédit Agricole Mutuel (UCEC) is a union of savings and credit cooperatives that offers loans and other financial services to smallholder farmers, supporting their agricultural activities and overall financial well-being.

Despite these initiatives, there is still 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.

6.3.3 Suppliers of financial products and services

In Burkina Faso, several financial institutions and organizations provide agricultural loans to small farmers. These institutions aim to support agricultural development, enhance food security, and improve the livelihoods of smallholder farmers. Here are some key entities involved in providing such financial services:

1. **Banque Agricole du Faso (BADF):** BADF is a specialized agricultural bank in Burkina Faso. It provides financial services tailored to the needs of the agricultural sector, including loans for farming activities, equipment purchase, and other agribusiness ventures.
2. **Commercial Banks:** Ecobank Burkina, Banque de l'Union (BDU), Banque Internationale pour le Commerce, l'Industrie et l'Agriculture du Burkina (BICIA-B), and Coris Bank International offer specialized loan products for the agricultural sector, targeting both smallholder and commercial farmers.
3. **Microfinance Institutions (MFIs):** RCPB (Réseau des Caisses Populaires du Burkina), ACEP Burkina, and PAMF (Première Agence de Microfinance). These institutions offer microloans to smallholder farmers, often with flexible repayment terms suited to agricultural cycles. They play a crucial role in rural financing by providing access to credit for farmers who may not qualify for traditional bank loans.

4. **Cooperative Banks and Savings Groups:** Union des Banques Coopératives (UBC) and various local agricultural cooperatives. These entities provide financial services, including loans, to their members. They are crucial in pooling resources and offering financial products tailored to the needs of smallholder farmers.
5. **Fonds d'Appui à la Sécurité Alimentaire (FASA):** This fund supports food security initiatives by providing loans and grants to smallholder farmers. It aims to enhance agricultural productivity and sustainability.

Besides those, the government of Burkina Faso, through its Ministry of Agriculture and other related agencies, implements various programs and initiatives that provide financial support to small farmers. These initiatives often include subsidized loans and grants to enhance agricultural productivity.

Cooperation with those major financing institutions is crucial for the success of RE-GAIN programme. In Burkina Faso, AGRA has already discussed collaboration opportunities, and signed Letters of Interest (LoI) with several financial institutions such as CORIS and BDU, 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 Burkina Faso as potential partners for the RE-GAIN programme (Table 6-1):

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

Financial partner	Overview
Banque de l'Union (BDU)	B DU supports the agricultural sector by offering loans specifically designed for farmers and agribusinesses. These loans help finance the purchase of inputs, equipment, and other agricultural needs.
CORIS Bank International (CBI)	Coris Bank International (CBI) is a key financial institution in Burkina Faso, offering a wide range of banking services to individuals, businesses, and the agricultural sector. CBI supports the agricultural sector by providing loans specifically designed for farmers and agribusinesses, helping them finance the purchase of inputs, equipment, and other agricultural needs.
Banque Agricole du Faso (BADF)	Specialized agricultural bank in Burkina Faso. It provides financial services tailored to the needs of the agricultural sector, including loans for farming activities, equipment purchase, and other agribusiness ventures.

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

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

The approach taken in the financial model design is focused on strategically using grants to catalyse the development of the market for food loss reducing solutions (FL-RS). These financial mechanisms are designed to address the current market dynamics and challenges faced by smallholder farmers and agricultural MSMEs. The mechanisms do this by enhancing the supply and affordability of FL-RS, thus creating a self-sustaining market and reducing the need for continued programme support.

Despite the potential benefits these models offer, there are several challenges that need to be addressed to ensure effective access and leveraging of FL-RS through financing. One of the primary challenges in accessing FL-RS is the high initial cost of these solutions. Smallholder farmers and agricultural MSMEs often operate with limited capital, making it difficult for them to invest in new technologies and equipment without substantial financial support. This high-cost barrier discourages adoption and limits market penetration. Another significant challenge is the lack of financial products tailored specifically to the agricultural sector. Many financial institutions are hesitant to develop and offer products for smallholder farmers and MSMEs due to perceived high risks and low profitability. Consequently, there is a scarcity of suitable financing options that can support the acquisition and implementation of FL-RS. Smallholder farmers and MSMEs often face difficulties in accessing credit due to stringent requirements set by financial institutions. These requirements typically include collateral, credit history, and other financial credentials that many small-scale agricultural enterprises lack. Without access to credit, these enterprises cannot afford to invest in FL-RS, hampering efforts to reduce food loss.

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

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

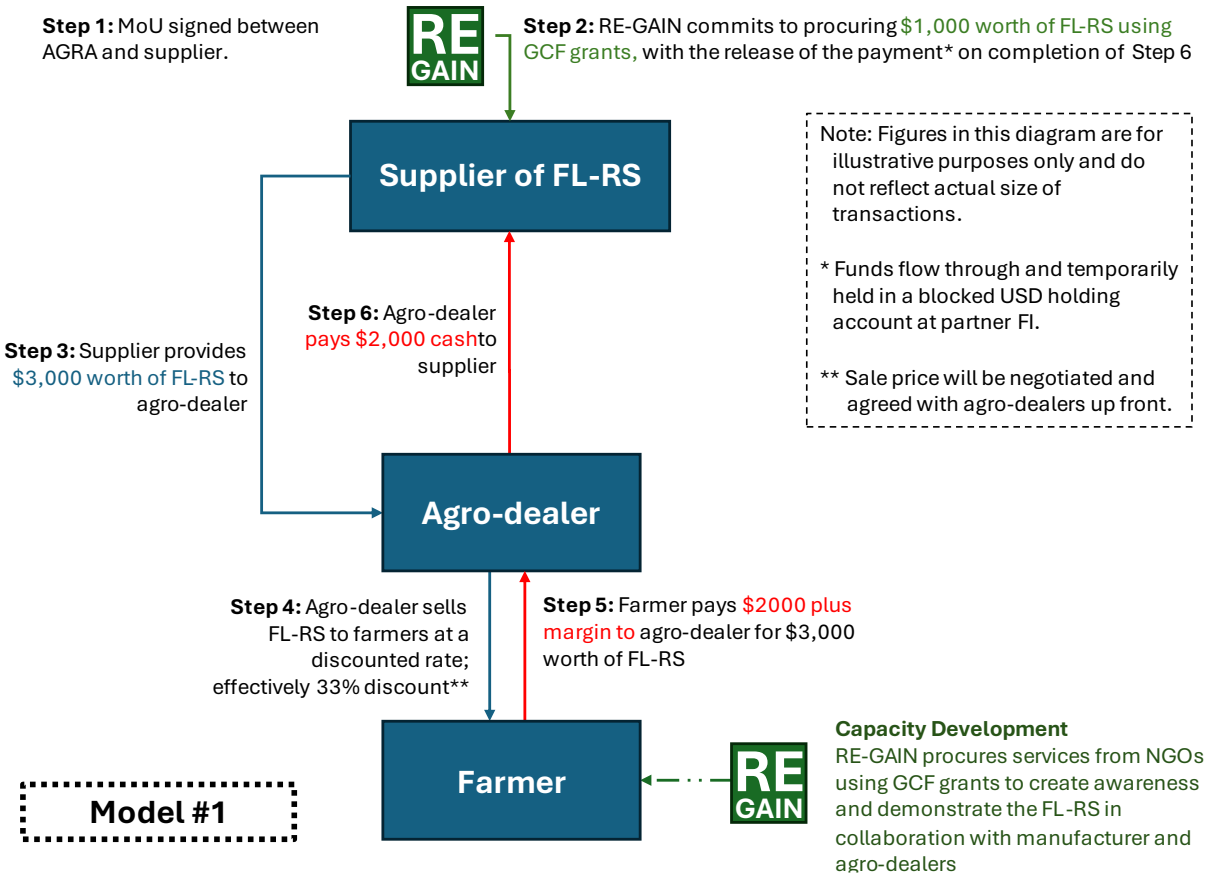
The models developed to enhance adoption and uptake of FL-RS consists of (1) conditional procurement **for smallholder farmers** to reduce the cost of hermetic technology and drying sheets and (2) smart grants to reduce the cost and risk of providing loans **to Agricultural MSME** buying FL-R equipment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

6.4.1 Solutions for smallholder farmers (part of activity 2.2.1)

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

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

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



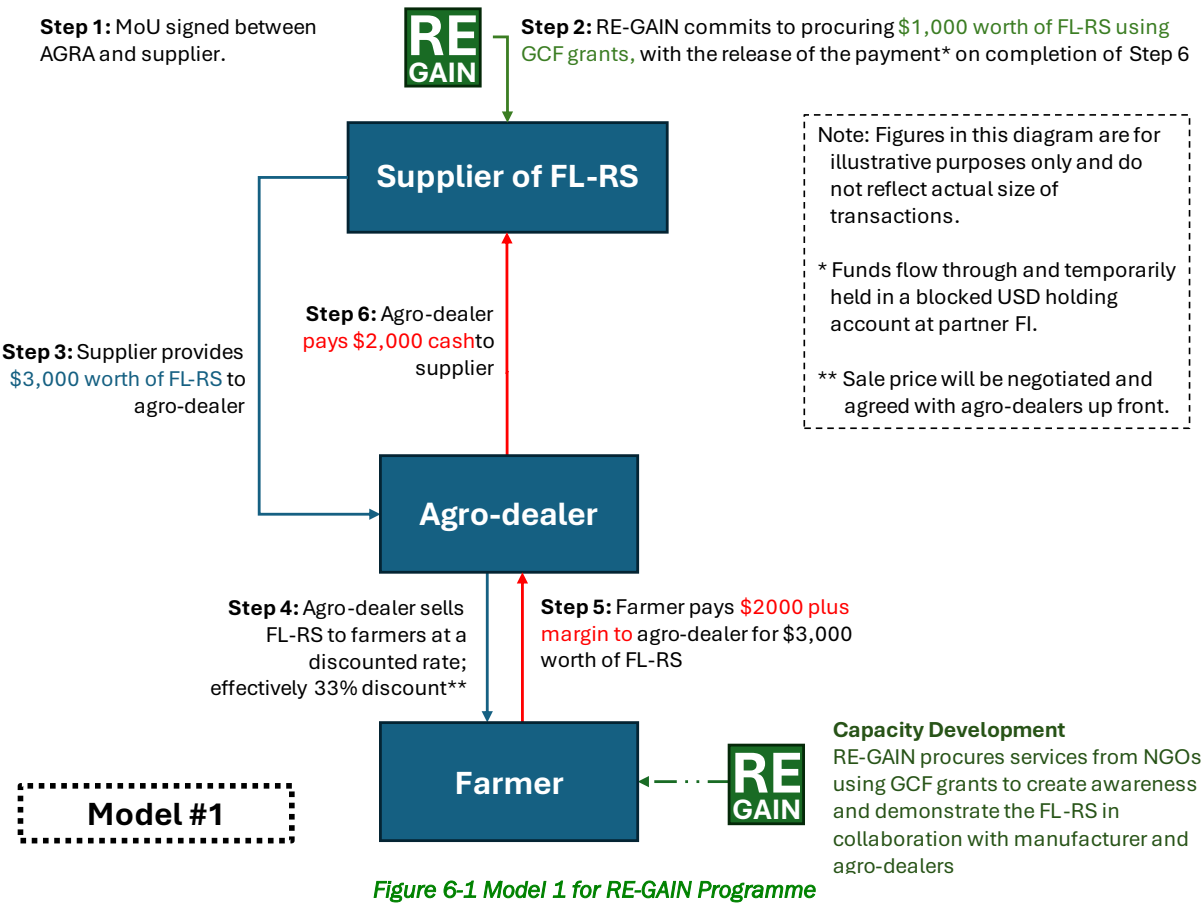


Figure 6-1 Model 1 for RE-GAIN Programme

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

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

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

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

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

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

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

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

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

- Legal capacity to operate: Registration (and ability to produce registration certificate) as a sole trader, partnership, franchise, cooperative, or limited liability company in good order with the local tax authorities
- If operating as an importer, evidence of compliance with import permits

- If appropriate, demonstrated compliance with any Environmental standards or requirements to obtain licences or environmental impact assessments, reports or management plans as required by local laws
- Proof of VAT registration
- Preferably a track record of producing and selling FL-RS as defined as part of the RE-GAIN programme that is approved by the national authorities
- Evidence of record keeping, including financial records;
- Willingness and financial capacity to expand the production levels and distribution network (agrodealers, cooperatives, development projects,) for the FL-RS
- Willingness and financial and human capacity to develop and deploy (subsidized) marketing efforts to enhance uptake of the FL-RS among small scale producers
- Presence in the target regions in the selected countries for the programme;
  Preferably engaging in the provision of solutions for smallholder farmers

6.4.1.2 Eligibility Criteria for Agricultural Traders, Processors, and Agrodealers

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

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

6.4.1.3 Eligibility Criteria for Smallholder Farmers and Communities

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

6.4.2 Solutions for Agricultural MSMEs

The second financial model is specifically targeted at assisting Agricultural MSMEs to invest in higher value itemsFL-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

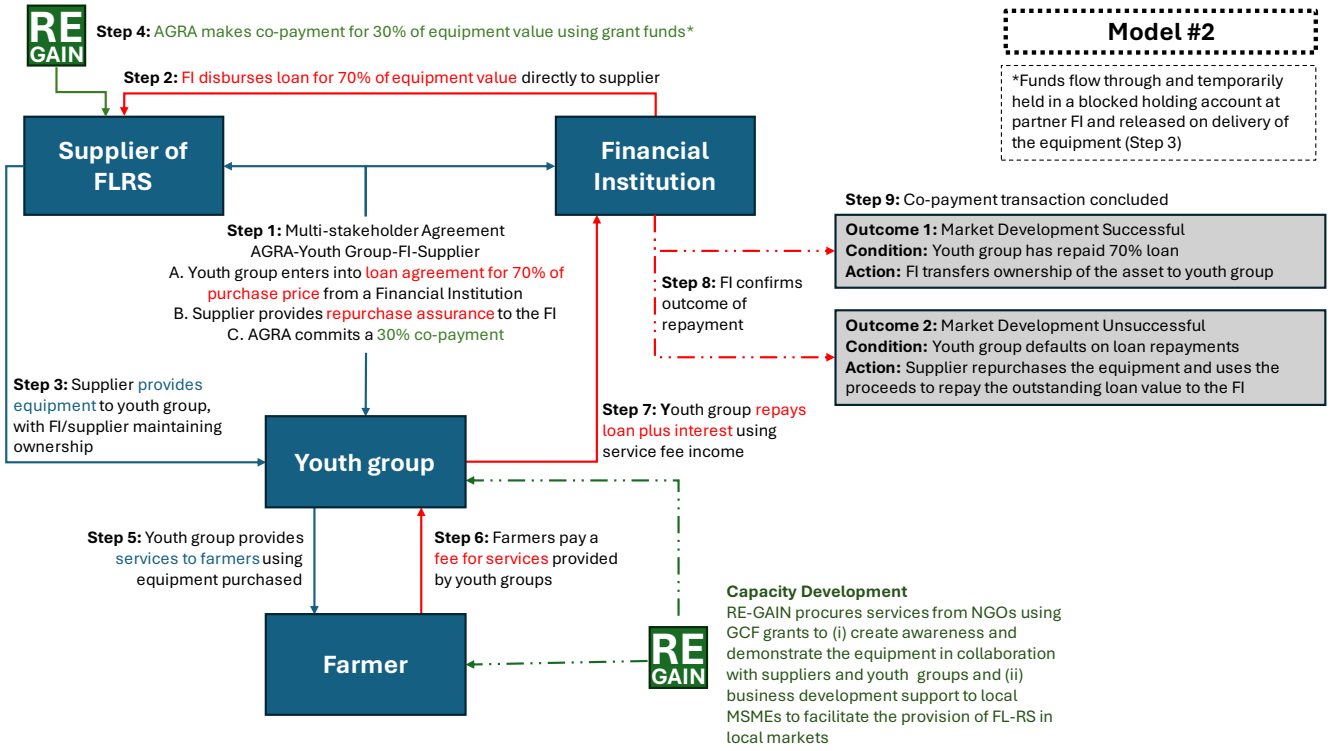


Figure 6-2, with detailed descriptions of each step in the following text. While RE-GAIN will facilitate the establishment of the entire process, its active involvement beyond Step 4, with ownership of Steps 5-9 transitioning to the three partners: youth groups, suppliers, and financial institutions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

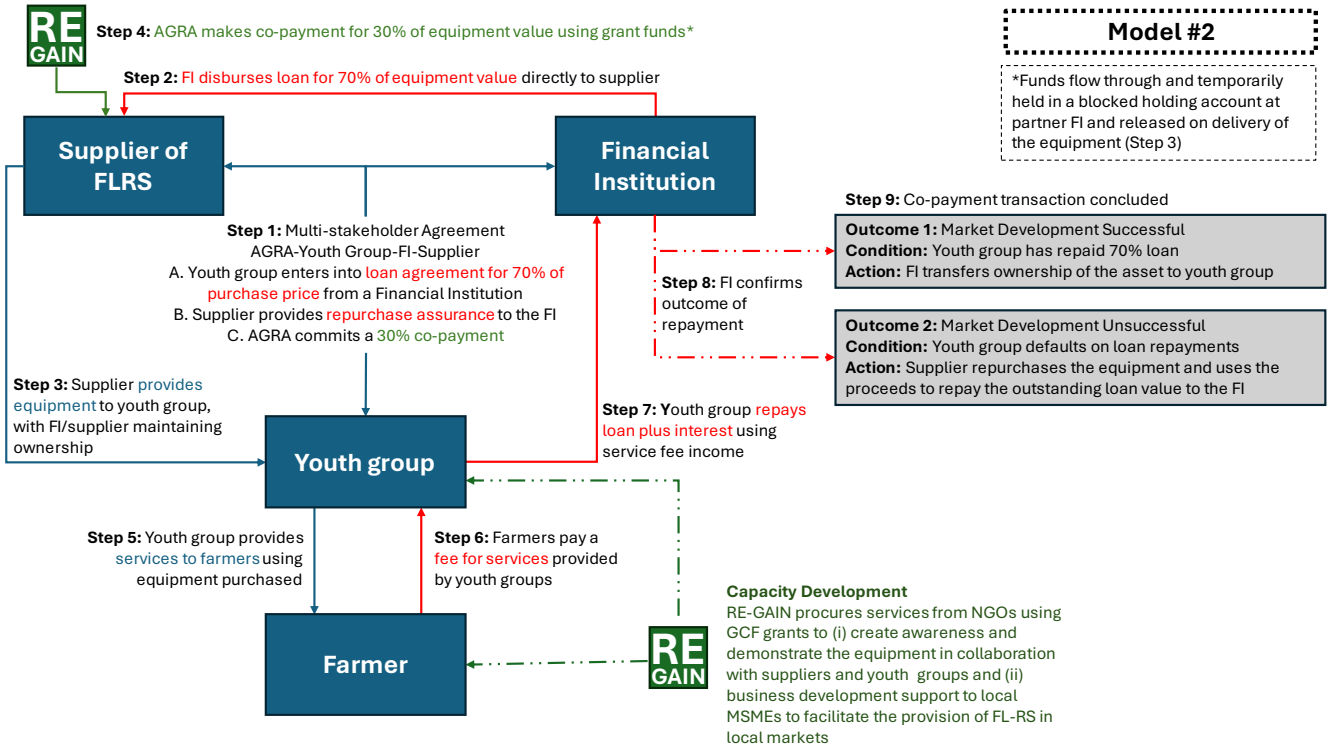


Figure 6-2 Model 2 for RE-GAIN programme

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 theregions 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 Burkina Faso 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 Burkina Faso. The Ministry of Agriculture of Burkina Faso will be a key partner, who is operating the extension services and several smallholder-oriented projects. UN and other international development organisations should be considered as potential partners in the awareness raising and capacity building activities in Burkina Faso.

Several other major agricultural NGOs and farmers' organizations are actively working to support the agricultural sector through various initiatives and programs. These organizations play a crucial role in enhancing agricultural productivity, promoting sustainable practices, and improving the livelihoods of farmers. Therefore, we recommend involving those agricultural NGOs and farmers' organizations to closely work on the RE-GAIN programme implementation in the area of capacity building and awareness raising. Recommended implementation partners are further shortlisted in Table 6-2.

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

Organization	Description
The Ministry of Agriculture of Burkina Faso	The Ministry of Agriculture, Hydraulic and Fisheries Resources is a key governmental body in Burkina Faso responsible for formulating and implementing agricultural policies, programs, and projects. The ministry aims to boost agricultural productivity, ensure food security, and promote sustainable agricultural practices.
Fédération des Professionnels Agricoles du Burkina (FEPAB)	FEPAB is a federation that brings together various agricultural producers' organizations. It focuses on representing farmers' interests, promoting sustainable agricultural practices, and improving access to agricultural inputs and services.
Union Nationale des Producteurs Agricoles du Faso (UNPA-BF)	UNPA-BF is a national union of agricultural producers that aims to strengthen the capacities of its members, improve agricultural productivity, and enhance food security. The union provides training, advocacy, and support services to farmers.
World Vision	World Vision is a global humanitarian organization that works in Burkina Faso to support agricultural development and food security among vulnerable communities.

Helvetas Swiss Intercooperation	Helvetas is an international NGO that implements development projects in Burkina Faso, focusing on sustainable agriculture and rural development.

These organizations play a critical role in advancing Burkina Faso'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.
- 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).

6.5.1.3 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; 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 Burkina Faso:

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 Burkinabe 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 Burkina Faso 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 Burkina Faso, with significant losses within the harvest and post-harvest stages for key crops in the country; rice and cowpea. 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 Burkina Faso. 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 Burkina Faso by addressing the key barriers identified during this phased study, as described in the image below:

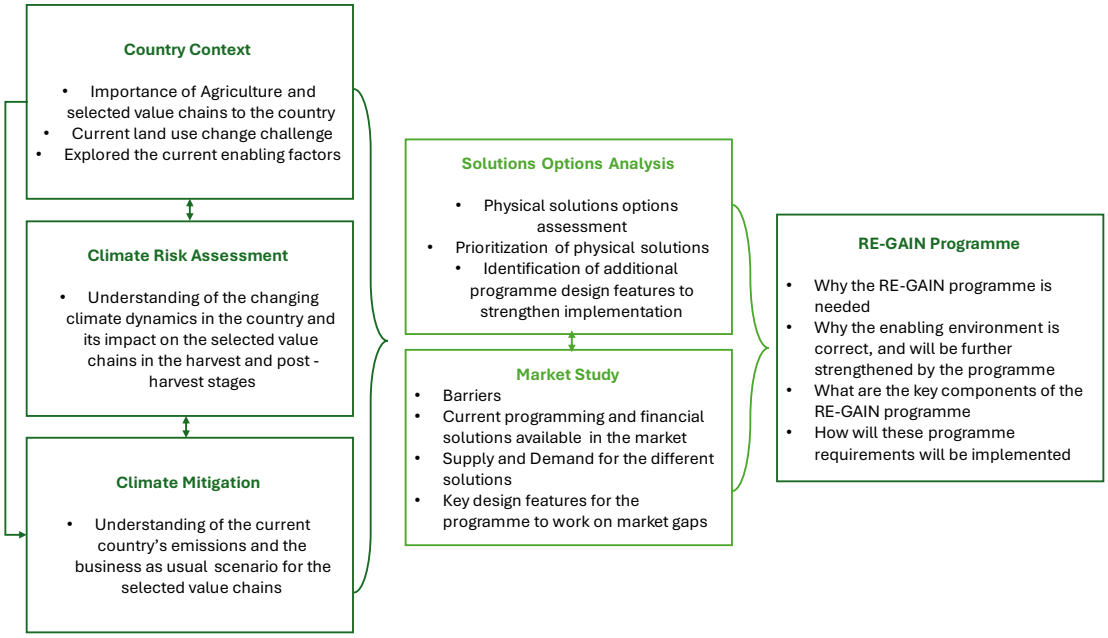


Figure 7-1 Content Summary of Feasibility Study for the RE-GAIN programme

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

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