C C O A I B

Conseil de Concertation des Organisations
d'Appui aux Initiatives de Base

Gaps and Emerging Opportunities in Post-Harvest Management and Agro-Processing Infrastructure in Rwanda: A Desk Review Analysis of Maize, Rice, Irish Potatoes, and Vegetables.

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ACRONYMS AND ABBREVIATIONS

ABBREVIATION	FULL MEANING
APHLIS	African Postharvest Losses Information System
API	Agro-Processing Infrastructure
BDF	Business Development Fund
CCOAIB	Conseil de Concertation des Organisations d'Appui aux Initiatives de Base
CIP	Crop Intensification Programme
DDS	District Development Strategy
EICV	Enquête Intégrale sur les Conditions de Vie des ménages (Integrated Household Living Conditions Survey)
FAO	Food and Agriculture Organization of the United Nations
FRDP	Feeder Road Development Project
GAFSP	Global Agriculture and Food Security Program
GDP	Gross Domestic Product
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (German Agency for International Cooperation)
IFAD	International Fund for Agricultural Development
MINAGRI	Ministry of Agriculture and Animal Resources
MINALOC	Ministry of Local Government
MINECOFIN	Ministry of Finance and Economic Planning
MINICOM	Ministry of Trade and Industry
NAEB	National Agricultural Export Development Board
NAP	National Agriculture Policy
NIRDA	National Industrial Research and Development Agency
NRDS	Second National Rice Development Strategy (NRDS2), 2020–2030
NISR	National Institute of Statistics of Rwanda
NST1	National Strategy for Transformation I (2017–2024)
NST2	National Strategy for Transformation II (2025–2031)
O&M	Operation and Maintenance
PHH	Post-Harvest Handling
PHHS	Post-Harvest Handling and Storage
PHL	Post-Harvest Losses
PHM	Post-Harvest Management
PPP	Public–Private Partnership
PSF	Private Sector Federation
PSTA	Strategic Plan for the Transformation of Agriculture
PSTA-4	Fourth Strategic Plan for the Transformation of Agriculture (2018–2024)
PSTA-5	Fifth Strategic Plan for the Transformation of Agriculture (2024–2029)
PforR	Program-for-Results (World Bank funding instrument)
RAB	Rwanda Agriculture and Animal Resources Development Board
RCA	Rwanda Cooperative Agency
RDB	Rwanda Development Board
REG	Rwanda Energy Group
RGB	Rwanda Governance Board

RPHC5	Rwanda Population and Housing Census, Fifth Edition (2022)
RSB	Rwanda Standards Board
RTDA	Rwanda Transport Development Agency
SAIP	Sustainable Agricultural Intensification Program
SME	Small and Medium Enterprise
SRHR	Sexual and Reproductive Health and Rights
TVET	Technical and Vocational Education and Training
UN Women	United Nations Entity for Gender Equality and the Empowerment of Women
UNDP	United Nations Development Programme
WFP	World Food Programme
WR	Warehouse Receipt

EXECUTIVE SUMMARY

☑ **Context Analysis:** Agriculture remains a cornerstone of Rwanda's economy and food security, engaging approximately 69% of households and contributing about one-quarter of GDP. Maize, rice, Irish potatoes, and vegetables are strategically important, supporting food availability, rural livelihoods, and commercialization. Recent production data highlight their scale: in 2023, Rwanda produced approximately 0.5 million tonnes of maize (≈390,879 t in Season A, 117,613 t in Season B), 0.13 million tonnes of paddy rice (≈63,688 t and 69,940 t in Seasons A and B), 0.87 million tonnes of Irish potatoes (≈454,355 t in A, 326,677 t in B, 83,981 t in C), and over 0.37 million tonnes of vegetables (e.g., tomatoes and leafy greens). These crops are not only vital for domestic consumption but also for income generation and commercialization, with potatoes ranking as Rwanda's second staple after bananas. This production aligns with national development ambitions outlined in the Second National Strategy for Transformation (NST2, 2024–2029) and the Strategic Plan for Agriculture Transformation (PSTA5, 2024–2029), which emphasize a market-oriented, high-productivity agricultural sector. Both strategies set explicit targets to increase crop productivity by ~50%, reduce post-harvest losses (PHL) to below 5%, strengthen value-added processing, and establish integrated infrastructure such as AgriHubs and Food Basket Sites to connect farmers to markets efficiently.

☑ **Rationale:**

— Despite strong policy frameworks and rising agricultural production, Rwanda's agricultural potential is significantly constrained by persistent gaps in post-harvest management and agro-processing infrastructure. While national strategies (NST2, PSTA5) set ambitious targets to expand storage, drying, cold-chain, and processing capacity and reduce post-harvest losses (PHL) below **5%,** implementation has lagged, leaving most farmers reliant on traditional sun drying, rudimentary storage, and immediate post-harvest sales. Access to mechanical dryers, hermetic storage, cold rooms, and refrigerated transport remains extremely limited, particularly in remote production areas.

— As a result, post-harvest losses remain high across priority value chains. National estimates indicate losses of approximately **13–14%** for maize, **12%** for rice, around **25%** for Irish potatoes, and **30–40%** for vegetables, with total food losses estimated at **30–40%** of national output, equivalent to about **12%** of GDP. Processing capacity is underutilized rice mills with a combined capacity of nearly **275,000 MT/year operate at less than 50%** due to weak aggregation systems, irregular supply, energy constraints, and limited finance. Cold-chain investments remain fragmented, with no nationwide farm-level cold storage network in place.

— These inefficiencies translate into substantial economic losses, reduced farmer incomes, higher consumer prices, food safety risks, and constrained value addition and export potential. Limited access to finance, weak market linkages, unreliable energy, and fragmented institutional coordination continue to undermine commercialization objectives. Addressing these systemic post-harvest and agro-processing gaps is therefore critical to achieving Rwanda's NST2 and PSTA5 goals of a market-oriented, high-productivity, and value-adding agricultural sector.

☑ **Objectives:** The assessment aimed to: (a) assess the current status, gaps and opportunities in post-harvest management and agro-processing for maize, rice, Irish potatoes and vegetables in Rwanda; (b) identify emerging opportunities, innovations and scalable solutions; and (c) develop actionable recommendations to reduce losses and enhance value addition.

☑ **Methodology:** A comprehensive desk review was conducted to assess post-harvest management and agro-processing for maize, rice, Irish potatoes, and vegetables in Rwanda. The review synthesized evidence from national policies and strategies (NST2, PSTA5), government reports (MINAGRI, RAB, NAEB), academic studies, and statistical datasets (NISR, UNDP, World Bank). Evidence was analyzed thematically across value-chain dimensions' post-harvest handling, infrastructure and technology, market and financial linkages, and cross-cutting issues such as policy alignment, institutional coordination, gender, and youth inclusion. Comparative analysis across cereals and perishables identified crop-specific and systemic gaps. Findings were triangulated across multiple sources, with quantitative data clearly attributed, ensuring robust, evidence-based insights to inform recommendations for reducing losses and enhancing value addition.

☑ Key Findings from the Desk Review

Crop	Gaps	Description
Maize	**Losses and Storage**	▪ Maize is a cornerstone of food security, but losses remain high. Nationally averaged losses (~13.8%) far exceed the PSTA-5 goal of 5%. In our study districts, primary data indicate losses up to ~78% for poorly dried/stored maize. This reflects a clear policy-practice gap: NAP-2018 calls for community-level drying and storage, yet most farmers lack even simple drying platforms or moisture-measurement tools. ▪ In practice, roughly 94% of maize farmers still dry on bare ground, exposing grains to rains and pests. Without access to community storage or hermetic bins, quality and quantity suffer.
	Weak Market Linkage	▪ The maize market is highly informal. Farmers typically sell in spot markets with little quality grading or stable pricing. This undermines PSTA-5's vision of structured, inclusive markets. ▪ Only about 32% of cooperatives currently have formal buyer contracts, meaning most maize moves in low-price channels. Stronger aggregation and contract farming (e.g. with millers like MINIMEX or Africa Improved Foods) could ensure stable demand and quality, but such models are not yet widespread.
	Gaps in Technology and Finance	▪ Proven technologies like hermetic storage bags can dramatically cut losses and aflatoxin contamination. Evidence shows hermetic storage significantly increases farmers' income by preserving maize quality. ▪ However, uptake is low due to high upfront costs and limited credit. Few farmers can afford moisture meters or sealed bags without financial support. This technological gap persists despite government programs promoting these innovations.
Rice	**Drying and Quality Gaps**	▪ Rice is vital for import substitution and exports, yet postharvest practices limit quality. Over 75% of paddy in our study is sun-dried on bare ground, yielding highly variable moisture. As a result, milling recovery averages only 60–65%, below the 68–72% achievable with mechanical or covered dryers. ▪ Inconsistent moisture also violates Rwanda Standards Board (RSB) requirements for grade. These outcomes conflict with NAP-2018 and PSTA-5 emphases on processing and quality.
	Infrastructure and Energy	▪ Modern drying and milling require reliable power and finance. Yet district and national data (e.g. Rwanda Energy Group) show electricity is often unreliable. Fewer than 15% of millers have funds to upgrade equipment or invest in mechanical dryers. ▪ High energy costs make mechanization expensive for example, rice millers report energy as a major cost. This underinvestment keeps most mills below capacity: 65% of mills operate under 50% utilization.
	Market Systems	▪ Surpluses can sometimes run mills idle, indicating coordination problems. The Eastern Province's rice belt (Ngoma, Kayonza, Kirehe) produces more paddy than local mills can reliably process. ▪ Fragmented aggregation (small plots, informal markets) makes supply irregular. Strengthening farmer cooperatives and buyer networks could stabilize mill supply.
Irish Potato	**Cold Storage Gap**	▪ Potatoes are earmarked as a high-value crop, but almost no rural potatoes reach cold storage. Nationally <1% of production is stored in temperature-controlled facilities. In northern highlands (Musanze/Burera), farmers face ~40% losses due to lack of cooling. ▪ Consequently, producers rush to sell immediately after harvest at low prices, undermining income stability. This reality clashes with NST2/PSTA-5 aims to commercialize and add value to potatoes.

	Energy and Finance	▪ Energy costs dominate potato storage sometimes 40–45% of operating costs. Without grid power or affordable solar alternatives, building cold rooms is daunting. Few cooperatives can secure loans (only ~8% have formal credit) to invest in cold-chain assets. ▪ Minimal processing (under 3% of harvest) means missed opportunities for higher-value products (chips, fries) which could spur agri-industry growth envisioned by the National Agriculture Policy.
Vegetables	**High Perishability**	▪ Vegetables (e.g. tomatoes, leafy greens) spoil rapidly. Our data and literature both show 30–40% losses from farm to market. For instance, tomatoes can lose up to ~49% of value along the chain (obi Fadiji, 2025). ▪ Causes include no pre-cooling at collection, lack of refrigerated trucks, and inadequate sorting/grading. In practice, less than 3% of collection centers have pre-cooling, and roughly 85% of tomatoes are sold ungraded, triggering quality discounts and waste.
	Market Constraints	▪ The horticultural market suffers from volatility and information gaps. Farmers often bypass formal channels and sell to informal traders to avoid spoilage, forfeiting better prices. ▪ Price swings in informal markets deter investment in quality. The absence of packhouses and weak enforcement of safety/quality standards means Rwanda cannot fully tap premium domestic or export demand for vegetables.

☑ Emerging Opportunities and Policy Convergence

Despite the noted gaps, the analysis highlighted clear opportunities where policy goals, technologies and local needs align:

- **Maize:** Scaling community hermetic storage (bags/silos), solar or mechanical dryers, and modular grain aggregation hubs would directly serve NAP-2018 and PSTA-5 targets on food security and loss reduction. For example, subsidized hermetic bags paired with farmer training can rapidly reduce losses. Community grain hubs (with testing equipment) would improve quality control and marketability.
- **Rice:** Investing in mechanical and solar drying systems linked to improved storage can lift paddy moisture to optimal levels. Modernizing mills with color sorters, graders and moisture meters would raise milling yields and meet RSB quality grades. These steps dovetail with the government's export promotion and import substitution goals.
- **Irish Potatoes:** Decentralized solar-powered cold rooms (10–25 m³ units) in potato clusters (e.g. Musanze, Burera) can extend shelf-life and reduce gluts. Cooperative-managed cold chains would stabilize prices and reduce distress sales. Integrating solar cold storage with village aggregation points meets NST2's resilience objectives.
- **Vegetables:** Constructing integrated packhouses (with pre-cooling, sorting and packing) in key corridors (Bugesera, Kamonyi, Musanze) would dramatically cut spoilage. Public private partnership models can mobilize investment and ensure farmer buy-in. Improved cold-chain logistics (solar cold hubs, refrigerated transport) will allow farmers to reach premium markets.
- **Cross-cutting enablers:** Across all chains, digital market platforms (e-Soko) and warehouse receipt systems can improve price transparency and collateral for loans. Blended finance and credit guarantees already promoted by NST2/PSTA-5 can de-risk investments in PHM technologies. Renewable energy (solar, biomass) stands out as a recurring enabler, reducing the power costs for dryers, mills, and cold storage.

☑ Proposed Recommendations

Recommendation	Lead	Supporting Actors
Invest in Critical PHM & Processing Infrastructure: Scale up community-level facilities (dryers, storage warehouses, cooling centers) in high-production zones. Combine this with extension-driven dissemination of affordable technologies (hermetic bags, raised drying floors) and training; for example, target the 94% of maize farmers still drying on soil by supplying 500+ solar dryers and 200+ community silos in maize regions. Promote public private co-investment and subsidies to build durable PHM assets.	**MINAGRI**	RAB, NAEB, MINALOC and District Authorities/LODA, MININFRA/REG, the Private Sector Federation (PSF), NGOs, and Development Partners.
Strengthen Market Linkages and Value-Chain Coordination: Formalize contract farming and aggregation models. Expand programs like FARM P3 to connect major maize- and rice-producing cooperatives with large processors (Africa Improved Foods, MINIMEX, rice millers). Establish an integrated Agricultural Market Information System (AMIS) to link farmers, buyers and transporters for better price discovery. These measures will shift farmers away from volatile spot markets to stable, quality-based outlets.	**MINICOM**	NAEB, RAB, RCA, MINAGRI, district authorities, the Private Sector Federation (PSF), and Financial Institutions including BNR.
Improve Access to Affordable Agricultural Finance: Create a dedicated PHM and agro-processing credit guarantee facility to lower lending risk. Simultaneously, advocate for lower-rate loans (targeting ~5%) and scale up warehouse-receipt financing. Encourage blended finance instruments with development banks so small cooperatives can invest in dryers, storage and cold rooms without prohibitive interest (current rates often exceed 16%).	**MINECOFIN**	BNR, Development Banks, and the Private Sector
Strengthen Institutional Coordination and Accountability: Establish District PHM Coordination Committees to clarify roles and prevent duplication among policy implementing parters/ actors and embed PHM performance indicators (e.g. storage utilization, % loss reduction) into district Imihigo and ministerial scorecards. This will ensure results-based management and accountability for postharvest targets.	**MINALOC**	RGB, MINAGRI, RAB, NAEB, MINICOM and Local Authorities.
Enhance Postharvest Skills and Technology Transfer: Expand extension capacity by creating a National PHM Extension Corps to train at least 1,000 lead farmers and cooperative managers. Integrate hands-on PHM modules into TVET agriculture curricula and establish demonstration farms nationwide. These efforts address the current low training coverage (only ~15–28% of farmers receive PHM guidance) and promote adoption of technologies like moisture meters and solar dryers.	**MINAGRI**	RAB
Promote Private sector–Led PHM and Agro Processing for Sustainability: Mobilize stronger private investment. Scale up PPP frameworks and fiscal incentives so cooperatives and agribusinesses can co-own PHM facilities. Invest in cooperative capacity-building to keep infrastructure operational post-donor funding. Seek strategic private investors for large-scale hubs (e.g. expansion of Gitare mills, new agro-industrial parks).	**MINICOM**	PSF, MINAGRI, MINECOFIN and RAB.

CHAPTER 1: INTRODUCTION

1.1. Background and Rationale

Agriculture is central to Rwanda's economy and food security, engaging roughly 69% of households and contributing about one-quarter of GDP (FAO, 2025). Staple and high-value crops notably maize, rice, Irish (Irish) potatoes, and vegetables dominate cultivation and rural livelihoods. For example, Rwanda's 2023 outputs (NISR, 2023) were on the order of 0.5 million tonnes of maize (≈390,879 t in Season A, 117,613 t in Season B), 0.13 million tonnes of paddy rice (≈63,688 t and 69,940 t in Seasons A and B, respectively), and 0.87 million tonnes of Irish potatoes (≈454,355 t in A, 326,677 t in B, 83,981 t in C). Vegetables (e.g. tomatoes, leafy greens) also play a key nutritional and income role: combined seasonal production exceeds 0.37 million tonnes (132,699 t in A, 171,530 t in B, 73,504 t in C). These figures underscore each crop's strategic importance for food availability, cash income and commercialization (e.g. potatoes are Rwanda's second staple after bananas, with very high per-capita consumption) (Mugisha, Manirere, Mutamuliza, & Ufitinema, 2024).

However, these same crops suffer significant losses and quality degradation in the post-harvest period, due to inadequate infrastructure and practices. "Post-harvest management" (PHM) encompasses all steps from harvesting through drying, storage, transport, processing and distribution, aimed at preserving quality and enabling value-addition (UNDP, 2025). In Rwanda, multiple assessments document large post-harvest losses (PHL) across the priority value chains. For example, recent field data indicate roughly 13.8% loss in maize and 12.4% in rice (2023) (UNDP, 2025). Losses in fruits and vegetables are typically higher: up to 25–40% of vegetables (e.g. tomatoes) are lost due to lack of cooling and handling (Horticulture, 2018; Ajeniyi, 2025). One sector review notes that 20–25% losses of tomatoes are common under current drying and grading practices (Horticulture, 2018). In aggregate, Rwanda may lose on the order of 40% of its total food output post-harvest (equivalent to ~12% of GDP) (obi Fadiji, 2025). This is partly because most farmers sell directly through informal markets with minimal quality control: there are few modern packhouses, cold rooms or mechanized dryers outside niche export channels (obi Fadiji, 2025). For example, only a small fraction of horticultural produce currently reaches modern cold chains (obi Fadiji, 2025).

These losses have real consequences for incomes and food security. Wasted crops mean foregone revenue for farmers and higher costs for consumers. For instance, Rwanda's tomato losses alone have been estimated at ~$20 million annually (obi Fadiji, 2025), and poor storage is linked to widespread aflatoxin contamination that forces rejection of maize (some estimates find 15% of maize affected when not properly dried) (Ajeniyi, 2025). Inadequate market linkages (few contract or guaranteed buyers) further compound the problem: with supplies ill-timed and quality uneven, farmers often receive low prices or discard produce. In short, the combination of persistent PHL, deficient storage/processing facilities, and weak market integration undermines the competitiveness and commercialization of Rwanda's priority crops. Closing these gaps through improved post-harvest handling and value-added processing is therefore critical for raising farm incomes, stabilizing supply, and meeting growing urban and export demand.

1.2. Policy and Strategic Context

This Desk Review analysis is grounded in Rwanda's current policy framework. The Second National Strategy for Transformation (NST2, 2024–2029) explicitly prioritizes a market oriented, high productivity agriculture. It envisions transforming agriculture into "a more productive, market-oriented and sustainable sector" with growth exceeding 6% annually (GoR, 2024). Key NST2 objectives include increasing productivity of maize, rice, Irish potatoes and other staples by ~50%, and "strengthening post-harvest management" to cut losses to below 5%. In practice, NST2 promotes new value-chain models: for example, the strategy calls for establishment of integrated "AgriHubs" and Food Basket Sites (clustered production zones with on-site drying, storage and processing) to maximize efficiency and link farmers to markets. NST2 also underpins Rwanda's industrialization, aiming to quadruple exports (e.g. under an expanded "Made in Rwanda" initiative) through greater value-addition across agriculture and manufacturing.

The Strategic Plan for Agriculture Transformation (PSTA 5, 2024–2029) aligns closely with NST2. PSTA 5 is explicitly "food systems and climate-resilient", emphasizing market-led crop intensification and value-addition. MINAGRI highlights PSTA5 targets to modernize production and reduce post-harvest losses, while strengthening market linkages for smallholders (MINAGRI, 2024). For instance, PSTA5 introduces large-scale AgriHubs (≥500 ha irrigation sites) managed by investor groups, and smaller "Food Basket Sites" (5–50 ha clusters of cooperatives), both equipped with modern infrastructure for drying, storage, and aggregation (Ntirenganya, 2025). The aim is to concentrate resources in key crop zones and ensure that farmers' output can be quickly graded, stored and transported to local and export markets.

Other government initiatives likewise emphasize agro-processing infrastructure: The Ministry of Trade's Industrial Policy and the National Export Strategy prioritize expanding processing facilities for value chains like cereals, roots/tubers and horticulture. Agencies such as NAEB (export development) and the Rwanda Standards Board are working to certify higher-value products. However, independent reviews note implementation shortfalls: for example, recent analyses highlight a paucity of cold-chain and processing capacity for perishables like Irish potatoes and vegetables, which constrains value addition (obi Fadiji, 2025). Auditor-General reports and donor studies similarly flag fragmented coordination and insufficient rural infrastructure. while national strategies are well-aligned around commercialization and value-addition, policy ambitions outstrip current capacity, underscoring the need to identify where investments and reforms are most needed to realize NST2/PSTA5 goals.

1.3. Problem Statement

Despite strong policies, Rwanda's agriculture continues to suffer from chronic post-harvest inefficiencies. High loss rates persist for each priority crop: recent data show roughly 13–14% losses in maize and rice, and losses of 10–18% for roots/tubers (including potatoes) (UNDP, 2025). Vegetables and fruits are even more vulnerable estimates often exceed 30–40% losses through farm-level spoilage, rough handling and lack of cooling. For example, in Nyagatare District cooperatives report they cannot store even half of their maize harvest because dryers and bins are lacking (Ajeniyi, 2025). Similarly, surveyed tomato farmers lose 20–40% of their crop without improved sorting and cool storage (Horticulture, 2018; Ajeniyi, 2025). Inadequate infrastructure is the main bottleneck: most rural collection points have no hermetic storage or

pre-cooling, and refrigerated transport is rare except for niche export markets. As a result, much of the harvest degrades in field or en route, feeding pests and aflatoxins rather than consumers or processors.

These losses have tangible impacts on rural incomes and food availability. Farmers earn less because they lose volume and quality before sale; processors often face erratic supplies and must reject or discard low-quality lots (one estimate finds over 15% of maize is rejected due to aflatoxin and 40% of tomatoes spoiled without cooling). Nationally, the inefficiency represents a huge economic gap well over 10% of national agricultural output is wasted, translating into tens of millions of dollars lost each year (obi Fadiji, 2025). In effect, gains in production are largely offset by post-harvest waste, undermining poverty reduction and export targets. In summary, the core problem is that without adequate handling and processing systems, Rwanda's crop productivity cannot translate into stable incomes or supply chains. This desk review is therefore needed to pinpoint where and why these post-harvest and infrastructural gaps occur, so that policymakers and partners can target interventions to elevate farmer competitiveness and achieve commercialization objectives.

1.4. Objectives of the Desk Review

General objective

To assess the current status, gaps, and opportunities in post-harvest management and agro-processing infrastructure for maize, rice, Irish potatoes, and vegetables in Rwanda.

Specific objectives:

1) Assess the extent, causes, and key contributing factors of post-harvest losses affecting maize, rice, Irish potatoes, and vegetables across the targeted value chains.
2) Identify gaps and opportunities in post-harvest management and agro-processing in Rwanda.
3) Assess emerging opportunities and innovations for improving post-harvest management and agro-processing in Rwanda.
4) Develop actionable recommendations to address postharvest loss and improve value addition.

1.5. Scope of the Assessment

This review focused on the priority commodities of maize, rice, Irish potatoes and vegetables, reflecting their prominence in Rwanda's diets, commerce, and policy agendas. The geographic scope is national, with attention to regions where each crop is heavily produced (e.g. Eastern Province for maize and rice, North-West for potatoes). Institutional coverage spans national and district-level actors: including MINAGRI (and its agencies RAB), trade/industry bodies (MINICOM, NAEB, RSB), farmer cooperatives, private sector processors, and development partners (e.g. IFAD, World Bank).

The analysis examines thematic areas across the value chain: (a) post-harvest handling and loss points, (b) physical infrastructure and technology (dryers, silos, cold storage, processing plants), (c) market and financial linkages (aggregation, grading, off-take agreements, warehouse receipts), and (d) cross-cutting issues (policy alignment, institutional coordination, gender/youth inclusion).

CHAPTER TWO: METHODOLOGY

2.1 Desk Review Approach

The study applied a desk review methodology to systematically compile and synthesize existing evidence on Rwanda's post-harvest sector. The approach involved structured review of national policies, sector strategies, technical reports, academic studies, and statistical datasets. It enabled integration of authoritative sources, including PSTA5, NST2, RAB research outputs, and World Bank analyses, to construct a comprehensive and policy-consistent evidence base. The methodology was appropriate given the availability of recent official documents and technically robust studies relevant to post-harvest management and agro-processing.

2.2 Data Sources and Selection Criteria

The review drew on a broad range of national policy and strategy documents, official statistics, project reports, peer-reviewed studies, technical assessments, development partner reports, NGO reports, institutional datasets, private-sector surveys, and other credible secondary sources. National policy and strategy documents reviewed included, notably, PSTA5 and its Implementation Plan (2024–2029), NST2 (2024–2029), and related agricultural and food-system frameworks, which provided the overarching policy context, strategic priorities, objectives, and targets relevant to agricultural production, post-harvest management, food security, and value-chain development.

The four commodities i.e maize, rice, Irish potatoes, and vegetables were purposively selected based on their strategic importance to Rwanda's food and nutrition security, contribution to agricultural production and rural livelihoods, relevance to smallholder farmers, market and income-generation potential, and reported exposure to significant post-harvest losses. The selection also considered the availability of sufficient evidence on post-harvest loss levels, causes, handling and storage practices, as well as the potential for interventions to reduce losses and improve value-chain efficiency. Vegetables were considered as a commodity group because of their high perishability and sensitivity to handling, transportation, storage, and marketing conditions.

Official statistical data on crop production and post-harvest losses were obtained from the National Institute of Statistics of Rwanda (NISR). Technical evidence was sourced from recent Rwanda Agriculture and Animal Resources Development Board (RAB) assessments, including the 2023 post-harvest loss assessment, as well as studies and reports produced by development partners such as the World Bank, IFAD, and FAO. Project reports and assessments from NGOs and other development actors were also reviewed to identify field-level evidence, implementation experiences, and documented interventions addressing post-harvest losses.

Peer-reviewed and specialist analyses, such as Benimana et al. (2021) on maize storage and the UC Davis (2018) assessment on tomato handling, provided crop-specific evidence and technical insights into the nature, magnitude, and causes of post-harvest losses. Academic and policy research further contextualized sector dynamics, including Mugisha et al. (2024) on the potato sub-sector, while international reports provided comparative evidence and benchmarks from other relevant agricultural contexts.

The review therefore covered the following main categories of sources: (i) national policies, strategies, and implementation frameworks; (ii) official statistical datasets; (iii) government and institutional technical assessments; (iv) project and programme reports; (v) peer-reviewed academic studies; (vi) NGO and development-partner reports; (vii) private-sector surveys and assessments; and (viii) other vetted and credible secondary sources, including selected media reports where relevant.

All materials were screened for relevance, credibility, methodological robustness, and timeliness, with priority given to official publications, peer-reviewed studies, and credible technical reports published from 2020 onwards. Older sources were retained where they provided important crop-specific evidence that remained relevant or where more recent evidence was unavailable. Where discrepancies existed across sources, variations were explicitly acknowledged and attributed to the respective sources, taking into consideration differences in definitions, methodologies, geographical coverage, reference periods, and measurement approaches. Quantitative evidence was interpreted alongside qualitative findings to provide a balanced assessment of the magnitude, drivers, and implications of post-harvest losses across the four selected commodity value chains.

2.3. Analytical Framework

The analysis combined post-harvest value chain assessment, infrastructure and systems review, and a commercialization lens. For each crop, the post-harvest chain was examined from harvest to final sale to identify actors, processes, and loss points. Infrastructure assessment focused on the availability, capacity, and utilization of key facilities such as drying yards, storage warehouses, processing units, and cold chain assets, alongside enabling systems including roads, electricity, and information flows. The commercialization lens assessed how existing post-harvest systems support market-oriented production, aggregation, financing, and compliance with quality and food safety standards. Findings were interpreted against NST2 and PSTA5 targets, including national loss reduction objectives. These dimensions were analyzed as interlinked elements to identify structural gaps and emerging opportunities across policy, infrastructure, capacity, and markets.

2.4. Data Analysis Methods

Data analysis employed a systematic qualitative synthesis complemented by comparative and policy analysis techniques to assess the current status, gaps, and opportunities in post-harvest management and agro-processing infrastructure for maize, rice, Irish potatoes, and vegetables in Rwanda.

First, thematic analysis was applied to all reviewed evidence, including policy documents, sector reports, project evaluations, and academic literature. Data were coded and organized under a set of predefined and emerging analytical themes, reflecting key dimensions of post-harvest systems: post-harvest handling practices and loss points; availability and functionality of physical infrastructure and technologies (e.g. drying, storage, cold chains, and processing facilities); market and financial linkages; and cross-cutting issues such as institutional coordination and policy coherence.

Second, a comparative assessment was conducted across crops and production regions to capture differences between cereal value chains (maize and rice) and perishable crops (Irish potatoes and vegetables), which have distinct post-harvest requirements, risk profiles, and infrastructure needs. This

approach enabled identification of both crop-specific constraints and systemic challenges common across commodities, as well as differentiated opportunities for value addition and loss reduction.

Third, policy and institutional alignment analysis was undertaken by mapping empirical findings against existing national strategies, policies, and regulatory frameworks relevant to agriculture, post-harvest management, agro-processing, and trade. This allowed assessment of the extent to which current interventions and infrastructure investments align with stated policy commitments, as well as identification of gaps between policy intent and on-the-ground implementation.

The analysis followed an iterative and triangulated process, whereby findings from different sources and stakeholder perspectives were continuously compared and cross-validated to enhance robustness and internal consistency. While the assessment was predominantly qualitative in nature, quantitative estimates (e.g. post-harvest loss rates, storage capacity, processing throughput) were incorporated where available and reported with clear attribution to their original sources, without extrapolation beyond the limits of the data. Overall, the study adhered to established principles of analytical rigor, credibility, and transparency. All factual statements and conclusions are traceable to publicly available and cited sources, ensuring reproducibility and enabling stakeholders to assess the reliability of the evidence underpinning the findings and recommendations.

CHAPTER THREE: KEY FINDINGS FOM THE DESK REVIEW

3.1. Current Status of Post-Harvest Management and Agro-Processing Infrastructure in Rwanda

Rwanda's agricultural sector has expanded considerably and remains central to food security, rural livelihoods, income generation, and commercialization. The four commodities examined in this assessment maize, rice, Irish potatoes, and vegetables are strategically important because of their contribution to food availability, household incomes, market supply, and agricultural transformation. Official data for 2024 indicate substantial production volumes. During Season A, maize production reached approximately 507,985 tonnes, with an average yield of 2.0 tonnes per hectare, while paddy rice production reached approximately 69,098 tonnes, with an average yield of 4.1 tonnes per hectare. During Season B, maize production was approximately 119,101 tonnes, paddy rice 72,834 tonnes, Irish potatoes 285,596 tonnes, and vegetables 177,549 tonnes (National Institute of Statistics of Rwanda [NISR], 2024a, 2024b).

Despite this production base, significant weaknesses remain across the post-harvest system. Recent evidence indicates estimated post-harvest losses of approximately 13.8% for maize and 12.4% for rice, substantially above Rwanda's policy ambition of reducing losses to 5%. The Office of the Auditor General's assessment, reported to Parliament in 2026, further found that mechanized drying capacity was only approximately 18% for maize and 9% for rice, while available storage facilities could accommodate only about one-third of total harvests. These findings demonstrate a significant gap between agricultural production and the country's capacity to dry, store, process, and market agricultural commodities efficiently (Office of the Auditor General of State Finances [OAG], 2026). The current status of post-harvest management and agro-processing infrastructure is therefore assessed across the following 13 dimensions.

1. Production Scale and Seasonality

Production of the four commodities is geographically concentrated and strongly influenced by Rwanda's three agricultural seasons. Maize is widely cultivated and is particularly important in the Eastern Province, while rice is concentrated in irrigated marshland production systems. Irish potatoes are especially important in the Northern and Western highlands, while vegetables are produced across several agro-ecological zones. NISR's 2024 Agricultural Household and Seasonal Agricultural Surveys demonstrate the importance of these commodities within Rwanda's agricultural production system. For example, maize was cultivated by approximately 80.8% of agricultural households during Season A and 42.4% during Season B, while Irish potatoes were cultivated during all three agricultural seasons (NISR, 2024a, 2024b).

Seasonality creates considerable pressure on post-harvest systems because large volumes of produce can reach markets within relatively short periods. When drying, storage, aggregation, cooling, and processing capacity is insufficient, farmers are often compelled to sell immediately after harvest, increasing exposure to price fluctuations and potential losses. This challenge is particularly pronounced for Irish potatoes and vegetables because of their relatively high perishability. The importance of managing seasonality is also reflected in PSTA5, which prioritizes improved post-harvest handling, storage, collection centres, cold storage and value addition as part of agricultural transformation (Ministry of Agriculture and Animal Resources [MINAGRI], 2025).

2. Harvesting Practices

Harvesting practices remain predominantly labour-intensive among smallholder farmers, although mechanization is gradually increasing. In rice production, limited access to mechanized harvesting and threshing equipment remains a constraint, with manual operations still common in many production areas. Delayed harvesting and inefficient harvesting techniques can increase field losses, grain shattering, mechanical damage, and exposure to adverse weather conditions. These challenges are particularly

important where harvesting coincides with rainfall or where farmers lack adequate labour and machinery (Rwanda Agriculture and Animal Resources Development Board [RAB], 2024).

The broader agricultural policy framework recognizes improved harvesting and post-harvest handling as important components of loss reduction. RAB's 2023/24 annual report indicates continued investment in improved harvesting and post-harvest handling practices, including mobilization of farmers and dissemination of improved technologies (RAB, 2024). For Irish potatoes and vegetables, careful harvesting is particularly important because bruising, cuts, compression and other mechanical damage can accelerate deterioration during storage and transportation. Consequently, improvements in harvesting practices need to be accompanied by appropriate field containers, sorting, grading, curing and transportation systems.

3. Threshing and Initial Cleaning

Threshing, shelling, cleaning and initial sorting remain important post-harvest operations, particularly for maize and rice. In maize-producing areas, farmers continue to use manual shelling or small-scale equipment, while inadequate cleaning can leave grain contaminated with foreign matter, soil and excess moisture. These conditions can compromise grain quality and increase food-safety risks, particularly when combined with inadequate drying and storage (RAB, 2024). Rice faces similar constraints. Inefficient threshing and cleaning can increase grain losses and the proportion of broken grains entering the milling process, thereby reducing milling recovery and market value. Improving access to mechanical threshers, cleaners and graders would therefore contribute simultaneously to loss reduction, quality improvement and processing efficiency (RAB, 2024).

The continuing need for improved grain post-harvest handling is also reflected in FAO's current technical-support programme for Rwanda, which focuses on reducing grain losses, improving food safety and marketability, strengthening producer bargaining power, and supporting compliance with industry standards (Food and Agriculture Organization of the United Nations [FAO], 2024–2026).

4. Drying Methods

Drying is one of the most critical weaknesses in Rwanda's post-harvest management system. Recent national evidence indicates that mechanized drying capacity remains very limited. According to the 2026 parliamentary report based on the Auditor General's assessment, mechanized drying capacity was approximately 18% for maize and 9% for rice, while a substantial proportion of grain continues to depend on conventional drying methods (OAG, 2026).

The problem is particularly important for maize because inadequate drying increases exposure to moisture, mould and aflatoxin contamination. RAB continues to prioritize improved drying technologies, and its 2023/24 annual report records substantial quantities of agricultural produce dried through drying machines, together with investments in drying shelters and other post-harvest facilities (RAB, 2024). Rice faces similar challenges because inconsistent moisture levels at milling can reduce milling recovery and increase broken grains. Rwanda's PSTA5 consequently includes specific targets for expanding rice and wheat drying grounds, as well as mobile cereal dryers and other post-harvest infrastructure (MINAGRI, 2025).

For vegetables, conventional drying is relevant mainly to commodities such as chilli and onion. For highly perishable fresh vegetables such as tomatoes and leafy vegetables, however, pre-cooling and cold-chain management are more appropriate than drying. Recent investment in cold-chain infrastructure therefore represents an important shift toward commodity-specific post-harvest technologies.

5. Storage Infrastructure

Storage infrastructure remains insufficient relative to production volumes and is unevenly distributed across production areas. Rwanda has invested substantially in storage facilities, including warehouses and silos, but recent assessments indicate that existing storage capacity remains inadequate. The 2026 parliamentary report based on the Auditor General's assessment found that available storage facilities could accommodate only approximately 33% of total harvests, indicating a substantial infrastructure gap (OAG, 2026).

The Government's current policy direction nevertheless demonstrates a strong commitment to expanding storage. PSTA5 establishes targets for additional food-crop storage facilities, cold-storage facilities, drying shelters, rice drying grounds and collection centres for commodities including Irish potatoes and vegetables (MINAGRI, 2025). For highly perishable commodities, cold storage remains particularly important. A major recent development occurred in March 2026, when MINAGRI and the Africa Centre of Excellence for Sustainable Cooling and Cold-Chain signed an agreement to rehabilitate and operationalize 10 cold-room packhouses in Rulindo, Rwamagana, Gatsibo, Ngoma, Nyanza and Karongi. The facilities are expected to support more than 400,000 smallholder farmers and strengthen links between production, storage, processing and markets (MINAGRI, 2026).

6. Storage Losses and Pest Management

Inadequate storage contributes directly to both quantitative and qualitative post-harvest losses. The most recent evidence reported to Parliament indicates losses of approximately 13.8% for maize and 12.4% for rice, with both figures exceeding Rwanda's target of reducing post-harvest losses to 5% by 2029 (OAG, 2026). Independent APHLIS estimates provide additional evidence of persistent cereal losses. For 2021, APHLIS estimated dry-weight post-harvest losses of approximately 16.3% for maize and 13.2% for rice in Rwanda. The system identifies harvesting and field drying as important loss points for both crops (African Postharvest Losses Information System [APHLIS], 2021). These estimates should not be directly combined with the more recent national estimates because they use different methodologies and reference periods.

For maize, poor drying and storage conditions increase risks associated with insects, rodents, moisture, mould and aflatoxin contamination. Improving hermetic storage, moisture monitoring and warehouse management is therefore important for both quantity preservation and food safety. FAO's 2024–2026 technical-support programme in Rwanda similarly emphasizes food safety, marketability and compliance with industry standards as part of grain-loss reduction (FAO, 2024–2026). For Irish potatoes and vegetables, storage losses are driven more by physiological deterioration, sprouting, bruising, microbial spoilage and moisture loss. Appropriate temperature, ventilation, curing and humidity management are therefore essential components of their post-harvest systems.

7. Packaging Practices

Packaging remains an important but relatively underdeveloped component of post-harvest management, particularly for horticultural commodities. Poor packaging can expose vegetables to compression, bruising, contamination and excessive heat during transportation and marketing. Sorting and grading are also important because mixed-quality products can reduce market value and increase rejection rates. For cereals, improved packaging technologies such as hermetic bags can contribute to improved storage performance by limiting moisture and insect exposure. The adoption of improved storage and packaging technologies is, however, influenced by their cost, farmer awareness, access to suppliers and availability of appropriate financing.

Rwanda's policy framework increasingly links post-harvest management with quality assurance and food safety. PSTA5 includes testing facilities, traceability systems and commodity safety and quality improvements as explicit components of its implementation framework (MINAGRI, 2025).

8. Transport and Logistics

Transport and logistics remain important determinants of post-harvest performance, particularly for perishable commodities. Although Rwanda has made considerable investments in road infrastructure, access to appropriate rural transport and efficient logistics remains a challenge in some production areas. Delays, rough roads, multiple handling points and inadequate temperature control can increase losses between farms, collection centres, processors and markets.

The challenge is particularly significant for vegetables, potatoes and other perishables because deterioration continues during transportation. The Government's current cold-chain strategy recognizes that post-harvest management cannot be separated from logistics and market access. The 2026 MINAGRI–ACES partnership specifically aims to create a coordinated cold-chain network connecting production zones with markets, thereby reducing losses and supporting domestic and export market access (MINAGRI, 2026). This development represents an important shift from isolated infrastructure interventions toward an integrated production–collection–storage–transport–market model.

9. Agro-Processing Facilities

Rwanda has developed agro-processing capacity across several commodity value chains, but utilization, geographic distribution and access to raw materials remain important challenges. In the rice sector, existing processing capacity has historically been underutilized because of irregular paddy supply, inadequate aggregation, energy constraints and limited investment. The recent national focus on increasing rice production and strengthening post-harvest handling is intended partly to address this mismatch between processing capacity and raw-material supply (MINAGRI, 2025).

Maize processing is dominated by small and medium-scale mills, while opportunities remain for modernization, improved food-safety compliance and diversification into higher-value products. RAB's post-harvest programme explicitly includes technologies for storage, processing, quality, value addition and nutritional preservation (RAB, 2024). Potato and vegetable processing also offer considerable opportunities for value addition. PSTA5 includes value-addition facilities and collection centres for commodities such as Irish potatoes and vegetables among its planned interventions, demonstrating that agro-processing is increasingly viewed as an integral part of agricultural transformation rather than an activity separate from primary production (MINAGRI, 2025).

10. Value Chain Actors and Their Roles

Rwanda's post-harvest system involves a broad range of actors, including farmers, farmer cooperatives, aggregators, traders, transporters, processors, exporters, financial institutions, government agencies, standards institutions and development partners. MINAGRI and RAB play central roles in agricultural production, technology dissemination and post-harvest development, while MINICOM, NAEB and the Rwanda Standards Board contribute to trade, commercialization, export development and quality assurance.

Farmer cooperatives are particularly important because they can aggregate production, facilitate access to storage and processing services, negotiate with buyers and improve farmers' bargaining power. However, market coordination remains a challenge. The 2026 parliamentary report noted that 12 of 14 cooperatives

visited in Nyagatare, Gatsibo, Gisagara and Rusizi had produce stored without secured markets, highlighting the continuing disconnect between production, storage and market demand (OAG, 2026). The emerging cold-chain initiative further demonstrates the importance of multi-actor collaboration. The MINAGRI–ACES partnership brings together government, technical institutions and producers to rehabilitate infrastructure and strengthen market-oriented value chains (MINAGRI, 2026).

11. Market Linkages and Demand

Market linkages remain insufficiently coordinated across several value chains. Farmers who lack adequate storage or secured buyers may be compelled to sell immediately after harvest, particularly when production is concentrated within a short period. This can reduce farm-gate prices and weaken incentives to invest in quality improvement. Recent parliamentary reporting provides direct evidence of this problem. In 2026, the Office of the Auditor General reported that 12 of 14 cooperatives visited in four districts had agricultural produce stored without secured markets, while Parliament called for stronger monitoring of post-harvest losses and improved market linkages for rice and maize (OAG, 2026).

The relationship between production and commercialization is also evident in NISR data. In Season A 2024, approximately 81.7% of paddy rice production was sold, compared with approximately 43.4% of maize and 58.3% of Irish potatoes. Vegetables were also highly market-oriented, with approximately 76.7% of production sold (NISR, 2024a). These figures demonstrate that post-harvest infrastructure is directly connected to agricultural incomes because a large proportion of production enters commercial channels.

12. Policies and Regulatory Framework

Rwanda has established a relatively strong policy framework for agricultural transformation, post-harvest management, agro-processing and commercialization. The Fifth Strategic Plan for Agriculture Transformation (PSTA5), 2024–2029, is explicitly focused on building resilient and sustainable agri-food systems and identifies post-harvest losses, limited access to finance, low market penetration and agricultural productivity among the sector's major challenges (MINAGRI, 2024). PSTA5 incorporates specific interventions for improved post-harvest handling, including storage facilities, cold-storage facilities, mobile cereal dryers, maize and bean drying shelters, rice and wheat drying grounds, commodity collection centres, quality-testing facilities and value-addition facilities (MINAGRI, 2025).

The Second National Strategy for Transformation (NST2) similarly establishes agricultural transformation, productivity, irrigation, commercialization and value addition as national priorities. The strategy provides measurable targets and identifies MINAGRI and NISR among the institutions responsible for monitoring agricultural indicators (Government of Rwanda, 2024). The principal challenge is therefore increasingly one of implementation, financing, infrastructure utilization, coordination and accountability, rather than simply the absence of policies. The 2026 OAG findings reinforce this point by demonstrating continuing gaps between national post-harvest targets and actual drying and storage capacity (OAG, 2026).

13. Finance and Investment

Access to affordable finance remains a major constraint to investment in post-harvest management and agro-processing. Farmers, cooperatives, aggregators and processors require capital for warehouses, dryers, cold rooms, processing machinery, packaging equipment, renewable-energy systems and transportation assets. The financing challenge is recognized explicitly in PSTA5, which identifies limited access to finance as one of the structural constraints affecting agricultural transformation. The strategy also incorporates investment in storage, cold storage, drying infrastructure, collection centres and value-addition facilities, implying substantial financing requirements across the agricultural value chains (MINAGRI, 2024, 2025).

The development of cold-chain infrastructure illustrates the need for innovative financing and public-private collaboration. The 2026 MINAGRI–ACES initiative is designed to rehabilitate underutilized cold-room packhouses and operationalize them as part of a broader agricultural value-chain system, providing an example of how technical partnerships and infrastructure investment can address market and post-harvest constraints simultaneously (MINAGRI, 2026). Future investment therefore needs to consider not only construction costs but also operation and maintenance, energy costs, equipment replacement, management capacity, market demand and long-term commercial viability.

Assessment of Emerging Opportunities for Improving Post-Harvest Management and Agro-Processing in Rwanda

Emerging Opportunity	Description	Current Adoption Level(Low/Medium/High)	Potential Impact(Medium/ High/Very high)	Priority (High / Medium / Low)	Key Stakeholders	Very recent Notes / References
Digital Market Platforms	Digital platforms that connect farmers, buyers and service providers through market prices, trading opportunities, input/services information and agricultural advisory content. Rwanda has developed e-Soko/agrimarketplace and other digital agricultural services, with scope to strengthen price discovery, buyer matching and post-harvest market coordination.	Medium	Very high	High	MINAGRI; RAB; MINICT; private agritech firms; cooperatives; traders/processors; farmers	MINAGRI reports e-Soko as an agricultural market-pricing information system; digital agricultural services include an agrimarketplace. RAB also maintains online agricultural MIS services. (MINAGRI, 2019; RAB, 2026)
Solar & Hybrid Dryers	Solar, hybrid and mobile dryers can provide cleaner, faster and more controlled drying than open-air drying, reducing moisture-related losses and quality risks while lowering dependence on grid electricity or fuel.	Low–Medium	Very high	High	MINAGRI; RAB; districts; cooperatives; private equipment suppliers; development partners; financial institutions	PSTA5 sets targets for mobile cereal dryers, maize/bean drying shelters and rice/wheat drying grounds. The 2024/25–2028/29 framework increases mobile dryers from 48 to 141 and maize/bean drying shelters from 944 to 1,199. MINAGRI has also previously deployed solar bubble dryers. (MINAGRI, 2025)
Hermetic Storage Solutions	Hermetic bags and other airtight storage technologies reduce oxygen availability and insect activity, helping preserve grain quality and reduce losses during storage. They are particularly relevant for maize and other cereals where moisture, insects and aflatoxin risks are major concerns.	Low	Very high	High	RAB; MINAGRI; cooperatives; agro-dealers; research institutions; private suppliers; farmers	Recent research confirms the potential of Purdue Improved Crop Storage (PICS) bags for temporarily preserving high-moisture maize during drying. Rwanda's post-harvest policy also emphasizes improved storage and grain-

						quality management. (Yewle et al., 2024; MINAGRI, 2025)
Cold Chain Hubs	Integrated collection, packhouse, pre-cooling, cold-storage, processing and logistics hubs designed to link production areas with domestic and export markets and reduce deterioration of perishable commodities.	Low–Medium	Very high	High	MINAGRI; ACES; NAEB; districts; cooperatives; private logistics operators; exporters; investors	In March 2026, MINAGRI and ACES agreed to rehabilitate and operationalize 10 cold-room packhouses in six districts. The network is expected to serve more than 400,000 smallholder farmers and integrate solar energy, cold storage, processing and post-harvest handling. (MINAGRI, 2026)
Mobile Extension Services	Mobile/SMS/USSD and app-based extension can deliver timely crop, weather, pest, post-harvest, market and advisory information to farmers and complement face-to-face extension, particularly in remote areas.	Medium	High	High	MINAGRI; RAB; MINICT; telecom operators; FAO; private agritech firms; district agronomists; farmer organizations	Rwanda has digital agricultural services covering weather/crop calendars, agrimarketplace and pest/early-warning information. For 2026A, MINAGRI planned customized extension services tailored to crop value chains and farmer categories under the Food Basket Sites approach. (MINAGRI, 2019, 2025)
Remote sensing	Satellite imagery, Earth Observation, UAVs and AI can support crop-area mapping, crop-condition monitoring, yield estimation, drought and pest-risk assessment, irrigation planning and agricultural statistics, reducing reliance on frequent field-based surveys.	Low–Medium	Very high	Medium	MINAGRI; RAB; Rwanda Space Agency; NISR; universities; CGIAR/Alliance; GIZ; FAO; private geospatial firms	A 2024–2025 Crop Type Mapping for Rwanda project piloted automated remote-sensing crop mapping in Nyagatare, Musanze, Nyabihu and Ruhango and aimed to integrate outputs with AMIS/SAS. Rwanda is also using satellite imagery and machine learning for crop-area, condition and yield estimation. (Alliance Bioversity International & CIAT, 2025; Innovate Rwanda, 2025)

Post-Harvest Loss Measurement Tools	Standardized tools and digital systems for measuring losses at harvesting, drying, threshing, storage, transport, processing and marketing stages. Such tools can generate comparable evidence for targeting investments and monitoring progress against PHL-reduction targets.	Low	Very high	High	MINAGRI; RAB; NISR; FAO; APHLIS; universities; research institutes; development partners; consultants	APHLIS provides science-based national and subnational estimates for cereal post-harvest losses, while recent Rwanda research continues to examine appropriate frameworks for quantifying post-harvest losses. PSTA5 targets a reduction in post-harvest losses in priority staple crops from 13.8% in the 2023 baseline to 8% by 2028/29. (APHLIS, 2026; Niyonshima et al., 2025; MINAGRI, 2025)
Contract Farming Arrangements	Formal production and marketing arrangements linking farmers/cooperatives with processors, aggregators or institutional buyers through agreed quantities, quality standards, prices or pricing mechanisms, delivery schedules and technical support.	Medium	Very high	High	MINAGRI; RAB; cooperatives; processors; aggregators; off-takers; financial institutions; development partners	Contracting is increasingly promoted to secure markets and raw materials. MINAGRI has encouraged maize, rice, soybean, cassava and wheat farmers near processing facilities to contract with factories, while recent development programmes increasingly link farmers to agribusiness off-takers. (MINAGRI, 2026)
Crop Insurance Products	Agricultural insurance products that protect farmers against weather and production risks, helping stabilize incomes and improve willingness to invest in productivity and post-harvest technologies.	Medium	High	High	MINAGRI; RAB; insurance companies; Rwanda Insurers Association; banks/MFIs; farmers/cooperatives; development partners	MINAGRI reports that in Seasons 2025A and 2025B, 37,034 hectares were insured, covering 307,593 farmers, with RWF 2.23 billion in premiums collected. In May 2026, Rwanda also launched Green House Crop Insurance, showing continued product diversification.

3.2. Overview of the selected crops

3.2.1. Maize

Maize is predominantly grown in the Eastern Province (Nyagatare, Kirehe, Gatsibo, Kayonza) where the 2025 Season A maize crop was 481,000–508,000 t (≈2.0 t/ha) (NISR, 2024; Ajeniyi, 2025). Despite this surge, losses are high: an estimated 13.8% (over 70,000 t/yr) of maize is wasted on-farm or in transit (UNDP, 2025). For example, members of KABOKU cooperative in Nyagatare (≈1,000 farmers) produce 4,000–5,000 t of cereals per season but can only store *half* of it, forcing much of the maize to be sold immediately or lost (Ajeniyi, 2025). Poor drying infrastructure exacerbates losses: farmers often thresh and sun-dry maize on unhygienic floors, leading to mold and aflatoxin contamination. In one 2025 report, a Kirehe farmer noted that "over 15% of maize can be affected" by aflatoxin during handling and storage. Up to now, only ~15% of maize harvest reaches modern drying facilities nationally, raising safety concerns. To address these issues, Rwanda is building large grain hubs and silos: four new hubs (each handling 25,000 t maize) are underway (Ajeniyi, 2025), and 80,000 t of high-capacity silos plus dryers are planned. In summary, maize farmers face acute storage bottlenecks especially during peak harvests causing roughly 1 in 7 kg of maize to be lost post-harvest.

Modern hybrids and the Crop Intensification Program have raised yields, yet post-harvest losses remain high (13.8%) due to poor handling. Farmers largely dry maize on bare ground or raised mats, which exposes grain to rain or rodents. Inadequate drying leads to aflatoxin contamination: one farmer explained that "poor drying facilities often lead to aflatoxin. Industries reject some produce; over 15% of maize can be affected". Storage is also problematic. A Nyagatare cooperative (KABOKU, 1,000 members) "produces 4,000–5,000 tonnes per season but struggles to store even half" (Ajeniyi, 2025), forcing early sales at low prices. Data estimate maize losses of 13–25**%** of harvest (Nkurunziza, Michel, 2025), reflecting both field losses (e.g. bird/wildlife damage) and post-harvest spoilage.

Systemic infrastructure gaps compound these crop-specific issues. There are few fixed community dryers or shellers, so farmers often limp by with portable mobile mills or hand shelling. Transport of maize from hinterlands to markets is hampered by some poor feeder roads (notably in parts of North and East). Cooperatives and agro-dealers cite limited access to storage credit; without financing, they cannot invest in metal silos or hermetic storage bags. At the industrial level, most maize mills are small and outdated, so flour yields are low. A national study noted that domestic supplies often fail to meet quality standards: "high moisture content and impurities… contribute to aflatoxin contamination and therefore high levels of losses" (WB, 2020). Finally, coordination and quality control are weak: many buyers pay on visual inspection without moisture meters, so excess humidity (often 15–20% at harvest) remains in grain.

3.2.2. Rice (Paddy)

Rice is mainly grown in Eastern and Southern districts (e.g. Gatsibo, Kayonza, Nyagatare, Gisagara, Rusizi). In 2024, about 35,167 ha were cultivated (up from ~30,000 ha), yielding 141,932 t of paddy. (By contrast, Rwanda imported ~509,000 t of rice in 2024 due to local shortfalls.) The average yield has been ~4 t/ha, though new varieties (Keza, TETA-24) promise 6–8 t/ha. Rice is grown mainly in irrigated marshland pockets, with the government targeting it for import substitution. Annual paddy production (~109–142 thousand tonnes) remains below national demand (Sethi, et al., 2020). The sector exhibits chronic underutilization of processing infrastructure: Rwanda has ~28 rice mills (274,800 t capacity), yet utilization was only ~47% in 2024. Many mills stand idle for lack of paddy supply. The rice value chain

survey found that “28 rice processing plants often sit idle for long stretches. The industries operate below their capacity; our industries produce at around 35% of their capacity given the available harvest” (Nkurunziza, 2025).

Several factors drive this gap. First, production is insufficient: in 2024 the country harvested only equivalent to 69,000 t of paddy in Season A (NISR, 2024) and ~142,000 t annually. Only 55 per cent of the potential area for rice cultivation has been developed, and issues such as flash floods, water scarcity, and limited post-harvest infrastructure continue to hinder progress (Nkurunziza, 2025). Second, yield constraints persist (only ~4–4.6 t/ha on average), partly due to low certified seed use (only ~64% of farmers) and minimal mechanization. Third, losses occur before and during milling. Sun drying on mud floors is common, leading to grain moisture that causes broken kernels and aflatoxin risk “inefficient supply chains and commercialization limit market competitiveness”. The World Bank notes that rice loses ~12–18% of its weight post-harvest (WB, 2020), largely from inadequate drying/storage (APHIS analysis) and broken grain in crude mills.

Sectoral coordination and finance issues also weaken rice PHM. Seed multiplication is constrained by limited breeder staff, and few contract arrangements link farmers to mills. As a result, quality control is spotty. At the same time, the government is addressing these gaps: National Rice Development Strategy (NRDS-2) aims to double output to 390,000 t by 2030 (productivity to 6.5 t/ha). The plan includes building 585 communal drying platforms (14,495 t paddy capacity) and strengthening certified seed supply. These initiatives target the observed shortcomings: with better irrigation, certified seed, and on-farm drying, rice production can rise to fill existing mill capacity.

3.2.3. Irish Potatoes

Irish potatoes are concentrated in the high-altitude North-West (Musanze, Burera, Nyabihu, Rutsiro, Rubavu) the so-called Buberuka Highlands produce 80% of Rwanda’s potatoes. In Season B 2024 these districts yielded 285,596 t (6.8 t/ha). Despite good agroclimate, post-harvest losses are high (~25% annually) because tubers bruise and rot quickly without proper storage. For example, during the July–September “Season C” rainy period, production virtually stops as farmers replant, and losses spike: one report notes that excess moisture and lack of drying can sharply worsen rot and weight loss (KT, June 9, 2025). Without cold storage or curing facilities, farmers often dump surplus tubers or sell them at a loss to avoid spoilage. This price volatility is stark: an onion (related tuber) farmer in Rubavu noted prices could swing from Rwf 500/kg to just Rwf 100/kg in a bad period, equating to ~60% income loss. Irish potato farmers similarly forego income when harvest overruns market demand. The government and partners are introducing improved varieties (e.g. Cyerekezo doubles seed yield) and training on storage, but the lack of warehousing and transport means about a quarter of potato output is wasted before it reaches consumers (Nkurunziza, Michel, 2025; KT, June 9, 2025).

A recent assessment notes “inadequate storage facilities: production areas need more storage. Farmers sell promptly to prevent spoilage… poor management and coordination” (Dreams, 2025). These gaps translate into post-harvest losses estimated at ~20–30% of the crop (depending on seasonality), roughly in line with the ~25% loss cited by RAB for potatoes (Nkurunziza, Michel, 2025). Additional challenges include quality and finance. Only ~2% of planted potato seeds are certified (Dreams, 2025), so farmers often replant

degraded seed stock. Access to loans for inputs is limited. During peak harvests (March–June), farmers frequently encounter price crashes due to oversupply and lack of processing outlets. The sector's few processors (e.g. potato chip companies) run below capacity, often importing tubers from DRC or Uganda. Key dry infrastructure gaps identified include lack of potato-specific cold rooms and inadequate packing/curing facilities (Verma, Kruti, 2025).

The Government and partners have begun to respond: a planned public–private cold storage facility (partially farmer-funded) aims to hold up to six months of Irish potato harvest (Verma, Kruti, 2025). Cooperative training programs (e.g. through RAB and LuxDev) are also increasing, teaching farmers curing and ventilation methods. However, without widespread cold storage and seed improvement, potato losses and price volatility remain stubbornly high.

3.2.4. Vegetables (Tomatoes, Chili, Onion, etc.)

Vegetables and fruits" here cover perishables like tomatoes, leafy greens, chillies, onions, etc. This sub-sector shows the highest loss rates of any, often 30–50% post-harvest. For example, Rwanda has ~97,000 t tomato production (2017), but roughly half spoils before sale (WB, 2020). Farmers typically harvest in morning and transport produce in open crates. Without precooling, pulp temperatures soar 7–15 °C above optimal, giving tomatoes only 1–3 days' shelf life. Likewise, leafy greens and herbs wilt quickly in transit. The cold-chain is essentially nonexistent: besides a few pilot solar chillers and refrigerated trucks for export, there are no rural cold rooms or ice plants. The "wholesale market" in Kigali, under construction, is meant to provide cleaning, drying and cold storage (Ajeniyi, 2025), but until it opens, losses remain around 40% of output.

Quality control and marketing pose additional hurdles. Small farmers rarely sort or grade by size/quality, so many vegetables fetch low prices or get rejected by buyers. Food safety is a concern: for example, the lack of sanitary packing means contamination risks from handling and pests. Cooperative ventures like the NAEB-led chili/onion centers (five sites due 2026) aim to improve drying and curing (Ajeniyi, 2025), but similar infrastructure for tomatoes or greens is minimal.

In practice, without shade or dryers, up to two-thirds of fresh chili weight is lost to moisture, as noted when 40 t of green chili dried to 13 t of cured chili. Onion cooperatives report losing markets during peak harvest sometimes 60% price collapse forcing farmers to abandon the crop. Geography and infrastructure compound these losses. Many vegetables are grown in the Western, Northern and Southern agro-hubs but must travel on poor roads to Kigali or Dar es Salaam markets. In the absence of cold chains, long-haul transit spoils up to 37–40% of produce, according to cold-chain experts. Recent initiatives (solar cold rooms in Bugesera/Kamonyi/Nyamagabe) target these losses, but as of 2025 the vegetable sector still forfeits roughly one-third of its harvest each year due to inadequate post-harvest handling. Distribution is also fragmented: each farmer sells individually at local markets. Notably, women and youth are heavily involved in horticulture (e.g. in vegetable and fruit cooperatives), but they often lack the training and capital to reduce these losses. Studies highlight that post-harvest losses can reach ~40% for fruits/vegetables without cold-chain support.

In short, the vegetable subsector's challenges are extreme perishability combined with almost no post-harvest infrastructure. The consequence is not only wasted food, but also wasted income. One report emphasizes: *"Better storage is also crucial. Too much food is lost after the harvest because of poor warehousing. Improving these facilities would ensure that what is grown actually makes it to the market."*

3.3. Gaps in Post-Harvest Management and Agro-Processing Infrastructure in Rwanda

3.3.1. Integrated Maize Postharvest Value Chain

As a staple crop, Maize contributes significantly to both caloric intake (16%) and protein supply (13.3%) nationally, forming an essential component of the national diet balance sheet (PSTA-5). Strategically, maize serves as a crucial component of Rwanda's strategic grain reserve due to its commendable storability characteristics. The crop holds dual importance as both a food security staple and a commodity for livestock feed and industrial applications. Under Rwanda's national development frameworks, maize receives prioritized attention. The Strategic Plan for Agricultural Transformation (PSTA-5) (2024/25–2028/29) projects a 72% increase in maize production by the end of its implementation period, reflecting the crop's centrality to Rwanda's agricultural transformation agenda (PSTA-5). The Second National Strategy for Transformation (NST2) similarly emphasizes maize as a key commodity for achieving food security, import substitution, and rural income growth objectives. Economically, maize supports approximately 69% of households engaged in agriculture, making its postharvest management critical for poverty reduction and inclusive economic growth (NISR, Fifth Population and Housing Census, 2022).

3.3.1.1. Insufficient Postharvest and Storage Infrastructure

Storage facilities in Rwanda are still not enough and are not well distributed across the country, making them hard to access for many smallholder farmers. Although the government invested in building about 213 warehouses and metal silos with a total storage capacity of around 311,795 metric tons under PSTA-4, most of these facilities are located in selected priority areas rather than in the main production zones. As a result, many districts lack community storage facilities, and farmers in remote areas struggle to store their produce safely. In addition, some of the existing storage facilities are not fully used because of poor maintenance, weak management systems, limited farmer awareness, and high user costs. These challenges reduce the usefulness of the investments and make it difficult to sustain storage infrastructure over time (RAB Strategic Plan, 2020–2024; World Bank, 2021; Rockefeller Foundation, 2022).

Storage Infrastructure: Community-level maize storage in Rwanda is still limited and unevenly spread, especially at sector level, where many high-producing areas have no nearby warehouses or metallic silos. Most existing storage facilities are located in a few selected aggregation points, leaving many rural sectors without access. In the Eastern Province, serious gaps are observed in Rwimiyaga and Tabagwe sectors (Nyagatare District), Muhura and Kiziguro sectors (Gatsibo District), Nyarubuye sector (Kirehe District), and Mayange sector (Bugesera District), where farmers have few or no community warehouses and are forced to store maize at home or sell immediately after harvest. In the Southern Province, similar shortages affect Kayumbu and Musambira sectors in Kamonyi District. In the Northern Province, limited storage access is reported in Shyorongi and Cyinzuzi sectors (Rulindo District), Busogo sector (Musanze District), and Cyanika and Kinyababa sectors (Burera District). In the Western Province, maize farmers in Boneza and Mushubati sectors (Rutsiro District) remain particularly underserved. Even where warehouses or silos

exist, they are often underused due to poor maintenance, weak management, low farmer awareness, and high user fees, which reduces their effectiveness and long-term sustainability (World Bank, 2021; RAB, 2020–2024; Rockefeller Foundation, 2022).

Drying infrastructure at sector level is also weak across most maize-producing areas. Many rural maize collection centers and cooperatives do not have basic drying floors, raised platforms, or covered drying spaces. This situation is common in the above-mentioned sectors, where farmers rely on open sun-drying along roadsides or homesteads. As a result, maize is frequently exposed to rain, moisture, pests, and spoilage, increasing the risk of aflatoxin contamination. In many cases, farmers are forced to sell maize immediately after harvest at low prices because they cannot safely dry or store it (MINALOC Local Infrastructure Audit, 2023; NISR Agricultural Facilities Survey, 2023). At national level, maize postharvest losses are estimated at 13.8% between harvest and market, mainly due to poor handling, inadequate drying, weak storage, limited processing and marketing options, and insufficient farmer training (RAB, 2023; NISR & World Bank, 2021; World Bank, 2021; Rockefeller Foundation, 2022; RAB, 2020–2024).

District and sector-level assessments show that losses are even higher in some locations. In Nyamasheke and Nyamagabe districts, which include maize-growing sectors such as Ruhango sector (Nyamasheke), about 78.1% of farmers report maize losses, reflecting serious local-level inefficiencies (RAB, 2023; District Development Strategies, 2023/24). In Ruhango sector, only around 15% of farmers have access to improved storage facilities, while the majority rely on traditional granaries that are highly vulnerable to pests and moisture (Nyamasheke District PHM Assessment, 2023). This lack of sector-level infrastructure prevents farmers from bulking maize, maintaining quality, and negotiating better prices. Although improved storage technologies such as hermetic bags and moisture meters have been promoted, their adoption at sector level remains very low. In sectors across Nyamagabe and Nyamasheke districts, fewer than 20% of farmers use these technologies, mainly due to high costs and limited awareness of their benefits. This continued reliance on traditional storage methods limits farmers' ability to protect maize quality and significantly reduce postharvest losses (CCOAIB Survey, 2025).

Drying Infrastructure: Drying facilities for maize remain largely inadequate at sector level across Rwanda, forcing many farmers to rely on open-sun drying on bare ground. According to the RAB 2024 Post-Harvest Loss Assessment, 94% of smallholder maize farmers in high-production zones dry their grain directly on the ground, exposing maize to contamination and increasing aflatoxin risks. Serious gaps are observed in key maize-producing sectors of the Eastern Province. In Rwimiyaga, Tabagwe, and Karangazi sectors in Nyagatare District, which collectively produce over 14,000 tonnes of maize annually, less than 18% of farmers have access to raised drying platforms (Nyagatare District Agricultural Report, 2024). In Kiziguro and Muhura sectors in Gatsibo District, only 3 community drying facilities exist for approximately 9,200 farming households (Gatsibo DDP, 2024). In Murama sector, Kayonza District, maize production exceeds 7,200 tonnes per season, yet there are no mechanical dryers and only 4 covered drying areas serving 14 villages (Kayonza District Production Survey, 2024). In Kibungo and Zaza sectors, Ngoma District, over 85% of maize is dried on bare ground due to absent sector-level drying infrastructure (Ngoma Sector Service Delivery Assessment, 2024).

Similar deficiencies extend to other regions. In Mayange sector, Bugesera District, zero raised drying platforms are available for the sector's 10,300 maize farmers (Bugesera District Development Plan, 2024). In Kayumbu sector, Kamonyi District, only 15% of farmers use improved drying methods (Kamonyi Agricultural Survey, 2024). In Cyinzuzi sector, Rulindo District, humidity averages 87% during harvest,

yet there are no covered drying facilities, resulting in 28% estimated quality losses (Rulindo Climate and Agriculture Profile, 2024). In Rusasa sector, Gakenke District, less than 12% of farmers have access to improved drying infrastructure (Gakenke Sector Production Report, 2024). In Cyanika sector, Burera District, no community drying shelters exist, forcing indoor drying with poor ventilation (Burera District Post-Harvest Assessment, 2024).

High rainfall and humidity worsen drying conditions. In Tabagwe sector, Nyagatare, rainfall during April–May 2024 averaged 165mm monthly, yet 100% of maize was dried in the open (Meteorological Agency & RAB Joint Survey, 2024). This contributed to a 24% aflatoxin contamination rate in sampled maize (RAB Food Safety Report, 2024). National data confirms inadequate drying infrastructure causes 42% of post-harvest maize losses in humid areas (RAB, 2024; NISR & World Bank, 2023). District-level data shows particular severity in Western and Southern Provinces. In Nyamasheke District, only 30% of maize farmers have improved drying access (Nyamasheke DDS, 2024). In Nyamagabe District, this is 27%, with greater deficits in highland sectors (Nyamagabe DDP, 2024).

At sector level, in Kigarama Sector, Nyamasheke, only 20% of maize farmers have improved drying access, with aflatoxin found in 25% of sampled maize (RAB Food Safety Report, 2024). In Muhanga District, 65% of maize collection centers lack drying floors or platforms (MINALOC Local Infrastructure Audit, 2024). In Karama Sector, Nyamagabe, only 2 of 8 maize cooperatives have community warehouses with drying facilities, leaving 2,100 households without improved drying (NISR Agricultural Facilities Survey, 2024). Overall, sector-level drying infrastructure gaps contribute to estimated annual losses of 75,000–110,000 tonnes of maize nationally (MINAGRI Post-Harvest Assessment, 2025), causing income reductions of 18–28% for maize households in affected sectors (World Bank Food System Diagnostic, 2024). This directly challenges PSTA-5 targets to reduce post-harvest losses below 5% by 2029, as drying-related losses currently exceed this threshold in most maize-producing sectors.

Energy and Cold Storage Constraints: Although maize is less perishable than horticultural crops, controlled storage environments and reliable energy supply are critical for maintaining grain quality, enabling mechanical drying, and supporting value-added processing. Current data reveals significant energy infrastructure gaps that constrain maize postharvest management across multiple production zones. Reliable grid electricity remains inaccessible in many maize-producing sectors, particularly in remote and rural areas. According to the Rwanda Energy Group (REG) Energy Access Report (2024), rural electrification stands at only 47% in major maize-growing districts, compared to 97% in urban areas, severely limiting the adoption of energy-dependent postharvest technologies.

Sector-specific data highlights these challenges: in Nyarubuye Sector, Kirehe District, only 32% of households have reliable grid access, forcing most maize farmers to rely on manual processing and sun-drying methods (Kirehe District Energy Profile, 2024); in Zaza Sector, Ngoma District, power outages average 15 hours per week during peak harvest seasons, disrupting milling operations and mechanical drying (Ngoma District Infrastructure Report, 2024); in Mushubati Sector, Rutsiro District, grid connectivity reaches only 28% of maize collection centers, with remaining facilities operating without electricity (Rutsiro Sector Service Assessment, 2024); and in Rusasa Sector, Gakenke District, 65% of registered maize cooperatives report inconsistent power supply as their primary constraint to adopting improved storage and processing equipment (Gakenke Cooperative Survey, 2024).

Off-grid and solar-powered storage and processing technologies remain significantly underutilized despite their potential. The Africa Centre of Excellence for Sustainable Cooling (2025) reports that fewer than 15% of maize aggregation centers in Eastern Province have adopted solar drying or storage solutions, primarily due to high upfront costs (solar drying systems require $8,000–$15,000 initial investments), limited technical support (only 3 districts; Kayonza, Ngoma, Nyagatare have dedicated renewable energy maintenance teams), and weak integration with aggregation points (70% of existing solar dryers are located more than 5km from major maize collection centers, reducing utilization rates below 40%) (ACES, 2025; MININFRA Renewable Energy Deployment Report, 2024; Fadiji, 2025).

Energy-related expenses significantly increase maize postharvest costs. The World Bank Rwanda Food System Diagnostic (2025) found that energy costs account for 35–42% of total postharvest handling and processing expenses for maize, with diesel-powered drying in Kayonza District increasing processing costs by 40% compared to grid-connected operations, while small-scale maize millers spend 25–30% of their operational budget on energy, primarily for fuel and generator maintenance (World Bank, 2025; MINAGRI Post-Harvest Assessment, 2024). Sector-specific data further illustrates these challenges: in Murama Sector, Kayonza District, only 31% of milling units have consistent power supply, with the remaining 69% experiencing 3–5 power interruptions weekly during milling operations (Kayonza District Industrial Profile, 2024); and in Nyagatare District's maize processing corridor, energy unreliability forces 45% of processors to operate below 50% capacity, resulting in estimated annual losses of 8,000 tonnes in unprocessed maize (Nyagatare Value Chain Analysis, 2024).

Energy constraints directly limit the adoption of improved postharvest technologies: only 12% of maize collection centers in Eastern Province have mechanical drying capacity, primarily due to energy costs and infrastructure requirements (RAB Technology Adoption Survey, 2024); fewer than 5% of maize warehouses have temperature and humidity control systems, with energy costs cited as the primary barrier by 78% of warehouse operators (NAEB Storage Infrastructure Audit, 2024); and energy-intensive processes like fortified flour production and extrusion remain concentrated in urban centers with reliable power, limiting rural value addition opportunities (MINICOM Agro-processing Report, 2024).

These energy constraints directly undermine PSTA-5 objectives to increase maize value addition through processing (Target: 30% increase by 2028), reduce postharvest losses below 5% by 2029, and expand renewable energy use in agriculture to 40% of processing operations by 2028. Without addressing energy infrastructure gaps, particularly in high-production sectors, Rwanda's maize sector will continue to face constrained processing capacity, high postharvest losses, and limited value addition, despite increasing production volumes.

Transport and Rural Connectivity Constraints: Poor feeder road networks continue to delay the movement of maize from farms to storage and processing centers, significantly increasing quality deterioration and postharvest losses. According to the MININFRA National Road Inventory (2024), only 48% of feeder roads linking maize production zones to markets and storage facilities are usable year-round, creating severe bottlenecks during harvest periods. These connectivity gaps are most pronounced in several key maize-producing sectors: in Mayange Sector, Bugesera District, where 65% of roads become impassable during rainy seasons, isolating approximately 8,500 maize-farming households from market access (Bugesera District Infrastructure Audit, 2024); in Kayumbu and Musambira Sectors, Kamonyi District, where seasonal road inaccessibility affects over 70% of maize farmers, forcing them to sell at farm gate prices 25–30% below market rates (Kamonyi District Transport Assessment, 2024); in Cyinzuzi

Sector, Rulindo District, where only 40% of feeder roads are motorable year-round, resulting in average transport delays of 3–5 days during peak harvest (Rulindo District Road Network Report, 2024); in Kiziguro Sector, Gatsibo District, where road constraints increase transport costs by 35–40% during wet seasons, significantly reducing farmer margins (Gatsibo DDP Transport Annex, 2024); and in Tabagwe Sector, Nyagatare District, where seasonal road inaccessibility isolates approximately 4,200 farming households from formal markets for 2–3 months annually (Nyagatare District Connectivity Assessment, 2024).

In the Western Province, districts such as Nyamasheke and Rutsiro face compounded challenges of high humidity, weak road connectivity, and limited community storage infrastructure. The Rwanda Transport Development Agency (RTDA) Feeder Roads Assessment (2024) reports that in Boneza Sector, Rutsiro, only 28% of feeder roads are paved, severely constraining maize evacuation and resulting in estimated losses of 20–25% of harvested maize due to delayed transport. Similarly, in the Northern Province, maize farmers in Rulindo, Burera, and Gakenke are constrained by both inadequate drying infrastructure and transport limitations, particularly in remote sectors where feeder roads are seasonally impassable. The NISR Agriculture Infrastructure Survey (2024) reveals that in Rusarabuye Sector, Burera, 92% of maize farmers lack access to any form of improved storage, with road inaccessibility cited as the primary reason by 78% of surveyed households.

These transport constraints directly contribute to significant postharvest losses across maize-producing regions. According to the MINAGRI Post-Harvest Assessment (2024), poor rural connectivity results in maize postharvest losses ranging between 15–28% in affected sectors, with transport delays accounting for approximately 40% of these losses. In Nyagatare District, where only 44% of feeder roads are usable year-round (MININFRA District Road Inventory, 2024), maize postharvest losses reach 22–25% in sectors such as Rwimiyaga and Karangazi, largely due to delayed evacuation and inadequate drying conditions exacerbated by transport bottlenecks. The World Bank Rwanda Agricultural Logistics Study (2024) estimates that transport-related losses for maize cost Rwandan farmers approximately $12–15 million annually in reduced quality and quantity.

These constraints are particularly acute across maize-producing districts in all provinces: in the Eastern Province (Nyagatare, Gatsibo, Kayonza, Ngoma, and Kirehe), difficult terrain and seasonal rainfall patterns combine with inadequate road infrastructure to create persistent transport challenges; in the Southern Province (Nyamagabe and Kamonyi), hilly topography and limited road maintenance capacity exacerbate connectivity issues; in the Western Province (Nyamasheke and Rutsiro), high humidity and remote production zones compound transport difficulties; and in the Northern Province (Rulindo, Burera, and Gakenke), mountainous terrain and seasonal road closures severely limit market access. According to the RAB District Agricultural Profiles (2024), these transport constraints directly undermine maize commercialization efforts, with estimated economic losses of 18–22% in potential farmer income due to reduced market access and quality deterioration during transport.

The persistent transport and connectivity gaps present a significant barrier to achieving PSTA-5 objectives of reducing maize postharvest losses below 5% by 2029 and increasing marketable surplus through improved rural infrastructure. Without targeted investments in feeder road rehabilitation and maintenance, particularly in high-production sectors, Rwanda's maize value chain will continue to face constrained market access, elevated postharvest losses, and limited income growth for smallholder farmers, despite increasing production volumes under national agricultural transformation initiatives.

Investments and Access to Postharvest Services: Although investments in grain hubs, warehouses, metallic silos, and feeder roads are increasing under PSTA-5 implementation, access remains limited for most smallholder maize producers, particularly in remote and hilly production zones. According to the World Bank's Rwanda Food Smart Country Diagnostic (2024), coverage of improved postharvest infrastructure remains insufficient to significantly reduce national maize losses, with only 32% of maize-farming households having access to essential services such as drying platforms, moisture testing, grading, and professionally managed storage. This service gap continues to constrain maize quality, value addition, and commercialization, despite national investment commitments.

The NAEB Investment Pipeline Report (2024) confirms that while the newly announced Kigali grain hub with 40-tonne daily processing capacity represents progress, district-level centers in Rulindo, Bugesera, Nyagatare, and Rubavu remain under construction with completion expected only by 2026, creating interim service gaps in high-production regions. These investment delays mean that many farmers continue to face significant access barriers: in Gatsibo District, only 3 of 14 sectors (21%) have professionally managed storage facilities, and most farmers lack access to moisture testing and grading services that are critical for quality-based pricing (World Bank, Rwanda Food Smart Country Diagnostic, 2024).

These service gaps are most evident in high-production districts of the Eastern Province, particularly in rural and peripheral sectors that lack agro-industrial infrastructure. In Rwimiyaga Sector, Nyagatare District, which produces over 9,200 tonnes of maize annually, there are no medium-scale milling facilities within a 15 km radius, forcing farmers to either sell raw grain or incur high transport costs for processing (Nyagatare District Agricultural Report, 2024). Similarly, in Kiziguro Sector, Gatsibo District, maize farmers must travel an average of 14 km to access a functioning milling unit, resulting in transport-related losses of 8-12% and added costs that reduce farmer margins by 15-20% (Gatsibo DDP, 2024).

Other significantly underserved sectors include Tabagwe and Karangazi (Nyagatare District), where over 75% of maize farmers lack access to community storage; Muhura and Gasange (Gatsibo District), where only 2 community drying platforms serve approximately 6,500 farming households; Murama and Rwinkwavu (Kayonza District), where postharvest service coverage reaches less than 30% of maize producers; Kibungo and Zaza (Ngoma District), where grading and moisture testing services are available to only 22% of farmers; and Nyarubuye and Mahama (Kirehe District), where professional storage management reaches just 18% of maize volumes (RAB District Profiles, 2024).

The infrastructure and service gaps are most pronounced in Rwanda's major maize-producing provinces. In the Eastern Province, districts including Nyagatare, Gatsibo, Kayonza, Ngoma, and Kirehe face acute shortages of drying platforms and community warehouses: in Tabagwe Sector, Nyagatare, maize farmers travel an average of 11 km to access the nearest storage facility, resulting in transport-related losses of 18% (RAB Post-Harvest Services Assessment, 2024). In the Southern Province, districts including Nyamagabe and Kamonyi experience limited access to improved drying and storage infrastructure: in Mugano Sector, Nyamagabe, 88% of maize is dried on bare ground, significantly increasing aflatoxin risks that affect approximately 25% of harvests (District Development Strategies, 2024).

These persistent service gaps directly undermine Rwanda's efforts to achieve PSTA-5 objectives of reducing maize postharvest losses below 5% by 2029 and increasing value addition through improved processing infrastructure. Without accelerated investment deployment and enhanced service coverage, particularly in high-production sectors, smallholder maize farmers will continue to face constrained market

access, quality limitations, and reduced income potential, despite increasing production volumes under national agricultural transformation initiatives.

3.3.1.2. Persistent Post-Harvest Losses

Maize postharvest losses remain a persistent and significant challenge in Rwanda, undermining food security, farmer incomes, and the country's agricultural transformation agenda. The most recent Rwanda Agriculture Board (RAB) assessments estimate national maize postharvest losses at approximately 13.8% between harvest and market, indicating that losses remain high despite ongoing policy and programmatic interventions (RAB, 2023). Evidence from international datasets, including APHLIS, suggests that maize losses in Rwanda typically range between 14–16%, reinforcing the persistence of the problem (APHLIS, 2022–2023).

National averages mask substantial subnational variation, with higher losses reported in major maize-producing districts where infrastructure and logistics constraints are most severe. Household-level surveys conducted in Nyamasheke and Nyamagabe districts show that a large proportion of maize farmers' experience postharvest losses, often exceeding 15–20% of harvested volumes, particularly during peak harvest periods when drying and storage capacity is overwhelmed (District Development Strategies, 2023/24; CCOAIB Smallholder Postharvest Survey, 2025). These findings indicate that household-level losses in some production zones significantly exceed national averages. Losses accumulate across multiple stages of the postharvest value chain. According to the MINAGRI Postharvest Loss Assessment, maize losses typically occur during harvesting (through spillage and incomplete collection), drying (due to rain exposure and poor practices), storage (from pests, moisture, and quality deterioration), and transportation and handling (MINAGRI, 2024).

The World Bank Rwanda Food Smart Country Diagnostic highlights that weak logistics, poor rural roads, and inadequate handling infrastructure are major contributors to food loss and waste across staple value chains, including maize, even though precise maize-specific proportions by stage are not consistently disaggregated (World Bank, 2021; World Bank, 2024). The economic implications of these losses are substantial. Food loss and waste are estimated to impose significant costs on Rwanda's economy, with staple crops such as maize accounting for a large share due to their production volumes and strategic importance (World Bank, 2021; Rockefeller Foundation, 2022). At farm level, postharvest losses translate into meaningful reductions in household income, particularly in high-production districts such as Nyagatare, Gatsibo, and Kayonza, where maize is a key livelihood crop (RAB, 2023; District Agricultural Profiles, 2024).

Persistent postharvest losses also undermine Rwanda's agricultural transformation objectives. While maize productivity has increased under PSTA-4 due to improved seed and agronomic practices, a significant share of these gains is eroded by inefficiencies in drying, storage, handling, and marketing (MINECOFIN, 2024; RAB, 2023). This poses a major risk to PSTA-5 targets, particularly the objective of reducing postharvest losses for priority staples to below 5% and accelerating commercialization and value addition. Food safety concerns further compound the problem. Monitoring by the Rwanda Standards Board (RSB) shows that aflatoxin contamination remains a recurring issue in maize from high-loss districts, largely linked to inadequate drying and poor storage conditions, which restrict access to formal markets and pose public health risks (RSB Food Safety Monitoring Report, 2024).

Overall, maize postharvest losses remain a critical bottleneck in Rwanda's food system. Addressing them will require coordinated investments in drying and storage infrastructure, improved rural connectivity, strengthened aggregation systems, and expanded farmer training on postharvest practices, in line with PSTA-5 priorities. Without such integrated interventions, productivity gains in maize will continue to be partially offset by avoidable losses, limiting progress toward food security, income growth, and agricultural transformation goals (PSTA-5; RAB, 2023; World Bank, 2021).

3.3.1.3. Low Adoption of Postharvest Technologies and Capacity Gaps

Across Rwanda's maize value chain, technical skill gaps remain a key driver of persistent postharvest losses. At the farmer level, adoption of modern postharvest technologies is extremely low, with fewer than 20% of maize farmers using hermetic storage (PICS bags, metal silos), moisture meters, solar dryers, or improved cribs (MINAGRI, 2024; NISR, 2023; CCOAIB Survey, 2025). In Nyamagabe District, access to these technologies is particularly limited, driving demand for affordable dryers, cold rooms, and renewable-energy cooling systems. In Nyamasheke District, uptake is further constrained by limited technical knowledge, with only a few cooperatives such as KODIKA and CODEANYA using ZECCs, shellers, or improved drying facilities. Less than 50% of farmers reported having received any formal postharvest management training, and even when training occurs, follow-up support from extension services is inconsistent, limiting sustained adoption of best practices (CCOAIB Survey, 2025).

At the cooperative and small processing unit level, technical capacity is limited, contributing to underutilization of existing infrastructure. Many operators lack the skills to operate and maintain milling machines, calibrate fortification equipment, control contamination, or comply with Rwanda Standards Board (RSB) requirements, which reduces product quality and restricts market access. As a result, even where equipment exists, throughput and processing efficiency remain low, limiting opportunities for value addition and commercialization. Notable examples include small processing units in Nyagatare (Rwimiyaga, Tabagwe, Karangazi sectors), Gatsibo (Kiziguro, Muhura sectors), Kayonza (Murama sector), and Ngoma (Kibungo and Zaza sectors), where equipment is underutilized due to operator skill gaps (Agenda Agricole, 2023/24; RAB, 2023).

In terms of postharvest handling and logistics, maize aggregation, bagging, stack management, pest monitoring, and record-keeping are constrained by low technical knowledge among smallholders and cooperative managers. Surveys cited by RAB and the World Bank (2021–2023) show that a majority of farmers and value-chain actors, particularly in Nyamasheke, Nyamagabe, Kayonza, Nyagatare, and Gatsibo, cannot identify critical loss points or adopt improved practices. Women and youth are disproportionately affected due to lower access to tailored training and mentorship programs, further reinforcing inequities in postharvest management capacity.

At the institutional level, training programs remain insufficient and fragmented. Short-term workshops rarely provide practical, hands-on skills development, and coordination between extension services, TVET institutions, cooperatives, and the private sector is weak. Integration of Gender Equality and Social Inclusion (GESI) principles is limited, further restricting access for marginalized groups. Consequently, maize production gains under PSTA-4, including a 35% increase in maize yields between 2018–2023, are partially offset by postharvest losses caused by inadequate technical skills, undermining PSTA-5 targets for loss reduction, value addition, and income growth (NAP, NST2; Agenda Agricole 2023/24; RAB, 2023; World Bank, 2021–2023).

3.3.1.4. Weak Market Linkages

Weak market linkages between maize producers, aggregators, and processors remain a critical constraint in Rwanda, limiting both value addition and price realization for smallholder farmers. Aggregation systems are fragmented, with most farmers selling maize individually in informal or spot markets rather than through structured channels that could offer quality-based price incentives and long-term contracts. Informal market transactions dominate, and small traders and local collection points are the main outlets, while access to larger formal processors is limited and concentrated in urban centers (Maize Value Chain Report, 2024). Nationally, although about 44% of maize produced is marketed, only 23% passes through formal market channels, highlighting the significant reliance on informal sales where price premiums for quality are absent (Warner et al., 2024). Cooperative structures, intended to facilitate aggregation, often lack commercial orientation, management capacity, and financial resources to link farmers effectively with processors. Only around 32% of maize cooperatives have formal buyer contracts, limiting stable supply and reducing incentives for quality improvement (ATAI/CEGA, 2023).

District-specific evidence highlights pronounced challenges. In Nyamagabe District, smallholders often sell maize individually to middlemen, reducing bargaining power and limiting access to structured markets or postharvest infrastructure. Cooperative-led aggregation is weak, and price volatility at farm-gate levels remains high, undermining household incomes. In Nyamasheke District, most farmers operate independently rather than through cooperatives, limiting access to shared storage, sorting, and value-added facilities. Consequently, farmers face low and unpredictable prices despite being in high-production areas. In the Eastern Province, districts such as Nyagatare, Gatsibo, and Kayonza show similar patterns: fragmented aggregation, limited contractual arrangements with millers, and weak commercial orientation among farmer groups. Farmers in remote sectors such as Rwimiyaga (Nyagatare), Kiziguro (Gatsibo), and Murama (Kayonza) are particularly affected, often transporting maize long distances to access market points, which increases postharvest losses and reduces effective income.

Pilot initiatives are beginning to address these gaps. For example, the FARM P3 programme in Kayonza District facilitates structured partnerships between cooperatives, SMEs, buyers, and financial institutions. This model provides training in quality standards, postharvest handling, and aggregation, helping farmers access better prices and stabilize supply chains (IFAD/WFP FARM P3, 2025). However, the reach of such programs remains limited, and scaling these solutions is essential to reduce maize postharvest losses and improve commercialization across high-production districts.

3.3.1.5. Financial Constraints

Limited Access to Finance: Smallholder farmers and cooperatives struggle to secure affordable loans or grants due to strict collateral requirements, high operational risks, and lack of tailored financial products for postharvest infrastructure. This restricts investment in storage, drying, and processing technologies (MINAGRI, 2024; RAB, 2023). Investment Gaps: Lack of working capital prevents maize farmers and cooperatives from upgrading milling, drying, storage, and transport facilities, reducing value addition and competitiveness. For example, many cooperatives in Nyamasheke, Nyamagabe, and Nyagatare cannot afford solar dryers, mini-warehouses, or hermetic storage units (CCOAIB Survey, 2025).

High Cost of Cold-Chain Infrastructure: Only ~5% of agricultural firms use refrigerated transport due to high capital, operational, and fuel costs. Most smallholders rely on non-refrigerated means, which increases

losses for maize and other perishables (Clean Cooling, 2025). Limited Private Sector Investment: Low profitability and high financing barriers discourage private sector engagement in maize postharvest infrastructure, including mechanized drying, storage, and processing facilities (NAEB Annual Report, 2023–2024).

Fragmented Public Financing and Planning: Public investment in postharvest infrastructure is increasing under PSTA-5, but remains constrained by limited budgets and competing priorities. Fragmented planning and weak coordination across agriculture, transport, and energy sectors reduce the efficiency and sustainability of existing infrastructure investments (Clean Cooling, 2025; World Bank, 2021).

Insufficient Financial Instruments: The availability of blended finance, concessional loans, or partial credit guarantees targeting maize postharvest technologies is limited, restricting mobilization of private capital for community storage, mechanical dryers, and cold-chain expansion (Rwanda Agriculture Finance Year Book, 2018). Impact on Value Addition and Income: Financing constraints directly reduce maize value addition, quality, and access to formal markets. Farmers often sell immediately at low prices due to lack of storage or processing options, perpetuating income instability (RAB, 2023; CCOAIB Survey, 2025).

Access to affordable finance remains a major barrier for improving maize postharvest management across Rwanda. For smallholder maize farmers, the high upfront costs of improved storage technologies such as hermetic bags, metal silos, and solar or mechanical dryers limit adoption. Seasonal income variability further constrains investment decisions, as farmers often prioritize immediate consumption and debt repayment over longer-term infrastructure improvements (MINAGRI, 2024; RAB, 2023).

At the cooperative and SME level, limited access to tailored financial products restricts investments in shared postharvest infrastructure, including community storage facilities, mechanical dryers, and maize processing equipment. Commercial banks allocate only about 6% of lending to agriculture, with an even smaller fraction directed specifically to postharvest infrastructure (Public Financing in Rwanda's Agriculture Sector, 2018).

Collateral requirements and the perceived high risk of agricultural lending further reduce the flow of finance to smallholders and cooperatives (Rwanda Agriculture Finance Year Book, 2018). These constraints have tangible impacts on maize value addition and commercialization. Without affordable credit or partial credit guarantees, cooperatives in districts such as Nyamasheke, Nyamagabe, and Nyagatare cannot acquire solar dryers or mini-warehouses, limiting their capacity to maintain grain quality and supply formal and export markets. Working capital shortages also prevent upgrades to milling, drying, storage, and transport facilities, reducing competitiveness and the potential for value addition (MINAGRI, 2024; CCOAIB Survey, 2025).

Public financing for postharvest infrastructure, while increasing under PSTA-5, still faces budget limitations and competing priorities, constraining both infrastructure expansion and long-term maintenance. The limited availability of blended finance instruments, concessional loan windows, and partial credit guarantees targeted at maize postharvest solutions further restricts investment mobilization from private sources (Rwanda Agriculture Finance Year Book, 2018; NAEB, 2024). In summary, finance gaps at both the farm and cooperative level remain a key obstacle to reducing postharvest losses, enhancing maize quality, and promoting value addition, underscoring the need for innovative financing mechanisms tailored to the maize sector.

3.3.1.6. Aflatoxin Risks

Inadequate storage systems remain one of the most critical constraints to maize quality and safety in Rwanda. Traditional storage practices including storage in porous bags, open containers, and poorly ventilated rooms predominate among smallholder farmers, creating conditions favorable for aflatoxin contamination caused by Aspergillus fungi. National surveys indicate that approximately 10% of maize samples from 15 districts, including Nyamasheke, Nyagatare, and Gatsibo, are contaminated with aflatoxins, posing serious risks to human and animal health (Rockefeller Foundation, 2022; RAB, 2023).

The prevalence of aflatoxin is aggravated by several postharvest handling shortcomings. Improper drying leaves maize moisture levels above safe thresholds, particularly in high-humidity districts such as Nyamagabe and Nyagatare, while poor sanitation and storage hygiene facilitate cross-contamination. Limited monitoring systems for early detection and insufficient awareness among farmers and traders on mycotoxin risks further exacerbate the problem (MINAGRI, 2024; CCOAIB Survey, 2025). Economically, aflatoxin-contaminated maize suffers market rejection, price penalties, and restricted access to premium markets, including institutional buyers like the World Food Program and school feeding programs, as well as export channels (NAEB Annual Report, 2023–2024).

The limited adoption of hermetic storage solutions including PICS bags and metal silos remains a significant barrier. High upfront costs, limited availability, and insufficient technical support restrict uptake, particularly among smallholders in rural districts such as Nyamasheke, Nyagatare, and Kayonza (RAB, 2023; MINAGRI, 2024).

Even where improved storage facilities exist, operational challenges reduce their effectiveness. Irregular maintenance, improper loading techniques, and inadequate monitoring undermine the capacity of hermetic or community storage units to preserve grain quality and minimize mycotoxin accumulation. These deficiencies underscore the urgent need for targeted interventions in technical training, affordable storage solutions, and community-level postharvest infrastructure to reduce losses, enhance food safety, and improve marketability of maize in Rwanda (CCOAIB Survey, 2025; Clean Cooling, 2025).

3.3.1.7. Quality Control and Food Safety Compliance

Quality management systems for maize in Rwanda remain underdeveloped, undermining both domestic food safety and export potential. At farm and collection levels, quality assessment is predominantly visual rather than based on objective measurements of moisture content, foreign matter, or mycotoxin levels. This subjective approach leads to inconsistent quality standards and limits opportunities for price differentiation based on measurable quality attributes, particularly in high-production districts such as Nyagatare, Gatsibo, and Nyamasheke (RAB Smallholder Survey, 2023; CCOAIB Postharvest Survey, 2025).

Formal quality certification systems face implementation challenges, including limited laboratory capacity, high testing costs, and uneven enforcement across districts. The Rwanda Standards Board (RSB) has established maize quality standards, but their application remains partial, especially in rural and informal markets where most smallholders operate (RSB Food Safety Monitoring Report, 2024; NAEB Annual Report, 2023–2024). This variability constrains maize entry into higher-value market segments, including premium retail, industrial use, and export markets where consistent quality and safety are prerequisites.

Aflatoxin contamination exemplifies Rwanda's food safety compliance gaps. Approximately 10% of maize samples from 15 districts, including Nyamasheke, Nyagatare, Gatsibo, and Kayonza, exceed safe aflatoxin thresholds, highlighting limitations in monitoring and farmer awareness of mitigation strategies (Rockefeller Foundation, 2022; RAB Aflatoxin Assessment, 2023). Weak traceability and limited testing infrastructure allow contaminated maize to enter the food chain, posing health risks and undermining consumer confidence (MINAGRI, 2024; World Bank Rwanda Food System Diagnostic, 2024).

These quality and safety limitations directly affect Rwanda's strategic objectives under NST2, including substituting maize imports and developing export-oriented maize products with premium positioning in regional markets. Strengthening postharvest quality management systems including robust testing, certification, traceability, and farmer training remains critical for reducing losses, improving food safety, and enhancing market competitiveness (Clean Cooling, 2025; CCOAIB Survey, 2025).

3.3.1.8. Governance and Coordination Gaps

The institutional landscape for maize postharvest management in Rwanda is characterized by coordination gaps and overlapping mandates among implementing agencies. Key institutions including MINAGRI, RAB, NAEB, MINICOM, RSB, and district authorities hold responsibilities for postharvest systems, but integrated planning and execution remain limited (MINAGRI, 2024; RAB Postharvest Report, 2023). This fragmentation leads to duplication of efforts, inefficient resource use, and inconsistent guidance for farmers, cooperatives, and value chain actors. At the district level, implementation capacity varies considerably. Districts such as Nyagatare, Gatsibo, and Nyamasheke demonstrate technical capacity and planning constraints, with limited budget allocations and inadequate tools to operationalize national postharvest strategies effectively (District Agricultural Profiles, 2024). Coordination challenges are further compounded by investment sequencing issues, where storage facilities and cold-chain infrastructure are established without corresponding improvements in feeder roads, reliable electricity, or aggregation systems, reducing the utilization and effectiveness of these investments (World Bank, 2023; Clean Cooling, 2025).

Monitoring and evaluation (M&E) systems for maize postharvest interventions are underdeveloped. Standardized indicators for tracking postharvest losses, infrastructure usage, and quality improvements are limited, constraining evidence-based decision-making and reducing accountability for achieving maize postharvest reduction targets (Rwanda Governance Board, 2024; RAB, 2023). While RGB performance scorecards provide a potential platform for monitoring agricultural outcomes, they currently lack maize-specific postharvest metrics. Policy coherence between national strategies (NST2, PSTA-5) and district-level implementation requires strengthening to ensure maize postharvest priorities are effectively reflected in District Development Plans (DDPs) and receive adequate budgetary support (MINAGRI, 2024; PSTA-5 Review, 2024). Without improved coordination across administrative levels and sectoral institutions, efforts to reduce maize postharvest losses are likely to remain fragmented, limiting their overall impact on food security, farmer incomes, and national value chain development.

3.3.1.9. Information Flow

Information flow is an increasingly important constraint within Rwanda's maize value chain. Although the Government has introduced several agricultural information systems, farmers and other value-chain actors do not yet have uniformly timely, integrated and actionable information covering production, post-harvest

handling, grain quality, market prices, buyer requirements, storage options and processing demand. MINAGRI's 2024/25 Annual Report explicitly identifies poor market access and insufficient information on agricultural practices among the persistent challenges that Rwanda's agricultural digitalization agenda is intended to address. The same report identifies the Integrated Agriculture Management Information System (AMIS), e-Soko, Smart Nkunganire System (SNS), soil information systems and other digital platforms as components of the country's emerging digital agriculture architecture (MINAGRI, 2025).

For maize specifically, information asymmetry is particularly important because quality determines marketability. A World Bank assessment of Rwanda's food system found that domestic maize supplies have at times failed to meet the quality standards required by major buyers, with high moisture content and impurities contributing to aflatoxin contamination and losses. This indicates that farmers need timely information not only about prices but also about moisture requirements, drying standards, aflatoxin prevention, grading and buyer specifications before they sell their grain (World Bank, 2020).

Evidence from recent maize research also demonstrates the importance of information acquisition in technology adoption. Ngango and Hong (2021), using evidence from Rwanda, found that information acquired through extension services, media and farmer networks significantly influenced the speed at which farmers adopted improved maize varieties and fertilizer practices. The study therefore provides evidence that the effectiveness of agricultural transformation depends partly on how quickly and reliably information moves from extension systems and other knowledge sources to farmers.

The information gap also extends to plant health and pest management. Research involving 644 farmers across Rwanda found that maize farmers faced knowledge and information constraints regarding pests and diseases. Farmers using plant clinics demonstrated greater awareness and knowledge of maize stem borers and pest-management practices, illustrating the potential value of specialized information channels alongside conventional extension services (Uzayisenga et al., 2019). More recently, research on 967 maize plots in Rwanda found that sources of information are important determinants of farmers' technology-adoption decisions for fall armyworm and maize-stemborer management. The authors consequently emphasize awareness creation and improved access to information as important components of technology adoption (2025).

Key information-flow gaps

- Limited integration of information systems: Rwanda has AMIS, e-Soko and other digital platforms, but agricultural information remains distributed across multiple systems rather than being consistently integrated into a single farmer-oriented information service.
- Insufficient market information: Farmers need timely information on prevailing prices, buyers, quantities demanded, collection points and market opportunities.
- Weak quality information: Farmers require clearer information on acceptable moisture levels, grading, aflatoxin prevention and buyer-specific quality standards.
- Limited post-harvest information: Information services tend to be more strongly associated with production than with the full post-harvest sequence of drying, storage, pest management, quality testing, packaging and marketing.
- Information asymmetry between farmers and buyers: Farmers may not know the quality specifications required by processors until the grain is inspected or rejected.
- Uneven access to digital information: Digital platforms offer considerable potential, but their effectiveness depends on farmers' connectivity, digital literacy, language, affordability and ability to convert information into decisions.

- Weak feedback loops: Information should flow in both directions farmers need information from buyers and extension agents, while processors and policymakers need timely information from farmers about volumes, quality and expected supply.

3.3.1.10. Gaps in Agricultural Extension Services for Maize

The evidence indicates that Rwanda has an extensive agricultural extension architecture, but the major challenge is increasingly quality, specialization and responsiveness, rather than simply the existence of extension services. A particularly useful national benchmark comes from the 2020 Agricultural Household Survey (AHS). According to the Government's 2024 *Analysis of Employment and Skills in the Maize Value Chain in Rwanda*, approximately 65% of agricultural households accessed some form of agricultural extension service in 2020. However, extension was obtained through multiple channels: agricultural information through media accounted for 32.3%, local government officials at district, sector and cell levels for 21.2%, meetings and community work for 14.0%, farmer/livestock promoters for 11.4%, NGOs and companies for 8.4%, and central government officials for only 3.0%.

This evidence is important because it shows that extension coverage is not equivalent to intensive, specialized maize post-harvest advisory support. The 65% figure refers to households accessing *any form* of agricultural extension, covering a broad range of topics including soil erosion, nutrition, horticulture, post-harvest handling and storage, Smart Nkunganire, integrated pest management, weather information, livestock and agribusiness. It should therefore not be interpreted as 65% of maize farmers receiving maize-specific post-harvest extension. This distinction is particularly important for the present assessment. There is insufficient recent nationally representative evidence showing what proportion of maize farmers receive specific advice on drying, moisture measurement, hermetic storage, aflatoxin prevention, grain grading, packaging and post-harvest marketing. This itself constitutes an evidence and monitoring gap.

Extension services are not yet sufficiently specialized in post-harvest management

The Government has traditionally relied heavily on the Twigire Muhinzi model, involving Farmer Promoters and Farmer Field School facilitators. MINAGRI previously reported approximately 14,200 Farmer Promoters and 2,500 Farmer Field School facilitators, with training delivered through demonstration plots, field days and village meetings. At the same time, the Ministry explicitly recognized the need to strengthen the technical capacity of extension workers, Farmer Promoters and Farmer Field School facilitators and to harmonize the approaches used by public and private extension providers (MINAGRI, 2019). More recent evidence shows that Rwanda is still investing in professionalizing this system. In October 2025, RAB and One Acre Fund graduated the first cohort of 55 sector agronomists and Farmer Promoters from an agricultural extension certification programme covering four priority food-basket zones: Kirehe, Rwamagana, Kamonyi and Huye. The programme was explicitly designed to strengthen a coordinated, farmer-centred and market-responsive extension system (RAB, 2025).

This recent investment is positive, but it also demonstrates that professionalization and modernization of extension remain ongoing priorities. For maize post-harvest management, extension personnel need specialized competencies in optimal harvesting timing; shelling and threshing; moisture measurement; mechanical and solar drying; hermetic storage; pest and rodent management; aflatoxin prevention; grain grading and quality standards; warehouse management; aggregation; market information; contract farming; and linking farmers to processors and buyers.

In a nutshell, Rwanda has established a relatively extensive agricultural extension and information system, but important gaps remain in the coverage, specialization, integration and timeliness of information and advisory services relevant to maize post-harvest management. Evidence from the 2020 Agricultural Household Survey indicates that approximately 65% of agricultural households accessed some form of agricultural extension service; however, these services covered a broad range of agricultural topics and should not be interpreted as maize-specific or post-harvest-specific coverage. Extension information was obtained through multiple channels, including agricultural media (32.3%), local government officials (21.2%), meetings and community work (14.0%), farmer/livestock promoters (11.4%), and NGOs and private companies (8.4%) (Republic of Rwanda, 2024).

For maize, the critical gap is therefore not simply the absence of extension services but the limited availability of specialized and timely post-harvest advisory support. Farmers require practical information on harvesting, shelling, drying, moisture measurement, hermetic storage, aflatoxin prevention, grading, packaging, storage management and market requirements. Evidence from Rwanda shows that access to information through extension services, media and farmer networks significantly influences the adoption of improved maize technologies (Ngango & Hong, 2021), while more recent research confirms that information sources influence farmers' adoption of fall armyworm and stemborer management technologies (2025). Information asymmetry is also evident in maize marketing and quality management. World Bank evidence indicates that high moisture content and impurities have contributed to aflatoxin contamination and failure of domestic maize supplies to meet the quality requirements of major buyers (World Bank, 2020). Farmers therefore need better access to information concerning moisture standards, grain quality, aflatoxin prevention, buyer specifications, prevailing prices and available markets.

Rwanda has begun addressing these constraints through digital agricultural information systems, including AMIS and e-Soko, as well as through ongoing professionalization of extension services. In 2025, RAB and One Acre Fund trained and certified a first cohort of 55 sector agronomists and Farmer Promoters, while MINAGRI introduced plans for more customized, crop- and farmer-specific extension services under the Food Basket Sites approach (RAB, 2025; MINAGRI, 2025).

3.3.2. Integrated Postharvest Value Chain for Rice

Harvesting and Threshing Infrastructure: Inadequate access to mechanical harvesting and threshing equipment remains a major constraint in Rwanda's rice postharvest system, leading to significant field losses and grain quality deterioration. Recent assessments indicate that mechanization levels in rice harvesting and threshing are still very low, with the majority of farmers relying on labor-intensive manual practices. According to the Rwanda Agriculture Board (RAB) Rice Value Chain Assessment (2024), only about 18% of rice farmers use mechanical threshers, while 82% depend on manual threshing, a practice associated with 8–12% grain losses and a higher proportion of broken grains that reduce market value. These challenges are particularly evident in major marshland rice production zones such as Rwasave Marshland in Huye District and Rugezi Marshland in Burera District, where limited availability of harvesting and threshing equipment causes delays at peak harvest periods. As a result, farmers experience additional 5–7% pre-harvest losses due to bird damage and grain shattering when mature rice remains unharvested in the field. These losses undermine productivity gains, lower farmer incomes, and reduce the overall efficiency of the rice value chain (RAB, 2024; MINAGRI Rice Sector Profile, 2024).

Insufficient drying infrastructure and weak moisture management remain critical gaps in Rwanda's rice postharvest system, forcing most producers and cooperatives to rely on traditional open-air drying methods that compromise grain quality. National evidence shows that drying practices are largely inadequate: the MINAGRI National Post-Harvest Assessment (2024) estimates that over 75% of rice is

sun-dried on bare ground or paved surfaces, exposing paddy to contamination and resulting in high moisture variability ranging from 14% to 22%, well above recommended safe storage levels. This uneven drying significantly increases the risk of mold development and mycotoxin contamination, particularly during periods of high humidity and rainfall. The challenge is most pronounced in major marshland rice production zones such as Nasho Marshland in Kirehe District and Muvumba Marshland in Nyagatare District, where access to improved drying infrastructure remains limited. In these areas, only about 15% of rice cooperatives have access to mechanical dryers, forcing the majority to depend on sun drying even during the rainy season. As a result, drying-related losses are estimated at 6–9%, eroding both the quantity and market quality of rice produced. These constraints undermine farmers' ability to meet quality standards required by millers and formal markets, ultimately reducing price realization and value addition along the rice value chain (MINAGRI, 2024; RAB Marshland Rice Report, 2024).

Inadequate and poorly maintained storage infrastructure remains a major constraint in Rwanda's rice postharvest system, contributing significantly to quantitative and qualitative losses after harvest. Evidence from the RAB Storage Infrastructure Audit (2024) indicates that only 35% of rice storage facilities in the Eastern Province meet recommended standards for aeration and pest control, exposing stored paddy to insect infestation, moisture ingress, and contamination. The situation is particularly acute in rice-producing districts such as Ngoma and Kayonza, where storage is still dominated by traditional or semi-improved facilities. In these districts, rice stored under such conditions experiences 8–10% weight loss within six months, largely driven by insect damage and poor sanitation. Compounding these losses, the MINAGRI Rice Warehousing Study (2024) reports that fewer than 20% of rice warehouses nationwide are equipped with humidity control systems, a critical shortfall in humid and flood-prone marshland environments. The absence of controlled storage conditions accelerates grain deterioration, reduces milling recovery rates, and limits the ability of farmers and cooperatives to store rice for off-season sales, ultimately undermining income stability and value chain efficiency (RAB, 2024; MINAGRI, 2024).

Limited milling and processing capacity continues to constrain value addition and quality upgrading in Rwanda's rice value chain. The sector is dominated by small-scale milling units operating with outdated and inefficient technology, resulting in low milling recovery rates and inconsistent grain quality. According to the Rwanda Standards Board (RSB) Milling Sector Survey (2024), more than 65% of rice mills operate below 50% of their installed capacity, primarily due to aging equipment, frequent breakdowns, and unreliable electricity supply. As a result, the average milling recovery rate ranges between 60–65%, significantly below the 68–72% recovery rates achievable with modern milling technologies, leading to higher proportions of broken rice and reduced market value.

These constraints are particularly evident in emerging rice production hubs such as Bugesera and Gatsibo districts, where production volumes are increasing but processing capacity has not kept pace. In these districts, fewer than 10% of mills are equipped with essential quality-enhancing technologies such as color sorters and graders, limiting compliance with Rwanda Standards Board quality requirements and reducing competitiveness in premium domestic and regional markets. The MINICOM Rice Processing Report (2024) further notes that these processing inefficiencies discourage private investment and weaken linkages with institutional buyers, ultimately constraining income gains for rice farmers and cooperatives (RSB, 2024; MINICOM, 2024).

Weak quality control systems and limited enforcement of standards continue to undermine the marketability and competitiveness of Rwandan rice. Although national quality standards for rice are clearly

defined by the Rwanda Standards Board (RSB), compliance remains low across much of the value chain, particularly among small- and medium-scale millers. The RSB Food Safety and Quality Report (2024) indicates that only about 40% of milled rice available on the market meets national standards for key parameters such as moisture content, percentage of broken grains, and foreign matter. At the processing level, quality assurance practices are insufficient: in major rice production hubs in Eastern Province, fewer than 25% of rice mills conduct regular laboratory-based quality testing, relying instead on visual inspection and informal grading methods (RSB, 2024).

Food safety risks further compound these challenges. The same RSB assessment reports that aflatoxin contamination is detected in approximately 8% of sampled rice, reflecting gaps in drying, storage, and post-milling handling practices. Limited testing capacity, high costs of laboratory analysis, and uneven enforcement across districts restrict routine monitoring and compliance, allowing substandard rice to circulate in domestic markets. These weaknesses erode consumer confidence and significantly constrain Rwanda's ability to access higher-value outlets, including institutional buyers and regional export markets. The NAEB Export Readiness Assessment (2024) highlights that inconsistent quality and weak traceability remain key barriers to scaling rice exports, despite rising production. Strengthening quality control, expanding affordable testing services, and enforcing standards more consistently are therefore critical to improving rice market performance and supporting national objectives on import substitution and export competitiveness (RSB, 2024; NAEB, 2024).

Unreliable and costly energy supply remains a critical constraint to efficient rice milling and postharvest operations, particularly for parboiled rice, which is highly energy-intensive. The REG Energy Access in Agriculture Report (2024) indicates that rice mills located in rural and peri-urban areas experience an average of 12–15 electricity outages per month, resulting in frequent production stoppages, equipment damage risks, and delays in order fulfillment. To cope with these disruptions, many processors rely on diesel generators, which significantly increase operating costs. REG estimates that generator use raises rice processing costs by 20–25%, reducing profit margins and competitiveness, especially for small and medium-scale millers (REG, 2024). The impact is particularly pronounced in key rice-producing districts such as Huye and Nyamagabe, where energy constraints directly limit value addition. According to the same REG report, 45% of rice processors in these districts identify high and unreliable energy costs as the primary barrier to expanding milling and parboiling operations.

Power instability also constrains the adoption of improved technologies such as mechanical dryers, parboilers, and cold storage for processed rice, undermining quality consistency and market access. The MININFRA Rural Electrification Update (2024) further notes that while rural electrification coverage has expanded, supply reliability and affordability for agro-processing remain weak, highlighting the need for targeted investments in grid stabilization, three-phase power, and renewable energy solutions tailored to rice value chains (REG, 2024; MININFRA, 2024).

Fragmented market linkages and weak aggregation mechanisms continue to constrain the efficiency and competitiveness of Rwanda's rice value chain. The World Bank Agri-Food System Diagnostic (2024) reports that only about 30% of rice farmers market their produce through cooperatives or formal contractual arrangements, while the remaining majority depend on informal spot markets. These transactions are typically characterized by weak bargaining power, limited quality differentiation, and high price volatility, which reduce incentives for farmers to invest in improved production and postharvest practices (World Bank, 2024).

The absence of effective aggregation infrastructure further exacerbates these challenges. In major marshland rice production clusters such as Rweru (Bugesera District) and Gashora, the NAEB Market Linkages Study (2024) finds that approximately 70% of rice-producing sectors lack functional aggregation centers equipped for collective bulking, grading, and storage. As a result, farmers are often compelled to sell paddy immediately after harvest to itinerant traders at depressed prices, particularly during peak harvest periods. This weak aggregation undermines economies of scale, disrupts consistent supply to mills, and limits the development of stable farmer processor relationships necessary for price stability, quality upgrading, and expanded rice value addition (World Bank, 2024; NAEB, 2024).

Limited access to affordable finance remains a critical constraint to upgrading rice postharvest and processing technologies in Rwanda. According to the BNR Sectoral Credit Survey (2024), only 12% of rice millers and processors have accessed formal credit for technology upgrading, with stringent collateral requirements, high interest rates, and perceived lending risks cited as the main barriers. These financing constraints are particularly acute at cooperative level. In the Eastern Province, where rice production is expanding rapidly, more than 80% of rice cooperatives lack sufficient capital to invest in mechanical dryers, improved storage facilities, or modern milling equipment, forcing continued reliance on inefficient and loss-prone postharvest practices (BNR, 2024). The MINECOFIN Agribusiness Financing Review (2024) further highlights that the absence of tailored financial products, concessional credit lines, and partial credit guarantees for agro-processing discourages both cooperative and private-sector investment in rice value addition. As a result, technological upgrading remains slow, postharvest losses persist, and opportunities for quality improvement and market competitiveness in the rice sector remain underexploited.

Institutional coordination remains a significant constraint to the effective development of Rwanda's rice value chain. Overlapping Roles and Responsibilities in Coordination among key institutions including MINAGRI, RAB, NAEB, and the Rwanda Standards Board (RSB) continue to hinder integrated planning and implementation of rice postharvest interventions. The Rwanda Governance Board (RGB) Sector Coordination Assessment (2024) reports that duplication of postharvest and value chain support programs affects approximately 40% of rice-growing districts, leading to inefficient use of financial and human resources and inconsistent guidance to farmers, cooperatives, and processors. These coordination challenges are compounded by weak decentralized implementation capacity. Only 35% of rice-producing districts have dedicated postharvest or value chain extension officers, limiting the translation of national strategies and standards into effective on-the-ground support (RGB, 2024). As a result, investments in harvesting, drying, storage, quality control, and market linkages are often poorly sequenced and insufficiently aligned, reducing their overall impact on rice commercialization, quality improvement, and competitiveness.

Climate resilience of post-harvest infrastructure is a critical gap in Rwanda's rice value chain, as most storage and drying facilities are vulnerable to extreme weather events. The MINEMA Climate Risk Assessment (2024) indicates that over 60% of rice storage facilities in flood-prone districts such as Rwamagana and Kayonza are at high risk of flood damage. In addition, less than 20% of rice drying platforms are elevated or covered, leaving harvested rice exposed to unseasonal rains and increasing post-harvest losses (MINEMA, 2024). These vulnerabilities undermine the effectiveness of existing infrastructure and highlight the need for climate-smart designs and materials, including raised platforms, waterproof shelters, and flood-resistant storage structures, to protect rice quality and reduce economic losses (MINEMA Climate Risk Assessment (2024); RAB Climate-Smart Post-Harvest Review (2024).

Gaps in Information Flow and Extension Services for Rice in Rwanda

★ Gaps in Information Flow

Information flow within Rwanda's rice value chain remains an important constraint, particularly in relation to technical knowledge, market information, quality requirements, mechanization, pest and disease management, and post-harvest practices. The Second National Rice Development Strategy (NRDS2) recognizes research, extension, technology dissemination and advisory services as critical to increasing rice productivity and competitiveness. It specifically calls for improved dissemination of good agricultural practices and innovations to farmers and other rice value-chain actors (Ministry of Agriculture and Animal Resources [MINAGRI], 2021).

A particularly important and very recent indicator comes from Rwanda's Second Annual Rice Sector Review Meeting held in March 2026. The review reported that although Rwanda had made progress in access to agricultural credit, insurance and fertilizer subsidies, only 3% of rice farmers had accessed technical training through plural extension services. The rice-sector stakeholders consequently identified a gap in providing farmers with good agricultural practices (GAPs) through proximity extension services and considered this an important opportunity for improving on-farm productivity (Coalition for African Rice Development [CARD], 2026).

This 3% figure is particularly significant for the present assessment. It should be interpreted as the proportion of farmers accessing technical training through plural extension services, rather than as the proportion receiving no extension services at all. Nevertheless, it provides strong recent evidence of a substantial gap in structured, technical and specialized training for rice farmers. Information gaps are also evident in relation to market demand and quality requirements. Rwanda's NRDS2 envisages a more market-oriented rice industry based on quality-based pricing, production contracts between cooperatives and millers, and grading according to moisture content, purity, variety purity and other grain characteristics (MINAGRI, 2021).

The need for better market and quality information is reinforced by the 2026 rice-sector review. It found that local rice accounted for only 12.81% of mainstream rice markets in Kigali, while the share of mixed-grade rice processed by millers had declined to 24.7%. The review also found differences in price movements between locally produced short-grain and long-grain rice and recommended further attention to market preferences and competitiveness (CARD, 2026).

Consequently, rice farmers need more timely information on:

- prevailing paddy and milled-rice prices;
- buyer and miller requirements;
- moisture and purity standards;
- appropriate rice varieties for different production environments;
- fertilizer and pest-management recommendations;
- irrigation and water-management practices;
- harvesting and post-harvest technologies;
- available mechanization services;
- available drying and milling facilities;
- market demand and consumer preferences; and
- opportunities for contractual arrangements with processors and buyers.

The NRDS2 baseline also provides evidence that rice-sector information needs are not limited to production. In a survey of rice traders, recommendations for improving consumption of local rice included increasing quality and quantity, improving hygiene, purity and whitening, introducing high-yielding

varieties and improving prices. These findings demonstrate the importance of transmitting market feedback from traders and consumers back to farmers and cooperatives (Nzeyimana et al., 2023).

★ Gaps in Extension Services

The most compelling evidence of an extension-service gap is the 3% technical-training access figure reported in the 2026 Annual Rice Sector Review. Despite the existence of Rwanda's decentralized extension architecture, only 3% of rice farmers were reported to have accessed technical training through plural extension services. Rice-sector stakeholders explicitly identified improved proximity extension services as an opportunity for increasing on-farm productivity (CARD, 2026).

This finding is consistent with the NRDS2's earlier diagnosis that the rice subsector required stronger extension and advisory services. NRDS2 describes Twigire Muhinzi as Rwanda's decentralized farmer-oriented extension model, combining Farmer Promoters for broad dissemination of basic messages and Farmer Field Schools (FFS) for more intensive experiential learning. The strategy nevertheless recognizes the need to improve technology dissemination and extension across rice schemes (MINAGRI, 2021). The extension gap is therefore better characterized as a specialization and intensity problem rather than simply the complete absence of an extension system. Rice farmers may receive general agricultural messages while receiving insufficient specialized support on the technical practices required to raise rice productivity and quality.

Limited specialization in rice-specific technical advice
Rice production requires specialized knowledge relating to:

- land preparation and leveling;
- nursery management;
- appropriate transplanting and spacing;
- water management;
- fertilizer application;
- integrated pest and disease management;
- harvesting timing;
- threshing;
- drying and moisture management;
- grain grading;
- post-harvest equipment; and
- milling and quality improvement.

The NRDS2 therefore identifies research and extension as one of its strategic pillars and calls for development and dissemination of appropriate rice technologies and good agricultural practices (MINAGRI, 2021). The 2022 FAO experience in Rwamagana illustrates the value of more intensive, practical extension. A Farmer Field School was established with a 264-member rice cooperative to introduce an integrated fish-rice system. The participating farmer reported that production on the demonstration area increased from approximately 800 kg to 1,108 kg after adopting the new approach. While this is a project-level example rather than a nationally representative estimate, it demonstrates the potential of practical, farmer-centred learning to accelerate adoption of improved rice technologies (FAO, 2022).

3.3.3. Integrated Postharvest Value Chain for Irish Potatoes

Infrastructure Deficiency: Curing infrastructure for Irish potatoes in Rwanda is critically deficient, with near-total absence of dedicated facilities to allow proper wound healing after harvest. According to the RAB Potato Value Chain Assessment (2024), less than 5% of potato farmers have access to curing facilities, and most store potatoes immediately after harvest. This practice contributes to 12–15% losses within the first month of storage due to rot and shrinkage. In high-production zones such as Musanze and Burera districts, which together produce over 200,000 tonnes annually, only 3 commercial curing facilities exist, serving less than 8% of total production (RAB Potato Value Chain Assessment, 2024; MINAGRI National Potato Strategy Implementation Report, 2024). The lack of accessible curing infrastructure directly undermines potato shelf life, quality, and marketability.

Cold Storage Infrastructure Gap: Cold storage infrastructure for Irish potatoes in Rwanda remains critically insufficient, particularly for temperature-sensitive storage in highland production zones. According to the Clean Cooling Rwanda Cold Chain Assessment (2025), fewer than 10 operational cold storage facilities serve the entire potato sector, with a combined capacity below 2,000 tonnes, representing less than 1% of annual potato production. In Musanze District, which produces roughly 35% of national potato output, only 2 cold rooms with a total capacity of 300 tonnes are available, forcing farmers to sell immediately at low prices. The RAB Post-Harvest Loss Survey (2024) found that temperature-related losses account for 40% of total potato post-harvest losses in Northern Province (Clean Cooling Rwanda Cold Chain Assessment, 2025; RAB Post-Harvest Loss Survey, 2024; MININFRA Cold Chain Infrastructure Mapping, 2024). This shortage severely limits the ability to preserve potato quality, stabilize prices, and support market access.

Inadequate Transport and Handling Systems: Transport and handling systems for Irish potatoes in Rwanda are inadequate, contributing significantly to post-harvest losses. The National Transport Policy Implementation Review (2024) reports that 65% of feeder roads in potato-producing districts of the Northern and Western provinces are unpaved or seasonally impassable, increasing transport times and causing mechanical damage. According to the RAB Potato Quality Assessment (2024), transport and handling practices result in 8–12% bruising and mechanical damage, which further contributes to an additional 10–15% storage losses. In remote sectors such as Kinigi (Musanze) and Rwerere (Burera), transport delays of 3–5 days are common during rainy seasons, exacerbating spoilage (National Transport Policy Implementation Review, 2024; RAB Potato Quality Assessment, 2024; MINAGRI Rural Connectivity Report, 2024). These constraints highlight the need for improved rural roads, mechanized handling, and logistics solutions to reduce losses and maintain potato quality.

Processing Capacity Limitations: Processing capacity for Irish potatoes in Rwanda remains severely limited, constraining value addition and industrial diversification. The MINICOM Agro-Processing Capacity Survey (2024) indicates that less than 3% of national potato production is processed into value-added products such as chips, flakes, or flour. Rwanda has only four medium-scale potato processing plants with a combined annual capacity of 8,000 tonnes, against a production volume exceeding 1.2 million tonnes. Furthermore, 85% of existing processing equipment is outdated, operating at energy efficiency levels 30–40% below modern standards. According to the RDB Investment Climate Assessment (2024), 70% of processors cite the lack of consistent quality raw material primarily due to poor post-harvest

handling as their main constraint. These gaps underscore the need for investment in modern processing technologies and improved supply chain management to enhance potato value addition (MINICOM Agro-Processing Capacity Survey, 2024; RDB Investment Climate Assessment, 2024; NAEB Value Addition Report, 2024).

Storage Facility Shortages and Quality Issues: Storage facility shortages and quality issues significantly undermine post-harvest management of Irish potatoes in Rwanda. The RAB Storage Infrastructure Audit (2024) reports that only 25% of potato cooperatives in Northern Province have access to improved storage facilities. Traditional storage practices such as keeping potatoes in homes or simple sheds lead to sprouting losses of 15–20% and weight losses of 10–12% over a 3–4-month storage period. In Musanze District, which produces over 400,000 tonnes annually, the total improved storage capacity is approximately 25,000 tonnes, representing just 6% of production, with 60% of existing stores showing ventilation deficiencies. These gaps highlight the urgent need for investment in community-level storage solutions and improved facility design to reduce losses and maintain potato quality (RAB Storage Infrastructure Audit, 2024; District Potato Sector Profiles, 2024; MINAGRI Storage Infrastructure Assessment, 2024).

Energy Constraints for Cooling and Processing: One of the key gaps in postharvest management and agro-processing infrastructure for Irish potatoes is energy constraints for cooling and processing. High energy costs and unreliable electricity supply significantly limit the adoption of cold storage and processing technologies. The Rwanda Energy Group (REG) Agricultural Energy Use Study (2024) reports that energy expenses account for 35–45% of operational costs for potato cold storage, making such facilities economically unviable for most farmers and cooperatives. In Musanze and Burera districts, only 45% of potato collection centers have reliable electricity, with power outages averaging 8–10 hours per week during peak harvesting seasons. Furthermore, the World Bank Energy for Agribusiness Report (2024) estimates that these energy limitations reduce potential potato processing capacity by 40–50% in high-production areas. These findings highlight the need for targeted interventions to improve energy reliability and affordability for potato postharvest and processing operations (REG, 2024; World Bank, 2024; MININFRA, 2024).

Quality Standards and Food Safety Compliance: Another critical gap in the Irish potato value chain is quality standards and food safety compliance. Weak quality grading systems and limited food safety monitoring continue to affect both marketability and consumer safety. The Rwanda Standards Board (RSB) Potato Quality Monitoring (2024) reports that only 30% of potatoes in formal markets meet minimum size and quality standards, with significant variation in dry matter content that affects processing suitability. The RAB Food Safety Assessment (2024) found that 12% of sampled potatoes from traditional storage exceeded safe glycoalkaloid levels, posing health risks to consumers. Furthermore, less than 20% of potato aggregators conduct regular quality testing, which limits market differentiation and access to premium pricing. These findings underscore the need for strengthened grading systems, routine food safety monitoring, and capacity building for market actors (RSB, 2024; RAB, 2024; NAEB, 2024).

Financial Access for Infrastructure Investment: A significant gap in the Irish potato value chain is financial access for post-harvest infrastructure investment. Limited access to affordable finance restricts farmers and cooperatives from investing in essential storage and processing facilities. The Bank of Rwanda (BNR) Agricultural Credit Survey (2024) indicates that only 8% of potato cooperatives have secured loans

for post-harvest infrastructure, with high collateral requirements cited as the main barrier by 75% of applicants. The MINECOFIN Agribusiness Financing Review (2024) highlights that constructing a cold storage facility requires an investment of $15,000–$25,000 per 50-tonne unit, which is largely beyond the financial capacity of most farmer groups without access to blended finance or concessional funding. These challenges underscore the urgent need for targeted financial mechanisms to support infrastructure development and enhance value addition in the potato sector (BNR, 2024; MINECOFIN, 2024; World Bank, 2024).

Climate Vulnerability of Post-Harvest Systems: A key gap in the Irish potato value chain is the climate vulnerability of post-harvest systems. Existing storage infrastructure and post-harvest practices are poorly adapted to climate variability, increasing the risk of losses. The MINEMA Climate Risk Assessment for Agriculture (2024) identifies potato storage facilities as highly vulnerable to temperature and humidity fluctuations associated with climate change. In Musanze District, projected temperature increases of 1.5–2°C by 2030 could lead to 15–20% higher storage losses if no adaptation measures are implemented. Moreover, the RAB Climate-Smart Agriculture Review (2024) reports that less than 10% of potato storage facilities currently incorporate climate resilience features. These findings highlight the urgent need for climate-smart storage solutions and infrastructure that can withstand evolving environmental risks (MINEMA, 2024; RAB, 2024; Meteo Rwanda, 2024).

Knowledge and Skills Gaps: Another significant gap in the Irish potato value chain is knowledge and skills among value chain actors. Limited technical knowledge on improved potato handling, storage, and processing constrains efficiency and quality. The RAB Farmer Capacity Assessment (2024) reports that only 28% of potato farmers have received training on improved post-harvest handling, with even lower coverage for curing techniques (12%) and storage management (15%). Among potato aggregators and processors, 45% report difficulty in finding technically skilled staff for quality control and equipment operation. Additionally, the MINEDUC Agricultural Skills Audit (2024) identifies the operation of post-harvest technologies as a critical skills gap in potato-producing regions. These findings underscore the need for targeted capacity-building programs to strengthen post-harvest management and enhance value addition (RAB, 2024; MINEDUC, 2024; NAEB, 2024).

3.3.4. Integrated Postharvest Value Chain for Vegetables.

Pre-Cooling Infrastructure Deficiency: A critical gap in the vegetable value chain is the deficiency of pre-cooling infrastructure. The near-total absence of pre-cooling facilities at farm and collection points leads to rapid quality deterioration. The Rwanda Agriculture Board (RAB) Vegetable Value Chain Assessment (2024) reports that less than 3% of vegetable collection centers have pre-cooling facilities, resulting in field heat retention that accelerates spoilage by 40–50%. In high-production areas such as Bugesera and Kamonyi districts, where tomatoes and leafy vegetables dominate, ambient temperatures of 25–30°C at harvest, combined with 2–4 hour delays before cooling, result in 15–20% quality loss within the first 24 hours. The Clean Cooling Rwanda Assessment (2025) further notes that installing pre-coolers at just 20 key collection points could reduce vegetable losses by 30% nationally. These findings highlight the urgent need to invest in pre-cooling infrastructure to preserve quality and minimize post-harvest losses (RAB, 2024; Clean Cooling Rwanda, 2025; MINAGRI, 2024).

Cold Storage Infrastructure Gap: A major gap in the vegetable value chain is the insufficient cold storage infrastructure. Cold chain capacity is critically limited for highly perishable vegetables, particularly in key production zones. The NAEB Cold Chain Mapping Study (2024) indicates that Rwanda has only approximately 8,000 cubic meters of cold storage dedicated to vegetables nationally, which covers less than 5% of daily vegetable production during peak seasons. In the Eastern Province vegetable corridors (Kayonza, Ngoma, Bugesera), cold storage capacity reaches only 12% of vegetable volumes, forcing farmers to sell immediately and contributing to price collapses. The World Bank Food System Diagnostic (2024) estimates that temperature-related losses account for 60% of total vegetable post-harvest losses, representing an economic loss of $25–30 million annually. These findings highlight the urgent need to expand cold chain infrastructure to preserve quality, reduce losses, and stabilize market prices (NAEB, 2024; World Bank, 2024; MININFRA, 2024).

Packhouse and Sorting Infrastructure: A significant gap in the vegetable value chain is the lack of adequate packhouse and sorting infrastructure. Facilities for sorting, grading, and packaging vegetables to meet market standards remain limited. The Rwanda Standards Board (RSB) Packhouse Assessment (2024) found that only 15% of vegetable aggregators have access to basic packhouse facilities, including sorting tables and washing stations. In Musanze District's tomato sector, over 85% of tomatoes are sold without grading, leading to price discounts of 30–40% for mixed-quality lots. The MINICOM Agro-Processing Survey (2024) estimates that investing in 50 community packhouses across high-production zones could increase vegetable exports by 40% and improve domestic retail quality by 60%. These findings emphasize the need for targeted investment in packhouse infrastructure to enhance quality, marketability, and profitability for vegetable producers (RSB, 2024; MINICOM, 2024; RAB, 2024).

Refrigerated Transport Shortage: A major gap in the vegetable value chain is the shortage of refrigerated transport linking production areas to markets. Rwanda has fewer than 50 refrigerated trucks suitable for vegetable transport nationally, with 95% of vegetable movement occurring in non-refrigerated vehicles, according to the Clean Cooling Transport Analysis (2025). In the Kigali supply corridor from the Eastern Province, journey times of 3–5 hours without cooling result in 20–25% quality losses for leafy vegetables. The MININFRA Logistics Study (2024) estimates that establishing five refrigerated transport pools serving key corridors could reduce transport losses by 35% and extend shelf life by 3–5 days. These findings highlight the urgent need to expand refrigerated transport capacity to preserve quality, reduce post-harvest losses, and improve market access for vegetable producers (Clean Cooling, 2025; MININFRA, 2024; NAEB, 2024).

Processing Capacity Limitations: A key gap in the vegetable value chain is the limited processing capacity for preservation and value addition. Minimal infrastructure exists to transform vegetables into dried, canned, or frozen products, with less than 2% of total vegetable production currently processed, according to the MINICOM Vegetable Processing Capacity Audit (2024). Rwanda has only three medium-scale vegetable processing plants with a combined annual capacity of 4,000 tonnes, while total vegetable production exceeds 800,000 tonnes. The RDB Investment Assessment (2024) notes that up to 85% of vegetable gluts during peak seasons could be absorbed through processing, but currently go to waste due to inadequate capacity. These findings highlight the urgent need for investment in vegetable processing infrastructure to reduce losses, enhance value addition, and stabilize markets (MINICOM, 2024; RDB, 2024; NAEB, 2024).

Energy Access for Cold Chain Operations: A significant gap in the vegetable value chain is energy access for cold chain operations. High energy costs and unreliable electricity supply constrain the operation of cold storage and processing facilities. The Rwanda Energy Group (REG) Agricultural Energy Cost Analysis (2024) reports that energy expenses account for 45–55% of operating costs for vegetable cold storage, with commercial electricity tariffs ranging from $0.22–$0.28 per kWh, among the highest in the region. In rural vegetable hubs, power reliability averages 65%, with 8–12 outages per month disrupting cold chain operations. The World Bank Energy for Agribusiness Report (2024) estimates that adopting solar-powered cold storage could reduce energy costs by 60%, but would require initial investments of $20,000–$35,000 per unit. These findings underscore the need for affordable and reliable energy solutions to support vegetable cold chain operations (REG, 2024; World Bank, 2024; MININFRA, 2024).

Quality Standards and Food Safety Systems: A key gap in the vegetable value chain is the weak implementation of quality standards and limited food safety monitoring. According to the RSB Vegetable Quality Compliance Report (2024), only 25% of vegetables in formal markets meet national quality standards for pesticide residues, freshness, and grading. In tomato and cabbage value chains, pesticide misuse results in 12–15% rejection rates in premium markets. The RAB Food Safety Monitoring (2024) further reports that less than 20% of vegetable farmers have received training on safe pesticide use and maximum residue limits (MRLs), while national testing capacity is limited to 500 samples per month. These findings highlight the need for strengthened quality control systems, farmer training, and expanded food safety testing to ensure market compliance and consumer protection (RSB, 2024; RAB, 2024; MINAGRI, 2024).

Market Information and Linkage Systems: A critical gap in the vegetable value chain is poor market information flow and weak producer-buyer linkages. The NAEB Market Information System Evaluation (2024) found that only 30% of vegetable farmers receive timely price information, with market data often delayed by 24–48 hours, resulting in 35–40% price variations between production zones and urban markets. The MINICOM Digital Agriculture Assessment (2024) highlights that integrating digital platforms such as e-Soko with cold chain logistics could improve price realization by 25%, but this requires digital literacy training for 70% of vegetable farmers who are currently offline. These findings emphasize the need to strengthen market information systems, enhance producer-buyer linkages, and build digital capacity among farmers to optimize market access and profitability (NAEB, 2024; MINICOM, 2024; RAB, 2024).

Financial Access for Cold Chain Investment: A significant gap in the vegetable value chain is limited financial access for cold chain infrastructure development. The Bank of Rwanda (BNR) Agricultural Finance Review (2024) reports that only 5% of vegetable cooperatives have accessed loans for cold chain investments, with interest rates of 14–18% cited as prohibitive. The MINECOFIN Blended Finance Assessment (2024) highlights that investments in cold rooms ranging from $25,000–$50,000 exceed the borrowing capacity of most farmer groups, necessitating public-private partnerships or concessional financing. Additionally, the World Bank Agribusiness Finance Diagnostic (2024) estimates an annual financing gap of $15–20 million for vegetable cold chain development. These findings underscore the need for innovative financing solutions to expand cold chain infrastructure and reduce post-harvest losses (BNR, 2024; MINECOFIN, 2024; World Bank, 2024).

Climate Resilience of Post-Harvest Systems: A key gap in the vegetable value chain is the climate vulnerability of post-harvest systems. Vegetable post-harvest infrastructure and practices are highly exposed to climate variability and extreme weather, increasing the risk of losses. The MINEMA Climate Risk Assessment for Horticulture (2024) projects temperature increases of 1.5–2.5°C by 2030, which could raise post-harvest losses by 20–30% without adaptation measures. In Bugesera District, heat stress during transportation already contributes to an additional 10–15% losses during hot seasons. Furthermore, the RAB Climate Adaptation in Horticulture Report (2024) found that less than 15% of vegetable post-harvest infrastructure currently incorporates climate resilience features, with projected adaptation costs of $8–12 million needed by 2030. These findings highlight the urgent need for climate-smart post-harvest solutions to safeguard vegetable quality and reduce losses (MINEMA, 2024; RAB, 2024; Meteo Rwanda, 2024).

3.4. Emerging opportunities and innovations for improving post-harvest management and agro-processing infrastructure in Rwanda.

3.4.1. Emerging opportunities for Maize

Hermetic Storage Technologies: An emerging opportunity in post-harvest management is the scaling of hermetic storage technologies, including Purdue Improved Crop Storage (PICS) bags and metal silos, for smallholders and cooperatives. Hermetic storage effectively protects grains from pests, moisture, and mycotoxin contamination, offering a low-cost, high-impact solution for post-harvest losses. According to the RAB Technology Adoption Study (2024), the use of hermetic storage can reduce maize losses from 13.8% to 3–5% and lower aflatoxin contamination by 70–80%, significantly improving food safety and marketability. Despite these benefits, current adoption among smallholder farmers remains below 20%, although targeted subsidies, awareness campaigns, and distribution networks could increase adoption to 60%.

Supporting evidence from PMC Research on Hermetic Storage Efficacy (2023) confirms that hermetic storage maintains grain quality over longer storage periods, reduces post-harvest losses, and increases household incomes. The MINAGRI Postharvest Management Strategy (2021–2025) further identifies hermetic storage as a priority intervention to strengthen national food security and value chain resilience. These findings suggest that scaling hermetic storage technologies represents a tangible opportunity to enhance post-harvest management and reduce losses in Rwanda's maize and other cereal value chains (RAB, 2024; PMC, 2023; MINAGRI, 2024).

Community Drying Platforms and Solar Dryers: An important opportunity in post-harvest management is the deployment of community drying platforms and solar-assisted mechanical dryers at aggregation points. Raised, ventilated communal drying platforms provide a low-cost, scalable solution for reducing post-harvest losses during the drying stage, particularly for maize. The World Bank Feasibility Assessment (2024) estimates that such platforms can reduce maize drying losses from 6–8% to 2–3%, while being 3–5 times more cost-effective than individual household solutions. Solar-assisted mechanical dryers further enhance drying efficiency, capable of processing 2–3 tonnes daily with zero energy costs after installation, offering a sustainable alternative to conventional sun drying that is vulnerable to weather fluctuations. The MININFRA Renewable Energy for Agriculture Report (2024) and the RAB Drying Infrastructure Plan (2024) highlight the potential of these technologies to improve product quality, reduce aflatoxin contamination, and increase the marketability of maize. Scaling communal and solar-assisted drying

solutions represents a tangible opportunity to strengthen post-harvest systems, reduce losses, and support smallholder income growth (World Bank, 2024; MININFRA, 2024; RAB, 2024).

Modular Grain Hubs and Aggregation Centers: An emerging opportunity in post-harvest management is the establishment of modular grain hubs and aggregation centers equipped with cleaning, drying, storage, and primary processing capacity. According to the NAEB Grain Hub Development Plan (2025), Rwanda plans to establish 15 new hubs by 2027, with a total capacity exceeding 200,000 tonnes, creating approximately 3,500 direct jobs and serving over 200,000 farmers. Each hub is designed with an 8-tonne per hour cleaning capacity and hermetic storage for more than 5,000 tonnes, enabling the efficient handling of grains while reducing losses and improving quality. The RAB Infrastructure Investment Pipeline (2024) highlights these hubs as critical nodes linking smallholder farmers to value addition, markets, and food security initiatives. This initiative aligns with the PSTA-5 Implementation Framework (2024), which emphasizes modular, scalable infrastructure to enhance agricultural value chain efficiency and resilience. Modular grain hubs thus represent a strategic investment opportunity to strengthen post-harvest management, increase storage efficiency, and facilitate market access for smallholder farmers (NAEB, 2025; RAB, 2024; PSTA-5, 2024).

Mobile Processing Units: A promising opportunity in post-harvest management is the deployment of mobile processing units**,** such as mobile maize shellers and cleaners, offered as hire services to farmers. These units reduce the need to transport bulky maize cobs to distant processing facilities, while enabling on-farm quality upgrading**.** The MINAGRI Mobile Equipment Pilot (2024) demonstrates that mobile units can increase farmer incomes by 15–20%**,** primarily by improving product quality and reducing transport costs by up to 60%**.** Each unit has the capacity to serve 300–500 farmers annually**,** making it a flexible and scalable solution for smallholder communities. The RAB Mechanization Strategy (2024) and the Private Sector Federation Agribusiness Survey (2024) highlight mobile processing as a cost-effective way to enhance mechanization, improve post-harvest handling, and increase access to value addition services in rural areas. Scaling mobile processing units thus offers tangible benefits for farmer livelihoods, efficiency, and overall maize value chain performance (MINAGRI, 2024; RAB, 2024; PSF, 2024).

Fortified Flour and Value-Added Products: A key opportunity in the maize value chain is the development of fortified flour and value-added products, including composite blends designed to improve nutrition and substitute imports. The MINICOM Food Processing Strategy (2024) targets a 30% increase in fortified flour production by 2028, which could potentially replace $8–10 million in maize flour imports. Small-scale fortification units require investments of $50,000–$100,000, with projected payback periods of 2–3 years, making them economically viable for cooperatives and private entrepreneurs. The Rwanda FDA Fortification Standards (2024) provide the regulatory framework to ensure product safety and quality, while the World Bank Nutrition-Sensitive Agriculture Report (2024) emphasizes that fortification enhances dietary diversity and supports national nutrition objectives. Scaling fortified maize flour production therefore represents a strategic opportunity to increase value addition, strengthen food security, and improve smallholder farmer incomes (MINICOM, 2024; Rwanda FDA, 2024; World Bank, 2024).

3.4.2. Emerging opportunities for Rice

Mechanical and Solar Drying Systems: A significant opportunity in rice post-harvest management is the adoption of mechanical and solar drying systems to ensure uniform moisture content and improve grain quality. The RAB Rice Quality Improvement Program (2024) reports that mechanical drying can increase milling recovery from 60–65% to 68–72% while reducing drying time from 3–5 days to 6–8 hours, significantly improving processing efficiency. Solar drying tunnels offer a cost-effective alternative, capable of processing 1–2 tonnes daily with 40–50% lower operating costs compared to traditional methods. The MININFRA Solar Drying Assessment (2024) and RSB Rice Milling Standards (2024) emphasize that these technologies enhance grain quality, reduce post-harvest losses, and support compliance with milling standards. Scaling mechanical and solar drying solutions therefore presents a practical opportunity to strengthen rice post-harvest systems, improve milling outcomes, and increase smallholder farmer incomes (RAB, 2024; MININFRA, 2024; RSB, 2024).

Modern Milling and Sorting Technology: A key opportunity in rice post-harvest management is the adoption of modern milling and sorting technologies, including color sorters, polishers, and graders, to improve rice quality and market value. The MINICOM Rice Mill Modernization Scheme (2024) provides 30–40% investment subsidies for technology upgrades, which can potentially increase milled rice prices by 20–25%. Modern mills equipped with these technologies achieve breakage rates below 10%, compared to 20–30% in traditional milling operations, enhancing both product quality and competitiveness in domestic and export markets. The RSB Milling Quality Report (2024) and NAEB Export Quality Standards (2024) highlight that upgrading milling infrastructure ensures compliance with quality and safety standards, facilitates higher-value market access, and strengthens value addition. Scaling modern milling and sorting technologies therefore represents a strategic opportunity to enhance rice processing efficiency, reduce losses, and improve farmer and miller incomes (MINICOM, 2024; RSB, 2024; NAEB, 2024).

Parboiling and Value-Added Processing: A significant opportunity in rice post-harvest management is the expansion of parboiling facilities and development of rice-based value-added products, including rice flakes, flour, and snacks. The NAEB Rice Value Addition Study (2024) reports that parboiled rice commands 15–20% price premiums and benefits from extended shelf life, increasing marketability. Investment in 10 medium-scale parboiling units could process over 20,000 tonnes annually and create more than 500 jobs, enhancing both value addition and rural livelihoods. The RAB Processing Technology Assessment (2024) and MINAGRI Rice Sector Development Plan (2024) highlight that parboiling and related processing technologies reduce post-harvest losses, improve quality, and support compliance with domestic and export standards. Scaling parboiling and value-added processing thus represents a strategic opportunity to strengthen the rice value chain, increase farmer incomes, and diversify product offerings (NAEB, 2024; RAB, 2024; MINAGRI, 2024).

Integrated Rice Processing Hubs: A promising opportunity in rice post-harvest management is the establishment of integrated rice processing hubs within marshland clusters, incorporating drying, milling, and packaging facilities. The RDB Investment Prospectus (2024) identifies five priority hubs in Bugesera, Kayonza, Ngoma, Kirehe, and Gatsibo, requiring a total investment of $15–20 million and offering a potential internal rate of return (IRR) of 18–22%. Each hub is designed to serve between 5,000 and 8,000 farmers, providing centralized processing and value addition to enhance efficiency and reduce post-harvest

losses. The MINAGRI Marshland Development Strategy (2024) and World Bank Agribusiness Investment Analysis (2024) emphasize that integrated hubs can improve market access, ensure consistent quality, and facilitate compliance with export standards. Developing these hubs represents a strategic investment to strengthen rice value chains, support farmer incomes, and promote scalable, climate-resilient post-harvest infrastructure (RDB, 2024; MINAGRI, 2024; World Bank, 2024).

3.4.3. Emerging opportunities for Irish Potatoes

Decentralized Cold Storage Solutions: A key opportunity in potato post-harvest management is the deployment of decentralized cold storage solutions, such as solar or hybrid cold rooms, at strategic aggregation points. The Clean Cooling Rwanda (2025) study demonstrates that 10–25 m³ solar cold rooms can extend potato shelf life from 7–10 days to 30–45 days, while achieving energy savings of 60–70%. Each unit can serve 50–100 farmers, with a projected payback period of 2–3 years, making them cost-effective for smallholder communities. The MININFRA Cold Chain Development Plan (2024) and RAB Potato Storage Assessment (2024) highlight the potential of decentralized cold storage to reduce post-harvest losses, improve market access, and enhance profitability for potato farmers. Scaling solar and hybrid cold rooms thus represents a strategic intervention to strengthen potato value chains and build climate-resilient storage infrastructure (Clean Cooling Rwanda, 2025; MININFRA, 2024; RAB, 2024).

Ventilated Storage and Curing Facilities: A significant opportunity in potato post-harvest management is the establishment of ventilated storage and curing facilities, including community curing sheds with humidity control. The MINAGRI Potato Post-Harvest Program (2024) reports that proper curing can reduce storage losses from 25–30% to 8–12%, while improving marketability and shelf life. Community facilities designed to serve 200–300 farmers require an investment of $20,000–$30,000, making them accessible for cooperatives and farmer groups. The RAB Storage Infrastructure Guidelines (2024) and NAEB Quality Standards for Potatoes (2024) emphasize that ventilated storage and curing are critical for maintaining tuber quality, minimizing post-harvest losses, and enabling price premiums in formal markets. Scaling these facilities offers a practical pathway to strengthen potato storage systems and enhance farmer incomes (MINAGRI, 2024; RAB, 2024; NAEB, 2024).

SME Processing Clusters: A promising opportunity in potato value chains is the development of SME processing clusters for products such as chips, crisps, flour, and other value-added items. The MINICOM SME Development Strategy (2024) targets the establishment of 50 new potato processing SMEs by 2028, which would create over 1,000 jobs and utilize more than 30,000 tonnes of potatoes annually. Basic processing lines for small-scale operations require investments of $15,000–$25,000, making them accessible to cooperatives and private entrepreneurs. The RDB Agribusiness Incubation Program (2024) and NAEB Value Addition Opportunities Report (2024) emphasize that clustered processing facilities can enhance economies of scale, improve product quality, and strengthen market access. Scaling SME processing clusters offers a practical pathway to increase value addition, reduce post-harvest losses, and boost incomes for smallholder potato farmers (MINICOM, 2024; RDB, 2024; NAEB, 2024).

Cold Chain Logistics for Fresh Potatoes: A critical opportunity in potato post-harvest management is the development of cold chain logistics, including refrigerated transport pools and packhouse facilities with pre-cooling. The World Bank Logistics Assessment (2024) estimates that refrigerated transport could reduce potato losses in transit from 15–20% to 5–8% and extend the market radius from 100 km to 300 km,

enabling farmers to access higher-value urban and regional markets. Each refrigerated truck is capable of serving 200–300 farmers annually, making this a scalable solution for smallholder communities. The MININFRA Transport Infrastructure Plan (2024) and RAB Market Access Study (2024) emphasize that integrating cold chain logistics with pre-cooling facilities improves product quality, reduces post-harvest losses, and enhances profitability along the potato value chain. Scaling cold chain logistics represents a strategic investment to strengthen market linkages, maintain tuber quality, and increase farmer incomes (World Bank, 2024; MININFRA, 2024; RAB, 2024).

3.4.5. Emerging opportunities for Vegetables

Integrated Packhouse Systems: A key opportunity in vegetable post-harvest management is the development of integrated packhouse systems that combine pre-cooling, sorting, grading, and packaging facilities. The NAEB Horticulture Export Program (2024) reports that packhouses can increase vegetable shelf life by 40–50% and enable 30–40% price premiums for graded produce, enhancing both market access and profitability. Each facility is designed to process 5–10 tonnes daily and serve 150–250 farmers, providing centralized post-harvest services to reduce losses and maintain quality. The RSB Packhouse Standards (2024) and MINAGRI Horticulture Infrastructure Plan (2024) emphasize that integrated packhouses are critical for meeting export and domestic quality standards, improving product consistency, and supporting value addition. Scaling packhouse systems offers a strategic approach to strengthen vegetable value chains, optimize post-harvest handling, and increase farmer incomes (NAEB, 2024; RSB, 2024; MINAGRI, 2024).

Solar-Powered Cold Hubs: A major opportunity in vegetable post-harvest management is the development of solar-powered cold hubs, comprising multiple cold rooms, ripening chambers, and value addition spaces. The Clean Cooling Rwanda (2025) study indicates that such hubs can reduce vegetable post-harvest losses from 30–40% to 8–12% while increasing farmer incomes by 25–35%. Investments in cold hubs range from $50,000–$150,000, with projected payback periods of 3–4 years, making them economically viable for cooperatives and private sector operators. The MININFRA Cold Chain Strategy (2024) and World Bank Renewable Energy for Agriculture (2024) emphasize that solar-powered cold hubs enhance energy efficiency, reduce spoilage, support value addition, and strengthen market linkages. Scaling these hubs represents a strategic intervention to improve vegetable quality, extend shelf life, and boost smallholder profitability (Clean Cooling Rwanda, 2025; MININFRA, 2024; World Bank, 2024).

Minimal Processing and Preservation: A significant opportunity in vegetable post-harvest management is the expansion of minimal processing and preservation facilities, including washing, cutting, packaging, drying, and freezing. The MINICOM Processing Capacity Assessment (2024) indicates that minimal processing can increase vegetable value by 50–100% while reducing post-harvest waste by 60–70%. Small-scale processing units require investments of $20,000–$40,000 and can handle 1–2 tonnes daily, making them accessible to cooperatives and private entrepreneurs. The RAB Preservation Technology Review (2024) and NAEB Export Market Requirements (2024) emphasize that such facilities enhance product quality, extend shelf life, and ensure compliance with both domestic and export standards. Scaling minimal processing and preservation solutions represents a practical pathway to reduce losses, increase profitability, and strengthen vegetable value chains (MINICOM, 2024; RAB, 2024; NAEB, 2024).

Greenhouse and Protected Cultivation: A notable opportunity in vegetable post-harvest management is the integration of greenhouse and protected cultivation with on-site packing and cooling facilities. The RAB Protected Agriculture Program (2024) reports that greenhouse-grown vegetables experience 50–60% lower post-harvest losses and achieve 2–3 times higher yields compared to open-field production. When combined with packhouse and pre-cooling infrastructure, greenhouse systems enable year-round quality production, meeting both domestic and export market standards. The MINAGRI Greenhouse Development Strategy (2024) and World Bank Climate-Smart Agriculture Report (2024) highlight that integrating protected cultivation with post-harvest handling technologies enhances product consistency, reduces waste, and supports climate-resilient agricultural systems. Scaling greenhouse-based production with linked processing and cooling facilities thus represents a strategic opportunity to increase productivity, maintain quality, and improve farmer incomes (RAB, 2024; MINAGRI, 2024; World Bank, 2024).

3.4.6. Cross-Cutting Opportunities

Digital Agriculture Platforms: A key opportunity in agricultural value chains is the enhancement of digital agriculture platforms, including e-Soko, warehouse receipt systems, and digital market linkages. The Rockefeller Foundation Digital Agriculture Study (2024) shows that these platforms can increase farmer prices by 15–20%, reduce transaction costs by 25–30%, and improve access to financing for 40% more farmers. Warehouse receipt systems further enable collateralized lending using stored commodities, providing smallholders with liquidity to invest in production and post-harvest improvements. The BNR Financial Inclusion Report (2024) and MINICOM E-commerce Strategy (2024) emphasize that digital platforms enhance market transparency, strengthen producer-buyer linkages, and facilitate value chain efficiency. Scaling digital agriculture solutions thus represents a strategic approach to increase farmer incomes, reduce losses, and improve market access (Rockefeller Foundation, 2024; BNR, 2024; MINICOM, 2024).

Blended Finance Mechanisms: A strategic opportunity to strengthen post-harvest systems is the development of blended finance instruments that combine public, private, and development funds. The World Bank Blended Finance Assessment (2024) identifies an annual $50–70 million financing gap for post-harvest infrastructure across Rwanda. Blended finance mechanisms can de-risk private investment and mobilize 3–5 times more capital than public funds alone, enabling the construction of storage, processing, and cold chain facilities at scale. The MINECOFIN Investment Promotion Strategy (2024) and RDB PPP Framework (2024) highlight that such instruments support public-private partnerships, attract long-term investment, and facilitate sustainable infrastructure development. Scaling blended finance solutions thus offers a critical pathway to address capital constraints, accelerate post-harvest system improvements, and enhance value chain resilience (World Bank, 2024; MINECOFIN, 2024; RDB, 2024).

Public-Private Partnerships (PPPs): A major opportunity to strengthen post-harvest systems and agro-processing infrastructure is the implementation of public-private partnership (PPP) models for agro-processing parks, cold chains, and grain hubs. The RDB PPP Portfolio (2024) outlines 15 planned agri-PPPs with a total projected investment of $100–150 million by 2028. Evidence from successful models indicates that private operators achieve 70–80% facility utilization, compared to 30–40% for publicly managed facilities, demonstrating the efficiency and scalability benefits of PPP arrangements. The World Bank PPP Success Stories (2024) and MINECOFIN Infrastructure Financing Report (2024) highlight that PPPs can mobilize private capital, improve operational performance, and ensure sustainable management of post-harvest and processing infrastructure. Expanding PPP models thus offers a strategic pathway to

enhance value chain efficiency, reduce post-harvest losses, and maximize returns on investment (RDB, 2024; World Bank, 2024; MINECOFIN, 2024).

Renewable Energy Integration: A key opportunity to enhance post-harvest efficiency and sustainability is the integration of renewable energy systems, including solar, biogas, and hybrid solutions, with storage, processing, and cold chain infrastructure. The REG Renewable Energy for Agriculture (2024) study indicates that renewable energy can reduce operating costs by 40–60% for cold storage and processing facilities. Solar-powered systems offer payback periods of 3–5 years and can reduce carbon emissions by 70–80%, contributing to climate-friendly operations. The MININFRA Energy-Agriculture Nexus Strategy (2024) and Clean Cooling Rwanda (2025) highlight that renewable energy integration enhances energy reliability, lowers operational expenses, and supports sustainable value chain development. Scaling renewable energy solutions thus represents a strategic approach to reduce costs, improve post-harvest performance, and promote climate-smart agricultural infrastructure (REG, 2024; MININFRA, 2024; Clean Cooling Rwanda, 2025).

Climate-Resilient Infrastructure: Climate-Resilient Infrastructure represents a significant opportunity to strengthen post-harvest systems through the development of storage and processing facilities designed with flood protection, temperature regulation, and improved water management. According to the MINEMA Climate Adaptation Plan (2024), an estimated USD 15–20 million has been allocated for climate-resilient agricultural infrastructure by 2027. Evidence from climate-adapted facilities indicates that such investments can reduce weather-related post-harvest losses by 50–60% while ensuring continuity of operations during extreme climate events, including floods, heatwaves, and prolonged rainfall. The RAB Climate-Smart Agriculture Guidelines (2024) and the World Bank Climate Resilience Financing (2024) further highlight that integrating resilience features into post-harvest infrastructure is critical for safeguarding produce quality, stabilizing farmer incomes, and enhancing the overall sustainability of agricultural value chains under increasing climate variability.

Skills Development and Technology Transfer: Skills Development and Technology Transfer present a critical opportunity to strengthen post-harvest management through the establishment of dedicated training centers and technology demonstration sites. The MINEDUC Skills Development Program (2024) targets training 5,000 individuals annually in post-harvest technologies, addressing persistent skills gaps across farming, aggregation, and processing levels. Evidence from the RAB Extension Services Enhancement (2024) indicates that well-designed demonstration sites significantly accelerate learning and uptake, increasing technology adoption rates from 20–30% to 50–60% within 2–3 years. The World Bank Agricultural Education Report (2024) further underscores that combining hands-on training with practical demonstrations enhances operational efficiency, improves compliance with quality and food safety standards, and supports the sustainability of post-harvest investments across agricultural value chains.

CHAPTER 4: DISCUSSION OF FINDINGS

4.1. Introduction

This desk review combines Rwanda's policy frameworks (NST2, PSTA-5, NAP 2018) with literature. All major strategies share priorities: cutting postharvest losses, value addition, market linkages, and climate resilience in agriculture. For example, the National Agriculture Policy (2018) notes that 20–40% of crops are lost postharvest, depressing incomes. PSTA-5 targets reducing losses to below 5% by 2029. Yet district evidence shows these goals remain unmet. Farmers face critical gaps: drying and storage infrastructure is lacking, finance is scarce, energy is unreliable, and institutional coordination is weak. These persistent constraints echo national reports and stall Rwanda's agri-transformation.

4.1.1. Maize Value Chain

- **Losses and storage:** Maize is a cornerstone of food security, but losses remain high. Nationally averaged losses (~13.8%) far exceed the PSTA-5 goal of 5%. In our study districts, primary data indicate losses up to ~78% for poorly dried/stored maize. This reflects a clear policy-practice gap: NAP-2018 calls for community-level drying and storage, yet most farmers lack even simple drying platforms or moisture-measurement tools. In practice, roughly 94% of maize farmers still dry on bare ground, exposing grains to rains and pests. Without access to community storage or hermetic bins, quality and quantity suffer.
- **Market linkage:** The maize market is highly informal. Farmers typically sell in spot markets with little quality grading or stable pricing. This undermines PSTA-5's vision of structured, inclusive markets. Only about 32% of cooperatives currently have formal buyer contracts, meaning most maize moves in low-price channels. Stronger aggregation and contract farming (e.g. with millers like MINIMEX or Africa Improved Foods) could ensure stable demand and quality, but such models are not yet widespread.
- **Technology and finance:** Proven technologies like hermetic storage bags can dramatically cut losses and aflatoxin contamination. Evidence shows hermetic storage significantly increases farmers' income by preserving maize quality. However, uptake is low due to high upfront costs and limited credit. Few farmers can afford moisture meters or sealed bags without financial support. This technological gap persists despite government programs promoting these innovations.

4.1.2. Rice Value Chain

- **Drying and quality:** Rice is vital for import substitution and exports, yet postharvest practices limit quality. Over 75% of paddy in our study is sun-dried on bare ground, yielding highly variable moisture. As a result, milling recovery averages only 60–65%, below the 68–72% achievable with mechanical or covered dryers. Inconsistent moisture also violates Rwanda Standards Board (RSB) requirements for grade. These outcomes conflict with NAP-2018 and PSTA-5 emphases on processing and quality.
- **Infrastructure and energy:** Modern drying and milling require reliable power and finance. Yet district and national data (e.g. Rwanda Energy Group) show electricity is often unreliable. Fewer than 15% of millers have funds to upgrade equipment or invest in mechanical dryers. High energy costs make mechanization expensive – for example, rice millers report energy as a major cost. This underinvestment keeps most mills below capacity: 65% of mills operate under 50% utilization.

- **Market systems:** Surpluses can sometimes run mills idle, indicating coordination problems. The Eastern Province's rice belt (Ngoma, Kayonza, Kirehe) produces more paddy than local mills can reliably process. Fragmented aggregation (small plots, informal markets) makes supply irregular. Strengthening farmer cooperatives and buyer networks could stabilize mill supply.

4.1.3. Irish Potato Value Chain

- **Cold storage gap:** Potatoes are earmarked as a high-value crop, but almost no rural potatoes reach cold storage. Nationally <1% of production is stored in temperature-controlled facilities. In northern highlands (Musanze/Burera), farmers face ~40% losses due to lack of cooling. Consequently, producers rush to sell immediately after harvest at low prices, undermining income stability. This reality clashes with NST2/PSTA-5 aims to commercialize and add value to potatoes.
- **Energy and finance:** Energy costs dominate potato storage sometimes 40–45% of operating costs. Without grid power or affordable solar alternatives, building cold rooms is daunting. Few cooperatives can secure loans (only ~8% have formal credit) to invest in cold-chain assets. Minimal processing (under 3% of harvest) means missed opportunities for higher-value products (chips, fries) which could spur agri-industry growth envisioned by the National Agriculture Policy.

4.1.4. Vegetable Value Chain

- **High perishability:** Vegetables (e.g. tomatoes, leafy greens) spoil rapidly. Our data and literature both show 30–40% losses from farm to market. For instance, tomatoes can lose up to ~49% of value along the chain (obi Fadiji, 2025). Causes include no pre-cooling at collection, lack of refrigerated trucks, and inadequate sorting/grading. In practice, less than 3% of collection centers have pre-cooling, and roughly 85% of tomatoes are sold ungraded, triggering quality discounts and waste.
- **Market constraints:** The horticultural market suffers from volatility and information gaps. Farmers often bypass formal channels and sell to informal traders to avoid spoilage, forfeiting better prices. Price swings in informal markets deter investment in quality. The absence of packhouses and weak enforcement of safety/quality standards means Rwanda cannot fully tap premium domestic or export demand for vegetables.

4.2 Emerging Opportunities and Policy Convergence

Despite these challenges, our analysis highlights clear opportunities where policy goals, technologies and local needs align:

- **Maize:** Scaling community hermetic storage (bags/silos), solar or mechanical dryers, and modular grain aggregation hubs would directly serve NAP-2018 and PSTA-5 targets on food security and loss reduction. For example, subsidized hermetic bags paired with farmer training can rapidly reduce losses. Community grain hubs (with testing equipment) would improve quality control and marketability.
- **Rice:** Investing in mechanical and solar drying systems linked to improved storage can lift paddy moisture to optimal levels. Modernizing mills with color sorters, graders and moisture meters would raise milling yields and meet RSB quality grades. These steps dovetail with the government's export promotion and import substitution goals.

- **Irish Potatoes:** Decentralized solar-powered cold rooms (10–25 m³ units) in potato clusters (e.g. Musanze, Burera) can extend shelf-life and reduce gluts. Cooperative-managed cold chains would stabilize prices and reduce distress sales. Integrating solar cold storage with village aggregation points meets NST2's resilience objectives.
- **Vegetables:** Constructing integrated packhouses (with pre-cooling, sorting and packing) in key corridors (Bugesera, Kamonyi, Musanze) would dramatically cut spoilage. Public private partnership models can mobilize investment and ensure farmer buy-in. Improved cold-chain logistics (solar cold hubs, refrigerated transport) will allow farmers to reach premium markets.
- **Cross-cutting enablers:** Across all chains, digital market platforms (e-Soko) and warehouse receipt systems can improve price transparency and collateral for loans. Blended finance and credit guarantees already promoted by NST2/PSTA-5 can de-risk investments in PHM technologies. Renewable energy (solar, biomass) stands out as a recurring enabler, reducing the power costs for dryers, mills, and cold storage.

4.3 Synthesis of Results and Implications

The evidence underscores that postharvest losses and agro-processing are pivotal to Rwanda's agricultural transformation. Current national estimates show losses of 15–30% for cereals, 35–40% for fruits and vegetables, and 16–18% for tubers, costing over USD 200 million annually (RAB, 2023). Our field surveys align with these figures: 93.9% of farmers reported some losses in maize, vegetables and beans. NST2 and PSTA-5 ambitiously target losses below 5% by 2029; achieving this will drive higher incomes and food security.

Yet the realization of these targets is uneven. Many districts remain at NST1-era levels, reflecting persistent constraints: inadequate drying/storage, weak aggregation, and delayed market access are endemic. For example, nearly all maize is sun-dried on the ground and >60% of rice drying platforms are uncovered (obi Fadiji, 2025), exposing crops to damage. Cold-chain assets are concentrated in cities, leaving rural farmers vulnerable. Over 75% of farmers report no nearby agro-processing plant, and existing plants often run under capacity due to supply and financing gaps.

These findings reveal a consistent pattern: strong policy frameworks but weak execution. Infrastructure deficits, high finance costs, and limited skills impede technology adoption and coordination. The necessary conditions for agro-processing reliable energy, affordable credit, skilled workers are still lacking in many areas. This situation closely mirrors earlier government assessments (e.g. NAP-2018) that identified these same barriers. Absent targeted interventions, productivity gains from seeds and inputs may not translate into higher farmer incomes or increased exports.

In short, Rwanda's agricultural policies are well-aligned and evidence-based, but their impact is stymied on the ground. Reducing losses is not just a technical issue; it is an integrated systems challenge. As one expert analysis notes, building an effective cold chain "requires a system-of-systems approach" linking energy, transport, storage and market infrastructure. Similarly, postharvest management needs coordination across institutions and value chains. Without such a holistic approach, the nation's strategic targets will remain aspirational.

4.4. Conclusion

In conclusion, bridging the gap between policy and practice is critical for Rwanda's agricultural vision. NST2, PSTA-5 and the National Agriculture Policy 2018 all make a strong, coherent case: cutting postharvest losses and expanding agro-processing are fundamental to food security, income growth and structural transformation. The challenge lies not in the absence of strategies, but in limited execution at the farm and district levels. A wide implementation gap persists driven by insufficient and poorly distributed infrastructure, scarce finance, weak institutional coordination, and low uptake of proven technologies.

If these gaps are not addressed, productivity gains will yield meager returns for farmers and limited economic value. For example, a rise in maize yields is undermined when most grain spoils postharvest; vegetables grown by farmers in remote areas still cannot command premium prices due to lack of cooling. Our analysis shows that targeted, coordinated action is needed to translate national ambitions into results. This means mobilizing public investments in PHM infrastructure, leveraging private-sector and community resources through PPPs and innovative finance, and intensifying capacity building. It also means integrating postharvest indicators into district performance metrics to ensure accountability.

Ultimately, realizing Rwanda's long-term goal of an inclusive, resilient agri-led economy hinges on these solutions. By urgently investing in postharvest management and processing and by strengthening the systems that support them Rwanda can close the policy-practice gap, substantially reduce losses, and unlock higher incomes for its farmers.

4.5 Proposed Recommendations

(1) Invest in Critical PHM & Processing Infrastructure

MINAGRI and partners should scale up community-level facilities (dryers, storage warehouses, cooling centers) in high-production zones. Combine this with extension-driven dissemination of affordable technologies (hermetic bags, raised drying floors) and training; for example, target the 94% of maize farmers still drying on soil by supplying 500+ solar dryers and 200+ community silos in maize regions. Promote public private co-investment and subsidies to build durable PHM assets.

(2) Strengthen Market Linkages and Value-Chain Coordination.

MINICOM, NAEB and stakeholders should formalize contract farming and aggregation models. Expand programs like FARM P3 to connect major maize- and rice-producing cooperatives with large processors (Africa Improved Foods, MINIMEX, rice millers). Establish an integrated Agricultural Market Information System (AMIS) to link farmers, buyers and transporters for better price discovery. These measures will shift farmers away from volatile spot markets to stable, quality-based outlets.

(3) Improve Access to Affordable Agricultural Finance

MINECOFIN, BNR and partners should create a dedicated PHM and agro-processing credit guarantee facility to lower lending risk. Simultaneously, advocate for lower-rate loans (targeting ~5%) and scale up

warehouse-receipt financing. Encourage blended finance instruments with development banks so small cooperatives can invest in dryers, storage and cold rooms without prohibitive interest (current rates often exceed 16%).

(4) Strengthen Institutional Coordination and Accountability

MINALOC and the Rwanda Governance Board should establish District PHM Coordination Committees to clarify roles and prevent duplication among MINAGRI, RAB, NAEB, MINICOM and local authorities. Embed PHM performance indicators (e.g. storage utilization, % loss reduction) into district Imihigo and ministerial scorecards. This will ensure results-based management and accountability for postharvest targets.

(5) Enhance Postharvest Skills and Technology Transfer

MINAGRI and RAB should expand extension capacity by creating a National PHM Extension Corps to train at least 1,000 lead farmers and cooperative managers. Integrate hands-on PHM modules into TVET agriculture curricula and establish demonstration farms nationwide. These efforts address the current low training coverage (only ~15–28% of farmers receive PHM guidance) and promote adoption of technologies like moisture meters and solar dryers.

(6) Promote Private sector–Led PHM and Agro Processing for Sustainability

MINICOM and the Private Sector Federation (PSF) should mobilize stronger private investment. Scale up PPP frameworks and fiscal incentives so cooperatives and agribusinesses can co-own PHM facilities. Invest in cooperative capacity-building to keep infrastructure operational post-donor funding. Seek strategic private investors for large-scale hubs (e.g. expansion of Gitare mills, new agro-industrial parks) with coordinated support from MINAGRI, MINECOFIN and RAB.

(7) Crop Specific Recommendations

Maize: Strengthen maize aggregation in key areas (e.g. Kayonza, Nyagatare) by enforcing structured contracts between cooperatives and processors (e.g. Africa Improved Foods, MINIMEX). This includes clear quality standards, pricing formulas and delivery schedules. Continue scaling the FARM P3 model. Concurrently, reduce milling energy costs via a "Green Energy for Agro-Processing" program: provide subsidies and tech support for solar dryers, biomass systems, and grid upgrades in Eastern/Northern provinces where energy accounts for 35–55% of maize processing costs.

Rice: Address surplus paddy and idle mills by subsidizing industrial construction materials (to lower new mill costs) and strengthening farmer aggregation in the Eastern Province rice belt (Ngoma, Kayonza, Kirehe) to ensure steady mill feedstock. Modernize 50+ priority mills (install color sorters, graders, moisture meters) in major rice districts to raise milling recovery. Tie equipment loans to RSB quality certification to boost exports. Establish mobile paddy-testing units at collection points for real-time quality control.

Irish potatoes: Pilot at least 20 decentralized solar-powered cold rooms (10–25 m³ capacity) in Musanze and Burera, anchored by cooperatives. Develop a cold-chain corridor linking these hubs to Kigali markets. This will cut the current ~40% cold-related losses. Local authorities and regulators (MININFRA/REG) should support off-grid energy solutions; RAB should advise on best storage practices. Engage Clean Cooling partners and private firms for technical operation support.

Vegetables: Construct 30+ integrated packhouses with pre-cooling, sorting and grading in high-value corridors (e.g. Bugesera, Kamonyi, Musanze). Implement these as PPPs with cooperative management to ensure efficiency. This addresses the lack of pre-cooling (currently <3% coverage) and reduces spoilage (85% of tomatoes now sold ungraded). Supporting agencies (NAEB, RSB, MINICOM, PSF) should facilitate market links and regulatory oversight to help farmers meet quality standards and access premium markets

ANNEX

Matrix of Proposed Actionable, Crop-Specific Recommendations for PHM and Agro-Processing in Rwanda

Key Gap / Challenge (Crop-Specific)	Proposed Recommendation	Proposed Lead	Supporting Actors	Priority Level	Proposed Timeline
CROSS-CUTTING RECOMMENDATIONS					
High Post-Harvest Losses (PHL) • ~94% of maize farmers dry on bare ground. • <20% access raised drying platforms. • <20% of farmers access agricultural credit. • Only ~15-28% of farmers receive PHM training.	Operationalize and expand community-level postharvest management (PHM) infrastructure, including drying, storage, and cooling facilities, particularly in high-production areas. Scaling up of improved postharvest handling practices and low-cost storage technologies, such as hermetic bags and raised drying platforms, delivered through strengthened extension services and farmer field schools to ensure widespread adoption and sustainability.	**MINAGRI**	RAB, NAEB MINALOC/Districts/LODA MININFRA/REG, PSF, NGOs Development Partners	**High Impact / Short-Term**	2026-2027
PHM Infrastructure District PHM plans (DDS) often unfunded. (RAB Postharvest Management Assessment, 2023 & MINALOC- DDD Reports, 2024) Fewer than **20% of rice drying platforms are**	Expand and upgrade PHM infrastructure by integrating drying, storage, and cooling facilities into District Development Strategies (DDS) and Imihigo, with dedicated budget allocations and alignment to PSTA-5 and NST2 targets.	**MINAGRI**	RAB, NAEB, MINALOC/DISTRICT, RHA, PSF, PPP	**High Impact / Medium -Term**	2026-2029

Key Gap / Challenge (Crop-Specific)	Proposed Recommendation	Proposed Lead	Supporting Actors	Priority Level	Proposed Timeline
elevated or covered, leaving harvested rice vulnerable to unseasonal rains and increasing post-harvest losses (RAB Climate-Smart Post-Harvest Review, 2024.) **Potato storage facilities**: Less than **10% of potato storage facilities** currently incorporate climate-resilient features. In **Musanze District**, projected temperature increases of **1.5–2°C by 2030** could increase storage losses by **15–20%** if no adaptation measures are implemented (RAB Climate-Smart Agriculture Review, 2024; Meteo Rwanda Climate Projections, 2024.) Only **15% of vegetable storage and cooling facilities** include climate-resilient features, with estimated adaptation costs of **USD 8–12 million** required by 2030 to ensure resilience (MINEMA	Enhance stakeholder coordination by clearly defining and harmonizing the roles of RAB, NAEB, MINALOC, district authorities, MINECOFIN, RGB, RHA, PSF, and PPP partners to ensure effective planning, implementation, and monitoring of PHM investments. Strengthen public-private partnerships (PPP) by engaging the Private Sector Federation and private investors through subsidies, incentives, and co-investment models to expand PHM infrastructure and agro-processing capacity. Build cooperative capacity and sustainability by providing continuous technical support, training, and business development services to cooperatives to maintain operations and effectiveness after donor-funded projects conclude. Promote awareness and private-sector participation by conducting farmer and community campaigns highlighting the benefits of				

Key Gap / Challenge (Crop-Specific)	Proposed Recommendation	Proposed Lead	Supporting Actors	Priority Level	Proposed Timeline
Climate Risk Assessment for Horticulture, 2024.) Over **60% of rice storage facilities in key production districts** are located in flood-prone areas, heightening vulnerability to extreme weather (NAEB Rice Infrastructure Mapping, 2024.) Fewer than **20% of rice drying platforms are covered**, and the majority of maize is dried in the open, exposing grains to rain and quality deterioration (RAB Post-Harvest Management Assessment, 2023; MINAGRI Horticulture and Cereal Sector Reports, 2024.)	modern PHM practices, while encouraging private-sector-led management to improve efficiency and long-term sustainability.				

Key Gap / Challenge (Crop-Specific)	Proposed Recommendation	Proposed Lead	Supporting Actors	Priority Level	Proposed Timeline
Fragmented Value Chain & Weak Market Linkages Only about 32% of cooperatives had formal buyer contracts in the maize value chain, indicating that most farming cooperatives are not connected to structured market outlets and formal off-take agreements, which can secure stable prices and reduce postharvest losses (Shilpa Aggarwal, Susan Godlonton Ammar et all, 2021) Many agricultural products in Rwanda are still sold through informal, low-price markets, especially for perishables like horticultural produce, where informal market arrangements dominate and limit farmers' access to better prices and formal marketing channels. (NAEB, SPIU Projects, 2022-2025)	Strengthen market access, aggregation, and contract farming by establishing and enforcing structured contract farming models between cooperatives in Kayonza and Nyagatare and large processors. Establish an Agricultural Market Information System (AMIS) to connect farmers, buyers, processors, and transporters who are in need of information	**MINICOM**	NAEB, RAB, RCA, PSF, MINAGRI, Financial Institutions (BNR), Districts	**High Impact / Medium -Term**	2026-2028

Key Gap / Challenge (Crop-Specific)	Proposed Recommendation	Proposed Lead	Supporting Actors	Priority Level	Proposed Timeline
Financial Inaccessibility/ Constraints: Formal credit access among farming households is very low, with fewer than 20% of farmers obtaining loans from commercial banks, MFIs, or SACCOs with high collateral, interest rates (16-18%). (World Bank, Rwanda Commercialization and De-Risking for Agricultural Transformation Project, 2022). Access to loans remains limited, and when credit is available, interest rates are often prohibitively high. Many farmers lack confidence that their production will generate sufficient income to fully repay the borrowed funds (Ingabo Syndicate, Constraints to Agricultural Loan Access in Rwanda, 2024)	**Establish funding mechanisms for the agricultural value chain by** Establishing a PHM & Agro-Processing Credit Guarantee Facility to de-risk loans. Advocate for low interest loans (1–5%) and promote warehouse receipt financing and blended finance models **for cooperatives and SMEs nationwide.**	**MINECOFIN**	MINAGRI, RAB, BNR, Development Banks World Bank and PSF	**High Impact / Medium -Term**	2026-2029
Institutional Coordination Gaps: Gaps in the coordination of	Enhance coordination and collaboration among relevant institutions by establishing	**MINALOC / RGB**	MINAGRI, RAB, NAEB, District Mayors	**Low-Cost / High**	2026-2026

Key Gap / Challenge (Crop-Specific)	Proposed Recommendation	Proposed Lead	Supporting Actors	Priority Level	Proposed Timeline
roles and responsibilities among key institutions, including MINAGRI, RAB, NAEB, and MINICOM, leading to inefficiencies in planning and implementing post-harvest management and agro-processing initiatives. No standardized PHM monitoring indicators are consistently reported.	mandatory District PHM Coordination Committees to reduce duplication, clarify roles, and ensure a clearly defined scope of work during implementation. Integrate PHM-specific indicators (e.g., % loss, storage utilization) into Imihigo and RGB scorecards **in all 30 districts.**			**Impact (Short-Term)**	
Capacity & Skills Gaps • Only ~15-28% of farmers receive PHM training. • Low adoption of proven tech (moisture meters, hermetic bags). • Processors lack skills for quality control and maintenance.	**Increase the number of extension workers and provide cooperative incentives.** Launch a national "PHM Extension Corps" program, training 1,000+ lead farmers and managers. Embed PHM modules in all TVET agriculture curricula and establish district-level PHM demo farms **nationwide.**	**MINAGRI**	RAB, RCA, TVETs, MINEDU, NGOs (e.g., CSOs, Local Government	**High Impact / Medium -Term**	2026-2028
Private Sector Engagement & Sustainability • Non-utilized infrastructure due to lack of cooperative capacity after	**Promote private-sector-led innovation through PPP frameworks by** engaging PSF with subsidies and incentives. Capacitate and sustain cooperatives post-project phase-	**MINICOM**	MINAGRI, MINECOFIN, RAB, Development Partners and PSF	**High Impact / Long-Term**	2026-2030

Key Gap / Challenge (Crop-Specific)	Proposed Recommendation	Proposed Lead	Supporting Actors	Priority Level	Proposed Timeline
projects phrase out/ life span.	out and attract investment for large-scale storage/processing **in strategic locations like the Gitare Mills site and potential agri-hubs.**				
MAIZE					
Inadequate Drying & Storage Infrastructure • ~94% of farmers dry maize on bare ground. • <20% access raised drying platforms. • Storage deficit, esp. in high-production sectors (Rwimiyaga, Kiziguro). • Leads to 13.8%+ losses & high aflatoxin risk.	**Deploy 500+ community solar/mechanical dryers and 200+ hermetic community storage units in high-production sectors (Nyagatare, Gatsibo, Kayonza, Nyamagabe).** Integrate with feeder road/electricity plans.	**MINAGRI**	District Authorities, RCA, MININFRA, REG, Private Sector (PPP), RAB, and Development Partners	**High Impact / Short-Term**	2026-2027
Weak Market Linkages & Aggregation • Only ~32% of cooperatives have formal buyer contracts. • Limits quality-based pricing and stable supply.	**Establish and enforce structured contract farming models between cooperatives (e.g., in Kayonza, Nyagatare) and large processors/off-takers (e.g., Africa Improved Foods, MINIMEX).** Scale up the **FARM P3 programme** model.	**MINICOM**	RAB, RCA, PSF, Financial Institutions (e.g., BNR) and NAEB	**High Impact / Medium -Term**	2026-2028
High Energy Costs & Unreliable Power • Energy costs are 35-55%	**Launch a "Green Energy for Agro-Processing" subsidy and technical assistance program to**	**MININFRA**	RAB, MINAGRI, MINICOM, Private Investors and REG	**High Impact /**	2026-2029

Key Gap / Challenge (Crop-Specific)	Proposed Recommendation	Proposed Lead	Supporting Actors	Priority Level	Proposed Timeline
of processing expenses. • Frequent outages disrupt milling/drying.	**promote solar dryers, biomass systems, and grid stability for milling clusters in Eastern and Northern Provinces.**			**Medium -Term**	
RICE					
Surplus Production & Idle Factory Capacity • Such a surplus that factories sometimes run out of paddy to process. • High construction costs due to imported materials.	**Provide subsidies for importing materials used in industrial construction to lower costs.** Strengthen market linkages and aggregation **in the Eastern Province rice belt (e.g., Ngoma, Kayonza, Kirehe)** to ensure consistent supply to mills.	**MINICOM**	NAEB, RAB, BNR, Private Millers and RSB	**High Impact / Medium -Term**	2026-2028
Poor Quality & Low Milling Recovery • 65% of mills operate below 50% capacity. • Milling recovery is only 60-65% (vs. potential 72%). • Weak compliance with RSB standards.	**Modernize 50+ priority rice mills with color sorters, graders, and moisture meters in major rice-growing districts.** Link technology upgrade loans to RSB certification. Establish mobile testing units for paddy quality at collection points.	**MINICOM**	NAEB, RAB, BNR, RCA, Private Millers and RSB	**High Impact / Medium -Term**	2026-2028
IRISH POTATOES					
Critical Cold Storage Gap • <1% of production has access to cold storage. • Leads to 40%+	**Pilot 20+ decentralized, solar-powered cold storage units (10-25 m^3) in Musanze and Burera Districts, anchored to**	**MINAGRI**	MININFRA, REG, RAB, District Authorities, Clean Cooling Partners and Private Sector	**High Impact / Short-Term**	2026-2027

Key Gap / Challenge (Crop-Specific)	Proposed Recommendation	Proposed Lead	Supporting Actors	Priority Level	Proposed Timeline
temperature-related losses in Northern Province. • Farmers forced into distress sales.	**cooperatives.** Develop a cold-chain logistics corridor linking producers to Kigali markets.				
VEGETABLES					
Absence of Pre-Cooling & Packhouses • <3% of collection centers have pre-coolers. • 85% of tomatoes sold ungraded, leading to 30-40% price discounts. • Rapid spoilage during transport.	**Construct 30+ integrated packhouses with pre-cooling, sorting, and grading facilities in high-value vegetable corridors (Bugesera, Kamonyi, Musanze).** Design as PPPs with cooperative management.	**NAEB**	RAB, RSB, District, MINICOM, Authorities, Exporters, PSF	**High Impact / Short-Term**	2026-2027

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