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Postharvest Loss Reduction Interventions in Sub-Saharan Africa

Experiences and Perspectives

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About the report

This report*, Postharvest Loss Reduction Interventions in Sub-Saharan Africa: Experiences and Perspectives*, maps and assesses the current landscape of actors and initiatives focused on reducing postharvest losses in Ethiopia, Nigeria, Kenya, Malawi, and Zimbabwe. It collates and analyses postharvest key informants' experiences and perspectives of postharvest loss reduction initiatives and opportunities in these countries. The authors of this report are Tanya Stathers, Gideon Onumah, and Richard Lamboll from the Natural Resources Institute (NRI), University of Greenwich. The authors bear sole responsibility for the content of this report, and any errors and omissions are the authors' sole responsibility. Please direct any comments or queries to the corresponding author, Tanya Stathers, at t.e.stathers@greenwich.ac.uk.

Review process

This report was reviewed by one external reviewer, Aine McGown and colleagues (Food & Agriculture R&D Adviser and colleagues, FCDO), Mark Engelbert (Senior Evaluation Specialist, 3ie), Dina Kiwan (Academic Director, RCC and Professor of Comparative Education, University of Birmingham).

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About the Research Commissioning Centre

The Foreign, Commonwealth and Development Office (FCDO) Research Commissioning Centre (RCC) has been established to commission and manage research to enhance development and foreign policy impact. Led by the International Initiative for Impact Evaluation (3ie), the University of Birmingham, and an unmatched consortium of UK and global research partners, the RCC aims to commission different types of high-quality research in FCDO's key priority areas.

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EXECUTIVE SUMMARY

Introduction

Tackling postharvest food loss offers an entry point to improve food security, reduce emissions from food systems and improve livelihoods/incomes for vulnerable smallholder producers in low- and middle-income countries (L&MICs). The UK Foreign and Commonwealth Development Office (FCDO) Food & Agriculture Research Team would like to explore research and innovation gaps for postharvest food loss (PHL) reduction, as a priority area for investment.

The aim of this study is to map and assess the current landscape of actors and initiatives working to implement interventions to address PHLs in selected sub-Saharan African countries. The focal countries (Ethiopia, Nigeria, Kenya, and Malawi together with Zimbabwe) were selected through a comparative analysis of a range of national-level metrics, eventually narrowing in on the criteria of levels of postharvest (PH) published research, urbanisation, levels of poverty, and regional representation to select focal countries which represented different levels of each of these factors. Thirty-three PH key informants (Appendix 1) were interviewed using a set of guide questions (Appendix 2) which draws on the High Level Panel of Experts (HLPE) (2020) sustainable food systems framework. Interviewees included individuals representing private, public, non-government, academic and government sectors from the focal countries. Interviews took place virtually from 25 June to 8 August 2024. The report is organized as follows. Firstly, an outline of key informants' understanding of what different actors are doing to reduce PHL, and the reasons why is provided. This is followed by perceived drivers influencing PH systems; outcomes of PHL reduction interventions and enablers and disablers for PHL reduction. Informants' suggestions for the future, including what needs to be done to support PHL and knowledge gaps and opportunities for enhancing learning are then presented, followed by conclusions and recommendations.

What are different actors doing to reduce PHL and why?

i) Farmers

In all the focal countries, the key informants we spoke to explained that many farmers still use their traditional postharvest systems, and / or (particularly for grains) external inputs such as pesticides, either according to recommended practices or not. The examples given by the key informants of farmers' traditional and/or commonly-used practices tended to highlight the problems they experience when using them, e.g. high moisture content, insect and rodent damage in grain stored in traditional granaries, incidences of deaths of farmers and their children from use of underground pits or toxic grain protection fumigants, mis-application of grain protectants or incorrect use of pesticides intended for field crops or livestock on stored grain, shaking of fruit trees to harvest fruits. 'Modern/ recommended' methods showing some uptake by farmers included the growing use of hermetic storage bags for chemical-free grain storage, mechanised threshing/shelling and harvesting services. For those farmers linked into fresh produce markets there is increasing uptake of simple harvesting tools, maturity indices and ripening processes to reduce deterioration during transport and extend shelf-life, along with use of plastic crates, aggregation and sorting and grading, some of which are becoming pre-requisites for accessing these markets. For those farmers involved in export value chains (VCs) the use of cold stores and trucks to maintain produce quality is also emerging. The limited time

available and virtual/online nature of the consultations, meant it was beyond the scope of this study to consult with men, women, youth or other groups of farmers, and so the information presented is from non-farmer stakeholders' perspectives. The relatively high cost of interventions and levels of poverty, the lack of cost benefit analyses and knowledge about other outcomes alongside perceived low awareness were perceived to be key barriers to increasing uptake of 'modern/recommended' PH methods by farmers. Some of the stakeholders we interviewed highlighted the need to engender greater ownership of projects by farmers, and to conduct needs assessments to gain a deeper understanding of why farmers are doing what they do and why they are not adopting PH interventions or following PH training messages. There was mention of how co-designed participatory research processes with farmers can help improve understanding and PHL reduction.

ii) Traders, aggregators, transporters, retailers

Despite the lack of data and analysis, there is a widely held view that there are high levels of loss in perishable produce VCs during trading, aggregation and transport stages. The seasonality of the production results in market gluts of this produce. Some farmers then arrive at markets but end up having to dump their produce, leading to loss and serious hygiene issues as huge quantities of cabbages, tomatoes etc. then are left to rot. During transport, poor packaging practices (e.g. stacking baskets of fresh produce on top of each other and over filling containers) all lead to high levels of loss. In Nigeria, the use of reusable plastic crates during handling and transport of tomatoes from the production zones in the north to the markets in the south could reduce losses during those stages from 40% to about 10%, according to one study. It is unclear what scale of uptake of these changed packaging or handling practices - that can pull higher quality produce through the food system and reduce quantity and quality losses – has occurred. Cooling can help in reducing losses and retaining the quality of fresh produce, and in at least 58 markets in Nigeria, some traders and retailers are now paying a daily fee to cool store their crates of perishable fruits and vegetables. Demand for such pay-to-cool services is reportedly growing rapidly in Nigeria, and stakeholders in other countries are interested in availing such services to their own market traders.

A range of small- and large-scale grain traders appear to be present in the focal countries. The East African Grain Council (EAGC) provides its members with access to structured trading, market information, trade-linkage solutions (G-SOKO). Where the market demands it, emphasis on grain quality may be present. This emerges particularly around fears of mycotoxin contamination of grain, and to support traders and farmers the EAGC support aflatoxin testing and other aflatoxin risk reduction measures (e.g. biocontrol field applied products, moisture content testing, drying, exploration of the viability of using ozonation aflatoxin decontamination plants, and trading practice changes such as purchasing grain on the cob as opposed to in shelled form). Increasing mechanisation of shelling/threshing, harvesting and drying in Ethiopia, Kenya and Nigeria, through mobile service providers who are often youth is an emerging trend in these VCs. Warehouse receipt systems have been significantly worked on, but do not appear to be operating in most of the countries. While retailers' practices directly influence levels of food waste occurring in their own businesses and in their customers' homes, they can also influence the levels and types of loss from the field onwards via their supply chain values and demands. There currently appears to be limited linkage between the traders and the researchers and other public sector actors in the focal countries, highlighting opportunities for greater involvement of traders and transporters in development-oriented PHL reduction initiatives.

iii) Service providers

Public sector

A range of **public sector actors** were consulted, many of whom were PH specialists. All the countries have PHL reduction / food loss and waste (FLW) research taking place in Ministry organizations or public universities, although there is stronger emphasis on agricultural production. To date, much of the PHL reduction work has focused on grains, but there is increasing interest – and to varying degrees action - in relation to perishables and root crops. All the countries have publicly funded and implemented agricultural extension services. These services are all to varying degrees decentralized and reportedly demand-led. These organizations also have a stronger focus on agricultural production, with varying levels of PH-related work. Key informants reported various capacity issues (see particularly sections 5, 6 and 7) including access to financial resources. Much of the funding for public sector PHL reduction work is from international development partners, rather than governments' budgets. This has raised questions about the continuity of PHL work and the extent to which it is able to respond to stakeholders' priorities. The development of National Postharvest Management Strategies (NPHMS) (Ethiopia, Kenya and Zimbabwe) has been an attempt to address these concerns. It is important to support public sector agricultural service organizations in countries where farming plays a key role in the economy and livelihoods.

NGOs

Both international and local NGOs have been identified as playing important roles in framing the PH R&D agenda, which is not only limited to articulating the scale of the PH challenges actors face but also involvement in testing/validating solutions. They are also involved in knowledge (technology) transfer, including cross-country sharing of knowledge on available technologies and supporting customisation to suit local conditions. They have been engaged in building local capacity for equipment fabrication/manufacture (through training and funding); piloting and upscaling adoption of some PH innovations as well as institutionalising standards for PH facilities and equipment. Quite common among local NGOs is their involvement in delivering extension services to encourage uptake of PH technologies and practices by smallholders. New roles for local NGOs, which is contributing to reduction in PHL in Kenya and is likely be replicated in other countries, include that of food redistribution and a related role in policy and legislative reforms.

Acknowledging the importance of NGOs role beyond promotion of new technologies and practices is needed. This requires capacity building in extension approaches which shifts the emphasis from technology-push, to the engagement of target actors in collectively defining R&D agendas as well as testing and validating innovations.

Private sector

There are far fewer private sector organisations or individuals involved in supplying goods or services for actors engaged in PH stages than there are for production. The PH-focused private sector actors mentioned for grain PH systems included those providing hermetic bags, plastic silo/containers, metal silo fabricators, pesticides, and service providers such as pest control companies who fumigate and treat large-scale grain warehouses, entrepreneurs offering mobile threshing or drying services, agro-processors, and warehouse receipting services. For perishable fruit and vegetable PH systems, private sector actors supply cold storage units and cooling-as-a-service. In Nigeria market-located cold stores operators are emerging to provide 'cooling-as-a-service' for wholesalers and retailers to keep crates of fresh produce in before they sell it on. While making a 'follow the cabbage' radio series, the firsthand experience of the scale of the gluts triggered a radio presenter in Nigeria to start tinkering with solar-powered cold storage systems. Many years and international research collaborations and grants later this has resulted in the ColdHubs business, and the emergence of the 'cooling-as-a-service' sector in markets in Nigeria. In rural areas of Kenya, cold store units are hired for use by commercial farmers and farmer groups aggregating produce such as avocadoes, mango, French beans and herbs grown for the quality sensitive export to Europe market.

Access to finance for smallholders and private sector enterprises to enable them to purchase PH goods or services was a challenge in all the countries. Innovative initiatives such as early-stage de-risking finance to help PH-focused companies promote their products and develop their supply and distribution chains has proved crucial. Another example of a successful intervention that incentivised hermetic bag companies to invest in promoting their products and developing their supply and distribution networks was the AgResults on-farm grain storage project, which provided results-based prize funds to companies for sales targets of pre-specified volumes of improved grain storage facilities. A further project of interest mentioned by informants is the ACELI Africa project which through data sharing and results-based financial rewards is incentivising banks to lend to agricultural SMEs, some of whom are likely focused on PH activities.

Development partners

Development partners (international development organisations and private philanthropic organisations) have been playing an important role in scaling up PH activities, including technology promotion and support for formulation of national PHMS. They have also, in some cases, supported multi-stakeholder processes (MSPs) engaged in PH issues. Examples of development partners involved in PHL reduction include the World Bank, USAID, Swiss Development Corporation. While continuing such support, there is a need to explore how project-based funding by donors can contribute to catalysing sustained actions needed to address PH issues. Funding models with a longer-term perspective need to be explored. Focused on loss reduction in grain crops, the multi-donor funded AgResults on-farm grain storage pilot in Kenya used a results-based approach to incentivise private sector investment in supply and distribution systems and sales of improved on-farm storage solutions (in this case particularly hermetic bags and plastic or metal silos). This was funded by the governments of Australia, Canada, the United Kingdom, and the United States, and by the Bill & Melinda Gates Foundation

Policy

Ethiopia, Kenya and Zimbabwe have National Postharvest Management Strategies (NPHMS). These have been developed using multi-stakeholder processes and are at different stages of being launched. Ethiopia had a previous NPHMS that was focused just on grains, while the new Ethiopian NPHMS covers cereals, fresh fruits and vegetables and livestock products. Although implementation guidelines are being developed, funding for these strategies is yet to be attained. However, due to the complexity and multi-sectoral nature of PH systems, many other agricultural, health, transport, industry policies affect PH elements of food systems. Coordination between actors involved in PHL reduction needs improving in all the countries to help ensure there is awareness of what problems and interventions are emerging and being studied, to share learning and to avoid 'reinventing the wheel' type problems. Lobbying has been on-going in the countries to exempt PH products from VAT and import duty as already happens for agricultural production (pre-harvest) inputs in many countries. In Kenya, there is an act of parliament on warehouse receipt systems, and a multi-stakeholder group is currently developing guidelines for food redistribution.

iv) Multi-stakeholder arrangements

Multi-stakeholder arrangements have taken different forms across the countries studied and are playing diverse roles, including contributing to the formulation of NPHMS and promoting national and subregional PH actions. What is evident, however, is the need for sustained rather than short-term, project-tied multi-stakeholder networks. Lesson-learning, including through subregional exchanges, will be helpful in this connection, but the key question is how the multi-stakeholder processes can be funded and managed in a way that assures sustainability and independent effective actions.

Perceived drivers influencing PH systems

A range of different drivers continually shape food systems and the postharvest elements of those systems. These drivers vary by context and over time, and to understand postharvest systems it is important to identify which key drivers are influencing PH systems and in what ways they are responding. The stakeholders we consulted identified a wide range of drivers, which we then grouped according to the HLPE (2020) sustainable food system framework categorization of drivers. The drivers mentioned can be summarised as follows. *Biophysical and environmental drivers* include climate-related changes impacting on production levels, produce perishability, crop drying, storage quantities and pests. *Technology, innovation and infrastructure* drivers include increased use of ICTs for learning and information sharing, cold chain investment, while storage and handling technologies exist so do access and affordability challenges, high yielding varieties with poor storage characteristics, and poor roads and stores which result in high PHLs. *Economic and market* drivers include poverty leading to consumption of low quality or contaminated produce, growth of quality sensitive markets and structured trading, high intra-seasonal price variation incentivising grain storage for food and sales, increasing imports of food, increasingly stringent export food safety regulations, crop exports as important source of hard currency, Forex instability affecting price of imported equipment, limited access to credit by farmers and SMEs. *Political and institutional* drivers include the dominance of the focus and expenditure on production activities by government and other

actors, growing awareness of scale and cost of PHLs particularly in relation to imports, internal and international conflicts affecting and/or lengthening trade routes resulting in higher loss, absence of VAT exemption for most imported PH technologies, creating youth employment opportunities in PH systems, emerging multistakeholder-developed PH strategies. *Socio-cultural* drivers include increasingly quality-aware consumers' concerns about food safety aspects such as aflatoxin contamination, Gen Z driven healthy living movement influencing food handling, increasing theft of crops in field driving earlier harvesting and affecting drying. *Demographic* drivers include rapid population growth and associated increased food demand, high proportion of youth and high youth unemployment and varying interest levels for engagement in food production and PH systems (e.g., mobile mechanised threshing or harvesting service provision), an emerging consumer class prepared to pay premiums for higher quality produce. Decisions about future PH interventions, which are aiming to achieve sustainable development outcomes, should be informed by an understanding of the food and PH systems drivers in a particular context.

Outcomes of PHL reduction interventions

From a development perspective, PH interventions aim to make a contribution towards economic, social and environmental outcomes based, for example, on the Sustainable Development Goals. We asked stakeholders for information regarding the outcomes of PHL reduction interventions using a deliberately open question to allow the respondent to frame their response in the way they thought best. There appears to be some promising innovative actions, such as a social entrepreneur introducing cold storage facilities for perishable produce in Nigeria. In Ethiopia there has been major expansion in the use of hermetic bags for storage and to a lesser extent in Malawi. In Kenya there have been a range of actions around grains and more recently perishables. Overall, however, across all the countries stakeholders reported that there had been little assessment of PHL reduction interventions and even less independent assessment. Hence, key informants mainly reported that they were unsure about the outcomes. Where there has been assessment it has been mainly focused on individual technologies. Hermetic bags have probably received the most attention. For example, in Ethiopia there appear to have been a number of technical and economic assessments, which suggest positive outcomes for farmers who are able to access the bags. Environmental and social outcomes appear to have received less attention. Many key informants commented on the need for such assessments to be done.

Enablers and disablers for PHL reduction

There was both agreement and disagreement among public, private and other actors regarding enablers and disablers for PHL reduction. The enabling factors identified by the key informants include growing awareness among public policymakers about PH issues, hence pushing them up the policy agenda; a process that is being prompted by global/continental initiatives such as the UN Food Systems Summit (which provides an opportunity to integrate PH in Food Systems Roadmaps), the UN's SDG12.3 and the AU's Malabo Declaration Commitment 3b. These initiatives are raising awareness and, in some cases, motivating development partners and NGOs to support PH actions, an example being the AgResults grain storage project in Kenya. Other identified enabling factors include the engagement of public research organizations, who

through R&D are coming up with PH innovations in food value chains e.g. staple grains, roots and tubers, and fruits and vegetables. Researchers have benefited from collaborative relations with national and international organisations. Climate change is reported to be accentuating PHL and may therefore be driving demand for PH innovations, some of which are attracting private investment including from actors such as small/medium-scale equipment fabricators and manufacturers. This is especially the case where there is demonstrable demand for new PH solutions from smallholders, micro/small-scale processors and traders. Rising awareness of food safety hazards among consumers in SSA, especially in urban areas, is boosting demand for quality food produce/products and therefore encouraging the adoption of PH handling practices and technologies which contribute to loss reduction. Engagements between researchers and target users of PH solutions is impacting positively on R&D priorities in PH and, potentially, the quality and suitability of the outputs. MSPs have also emerged in some of the focal countries, among others, to enhance dialogue for needed PH-related policy and regulatory reforms.

The disabling factors identified by key informants include fiscal policies which are skewed in favour of pre-harvest/production activities (e.g. PH equipment and their raw materials attract import duties and taxes/VAT in contrast with inputs for pre-harvest activities). Under-resourcing of public organizations in R&D and extension is a critical disabling factor, particularly because there is limited private investment in R&D in PH solutions. Knowledge and skills gaps, land access challenges, physical security concerns, infrastructure constraints (e.g. poor state of rural roads) and limited access to finance are some of the disabling factors identified by key informants. Some informants also mentioned that limited progress in promoting quality-sensitive output marketing systems sometimes dampens incentives for using new PH solutions. There was also mention of some interventions by governments, donors and NGOs which crowd out the private sector, including of youth seeking to invest in provision of PH services.

What needs to be done to support PHL reduction and how can investors best support this

Key informants' perspectives on **what** should be done to support PHL reduction at the **micro level** include: promoting uptake of proven PH technologies needed at different stages in staple grains, root and tubers and perishable crop value chains. This needs investments to strengthen local capacity to fabricate or manufacture PH equipment (e.g. hermetic storage bags or drums, threshing machines, for proximate processing of perishables, solar powered/mobile packhouses, refrigerator trucks, cold chains and other simple affordable labour-saving technologies) targeting smallholders as well as micro/small-scale traders, aggregators and processors. Some key informants stressed the need for more participatory processes that ensure effective engagement of target users in the design and testing of PH innovations. In addition, prior to uptake of the innovations being promoted, there should be robust assessment of technical efficacy as well as financial/economic viability and the social and environmental impacts.

Suggested key areas for investment at the **meso level** include the following: PH training and awareness creation for policymakers, extension workers, farmers, SMEs in PH, and other private sector actors; Improving opportunities for sharing knowledge and learning, e.g. through learning visits between stakeholders and countries; Access to appropriate finance for suppliers and users of proven technologies and at affordable interest rates (as was done through the

AgResults Project). The following **macro level interventions** were suggested: formulation and/or implementation of enabling policies e.g. NPHMS, which are also well-funded; institutionalising, harmonising and enforcing quality standards across subregions to facilitate cross-border trade and tax reforms e.g. removal of import duties and VAT exemptions on PH equipment and raw materials for manufacturing them. Furthermore, the way food reserves are managed should be integrated in marketing systems in ways which help to reduce PHL by offering predictable incentives.

Knowledge gaps and opportunities for enhancing learning

The PH stakeholders we consulted identified a long list of **important knowledge gaps for PHL reduction**. These included: 1) farmers' awareness of PHLs and 2) their access to information on weather services and commodity prices. Limited understanding of 3) farmers' perceptions and reasons for their decisions around uptake of interventions for PHL reduction services and technologies, 4) the causes of PHLs within the context of the wider food system, 5) gender and other social dimensions of PHLs, 6) the scale of losses actually occurring in order to inform targeted loss reduction decisions by various actors, 7) the viability of PHL reduction interventions, 8) finance provision and access decisions and needs for PHL reduction by both financial providers and users. More knowledge was needed on holistic approaches to PHL management and PHL reduction learning methods which are appropriate for resource-poor people in rural areas, and food waste and re-cycling particularly for urban dwellers. Further knowledge was also needed around a) crop drying, b) solar refrigeration technical and engineering skills, c) safe handling of food, d) localized protocols for PH management of specific VCs and contexts, e) safe use of pesticides, f) PH equipment and infrastructure that could reduce losses, and g) reducing the environmental footprint of PH interventions e.g. recycling of hermetic bags.

The following **opportunities for learning** were identified by key informants. Supporting farmers and other actors' learning through their organisations (e.g. farmer associations, farmer field schools, VC-focused associations such as an avocado association), Retail Traders Associations, consumer associations). Strengthening public agricultural extensions services PH knowledge and their curriculum. Ensuring greater collaboration and sharing of information and synergy of activities between different actors (e.g. using multi-stakeholder PH learning platforms, learning with decision makers, conferences/meetings, PH professionals study tours between countries (within and beyond the African continent), a PH professionals exchange programmes, private sector working with researchers to help mine the private sector's rich data sets and to inform and help develop relevant courses), special events (e.g. Ethiopia's postharvest week, Malawi's day of food loss waste commemoration.

This learning could involve the use of online virtual learning platforms, methods and resources, as well as traditional media (posters, newspapers, radio, TV) and popular social media platforms, short continued professional learning courses, local activities on the International Day of Food Loss and Waste awareness) and greater prominence or addition of PH training topics in technical vocational education centres, schools and a wider range of higher education courses.

Recommendations

Recommendation 1: Interventions should be informed by what stakeholders and systems are doing and why

Those planning and/or implementing interventions, appear to have limited recognition and understanding of what focal stakeholders are or are not doing currently to reduce PHLs, and why.

1.1 Planners and implementers of interventions should explore in more depth the PH-related activities of stakeholders (e.g. farmers, traders, transporters etc.) whose decisions and activities directly influence PHLs. This includes stakeholders' reasons for these decisions and their sphere of influence.
1.2 Measure and collect data on losses from the different activity stages across a range of VCs, to deepen understanding of the scale, types and causes of loss occurring.
1.3 Recognise the heterogeneity of situations, knowledge and aims between and among stakeholders (e.g. farmers, traders, transporters etc.).

Recommendation 2: Recognise and address the complex and dynamic nature of agri-food systems

Postharvest agriculture exists within a wider development context involving multiple drivers of change that continually shape agri-food systems and their postharvest elements (see section 3). Postharvest systems are complex and working with them requires a multi-stakeholder and multi-sectoral understanding and approach.

2.1 Build on this and other analyses of postharvest systems to understand the complex and dynamic relationships between actors, drivers, place and PH system attributes and outcomes to help prioritise interventions at micro, meso and macro levels within the existing system.
2.2 Explore scenarios for how agri-food systems might or should change in the future and the implications for the management of PHL reduction within wider development contexts.
2.3 Support multi-stakeholder learning processes in the development, implementation and assessment of PHL management strategies and interventions within a framework of contribution to sustainable and equitable farming and food systems transitions.
2.4 Understand the enablers and disablers (see examples in section 5), the degree of consensus around them, the proposed actions, and the trade-offs and potential winners and losers.
- Where there is consensus between stakeholders utilise this to potentially achieve early wins
- Where there is no consensus on forward actions, create and maintain a safe space to support dialogue and deliberation by diverse stakeholders to inform decision-making.

2.5 Integrate the well-established lessons for managing multi-stakeholder processes.
2.6 Explore with governments how multi-stakeholder processes can be sustained beyond specific projects and initiatives.

Recommendation 3: Recognise the diverse roles and support effective, fair partnerships among stakeholders in PH interventions

In development interventions, stakeholders are not always playing the roles for which they have appropriate strengths. When interventions require bringing stakeholders together, issues around power imbalances often emerge.

3.1 Recognise the importance and strengths of different actors in roles relating to PH systems and support them in ways that enable collective use of their strengths. For example:
- Support actors who can facilitate processes which address power imbalances
- Sustain capacity to engage in PH actions by going beyond promotion of new technologies and practices, to also actively empower smallholders and micro/small-scale actors to participate in R&D processes for PHL reduction
- Ensure that PHL reduction initiatives entailing eventual commercialisation of technologies or handling services, involve appropriate private sector partners from as early as possible to build ownership and sustainability. Care should be taken to avoid other stakeholders (e.g. NGOs, researchers, government) crowding out the private sector and vice versa.

Recommendation 4: Support appropriate research, innovation and learning processes

Although a number of researchers recognise the importance of how they work and interact with farmers and, perhaps to a lesser extent, other stakeholders (e.g., traders, private sector), extending this more widely requires appropriate skills, confidence and resourcing.

4.1 Increase involvement of core actors (such as farmers, traders and transporters) and their associations in PHL reduction programmes

4.2 Increase use by researchers and other stakeholders, of more participatory research and learning processes to enable the co-design of PHL reduction interventions, supporting processes which support engagement and ownership by farmers, farmer organisations and other actors to enable the co-design of accessible PHL reduction interventions that address their needs.

4.3 The social, economic and environmental outcomes of PH interventions alongside the technical outcomes, should be co-investigated with farmers and other actors to inform decisions on further promotion and investment in each PH intervention.

Recommendation 5: Embed appropriate learning, monitoring and evaluation approaches in PH intervention processes

Several interesting PHL reduction interventions were identified but key informants felt there had been little social, economic and environmental assessment of the changes they had brought about. Many stakeholders commented on the need for such assessments to be done. This raises the question of how best to assess the contribution of PH interventions to development outcomes.

5.1 Together with farmers and other food systems actors, investigate the social, economic and environmental outcomes of PH interventions, alongside the technical outcomes, to inform decisions on further promotion and investment.
5.2 Support the development and implementation of appropriate outcome and impact assessment approaches and tools to guide evaluative learning around PHL reduction strategies and actions.
5.3 Embed sustained monitoring, evaluation and learning in PH investments to enable prompt modifications where needed, e.g. as a result of unanticipated challenges/risks.

Recommendation 6: Support research on widening access to finance by key PH stakeholders

The key informants highlighted how lack of access to finance limits both the supply-side capacity of fabricators/manufacturers, distributors and service providers to sustainably deliver innovative PH tools, equipment and services, and the end-user uptake capacity of farmers, traders and SMEs in agri-food systems. Some examples of potential financial products (e.g. blended finance products) were identified but were not assessed in depth in this study.

6.1 Evaluate existing innovative finance products, e.g. de-risked financing products, result-based financial incentives, to understand their potential in catalysing private sector development of supply and distribution networks, and in stimulating financial organisations' PH-focused lending to SMEs and different types and groups of farmers.
6.2 Explore well-structured market relations and the ways in which they create or expand opportunities to de-risk and improve access to finance for different actors.

Recommendation 7: Greater focus on equity and social inclusion

The study illuminated the limited knowledge of the broader outcomes of PH interventions beyond the technical outcomes, and a dearth of knowledge around the relationships between PH interventions and systems and their gender and diversity aspects and implications. In line with national government priorities this would include consideration of opportunities for youth.

7.1 Ensure that equity and social inclusion dimensions of PH systems and PHL reduction interventions are given prominence in PH programmes, projects and other investments. This requires a ground-truthed understanding of the heterogeneity of situations and actors (e.g. farmers and traders), and their involvement in PH systems.
7.2 Support the involvement of PH actors, including SMEs, in co-designed equity-focused PH investments to enable women and youth and people living in extreme poverty to participate in and benefit from PHL reduction interventions.

Recommendation 8: Ensure continuity, financial sustainability and coordination of actions

Development partners' role in highlighting the issues and supporting PH interventions has been important in the countries studied. Continuity, coordination and financial sustainability of PHL reduction interventions were identified as issues that need to be addressed with short-, medium- and longer-term perspectives in mind.

8.1 Support the embedding of PH systems thinking in agricultural public sector organisations.
8.2 Support co-development, ownership and embedding of PH interventions in local systems/organisations to enhance the likelihood of their continuity following project end dates.
8.3 Strengthen public sector organisations' capacity to coordinate and secure diverse streams of resources for sustained PH actions, including funding of national PHMS.
8.4 Co-design longer term programmes and opportunities for actors to have continuity of funding within them.

Recommendation 9: Invest in capacity strengthening approaches to support PHL reduction in existing and future systems

The public, private and other sector stakeholders all reported capacity issues at different levels. At individual level these encompass capability, motivation and opportunity. Key informants identified a range of approaches and opportunities for enhanced learning, including formal training at a range of levels, experiential learning, virtual learning, professional exchange and collaboration, sharing and synergy between actors within and between different countries or regions (see sections 6 and 7).

At organisational level, much of the operational budget for public sector PHL reduction work is funded by international development funding through projects, rather than from governments' budgets. This has raised questions about the continuity of PHL work and alignment of stakeholders' priorities.

9.1 Support public sector agricultural service organizations in ways which strengthen capacity of individuals (capability, motivation and opportunity) and organizations (strategies, operational ability, reflection and learning practices, culture etc.) to respond to PH stakeholders' needs. This involves the public sector working with other key actors to consider holistically the agri-food systems, the drivers of change, the nature and causes of PHL under existing systems, and transitions towards more sustainable and equitable systems.
9.2 Support the development and implementation of PH learning and training strategies at different levels (e.g. national, sub-national, regional, sub-regional) and in different institutional contexts (e.g. school, extension programmes, farmer field schools, vocational and university curricula).
9.3 Strengthen capacity in farmer-centred, experiential learning extension approaches such as Farmer Field Schools, and participatory action research.

Recommendation 10: Deepen understanding of how markets influence PH actions

Some key informants mentioned that certain markets, especially formal market segments which offer price rewards for quality, can incentivise uptake of practices and technologies which reduce PHL.

10.1 Support transdisciplinary teams in exploring the barriers and facilitators to accessing PH products and services by disaggregated market segments.

10.2 Research is needed to understand the relationships between market factors (including quality standards and reward systems) and PHLs, the related incentives to use PHL-reducing interventions and the varied impacts of such emerging markets on the livelihoods of poorer and more vulnerable sections of the population.
10.3 Increase understanding of the context and conditions under which structured marketing systems - that offer predictable/transparent rewards for compliance with relevant standards – function, and the economic, social and environmental impacts.

Recommendation 11: Recognise technology is just a part of the change process

A few PHL reducing technologies, such as hermetic storage containers, mechanised threshing, plastic crates, and solar-powered cold chain technology were mentioned by key informants, along with a desire for increased local production of these technologies. However, several challenges were also mentioned, highlighting the need to understand the role of technology and its co-relationship with other types of interventions, to avoid further 'white elephant' type investments and other undesirable outcomes.

11.1 Within the change process, support the exploration of existing technology-options with key stakeholders, the co-development of new technology options, and assessment of their efficacy, affordability and acceptability and impacts at the appropriate contextual scales, while ensuring responsible innovation and just innovation are taken into consideration.
11.2 Support the necessary training and access (e.g. through supply and distribution systems, finance, local fabrication and renewable energy opportunities) for any selected and tested technologies.

Recommendation 12: Support research and learning to address wide ranging knowledge gaps for PHL reduction

Public, private and other sector key informants identified a range of PH knowledge gaps (see section 7). Some related to the knowledge among specific actors, such as farmers' awareness of PHLs. Others were more general in nature (e.g. the scale and causes of PHLs within the agri-food system; the social, economic and environmental outcomes of PHL reduction technologies currently being promoted) and others were more specific (e.g. crop drying, solar refrigeration, food safety). Many ideas for improving PH learning opportunities were suggested.

12.1 Support research and learning to address the important knowledge gaps (e.g. scale, causes and awareness of PHLs, social, economic and environmental outcomes of PHL reduction interventions, changing PH risks and opportunities) identified by key informants, following prioritisation with shorter and longer-term considerations and validation by stakeholders in context.

1. Introduction

1.1 Background and Aims of the Study

Tackling postharvest food loss offers an entry point to improve food security, reduce emissions from food systems and improve livelihoods/incomes for vulnerable smallholder producers in low- and middle-income countries (L&MICs). FCDO's Food & Agriculture Research Team commissioned this study as part of an exploration of research and innovation gaps for postharvest food loss[1] (PHL) reduction, as a priority area for investment under a new business case to be developed in 2024.

The aim of this consultation was to map and assess the current landscape of initiatives working to implement interventions to address PHLs in selected sub-Saharan African countries.

Postharvest (PH) key informants' experiences and perspectives of PHL reduction initiatives and opportunities in their countries, in sub-Saharan Africa, have been collated. This study was conducted alongside an update of a systematic scoping review of interventions for reducing crop postharvest losses in food systems in sub-Saharan Africa and South Asia which explored the existing research evidence available and is reported in Stathers et al. (2024), with the earlier scoping review published by Stathers et al. (2020). The consultation and updated systematic scoping review were developed to jointly inform FCDO's forthcoming PHL reduction investment planning.

The report is organised into the following sections. Section 1 Introduces the study and method. Section 2 summarises what different actors are already doing to reduce PHLs, and why. Section 3 explores the perceived drivers influencing PH systems. Section 4 provides details of what is known about the outcomes of PHL reduction interventions in the focal countries. Section 5 discusses the enablers and disablers for PHL reduction. Section 6 explains the key informants' perceptions of what needs to be done to support PHL reduction. Section 7 provides knowledge gaps and opportunities for enhancing learning identified by key informants. Section 8 presents the conclusions and recommendations.

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[1] **Food loss** refers to the unintentional loss of the edible parts of a food crop during or after harvesting up to and including the wholesale marketing stage (i.e., from crop maturity to marketing) and is often referred to as '**postharvest food loss or losses**'. This may include, for example, grains accidentally left behind in the field during harvesting; fruits or vegetables that over-mature and spoil on the plant; produce that is spilt, bruised, crushed or which wilts during the transportation of the crop to the homestead or market; produce eaten by animals or damaged by rain during crop drying; scattered and not collected during threshing; damaged or consumed by insect or rodent pests or spoiled by moisture during storage, and/or lost due to inefficient milling methods or contaminated during processing (Stathers and Mvumi, 2020). Food loss refers to the decrease in food quantity or quality, which makes it unfit for human consumption (Grolleaud, 2002), or of reduced nutritional or financial value, leading to nutritional and financial losses, reduced market opportunities and food safety and reputational risks (Hodges et al., 2011; Kader, 2005). Food loss is the unintended result of agricultural processes or technical or knowledge limitations in combination with environmental factors. **The term, postharvest food loss is used here to refer to food loss that occurs during or after the harvesting stages up to and including the wholesale marketing activity stage.**

Food waste, on the other hand, refers to food that is of good quality and fit for human consumption but does not get consumed either before it spoils, or as a result of it having spoiled before purchase, preparation or consumption occurs. Food waste can happen for a myriad of reasons including poor purchasing or menu planning; poor stock keeping or decision-making; poor cooking skills; uncertainty regarding levels of demand or highly variable demand; over purchasing or over serving; insufficient or poor storage facilities, and/or the highly perishable nature of some types of foods. Food waste typically, but not exclusively, occurs at the retail, food service provision and consumption stages in the food value chain (Parfitt et al., 2010; Brian et al., 2013).

1.2 Methodology

Consultations were held with an array of key PH informants representing a range of stakeholder types in each selected country. These key PH informants shared their experiences and perceptions of initiatives, lessons and opportunities to reduce PHLs in their country. The timeframe for this work was short due to delays; it was contracted on 16 June 2024 and the deliverable report was needed by mid-August 2024 to feed into strategic decision processes.

Selection of countries

The PH key informant consultation was to be done in four sub-Saharan African countries to provide an understanding of the current landscape of initiatives working to implement interventions to address PHLs in those countries. The focal countries were selected through a comparative analysis of a range of national-level metrics and discussion with FCDO staff. The following criteria were then narrowed in on: levels of PH published research[2], national PH management strategy[3], urbanisation[4], levels of poverty[5], and regional coverage (e.g., East, West, Southern Africa). The focal countries (Ethiopia, Nigeria, Kenya, and Malawi) were selected to represent a range of different levels of these factors. One Zimbabwean PH key informant was also interviewed due to the high level of PH research currently and historically in Zimbabwe.

Semi-structured interviews

Thirty-three PH key informants (Appendix 1) were interviewed using a set of guide questions (Appendix 2) which draw on the HLPE (2020) sustainable food systems framework (Figure 1.1).

A semi-structured interview guide (Appendix 2) was prepared to support the process. It explains the purpose of the consultation to the selected key informants, how their data would be managed, the consent and voluntary participation and withdrawal processes, and the guide questions ensured coverage of the different topics with each participant. Prior consent was obtained before beginning the interviews or audio-transcribing or recording them.

The interviews were held virtually, invitations to participate, and scheduling were arranged via email correspondence. Participants were sent the interview guide in advance of the interview to help to familiarise them with the aims and discussion topics, and to support their preparations.

Following an explanation of the aims of the work, and confirmation by the participant of their consent to be interviewed and transcribed or recorded, the interview began with brief introductions by all present. Two interviewers were present for the majority of the interviews and shared the questions between them. The length of the interviews varied between 30 minutes and 2 hours depending on the respondent's availability, their experience and explanations and whether one or two respondents were present. Four of the interviews were held with two respondents present. Where there were time constraints, particular questions were highlighted.

Although auto-transcription was used, the MS Teams software struggled to correctly record many aspects such as technical terms, place names and accents. The interviewers also took notes and made audio-recordings. Time-consuming correction work was required to produce accurate final interview transcripts, these were then stored within the secured MS Teams space.

[2] PH studies per country using data from the updated and the original systematic scoping reviews
[3] Whether or not the country had or was developing a national PH management strategy
[4] % of population residing in urban areas (2020 and projected 2050. Data: United Nations, Department of Economic and Social Affairs, Population Division (2018). World Urbanization Prospects: The 2018 Revision.
[5] % of population living on <$3.65 a day at 2017 PPP. Data: World Bank, Poverty and Inequality Platform.

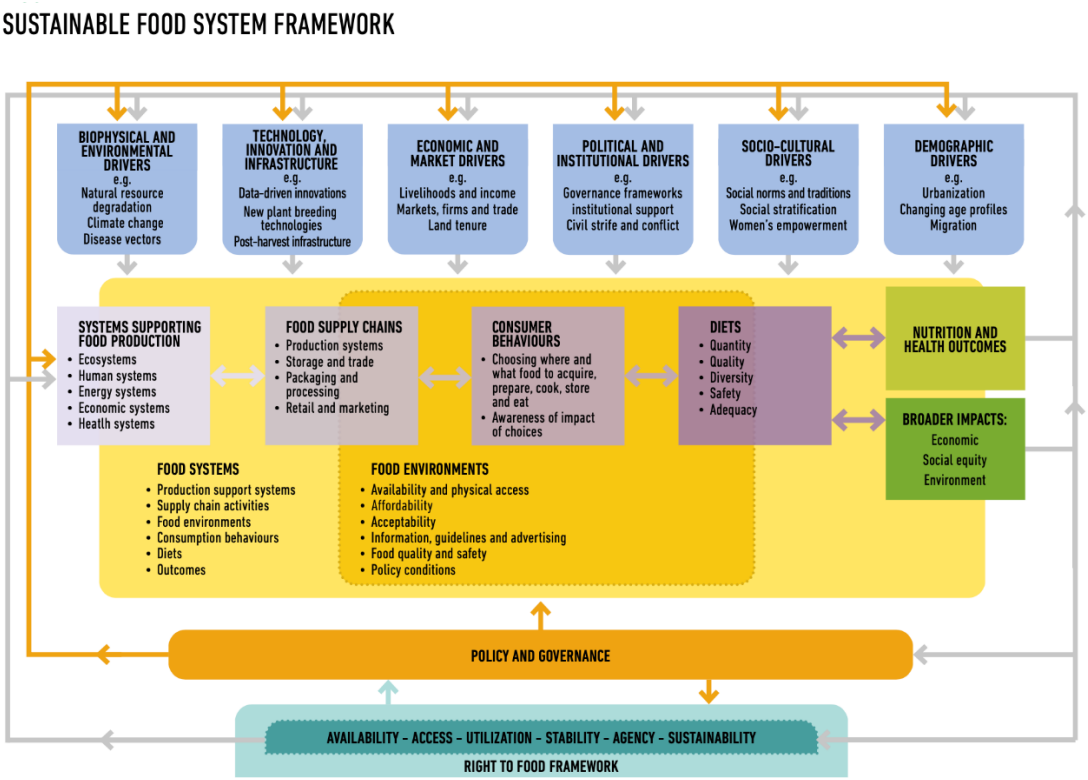

Figure 1.1 The Sustainable Food System Framework
Source: HLPE, 2020

Key informant identification and interviews

Recognising the importance of consulting a range of key informants relevant to PHL reduction in each country, a matrix was created for populating with potential key informants to interview as representatives of different stakeholder groups. The stakeholder groupings are:

- Public sector (Ministries, Research organisations/Universities, Advisory/training organisations, Policy/ regulatory organisations)
- Private sector (Directly involved actors (e.g., aggregators, traders, transporters, retailers); Indirectly involved service providers (e.g., equipment and input suppliers, finance))
- NGO sector
- Other (Farmer organisations, donors, international research centres, postharvest working groups or societies, Programmes)

Initially the matrix was populated with key PH informants known by the research team. The target was to interview a total of at least 20 informants, i.e., at least 5 per country. It was viewed as important that consultations were held with informants familiar with the PHL reduction of perishable crops (e.g. fresh fruits, vegetables, roots and tuber), and others familiar with PHL reduction of durable crops (e.g., cereal and legume grains which are typically stored for several months following drying), as the causes of PHL and the interventions for addressing them differ between perishable and durable crops and tend to be viewed as separate knowledge and experience sets. The team aimed to have an appropriate balance of female and male key informants, although women are under-represented in many of these PH roles and often tend to be focused on perishable rather than durable crops. During communication with the first few PH key informants, we asked for their suggestions for other informants who should be

interviewed from other stakeholder groups. This snowballing approach to identifying key informants was continued during the interviews, as the PHL reduction activities of other stakeholders in each country were discussed.

Potential key informants were contacted initially with an email invitation, and following a positive reply, arrangements were then made to schedule an MS Teams interview at time convenient to them and the interview guide was shared with them. As the acceptance rate of the invitations was >75%, invitation sending was staggered to keep the number of interviews per country and the associated transcription and analysis manageable. Interviews took place virtually via MS Teams from 25 June to 8 August 2024.

Of the 33 key informants interviewed, 51.5% were public sector, 27.3% were private sector, 9.1% were NGO sector, and 12.1% were other sector. Of those interviewed, 18.1% were women, although 23.3% of the 43 potential informants contacted were women. Four of the six women interviewed were in Kenya. Of the 33 key informants interviewed, 91% were of African heritage, with the other 9% being of Asian heritage and working as private sector stakeholders. The number of key informants interviewed per country was Ethiopia (7), Kenya (12), Malawi (6), Nigeria (7), and Zimbabwe (1).

Analysis and report

The interview responses were transferred to an excel database to facilitate analysis on all topics across all interviews. The report structure, which is linked to the sustainable food systems framework, was developed in an advance of the consultations. Following completion of the interviews, research team members carried out the thematic analysis and drafted different sections of the report's findings (sections 2 to 7). During the drafting of sections we referred to a number of agri-food and postharvest systems and project reports (e.g., evaluation reports) and strategies (e.g., national postharvest management strategies) of relevance to this consultation. Drafts were then shared internally for review, discussion, and improvement. Our conclusions emerge directly from our findings and this in turn informed our recommendations. Initially recommendations were identified from each section of the report and were then collated into one set of recommendations after removing any duplications.

Study limitations

The study had to be done through virtual consultations due to the resources available. While this enabled access to a wide range of informants across a huge geographical area in a time-efficient manner, the trade-off was that it hindered opportunities for consultation with actors such as farmers, aggregators, traders, small-scale mobile PH service providers all of whom play key roles in the PH system but are not easy to access and interview virtually. Therefore, while this study has provided a valuable and important way of ensuring the views and experiences of a wide range of PH informants in the focal countries have been shared to inform and strengthen PHL reduction investment decision-making – helping to move beyond the use of evidence coming only from the systematic review of published research outputs – it still has critical gaps with regards to collecting and sharing evidence and giving voice to the experiences of many key PH systems actors. Complementing this virtual consultation with physical consultation with these other actors would add value, as would longer timeframes for planning and implementing such activities. While the snowballing method we used to help identify key informants is fast, efficient and led to high interview acceptance rates, there are risks it could result in a reduced diversity of views and experiences being captured.

2. What are Different Actors doing to Reduce PHL, and Why?

This section provides a snapshot of what different actors in the food systems in the focal African countries are doing to reduce crop PHLs and why.

2.1 Farmers

What are farmers doing and why?

Nigeria

According to a number of respondents consulted, smallholder farmers in Nigeria have generally not shifted from their traditional methods to researcher-recommended PH technologies and practices. This was viewed as being partly because their *"... focus is on production, when you talk PHL with them* [farmers] *... they think it is to do with the cost of production".* Some of the respondents felt farmers were unaware of the recommended PH technologies and therefore need "*... to change their mentality so that they can get [*preserve for consumption or sale] *100% of what they produce ..."*[Ng031]. A senior technocrat added *that "Most of the technology the farmers are making use of, particularly in the perishable fruit and vegetables [value chains] is based on indigenous knowledge* (and technology)*, leading to high losses ... especially when produce is grown in the North and is being transported to the South"*[Ng033]. The huge losses of cabbages by farmers delivering their produce to markets during market gluts and having to just leave it to rot there was what motivated the Cold Hubs entrepreneur to start working on solar-powered cool storage service provision in markets.

"Most of the technology the farmers are making use of, particularly in the perishable fruit and vegetables [value chains] is based on indigenous knowledge (and technology)*, leading to high losses ... especially when produce is grown in the North and is being transported to the South"*[Ng033]

There are situations where farmers and public research and education institutions are collaborating in the development of improved processing equipment and new processed food products in both grains and perishables value chains. For example, a group of women farmers/micro-scale processors, under WOFAN in Kano, have collaborated directly with a public research and education institution in processing perishables such as tomato, into shelf-stable food products for household consumption and sale to immediate neighbours. However, they cannot *"... sell the products in the open market because they cannot obtain licences [for approved food processing] from NAFDAC"*[Ng0024].

A staff member at a leading technology development institute in Southern Nigeria explained that they involve "*... farmers and target processes right from ... design stage to testing out prototypes"*[Ng015]. Another leading research institute, the Nigerian Stored Products Research Institute (NSPRI), whose history dates back to the pre-independence era, is using social media platforms to facilitate needs assessment and the development of some PH technologies. For example, their researchers participate in a WhatsApp Group for Onion Stakeholders through which the farmers expressed their *"... cry ... for improved onion storage"*[Ng002]. Also expressed was the need for *"... farmers themselves to test the technology"* that is being taken to them.

Ethiopia

In Ethiopia, smallholder farmers are the main target users of many of the promoted PH technologies and are, in some cases, involved in R&D by local universities. The collaboration is seen by the researchers as an important part of *"… community engagement actions by the university*" and has been instrumental for example, in the development of avocado harvesters by a local university and their adoption.

However, some of the key informants emphasised that most smallholder farmers still use their traditional practices. For harvesting and threshing this includes harvesting manually or with sickles, and threshing the grain by getting livestock to trample on it or by using sticks to beat it which causes shattering and mixing with dust, stones etc. Farmers use of local methods such as biting and visual assessment of colour to judge moisture content of grain before loading it into storage structures was viewed as increasing the risk of aflatoxin contamination where grain of too high a moisture content was stored. Farmers were also reported to mainly still use their traditional storage systems e.g. *"… mud stores and underground pits"* and incur high levels of losses due to *"… pests [infestation] and aflatoxin"*[Et024]. There are also reported health and safety risks associated with some of these systems such as grain storage in underground pits: *"a father and daughter died whilst trying to collect stored grain from a pit as the oxygen had been depleted by the grain storage"*[Et053]. Safety concerns were also expressed by these stakeholders regarding many farmers' use of PH chemical treatments, "… *wrong use of phostoxin (a fumigant) poses health risks to farmers"* [Et073].

"… wrong use of phostoxin (a fumigant) poses health risks to farmers [Et073]

These considerations as well as food security and financial and economic benefits are reportedly contributing to uptake of hermetic storage technologies (mainly hermetic bags and metal silos) by smallholders in Ethiopia. The bags are reported to be considered *"very affordable"* though this was not validated through farmer interviews. In addition to reducing storage losses ("*by almost 100%"*), they are also able to hold stocks for *"6-8 months* [and gain from] *about 50% price increment without any additional costs"*[Et602]. As a result, some farmers *"… can get up to 64% extra income due to these hermetic bag storage facilities"*. In some areas farmers are selling their draught oxen for meat. These oxen used to do the threshing of their grain by trampling on it, and it was reported farmers in many areas are now increasingly paying for mobile mechanised shelling services.

For fruit and vegetables, poor harvesting and handling practices were reported, this had led to service providers encouraging use of harvesting poles for fruits, and plastic packaging crates and aggregation centres. They gave examples of fruits being left in piles in the heat, bananas still being transported in bunches and not de-handed or packed in crates or cartons, and recognised the need to still do a lot more[Et073].

Kenya

Public sector stakeholders in Kenya reported that smallholder farmers predominantly use their own traditional/ indigenous knowledge to conserve their produce and there are concerns that with changes in the climate and particularly how this effects pest and disease problems, this knowledge may be becoming outdated. These stakeholders would like to see farmers aligning themselves with emerging trends and technologies, including down to the varieties they are growing. They felt that although there has been a lot of training of farmers in harvest and PH handling, long-term adoption of the improved PH practices and technologies is not high, "*after the project's end, everything goes back to the old ways of doing things*" [Ke032]. Even basic store

hygiene practices which can help reduce PHLs were reportedly not being followed. However, no studies confirming or disproving this lack of adoption or of whether there are gendered differences in uptake of PH interventions were reported. Larger-scale farmers were reported to have been adopting technologies such as hermetic bags and Aflasafe.

"after the project's end everything goes back to the old ways of doing things Ke032

Farmers' harvesting methods for tree crops such as mangoes typically involve shaking and climbing of trees and throwing the fruits down to someone below. For perishable fruit and vegetable crops, PH training has therefore mainly focused on better handling practices and increased understanding of the optimum maturity time to harvest. Use of simple shade and sheds to keep produce cool after harvest and prior to collection could help reduce losses but is rarely practiced. The perishable produce is often transported in sacks, although for some farmers supplying supermarkets in Nairobi, use of plastic crates and improved handling practices are becoming a pre-requisite.

Some interviewees highlighted a need to ensure greater ownership of projects by farmers, and to conduct needs assessments to gain a deeper understanding of why farmers are doing what they do and why they are not adopting PH interventions or following training messages. One interviewee reflected on how a participatory action research project co-designed with farmers, in which the farmers had tested their own grain storage protection practices against new researcher-introduced practices, had been a more useful process to farmers than approaches used in many other projects. It is also important to recognise the heterogeneity among farmers, particularly within the smallholder farmer (SHF) grouping.

A large number of PHL reduction projects were described by the stakeholders interviewed. Among these were the AgResults on-farm grain storage pilot, which offered the private sector financial rewards for reaching agreed volumetric thresholds of improved storage device sales. This catalysed hermetic bag use for grain storage by smallholder Kenyan farmers[6] and developed the necessary distribution channels. A collective grain storage project, the Kenyan Cereals Enhancement Project, which offered farmer groups access to subsidised hermetic bags and built small warehouses for them was mentioned, but interviewees were not certain if the warehouses were now under community management and still operational following the project end last year. Access to finance for small scale farmers to purchase PH inputs or services is still limited, although the strengthened farmer cooperatives are increasingly able to access group loans from banks and then divide and manage these loans among their members. While warehouse receipting legislation has now been approved, and banks have developed associated products enabling farmers to access credit against their grain stored in professionally-managed warehouses, these products have yet to see much uptake. For some small PH items, farmers may use 'merry-go-round[7]' style savings groups to help save sufficient funds.

[6]An independent evaluation report by Abt Associates (see Ness-Edlestein et al., 2019 (and also Mainville and Ness-Edelstein, 2021)), suggests the AgResults initiative increased adoption of improved on-farm storage solutions by 23 percentage points in Eastern (with 28% of farmers reporting they adopted), and 6 percentage points in Rift valley (with 10% of farmers reporting they had adopted) compared to modelled projections of what would have happened in the project's absence.

[7] 'Merry-go-round' savings schemes are those were members contribute an agreed sum of money on a regular basis, often every week. Then each time the money is collected, the full sum is paid out to one of the members.

Kenya also has a size-able number of large-scale fresh produce farms, which produce for the export market (e.g. avocado, French beans, *mange tout* etc.) and therefore have to meet strict produce quality specifications. Such farms often generate large quantities of surplus or 'out-of-spec' produce. Some of these farmers donate their surplus to local initiatives (e.g. vegetables going into school meal soups in Naivasha). Food Banking Kenya is now organising the redistribution of surplus fresh fruits and vegetables from large commercial farms to vulnerable beneficiaries. Some of this surplus produce also gets purchased by pig farmers to feed their animals, although it was grown with the intention of providing food for humans.

Malawi

A public sector interviewee explained that most farmers produce for subsistence purposes, while there are also semi-commercial and commercial farmers.[Mw023] A new initiative being introduced by the government under the name of "Mega farming" aims to promote medium and larger scale farmers in order to increase foreign exchange reserves and make Malawi self-sufficient in food production.[8] [Mw041]

One respondent explained that "*the major cause of grain PHL in Malawi is insect pests and it is very serious"* [Mw014]. This includes the common weevil and, since 1992, the Larger Grain Borer beetle which arrived from neighbouring Tanzania. Farmers can sometimes store grains with too high a moisture content which results in losses. Farmers knowledge of mycotoxins was reported to be rather low, which was related to them not being directly affected (if the crop is sold) and/or the effects being gradual if consumed. This contrasts with insect damage, where farmers can see the direct loss resulting from these pests [Mw054].

It was reported by public sector key informants that the majority of farmers have recognized that PH losses are a problem, especially with maize [Mw071]. There appear to be a range of responses by farmers. Some farmers are buying storage pesticides to protect their grain. While this was reported to be the main grain protection practice, "*most farmers don't know how to properly use insecticides"* [Mw074]. Apart from the Actellic dust, some farmers are using pesticides that are meant for use at the field stage only. Some are also using fumigants and according to the Pesticide Control Board that is not acceptable [Mw023]. These are areas of concern for the Ministry. It was reported that there is a good supply of pesticides in rural areas, but quality is a challenge, with quite a lot of counterfeits on the market [Mw024]. Some traders expose products to sunshine, which causes degradation, while others are adulterated. The pesticide regulatory board (Pesticide Control Board) is thin on the ground, so regulation is a big challenge [Mw081].

"most farmers don't know how to properly use insecticides [Mw074]

According to one input supplier and retailer, almost 90% of farmers were previously buying ordinary (polypropylene (PP)) bags and chemical pesticides such as Actellic (Shumba), but currently almost 15-20% of farmer are using hermetic PICS bags. When buying PICS bags the initial investment is high (almost four times the price of PP bags), but with PICS bag they can, according to the interviewee, be used for five years. It was also reported that some people in urban areas are now buying PICS bags [Mw062].

Farmers who use hermetic bags may do so because they keep produce for a long time. Alternatively, some farmers sell their produce soon after harvest to traders who are using

[8] https://africabriefing.com/malawi-president-launches-mega-farms-initiative-to-combat-food-shortages-and-boost-agriculture/

warehouses to store their produce. It was suggested that medium-large scale (mega) farmers tend to produce for the market, so are more likely to sell quickly without a need for hermetic bags [Mw023].

Some farmers are using botanical pesticides both at pre and postharvest stages. Some of these have not been tested by researchers, but farmers are trying to see what works. Researchers are testing some of those botanicals for pre harvest protection, but it was not known to the interviewee whether they are looking at them for postharvest protection [Mw063].

There was uncertainty regarding trends in grain PHL and reason for change. One public sector interviewee suggested that PHL in grains may be reducing. However, if this was the case it was not clear to what extent this may be because of the interventions referred to above and /or that many farmers have experienced low production in recent years, which means that they do not store the grain for a prolonged period. It was suggested that the data to make that assessment is not really available [Mw061].

Overall, the use of some of the PHL technology by farmers is still low [Mw091]. LUANAR conducted a study in early 2024 to understand how many people are using hermetic bags. In a survey of 627 participants in four districts, only 7% of respondents were continuously using hermetic bags, and 20-23% had never even heard about hermetic bags.

Regarding fruit and vegetables, there are very serious losses of tomato and mango. One respondent estimated that "*in excess of 40% of them are wasted… they can't sell everything even if they reduce the prices by half they will still incur a lot of losses*" [Mw034]. This respondent reported that farmers perceive this as a problem, because the crop is present for a very short period of the year. For example, tomatoes are abundant at some stage, resulting in low prices for the producer, and then a few months later they are scarce and the price is very high because supply is low [Mw054].

"in excess of 40% of them are wasted… they can't sell everything even if they reduce the prices by half they will still incur a lot of losses"
Mw034

While not reported by KIs, for a root and tuber crop such as cassava, farmers have traditional cassava processing methods (e.g. *Kondowole*) and more recently there have been attempts to encourage high quality cassava flour (HQCF) production through the C:AVA project and other initiatives.

2.2 Aggregators, traders, transporters, retailers and other value chain actors

Nigeria

Small/micro-scale aggregators/traders, who transport produce from rural producing areas to urban and peri-urban markets, are reported to face very high losses, especially those in the perishable crop value chains. A respondent mentioned that widely reported PHL estimate for perishables in Nigeria is *"… about 40% of total production, … but it appears that losses are more likely to be up to 50% to 60%"*[Ng047]. Another respondent mentioned the *"… rude shock from observing the huge quantities of vegetables which are dumped in markets on days when there is a glut"*[Ng036] and how this affects traders and producers in the fruits and vegetables value chains

in terms of lost income[9]. They added that loss is not only in terms of quantity but also *"… there is significant loss of nutrients"*. It also affects consumers as "… *prices of many perishables rise very high not long after the main harvest period. For example, a basket of tomatoes [*average weight of about 60kg] *sells at about US$0.50 [*during the peak of the harvest season] *but a few months later sells for about $6 because of shortages"*[Ng054]. This is due to the seasonality of the crop and the limited capacity to store or transform the highly perishable produce into shelf-stable products.

"…a basket of tomatoes sells at about US$0.50 [during the peak of the harvest season] *but a few months later sells for about $6 because of shortages* [Ng054]

As noted by two researchers, smallholder farmers as well as small/micro-scale aggregators and traders use traditional equipment, e.g. for transporting produce, resulting in substantial damage to the produce and high levels of losses[Ng002, Ng005]. Some also *"… just dump produce which they cannot sell on a market day, causing a strong stench"* (and posing potential environmental and human health risks)[Ng035].

One study of tomato losses in Nigeria was reported to have found that the use of reusable plastic crates during handling and transport of tomatoes from the production zones in the north of the country to the markets in the south could reduce losses during those stages from 40% to about 10%[Ng077].

Medium to large-scale grain aggregators have invested in modern storage services, thereby contributing to reduction in PHL. This is mainly to facilitate inventory stockpiling at harvest and subsequent sales to quality-sensitive formal off-takers (flour millers and feed millers). One such large-scale aggregator is AFEX, which was cited by a high-level technocrat. The expectation had been that their involvement in the development of a structured grain marketing system would *"… make it possible for farmers to get paid at harvest"* and *"to get prices that reflect the quality of their produce, as in the informal market there is no price differentiation based on produce quality"*[Ng043].

Ethiopia

A public sector key informant commented that while they had "*not really worked with traders*" .. "*that is a main area of PHL*"[Et031]. Another key informant also reported that "*most traders are not interested in the issue of quality, their mixing of poor with good quality product and issues of pesticide application is a problem*"[Et026]. They suggested that "*Traders argue there is no market incentive*" and "*SHFs don't know if they will get a better price for selling their higher quality product or not*".

"…most traders are not interested in the issue of quality, their mixing of poor with good quality product and issues of pesticide application is a problem [Et026]

A public sector key informant further explained the following. "*Grain traders do not have storage structures or standard warehouses. Commonly they rent a house and use that as a storage room. They buy different varieties of wheat from different farmers, which they mix and are not happy to clean. They may adulterate the grain to increase weight, because the market does not separate the product based on its quality. There is a blanket price, so it does not pay the trader*

[9] It was the observation of very high levels of losses of cabbages by farmers and traders which encourage an entrepreneur to research and eventually successfully provide solar-powered cold storage services for vegetables and other perishables in local markets in Nigeria (see section 2.3.3 for further details)

to have good quality. They don't use appropriate packaging material, not even clean undamaged sacks, so there is also a loss during transportation, loading and unloading"[Et041].

The same key informant reported traders of perishable crops use wooden boxes which can hold 60-65kg of the product but are associated with mechanical damage of the produce during transportation. The key informant suggested that traders are happy to use the wooden boxes as a measure when they buy from farmers because it is an opportunity for fiddling with the prices. It was suggested that introducing standards could not only reduce PHL of perishable crops but also protect farmers from the retailers and traders, and that the same would be true for the durable crops. These practices were contrasted with those of the World Food Programme (WFP). As WFP was reported not to buy low-grade product, and asks farmers to clean their product and bring it to a decent standard. But the key informant explained "*in the local markets we don't have that system*"[Et041].

Regarding a cold chain, one key informant explained "*there are no cold chain systems available in the market, only commercial flower farmers have cold rooms*"[Et051]. Another explained, *"so far it is only commercial farms who were allowed to introduce refrigerated trucks free of tax other traders were not allowed*"[Et033], explaining there were now proposals to allow service providers to provide refrigerated trucks and services. Another key informant mentioned that the partnership with Flying Swans[10] and funding from the Dutch government helping in the construction of a cold hub at Mojo. They emphasised the importance of this given the landlocked situation of the country and the need to transport perishable export product from the south of Ethiopia to the North to reach Djibouti port. "*Currently there is a lot of deterioration of the produce on route, so the cold hub is being built at Mojo (approximately the halfway point) and then from Mojo the produce will be transported by train to Djibouti using refrigerated containers*[Et063]. This informant explained they had developed a ten year strategy to ensure Ethiopia would become the leading exporter of fruits in Africa, explaining they were currently second for avocado export after Kenya, but were better known for their flower export. The produce they are targeting for this export trade includes beef tomatoes, cherry tomatoes, sugar snaps, green peas, various herbs, banana, strawberries, mulberries and blueberries, "*but unless we work on the logistics the losses will be huge*"[Et073].

"Currently there is a lot of deterioration of the produce on route, so the cold hub is being built at Mojo [Et063]

One key informant explained that they also wanted to capacitate farmer organisations such as cooperative and unions so they can provide warehouse service, cold rooms. They reported that the Meki Batu Union https://mekibatuunion.org (the Fruits and Vegetables Producer and Distributer Cooperatives Union) is providing packaging and cold room service for horticulture crops, whereas for grain crops there are several warehouses providing aggregation and storage services. A cooperative is also delivering F&V to the Ethiopian airlines, they provide a cold room and packaging service for cooperative members and non-members. The limited use of standards for fruit and vegetables in domestic markets was reported to mean there was little grading or use of packhouses by those selling in domestic markets at present[Et043], it was said to just be being harvested and taken to the market. Packaging materials for fresh produce were said to currently be very limited in Ethiopia, "*to date we are importing simple carton boxes from Kenya. All of this together with being landlocked makes Ethiopian export products expensive on*

[10] Cool Port Addis https://www.flyingswans.org/projects/ethiopia/cool-port-addis/

the international market, as they are competing with countries with ports, packaging materials and good logistics"[Et053].

In terms of transport, key informants reported there are no standards in transportation practice. The same lorry carrying chemical to the farmers can then carry the product to the local market. Another key informant explained, things such as solar operated packhouses, mobile packhouses, refrigerated trucks etc, they could have been done without needing a lot of investment but the economic situation that the country had faced makes that difficult[Et063].

One key informant explained, "*The only established marketing system, in a good way, is for coffee. In this case the marketing system starting from farmers and how they process etc. is monitored by the coffee authority or the government with a standard operating system"* [Et-081]. It was suggested that if that happens for all crops (grains and perishables) that would be an interesting marketing system for PHL reduction and quality.

Kenya

Not all the public sector researchers interviewed had worked closely with value chain actors beyond farmers, and so some were not sure what these actors were doing and what PH challenges they faced. One research project that was described had trained and worked with farmers on aggregation and improving their harvesting and PH handling of mango fruits to help retain fruit quality, so they could access more quality sensitive markets and higher prices. However, following farmers production of higher quality fruits, the traders were reportedly not only unwilling to pay a premium for quality produce, but actually shunned these organised groups of farmers who had been trained in producing higher quality produce. This highlights the need for transdisciplinary work involving key VC actors, and the need for early engagement.

The **East African Grain Council (EAGC)** https://eagc.org/ is a member-based organisation involved in addressing issues all along the grain VCs from pre-production to processing and distribution. Their members include large- and small-scale farmers, and large-scale traders. Their interventions include structured trading, provision of market information, a trade linkage solution (G-SOKO) in which sampled and tested commodities are traded, advocacy to create an enabling policy environment for members, and through their Grain Business Institute they offer a whole range of training and capacity building courses along the VC. These are all relevant to PHL reduction, and they cover all the cereals, pulses and oilseeds such as groundnut.

Pre-production the EAGC has been involved in the development of seed with better storage qualities to reduce losses due to storage pests and diseases. Their training work with farmers covers handling of grain to reduce losses, and they use a grain trade business hub (G-hub) model where farmer-owned warehouses are converted to become one-stop-shops, providing services such as moisture testing, rapid Aflasafe testing or sampling for laboratory analysis of Aflasafe, input sales, and simplifying market linkage etc. Further analysis would be required to understand the demographics of the farmers served by the G-hubs.

EAGC is involved in many PHL reduction relevant initiatives, including:

- the '**cob model**' in which the off taker purchases unshelled maize (still on the cob) and then mechanically dries and shells the maize which reduces breakage of and aflatoxin contamination of grains and avoids it being left out for birds to take or contaminate;

- **promotion of hermetic storage bags**, with EAGC having led the development of a **standard for hermetic bags** to help retain the quality of hermetic bag products being sold, this standard has been adopted by East Africa;
- developing a **grain warehouse standard** to ensure conditions reduce the likelihood of pests and rodent attack. They have developed warehouse construction guidelines to help members, and are working on continental harmonising of standards for both warehouse infrastructure and bagged grain storage;
- mapping the **existing infrastructure** for commodity storage across the East African region and whether it meets the expected standards;
- promoting **mechanisation of shelling, threshing, drying and bagging** processes which reduces PHLs, increases efficiency and creates **employment opportunities for youth** (particularly males) who following training are investing in the equipment and then moving between collection centres offering mobile threshing service provision and becoming agri-business service providers. This was said to work much better than when NGOs buy shellers for farmers and are unable to operate them and so run the equipment down. An EAGC survey in 2016 in Malawi and Kenya apparently found that for the vast majority of these SMEs, the working capital was from savings or relatives, with very little coming from microfinance and banks. These mobile shelling service operators move heavy machinery around and tend to be done by men, although in some teams women are involved in collecting and loading the shelled grain into bags and stitching them closed;
- **trade and distribution logistics** including developed guidelines for safe movement of grain between locations in closed vessels that reduce spillage, and exposure to contaminants that may affect the food safety of the grain;
- working with Agricultural Research Institutes (ARIs) across east and southern Africa and IITA to help in commercialising and increasing farmer adoption of the Aflasafe biocontrol product. EAGC is also working with other interventions to reduce **aflatoxin** risks. Recently in Kenya, two aflatoxin decontamination plants (AflaZero) which use ozonation were installed (one in Nairobi and one in Bungoma) by an Italian company, The partners are currently still doing trials to determine the per tonne cost efficacy, particularly in terms of energy costs, of this method of rescuing aflatoxin contaminated grain that would otherwise have to be disposed of. Another aflatoxin decontamination plant using ozonation was recently installed in Uganda;
- EAGC and Soy Africa co-own a **food testing lab** just outside Nairobi where industry can send samples to receive a quality analysis report on them for a fee. They also have a team of inspectors doing ISO accredited in situ grain sampling and testing.

The International Trade Association is also proposing collaboration with the Kenyan government around guidelines for aflatoxin management.

The **Kenyan Fresh Produce Consortium (FPC)** is a trade association for fresh produce growers and last year provided training on FLW reduction in many areas of the country, funded by one of the banks.

Retailers. In terms of what retailers are doing, some respondents suggested supermarkets and retailers in informal wet markets were not doing much to reduce losses before the produce reaches them or to retain the quality of produce once it arrives. Attention to this could reduce the high waste of fruit and vegetables that occurs. There is limited measured (or other) data on the levels of losses occurring at different stages along the value chain. The World Resources

Institute (WRI) are about to start loss assessment work (using their own protocol), for a number of key value chains in Kenya and are reportedly keen to involve value chain actors such as millers and supermarkets in this loss assessment work to help in raising awareness of the business case for FLW reduction.

It was suggested that if retailers, supermarkets, hotels, restaurants etc. start to push for better produce handling practices (e.g. crates, refrigerated transportation etc.) this would drive higher standards by suppliers and transporters in the value chains. Supermarkets were reportedly contributing indirectly to FLW reduction through wanting to display quality produce and demanding that their produce is handled and transported in a certain way, but it was suggested they could be doing more during their own storage, handling and display of the produce. However, in the wet markets, the produce mainly arrives in sacks and high levels of waste occur apparently, although there is limited if any data being collected on this.

"Retailers say 'We would like to give our surplus food, but we don't want the liability that comes with it. Should something go wrong, and then we have no protection from the law' Ke053

The Retail Trade Association of Kenya (RETRAK) is involved in multi-stakeholder initiatives to reduce FLW. While RETRAK's focus has been on circularity over the last few years, particularly in relation to plastics, they are now focused on understanding and reducing food waste (FW) particularly in the supermarkets and restaurant sectors. Given the food insecurity situation in the country, the avoidance of waste and redistribution of food that will otherwise be wasted, matters. Following discussions with the Ministry of Health, RETRAK has started working on drafting guidelines for redistribution of food from supermarkets. Although supermarkets appear keen to start donating their surplus food they have concerns around liability and want to ensure they are protected by the law.

Through support from the Committee Linking Entrepreneurship-Agriculture-Development (COLEAD) and the Danish Embassy, RETRAK have been doing a small study to establish 1) whether there is food waste in the retail sector, 2) how much there is, 3) how much of that can be redirected for human consumption. Most of the F&V waste appears to be in the wet market currently. The International Institute for Sustainable Development (IISD) have supported them to scope what other countries across the globe have in place to reduce food waste. Their focus is on both the fresh produce and processed food in retail and restaurant outlets. They are also exploring consumer understanding of best before and expiry date labelling, and the seeming lack of awareness by individuals of the food they waste, e.g. when serving more than they will eat etc. Increasing consumer awareness of food waste is viewed by RETRAK as a major opportunity for reducing food waste, and they are planning in-store roadshows and demonstrations.

Some of the supermarkets are reported to have started thinking about their food waste to help improve their bottom line. International supermarket chains are typically very aware of the issue, and keen to find solutions for reducing or redistributing it. Those that bake bread in-house often dump any remaining at the end of the day. The introduction of price mark downs of surplus food at the end of the day is viewed as a promising intervention, although some supermarkets worry many customers will then just be waiting till 8pm for the mark downs, while others think it will be viewed as bad food and that awareness raising will be needed to remove negative connotations. Apps such as Too Good to Go, (in which retailers post notice of marked down priced surplus food at the end of each day so nearby customers can then go and purchase it) are not yet present in Kenya.

Malawi

Involvement of the private sector in PHL management in Malawi is perceived to be "*very limited*"[Mw031] The respondents we spoke to discussed grain traders and aggregators, and those selling pesticides and hermetic grain storage bags (see section 2.2.3).

Smaller and larger scale traders operate in Malawi. One respondent suggested that larger scale traders tend to put more emphasis on quality (and hence PHL). This is often because the market that they are selling to demands such quality [Mw084]. An example was given of a company working closely with farmer cooperatives to help ensure the farmers provided them with good quality groundnuts to sell to the South African market. However, there are some very big players exporting groundnuts and they have a very big aggregation centre in Lilongwe. They buy either direct from farmers or from other middlemen and the groundnuts go to East Africa. It is a big market, but the quality is not good. "*Unfortunately, while the big corporate companies may monitor aflatoxin levels, the small traders don't care whether there is aflatoxin or whether moisture content is high, they don't even measure anyway, so they do not attach any value to such quality issues. The small traders are the biggest market, the big companies are not middlemen in Malawi. The major buyers of the farmers' grain are these individual traders.*"[Mw094]

"...the small traders don't care whether there is aflatoxin or whether moisture content is high... [Mw094]

With funding from USAID, Pyxus Agriculture Malawi is also working on groundnuts but through the whole chain. This private sector initiative is trying to reduce aflatoxin contamination and other losses. They train farmers on how to dry, and they buy the nuts unshelled to minimise the contamination.

Pest damage from insect infestation of grain crops is a major problem postharvest. "*Some larger scale aggregators and agro processors have a pest control section where they make sure they employ qualified people (e.g. fumigators) who are trained by government and have certificates to show they are able to do pest control activities.*"[Mw011] There is limited knowledge about the pest control and other practices of smaller-scale itinerant traders and aggregators, but it was believed they would be trying to protect their produce from insect damage. "*Aggregators – maybe the only techniques that they could be using are to ensure the produce does not get damaged, so it does not get weevils or pests, they try and maintain better quality of their produce as they know if they don't they will lose out.*"[Mw033]

The USAID-funded Feed the Future (FtF) programme has been involved in the promotion of PICS bags in Malawi for last 5-6 years through their Palladium Initiative and this will continue under their new Growth Poles project.

A private sector key informant [Mw062] reported that big traders often cannot use PICS hermetic bags. For example, pigeon peas which are exported to India need to be closed and tied in a different way and stacked to a certain height. So these traders buy normal bags and fumigation sheets. However, he went on to say that bags are sold to private companies. For example, 2000 – 3000 bags were sold to a big tea estate company in Mulanji to store the maize grains for giving their workers lunch etc.

2.3 Service providers

In this section, we set out KIs' explanations of what service providers are doing to support actors who are directly involved in agri-food system activities. We report on the public, NGO and private sectors and for each sector we present the findings by country.

2.3.1 Public sector

Nigeria

Public research

The main government research organizations and universities consulted were NSPRI, FIIRO, FCAPT and FUNAAB. Two of the researchers interviewed reported "... *undertaking needs assessment involving farmers and other actors*"[Ng032, Ng065] using various means including studies by their students/staff, annual dissemination events and recently through social media (a WhatsApp Group) to prioritise their research agenda as well as testing of their equipment and products by stakeholders. Another key informant also mentioned that they engage farmers and field extension agents in consultation through which they obtain information about the needs of farmers, including PH issues, which are then channelled to the research institutions[Ng023]. The researchers explained they also engage in collaboration with international and local institutions in resourcing their research activities. The main PH activities include drying and grain storage technologies (e.g. NSPRI dust, hermetic drums), evaporative cooling facilities, processing equipment for grains, roots and tubers and perishables such as tomato, returnable plastic crates and breeding for varieties with optimal PH handling characteristics.

Funding of public research is primarily from the Federal Government. However, some reported that they have also received support from development partners including the Common Fund for Commodities (CFC) under the "Unleashing the Power of Cassava: Value addition and commercialization of cassava in Africa" (UPoCA), which was co-sponsored by USAID[Ng075]. Some public researchers have also benefited from participation in projects funded by AGRA, the African Development Bank (AfDB), BMGF as well as collaboration with IITA, GAIN, ICRISAT, AATF and Sasakawa Africa in implementing PH-related projects in Nigeria[Ng032]. One of the research institutions (FCAPT) as well as NAERLS also benefited from collaborating with WOFAN in a project which was funded by Mastercard Foundation and which had a gender focus. It was, however, apparent from the consultations that the funding obtained is inadequate. For one of the institutions, the fact that it has not been designated as a tertiary institution limited the level of Federal Government funding it could secure for R&D.

An important revenue stream for the research institutions is procurement by legislators and governors for distribution of new technologies in their areas. This is usually made possible when such politicians participate in annual dissemination events.

One of the leading research institutes has initiated a new model under which it *"... patents the designs it has developed for fabricators who pay fees for use of the designs"*[Ng072].

Extension

The NAERLS runs an elaborate national extension system, which also includes publishing annual data and information on agricultural production as well as estimates on levels of pre-harvest losses for several crops and livestock at state and federal levels. This includes losses

associated with natural risks such as flooding, drought as well as crop and livestock pests and diseases. However, NAERLS does not track or publish PHL data. This is partly why one of the respondents mentioned that *"You know the challenge in Nigeria majorly is providing* [access to reliable] *data"*[Ng053].

National extension delivery is through state-based agricultural development projects (ADPs), who have male and female field officers, with "... *women specialists trained in Home Economics and Food Technology being the focal persons for training women micro/small-scale processors in food value chains"*. They also specifically target farmers in "Adopted Villages" as well as with NGOs for sharing relevant extension information. While the ADPs may have the human capital, a major challenge is funding to make them operational (see Section 7).

NAERLS holds annual meetings with stakeholders including private sector players. It is during these meetings that key issues in their annual report are highlighted and used as basis for framing priority extension messages. The private sector is also encouraged to "... *come and display their PH equipment and introduce them to famers"*[Ng023]. Through such events information on *"... hermetic bags and multiple use plastic baskets have been shared with smallholders"*.

The private sector is also encouraged to "... *come and display their PH equipment and introduce them to famers"*[Ng023]

Evidence contained in their annual reports is also used to provide policy advice to the Federal Government. This they do in the form of policy briefs which they send to FMARD as well as *"... to legislators in the National Assembly*".

Ethiopia

Public research

Most of the identified technologies originated from "... *elsewhere, but we adapted, tested and made [them] eco-friendly, gender sensitive and suited to local conditions*". This was done by local researchers, mainly based at the universities. For instance, the *"original multi-crop thresher design was shared by IITA from what had been developed in Nigeria"*[Et076]. Many of these R&D actions have been supported through donor-funded projects as well as through collaborations with other local and external institutions.

"...but we adapted, tested and made [them] eco-friendly, gender sensitive and suited to local conditions [Et041]

Public organizations' PH research activities include work on the following: tree crop harvesters (avocado); multi-crop threshers and shellers; metal silos; hermetic bags; hermetic liners for traditional granaries; cold storage systems for fresh produce and dairy products; and solar driers[Et021&Et043].

PH knowledge transfer/extension

Ethiopia's elaborate national extension services system plays a crucial role in promoting uptake of innovative technologies and practices. However, the extension service is perceived to be weak on PH issues in comparison to production issues. One key informant explained the extension service employs three subject-matter specialists at each *kebele* (ward level), referred to as "Development Agents" (DAs). They previously focused on promoting increase in farm productivity or yield, while PHL issues were marginalised. Profitability was also perceived as critical in determining options which the DAs have to encourage farmers to adopt. The Farmer

Field School model (which FAO has been influential in encouraging and supporting the use of in Ethiopia) was reported to have helped to directly engage farmers in assessing the PHL-reducing innovations. Anecdotes suggest that this helped in the rapid growth in demand for the hermetic storage bags. Training of the DAs is coordinated at the district (woreda) level and also involves framing of generic extension information at the Federal level in the Ministry of Agriculture (MOA).

Government helps cover the cost of knowledge transfer involving the DAs. Government is also the principal source of funding for research and development in the local universities, which are mainly public universities. Research funding is often complemented with resources from donor-funded projects and collaborations with other external academic/research institutions.

A new extension strategy was reported to have been recently developed in Ethiopia and has PH management integrated within it[Et053]. It is currently just coming into practice and also aims to bring the public and private extensions systems into greater coexistence and functioning, enabling the private wings provision of extension and advisory services on production, processing, PH handling etc to increase effectiveness of extension activities.

Kenya

Research

In Kenya, many of the PHL reduction research areas that the Kenya Agriculture and Livestock Research Organisation (KALRO) researchers we interviewed have worked on, have been focused on storage of the staple food crop, maize, which typically suffers high losses due to insect and rodent pest damage if not protected from them during storage. The research has involved the on-farm testing of different brands of hermetic grain storage bags[11], and recently the field testing of two hermetic grain storage bags (AgroZ bags and Mavuno Bora bags) which have a chilli pepper-based coating to help repel rodents, as hermetic bags can be attacked by rodents. The higher price (~USD$5/100kg bag) of the rodent repellent hermetic bags is expected to make uptake of the product limited. One of the researchers described participatory trials in which they were previously involved, during which farmers co-designed and then compared their existing storage methods with other interventions the researchers knew about, to see which ones best protected their stored maize.

For the large-scale central storage warehouses, KALRO are currently seeking funding to support testing of the use of ozone as an alternative fumigant to phosphine. This is in response to the problem that many storage insect pests are surviving current fumigations with phosphine gas, possibly due to resistance, although resistance testing to confirm that has not yet occurred.

KALRO is also hosting a factory producing Aflasafe, but the uptake of it has been very low. Unlike fertiliser it is not included in any government subsidy packages, and farmers were said to be hesitant to spend money that does not directly lead to a tangible increase in the amount of food on their table, and instead addresses an invisible potential health risk.

Regarding fruits and vegetables, KALRO researchers have been testing the use of returnable plastic crates (RPCs) instead of the commonly-used wooden crates, to help reduce handling and transport damage and extend the shelf-life of tomatoes. This was done in Kirinyaga, central Kenya which is a major horticulture production area. That project also developed a manual and

[11] when hermetic bags are loaded with dry grain and closed correctly to render them air-tight, the respiration of the grains plus that of any insects and fungi present in the grain leads to depletion of oxygen and build-up of high levels of carbon dioxide resulting in asphyxiation of any insects present.

trained smallholder farmers (SHFs) on good harvest and PH handling practices. KALRO have also studied the use of natural gases from passionfruit and avocadoes for ripening of bananas in ripening chambers, and good uptake of the intervention by farmers was reported. KALRO teams have also just started a project working with North Carolina State University in Kisii and Kakamega on the use of solar driers sourced from China, for drying indigenous African vegetables. The Ministry of Agriculture has provided the 2-3 solar driers to the farmer groups for free. Training for export-focused horticultural farmers happens at the KALRO centre in Thika.

KALRO researchers have also been involved in developing manuals for more than14 crops, for use by trainers (extensionists), with support from the World Bank. They also deliver Training of Trainers (ToT) courses in response to demand from counties.

In terms of expanding use of the interventions the KALRO team described, they felt there was a need to create greater awareness of the technologies among farmers through demonstrations, ensuring distribution networks reach rural communities and that the pricing is affordable. This might require government subsidisation in the way that occurs with fertiliser, but to date no discussion of subsidisation of hermetic bags or other PH technologies has occurred.

KALRO researchers were aware of work on PH aspects of leafy vegetables being done by Professor Ambuko's team at the University of Nairobi, and the PH research on grain crops happening at Egerton University in Njoro.

The University of Nairobi delivers PH training at undergraduate, master's and PhD levels and to farmers. The research work of several staff at the University of Nairobi has a clear PHL reduction focus and ranges from laboratory studies to adaptive on-farm trials. The adaptive on-farm trials have involved improved handling processes for fresh fruit and vegetables, farmer organisation/ aggregation and quality specifications, and cold storage of fresh produce such as mangoes, leafy vegetables etc. Other researchers in the University are working on engineering aspects of drying and harvesting technologies, while yet others work on food safety aspects, with a recent project focused on food loss and waste of meat. Prof. Ambuko plays a leading regional and international role in the PH arena, organising the biennial All Africa Postharvest Congress and Exhibition, a platform for knowledge and experience sharing and technology showcasing across Africa, as well as events such as the International Day of Awareness of FLW. The adaptive PH research projects, in which the University of Nairobi researchers are involved, are typically grant funded by development partners rather than by national government, and often the commodity and geographical foci are predetermined.

One example given of a project that brought changes in PHLs, was a Rockefeller Foundation YieldWise programme investment, implemented across Kenya, Tanzania and Nigeria. This focused on produce aggregation centres equipped with cooling and small-scale processing facilities to enhance shelf-life, quality and market access of farmers while reducing losses. The project showed it could reduce PHLs, but did not deliver the anticipated outcomes for farmers. This was attributed to traders shunning these organised and aggregated farmers groups, which reduced their market access. The mango juice they produced through their zero-loss focused processing activities struggled to compete for market space with already established brands, or to penetrate potential markets such as school feeding programmes. The project has had influence in terms of learning from these experiences which other initiatives are building on. However, the challenge of identifying and linking to quality sensitive markets that value the extra efforts taken by farmers in meeting quality requirements was not successful and needs further exploration.

Extension

The stakeholders interviewed explained that the process of devolution to the national and county level governance system meant there was now a problem in facilitating extension staff to do training on PH issues. A demand-driven approach to extension training exists, and if farmers are not aware of the importance of PH training and do not demand it, then it would not happen. Extension workers are required to be general agricultural diploma holders. One respondent suggested the cost of PH technologies may deter farmers from requesting training on them. The focus on the technical efficacy of interventions as opposed to the financial returns and other outcomes of using them could also be part of the issue, although at least one willingness-to-pay (WTP) study on storage devices was mentioned.

The low ratio of extension workers to farmers, and the reported recent introduction of youth to act as agri-entrepreneurs, but without agricultural backgrounds or employment contracts, is leading to poor service delivery, with some stakeholders reporting that extension in Kenya had currently "*kind of collapsed as county government were not very keen on it*".

Postharvest and Aflatoxin Management Unit, Plant Protection and Food Safety Directorate, Ministry of Agriculture and Livestock Development

In the Kenyan Government structures, the Postharvest and Aflatoxin Management Unit sits within the Plant Protection and Food Safety Directorate of the Ministry of Agriculture and Livestock Development. This evolved from a unit handling migratory crop pests (e.g. locusts) to include a focus on reducing grain PHLs in the 1980s, and it also covers safe use of agrochemicals. Originally crop-wise their focus was on maize which then expanded to rice, but following the 2010 devolution in Kenya, the counties now determine which specific VCs they want to focus on. The Kenyan government's food security pillar focuses on maize, beef, Irish/ round potatoes, indigenous poultry, sweetpotato, mutton, banana, dairy, pork and fish VCs, and they are also trying to work on rice, wheat, oilseeds, sugarcane, sorghum, honey, wheat, cotton, coffee, tea, *miraa* (khat), fruit and vegetables, nuts and pyrethrum VCs.

Their PHL reduction interventions include **policy guidelines and strategies**, which are influenced by external policies, e.g. the AU Malabo Declaration and the SDG goals to reduce PHL and food waste. The NPHMS strategy was developed through an inclusive multi-stakeholder process, led by the Postharvest and Aflatoxin Management Unit with support from FAO and has been signed by the Minister and will be launched shortly alongside the implementation guidelines. A concept note will then be developed to request funding to action the NPHMS. Training of county officers on the NPHMS has already been completed. These PHL reduction strategies then drive what county governments do. At county level, there is a County Agricultural Sector Steering Committee (CASSCOM) and multi-institutional technology teams (MITT) sit in those offices to ensure clear communication flows on anything affecting agriculture from national level to county level.

Government regulations and quality checks help ensure produce intended for export meets the required quality standards. To help reduce risks in produce intended for domestic consumption the focus has been on promotion of, and training in good agricultural practices particularly to help reduce risks of chemical residues. At county level, focal persons are trained using a 'training of trainers' (ToT) approach with the aim of cascading to farmers.

Due to high fatalities from **aflatoxin** which have occurred in Kenya in some years, the mandate for managing aflatoxin is at national level and has not been devolved. Aflatoxin management

interventions have included awareness creation, promotion of the Aflasafe biocontrol product, training and demonstrations on grain storage using hermetic bags, moisture meters, tarpaulins or storage dusts, provision of grain driers, and with WFP they have introduced nixtamalization equipment for use by farmer groups supplying grains to school feeding programmes. Additionally, two large AflaZero aflatoxin decontamination plants have been installed, one in Bungoma and one in Nairobi, it is intended that large-scale farmers and millers can take their grain there for decontamination, but the economic viability of that is still being assessed..

It was feared that El Nino-related wet and rainy weather events this year which were preventing farmers from sufficiently drying their cereals, would result in widespread aflatoxin issues. In response the Kenyan Government recently procured around 100 large-scale solar driers. These were distributed to 15 maize-growing food basket counties to support more efficient drying. The modality by which farmers will access the driers was not yet clear to stakeholders, and there were concerns it might undermine business operations of existing SMEs offering drying as a service. There were suggestions by other respondents that it would be preferable to incentivise the private sector to bring in the machines. There was mention that a few years ago 50 driers were brought in but were neglected, with no modalities for maintenance being developed and recently those machines were converted to scrap metal. It was reported that currently onion farmers were asking where they could get their pack of Aflasafe. Aflatoxin management in Kenya is funded by the national government and from the donor funded kitty of the aflatoxin management project.

Although the Ministry staff member believed evaluations of the efficacy of these PH interventions had occurred, they did not have copies of that evidence and explained that documentation, data management and coordination of what has or is happening was problematic in the country, with people working in silos and duplication of efforts occurring, which the NPHMS would help in addressing. They also stressed the need for actual loss assessment studies so that more accurate understanding of how to target loss reduction could occur. In the absence of measured Kenyan loss studies, they rely on the African Postharvest Losses Information System (APHLIS www.aphlis.net) for loss data. They also explained that FAO was doing a mapping of all stakeholders' PHL reduction interventions happening in Kenya.

In some counties, milk coolers have been strategically positioned to develop the dairy cold chain. County Aggregation and Industrial Parks (CAIPs) are being constructed funded by the national government with support from the World Bank to help Kenya's counties grow specific agro-industries. It is envisaged the CAIPs will have cold storage and places for agro-processing. However, further resources are required from county government and beyond to equip the CAIPs appropriately. Although the primary focus of these CAIPs is business, they are expected to also reduce PHLs through supporting cold storage and small-scale processing.

Some stakeholders felt that although government was vocal about reducing PHLs, actual actions and investments were not frequent. While there had been an act of parliament passed on warehouse receipt systems (WRS) they have not really been implemented, and farmers face long delays and losses while waiting for the National Cereal Boards to buy their produce.

Representatives from the Ministry of Health and county government are currently working with RETRAK and others on the development of the food redistribution guidelines, which is anticipated to help in reducing food waste.

Malawi

The main focus of public sector PHL work "*has been on maize, sometimes on legumes, but mainly maize, maybe because it is our staple food crop and one where we have a lot of losses, especially during storage*" [Mw071].

Ministry of Agriculture

The main aim of the Ministry of Agriculture Government Research, Department of Agricultural Research Services (DARS) is to increase and sustain agricultural productivity by all stakeholders. Recent and/ or current PHL work by DARS has included promoting of the use of metal silos, including a regional "effective grain storage" project with CIMMYT and promotion of metal silos by Government with funding from FAO. Silos were fabricated by artisans and distributed to farmers for free. A public sector informant explained, "*the government thought the metal silos would be of great use to the farmers, and they do work, but the issue farmers have is to do with theft of the produce. Usually, the metal silos are kept outside their houses or within their compound and usually Malawi households do not have fencing, so the risk of theft of the grain is why the use of metal silos is low*". [Mw033]

Examples of other recent work are: exploring climate change and PHL (EU funded through an FAO-led project) which included work on hermetic storage facilities and pesticides in relation to climate change; promoting hermetic bags or hermetic storage facilities in general with GIZ, involving training of farmers and extension staff; training, mostly of extension staff (GIZ normally involves DARS) and also running some courses at LUANAR (see below).

The Ministry of Agriculture Department of Planning has done PHL surveys three times since 2008. The first PHL study focused on maize losses in storage only; farmers were interviewed about their storage losses and their storage facilities. The scope has since expanded with technical advice and support from FAO, to look at losses from harvesting up to storage, so losses at harvesting, transport, winnowing, and storage. The survey has also expanded to include all major crops, especially food crops such as rice, millets, sorghum, groundnuts, soya. FAO is trying to strengthen their capacity to collect PH data and they do this jointly when they are collecting the crop estimates. However, "*PHL measurement is not easy, it is very complex…. and apart from the complexity it also requires some equipment, which I need to buy for the lab measurement. It is a very expensive survey and that is why we don't do it every year*". [Mw055]

"PHL measurement is not easy, it is very complex…. and apart from the complexity it also requires some equipment… [Mw055]

The Ministry of Agriculture Department of Agriculture Extension Services' programme has a component on use of pesticides and use of storage facilities/ equipment that are available on the market, especially hermetic storage bags (including the PICS bags). The GIZ project has a component on PHL reduction. They were involved in training extension staff, farmers and to a certain extent agro-dealers. Extensionists are the enumerators for the PHL questionnaire survey.

One respondent commented, "*the public sector is mainly the extension workers from the municipality. The number of farmers is high, so extension workers are overwhelmed so issues of PH handling are given very little attention. It perhaps*

"… extension workers are overwhelmed so issues of PH handling are given very little attention. [Mw034]

goes back to the whole Ministry set up. They are still emphasising on production aspects".[Mw034]

The Feed the Future (FtF) project (USAID funded) is working with extension services and is expected to continue for another 3-4 years. They have selected10 districts, and then with help from the Government extension office they connect to lead farmers, supplying them with 2-3 hermetic bags and training.

The Malawi government with support from the EU has been using a Farmer Field School approach. A public sector respondent explained, "*It may seem like the Farmer Field School (FFS) can't work but it does. You take the farmers from field through to harvest you don't separate the PH activities, you make them part of the production process so that the FFS should be complete. If we just take PH it may seem like it is hanging, we should take the farmers from production to PH. … that is what is done when the product is to go through this whole process, but maybe we need to improve on this so the focus is not just on production but also on PH*".[Mw063]

Universities

LUANAR PHL Research and Development includes the following: food safety aspects, particularly mycotoxins and mainly trying to reduce the contamination of grains; some work on hermetic storage, including promoting hermetic bags (produced some radio messages and developed some posters) and involvement in a first meta-analysis that compared hermetic bags and conventional bags in terms of germination, mycotoxins and weevil control; assessing losses from the hulling process, particularly on maize (using dehullers in Malawi results in losses of 29% in terms of mass, i.e. this is a loss to SHFs if it is left at the dehullers). LUANAR is leading on a project with the Ministry of Agriculture which launched Malawi's day of food loss waste commemoration. They have been working with Kansas State University (KSU) under the PH Innovation lab. The original project has finished, but they are now continuing with the Ministry of Agriculture for sustainability. Bunda College/ LUANAR was asked by the company selling PICS bags to do research on PICS bags and their report to the Ministry of Agriculture "*confirmed it was good*".[Mw022] The funding came from USAID.

In terms of training, LUANAR runs a very short PH course, but it imports an expert to teach that from DARS since 2016. There is also teaching on food quality management and food toxicology and food analysis, and food law and regulation.

Agricultural Development and Marketing Corporation (ADMARC)

ADMARC was originally a public sector organization but is now a limited liability company effectively owned and controlled by the government. They were major buyers, storers and sellers of maize grain. It "has been hit by operational challenges, at one time it was closed down completely, and now it is open again but not the level we hope it to be". [Mw064]

Zimbabwe

Universities (University of Zimbabwe)

The University of Zimbabwe has been involved in a range of PHL initiatives. Research and development includes the following.

Projects involving Zimbabwe and Tanzania in 2002 aiming to introduce safer methods to control grain storage pests; there were still resistance problems and issues to do with access and fake products. They tried to introduce inert dusts which were commercial and also in the process

discovered that there were natural deposits of diatomaceous earth (DE) in Africa that could be exploited and commercialised but that had not been developed. Safety checks had to be done because some DEs contain crystalline silica which can be carcinogenic.

Reducing losses especially in shelled or threshed grain looking at traditional grains in particular.

Earlier work by University staff while working for the Institute of Agricultural Engineering (1991-97) involved traditional (small) grains, particularly sorghum with a focus on quality control. Farmers were encouraged to produce quite a lot of small grains, particularly sorghum for export to Botswana. The IAE provided machinery and a technician provided threshing and cleaning services to farmers to enhance the quality of the grain to make sure it met the quality standards required in Botswana. Quality control included inspecting all the grain and fumigating big piles of grain, and after the cleaning it would then be transported by rail to Botswana. Some of this was done by SeedCo private company that contracted some farmers to produce seed and any surplus was sold and shipped to Botswana. Later work with traditional grains was done in places like Buhera and Binga districts and this included a project introducing brick storage structures to replace their traditional granaries which required large amounts of timber and thatching grass which was becoming increasingly difficult to access. To show interest, farmers were asked to mould the bricks and gather the materials, and the government then brought in cement and wire mesh for enforcement of the base of the structure and provision of technical expertise. That went well and some of those structures are still being used.

Work on hermetic bags has been done with the aim of eliminating pesticides and ensuring people consume chemical-free grain. It was demonstrated that this technology works even under extremely high temperatures in Zambezi valley. However, it was observed that these bags can also be damaged by rodents and the LGB that can bore through them. To address this, bags in which a pesticide was incorporated into the fabric of the bag - Zero Fly Bag – were tested, but failed to prevent insects from damaging the grain stored in them. Later on the Zero Fly Bag manufacturer combined the pesticide-incorporated fabric outer bag with a hermetic liner placed inside it and this prevented the LGB from damaging and perforating these bags and the hermetic bag killed any other insects present inside the grain. Another hermetic technology was the metal silo. They demonstrated that this can work under different environments, and that it is good for preventing rodents from damaging the grain, and for seed storage too as sometimes farmers use stored grain for seed. There were good seed germination results, but the metal silos needed to be kept under shade.

They then moved on to horticultural crops and looked at crops/ value chains that were prioritised by government. Crops that farmers were incurring huge losses in included bananas and tomatoes. Solar driers were introduced to dry horticultural produce in a peri- urban area which produced quite a lot of horticultural produce for the public market in the city centre. They needed to dry it to reduce losses. A company called Olivine wanted dry vegetables and dried tomatoes to make soups and powders etc. Unfortunately, they needed large and reliable quantities and the farmers could not match the demand.

There are no agro-processing plants near market places in Zimbabwe for absorbing unsaleable produce, and it is realised that quite a lot of losses are happening at farm level and particularly at these aggregation points. Farmers tend to group and sell together and hire trucks. These trucks are not refrigerated and so they travel overnight using vehicles, but they are not designed for transporting very sensitive produce and sometimes because the farmers do not trust the drivers, they accompany the produce, sitting on top of the cabbages, tomatoes etc.

2.3.2 NGOs

One widely accepted definition of a non-governmental organization (NGO) is an organization that generally is formed independent from government. They are typically nonprofit entities, and many of them are active in humanitarianism or the social sciences. In the current study, key informants used a very broad interpretation of the term NGOs ranging from international research centres, a regional agricultural development entity, as well as more traditional international and local NGOs who have played important roles.

Nigeria

The Team was unable to interview representatives of donors and NGOs in Nigeria except a representative of the donor-funded Global Alliance for Nutrition (GAIN). Their involvement illustrates growing attention being paid to PHL by development partners and NGOs. Their primary goal is to promote nutrition security but PHL-reduction has become an important objective in Nigeria because of the high nutrient losses that occur in postharvest stages. The interventions they have supported include the Postharvest Loss Alliance for Nutrition (PLAN), uptake of cold storage and technologies for extending the shelf-life of e.g. tomatoes and sweetpotato. The latter involves production of an intermediate product used by bakers etc.; awareness creation on PHL and nutrient losses involving the Organisation for Technology Advancement of Cold Chain in West Africa (OTACCWA), which has emerged as a financially autonomous organisation that fosters among others business-to-business mentorship; and promoting proximate processing (i.e. processing of agricultural produce close to the source of production in order to minimise PHL). GAIN has also been involved in promoting use of hermetic bags by grain producers. Its awareness creation programmes includes working with "*... young people in the marketplace to help [in spreading] the message of safe handling and proper handling of produce and food products in the various markets. This is being done in three states in Nigeria under the EAT Safe Project.*"[Ng007]

Among the local NGOs with which researchers, extension personnel and implementers of various development projects collaborate in information dissemination are the Catholic Relief Services and Justice for Peace Development Commission, which are both church-based NGOs that are actively involved in agriculture.

Ethiopia

The perception among the informants interviewed was that local NGOs are hardly involved in PHL reduction in Ethiopia, and are more engaged in entrepreneurship and supporting rural youth and women. However, the international NGO Sasakawa Africa Association (SAA) is a major actor in the PH space in Ethiopia introducing multi-crop threshers, training artisans in fabrication of metal silos and maintenance of PH machinery, and promotion of hermetic storage bags. SAA are reportedly also waiting for arrival of solar-assisted cold storage systems for use by service providers which they are importing. "*The aim is to support the start-up of pay-per-crate cool storage services in markets, similar to those operations already seen in Nigeria, Tanzania and Uganda*"[Et023].

*"...to support the **start-up of pay-per-crate cool storage services** in markets, similar to those operations already seen in Nigeria, Tanzania and Uganda.* [Et023]

A public sector key informant reported that the international organisations, WFP and FAO, are working aggressively on PH issues, and that Global Alliance for Improved Nutrition (GAIN) and SNV are also working in the area. WRI is reportedly starting to get involved, particularly with

regards to loss assessment. ACDI-VOCA is working with farmers unions, supplying the grain cleaning and shelling machines to help improve grain quality, they do this in partnership with FAO and SAA.

Kenya

A number of NGOs whose work is related to PHL reduction in Kenya were mentioned, including:

- CARITAS who have promoted pesticide-free grain storage methods, such as hermetic metal silos in Homa Bay and Nakuru diocese in the SDC-funded CIMMYT-led project.
- One Acre Fund's work helping farmers access and use PHL reduction related interventions such as hermetic grain storage bags and Aflasafe.
- FAO Kenya who are about to map the PHL reduction interventions happening in Kenya to improve coordination of activities, knowledge sharing and learning.
- World Resources Institute (WRI) that wants to pilot their loss assessment protocol on fish, cereals, mango, banana and avocado to inform their 'target, measure, act' strategy
- Technoserve was involved in earlier YieldWise PHL reduction work, and currently have a BMGF-funded programme working on distribution and waste of indigenous vegetables.
- AGRA has worked on many PH activities, e.g. with EAGC on warehousing and professional grain storage and proper grain handling, GAIN and WRI on FLW reduction.
- GAIN is interested in introducing cold storage for the smallholder traders '*mama mbogas*' who source produce just for the day and have high levels of waste.
- IFAD is providing hermetic grain storage bags and training farmers in 30 counties.
- Practical Action are supporting circular economy work in Kakamega and Kisumu.
- Food Banking Kenya organises redistribution of farmers and supermarkets surplus produce to vulnerable groups and is helping develop food redistribution guidelines.
- Farm to Feed collected ugly/rejected food from the farm gate and distributed it in vulnerable areas during the COVID-19 pandemic; now selling it since funding ceased.
- Food Cloud buys food with a short expiry date from millers and sells it to those in the catering business or who can quickly use a bulk amount, e.g. for a wedding that week.
- There are also a number of informal organisations who get surplus food and move it around, some of it is being redistributed, some of it is being sold.
- WFP is involved in PHL reduction.

Food Banking Kenya (FBK) is a food recovery organisation which started in 2016/17. They typically recover surplus production and produce that is still fit for consumption but doesn't meet market standards (often these are export standards). Much of this excess produce is produced by large scale commercial farmers and would otherwise be thrown into landfill. Where SHFs production meets market gluts, FBK will step in and purchase it at a subsidised rate from the farm. They also do capacity building for SHFs in partnership with specialists (e.g. on potato production and storage, or on correct use of pesticides). In September 2023, they started using the Food EVAS app, developed by Food Cloud in Ireland. This is helping to remove

FBK's role as the intermediary and instead directly connect food donors and redistributors close to each other, reducing costs and enhancing redistribution. In some areas they have been using solar dehydrators to dry fresh produce to enable them to transport it to beneficiaries further away, e.g. to arid and semi-arid land (ASAL) areas, or to extend its shelf life by 6 months. However, consumer awareness is then needed to overcome certain negative perceptions about dried produce. They have three depots, two close to SHFs and one near commercial farms, they also have cold storage infrastructure and refrigerated trucks. The crops they rescue include green beans, potato, tomato and bell peppers. Most of the produce comes from commercial farmers or packhouses at the airport and are rejected for aesthetic rather than other quality reasons as being unsuitable for the export market. They do not work with maize due to aflatoxin risks. They have 18 full-time staff and between 10 to 50 volunteers, including corporate volunteers who contribute a fee to volunteer as part of their CSR activities. Most of their funding is from the Global Food Banking Network, but they have also received funding from Blumberg Capital, PIMCO, Rockefeller, *Beiersdorf* Nivea and Cargill. Food banking has been received positively in Kenya, and the team are involved in **developing guidelines for food redistribution as currently there is no legal framework for this.** This will help expand the amount of food that is redistributed in the country.

Malawi

The consensus among those consulted appears to be that PHL is not explicitly among the main priorities of NGOs in Malawi. It was reported that while addressing PHL may be a component of an NGO project or programme (e.g. the USAID funded Palladium project promoting hermetic bags), there was no NGO doing PH management in a holistic manner[Mw031]. There was also a suggestion that where NGOs have PH management interventions, when it comes to implementation they rely on government extension officers, who are "already overwhelmed".[Mw024] However, one public sector informant pointed out that, as well as being active in crop production, there are many NGOs active in value addition (e.g. working with women to process doughnuts, working with mixed groups to process soya, beans etc.). These interventions could be including PHL management considerations. [Mw053]

Zimbabwe

Seed bank groups have been created by a local NGO and the University of Zimbabwe is trying to look at seed storage and how these groups can retain seed, especially in the light of climate change. They are mainly dealing with sorghum, pearl millet and groundnuts to see if hermetic bags and silos can be used to store seeds so farmers can plant these seeds the following year. Another multi-institutional initiative is looking at primary processing. This involves an NGO working with SDC and UNZA, which is also working with Fibro (an organic organisation based in Switzerland) looking at food safety and also recipes to get delicious food prepared locally.

2.3.3 Private sector

Nigeria

Local fabricators have been the main suppliers of the PH equipment developed/improved or customised by local researchers (see below). An example is the local fabrication of Flash Driers for production of high quality cassava flour (HQCF), which have been used not only in Nigeria but also in Ghana, Malawi, Tanzania and Uganda (under the C:AVA[12] project). During the C:AVA project, a Nigerian university (FUNAAB) was involved not only in collaborating with international engineering experts in improving the cassava processing technology but also in promoting the production and utilisation of HQCF. The latter involved collaboration with several local research institutions e.g. the National Root Crops Research Institute (NRCRI), the Federal Institute of Industrial Research Oshodi (FIIRO), and the Nigerian Institute of Food Science and Technology (NIFST). FIIRO also works with local fabricators to manufacture and distribute processing equipment for cassava and other food produce.

The uptake model usually involves training fabricators who manufacture and distribute the equipment. However, one of the leading research institutes has initiated a new model under which it *"... patents the designs it has developed for fabricators who pay fees for use of the designs"*. This is to generate revenue for sustainability of the operations of the Institute.

The above model is in contrast with what an institution based in Northern Nigeria has chosen for commercial production of processed food products. The main target processors have been small/micro-processors who have been unable to market products on a commercial scale due to regulatory restrictions. They have opted to secure licences for commercial production and marketing of the processed food products, but that is yet to take off partly because of the length of time it takes to get products licensed and funding for commercial production.

Financial services: Access to finance remains a big challenge for equipment fabricators and users, including small/micro-scale processors. The state-owned Bank of Agriculture was expected to provide *"credit facilities for farmers and other actors ... who have been trained by extension officials"*. This has apparently, however, not really happened.

Other private service providers: Among these is a private cold storage services provider. The main motivation for him entering the cold storage business was observing at first hand the *"... very huge losses that vegetables (starting with cabbage) sellers face when they are unable to sell their produce in the markets at the end of a day"*[Ng076]. The search for designs of solar-powered cooling systems started with online research and a visit to a German university with previous experience in the development of such a technology. Unreliability of national power supply is one of the reasons for opting for a solar-powered solution. He collaborated with the German researchers in customising their original 1999 cold store design to fit the conditions in Nigeria and launched a pilot. This pilot has grown into providing market-located '*pay-as-you-cool-store*' services for local retailers and wholesalers and has rapidly expanded. They currently

> "[motivated by the] ...*very huge losses that vegetable sellers face when they are unable to sell their produce in the markets at the end of a day* [Ng076]

[12] C:AVA Cassava Adding Value for Africa - The C:AVA project approach is based mainly on three most potent intervention points to develop HQCF values chains: i) ensuring consistent supply of quality raw material, i.e. cassava roots and grits; ii) developing financially viable intermediaries; and iii) ensuring the confidence of end users of HQCF as a food ingredient or industrial raw material.

have 58 cold rooms operating in 28 states of Nigeria and a further 45 units under construction. Of these 58 cold rooms, 56 are of three tonne capacity and two are 100-tonne capacity. The 100-tonne capacity cold rooms are suited for installation in large scale food collection centres, one is in Farin Gada market in Jos Plateau state and the other is in Dan-Magaji Main market in Zaria, in Kaduna State. Those using the stores pay a flat storage fee of 200 Naira per day per crate[13] of fresh fruit or vegetable produce, in these markets the produce is predominantly locally grown although some imported produce such as apples and grapes also get stored by retailers in the cold stores. The fresh produce is usually just stored for short periods of between 1 and 14 days. Retailers may be depositing 20 crates of tomatoes in the cold store and then removing five crates to sell per day. At each store/ hub there is an operator who runs the cold store, loads and unloads food, regulates cooling temperatures, washes the crates, collects user fees and maintains the hygiene and sanitation of the location. All these operators are women, and most of the retailers are women and according to the key informant it is simpler for them to be managed by a female operator. Due to demand, the business is extending their cold storage services to fish and meat traders, with an increased cooling service rate of 500 Naira per day. They have also branched into producing ice blocks to meet demand from fish and meat sellers, who use these during sales and transport of their produce.

For this enterprise, not much financing has been obtained from local institutions. This is not only because of access difficulties, but also because of high interest rates, ranging between 26% and over 30% - a level that is deemed to make it difficult for enterprises to make profit and to service loans. Confirming this, a lead official at a local research institution mentioned that the Central Bank of Nigeria (CBN) has lower cost loan facilities (with interest rates in single digits), but access to these funds has proved to be extremely difficult for most actors. The cold storage company has, however, benefited from concessional grant/debt financing as well as social impact investments which have made it possible to expand their operations to small as well as major market centres in Nigeria. They have also had calls to extend operations into Zambia, Kenya, Sierra Leone, Chad, Niger and Mali as well as into the North African and Middle Eastern countries.

Ethiopia

"75 youth artisans have been trained [in metal silo fabrication], but those in Amhara region are particularly active"[Et056]

Local fabricators: Local artisans (mainly youth) have been trained by local researchers to fabricate e.g. metal silos which are then sold to smallholder farmers. These youth artisans are reportedly select by the regional government and receive both practical fabrication and business skills training, and some have tried to open workshops for fabricating metal silos. "*75 youth artisans have been trained, but those in Amhara region are particularly active*"[Et056]. Some of the trained artisans were linked to banks for financing but there are no indications that this worked due to the general reluctance of local banks to provide credit to players in the agricultural sector and in the case of metal silos their small uptake due to them being expensive items for smallholder farmers. The situation is similar for private sector actors who would like to "*engage in importing the raw metal sheets to make silos, given the government has now approved a tax holiday for importing galvanised metal sheets*"[Et046]. Some of the mechanised harvesting and threshing equipment, e.g., multi-crop threshers are also being fabricated locally[Et073].

[13] For example a 20 kg crate of tomatoes

Hermetic grain storage bag provision: As far as hermetic bags are concerned, there are two distributing agents which represent foreign manufacturers in Ethiopia. The market-leader, however, manufactures the bags locally. About 70% of the total turnover of this local company is from manufacturing and distributing hermetic bags. The company started operating in 2014 and transited from outsourced manufacturing to proprietary manufacturing. Their operations include use of digital tracking for distribution of the bags and provision of extension advice to users. They export grains to help generate the Forex required for importing the raw materials. They are currently expanding operations to include a plastics recycling plant which will enable them to recycle hermetic bags and reduce their expenditure on importing the raw materials for the bags.

It is evident that the financial return on their investment is attractive enough to ensure long-term involvement in the business. However, access to finance from the domestic financial sector has proved very difficult to secure. Funding from donor organisations therefore proved critical in ensuring start-up and expansion of their operations. Limited access to finance remains a major constraint to the smallholder farmers who are the main buyers of the bags.

Depreciation of the domestic currency has contributed to sharp increase in the price per unit cost of the bags (rising by over 200% in the past 2-3 years). However, the situation is further compounded by limited *"… access to foreign exchange"*. Despite these, the bags are perceived to be cost-effective investments for farmers, who on the average use the bags over 3-4 seasons. They also do not have to apply pesticides, which are costly in Ethiopia and also pose health risks as a result of chemical residue in food grains.

One key informant explained, "*we had 5 companies selling the hermetic bags for grain storage, (e.g., PICS, GrainPro, ZeroFly, AgroZ and then Wabi ehir (a local one)). Grain Pro switched to focus on the more lucrative coffee export, other companies did not have good distribution systems so couldn't compete with the PICS bags"*[Et083]. The PICS bag company are reportedly *"able to reach each and every corner of the country using rural youth as sales agents and they are advertising in every open market, demonstrating how to use the bags, and the benefits. It is providing job opportunities for a number of our rural youths"*[Et053].

"able to reach each and every corner of the country using rural youth as sales agents [Et053]

Threshing service provision: To encourage access by smallholder farmers, mobile threshing service provision by individual entrepreneurs on *"… custom hiring basis"*. In addition to hiring out the threshers, they are also trained to maintain them. A pioneer (Mr Thresher) subsequently grew his business and diversified into trading in other consumer items *"…cars imported from Dubai"*[Et044]. Government/SDC/FAO initiated action to encourage women to use the threshers. This included encouraging unemployed graduate women to own the equipment who may employ men as operators *(because of the physical strength needed to move the machines and cobs around)*. It was started in Amhara and is being scaled up. It is estimated that there are about 3000 threshers in the country now, but that this is just a '*drop in the ocean*' given the size of the farming population and potential end user market[Et034].

Cold chains: So far it was only commercial farms who can own and use refrigerated trucks free of tax. Other traders are not allowed but there are proposals for service providers to be allowed to enjoy similar tax benefits when providing services to end users. Cooperatives are also being encouraged to offer cold storage and warehousing services to their members, including a cooperative that delivers fruits and vegetables which are exported using cargo facilities provided

by the Ethiopian Airline. An export produce-oriented cool hub/port[14] is also under construction at Mojo the half-way point between the south of Ethiopia and the port of Djibouti, from Mojo the produce will travel by refrigerated train containers to the port. Flying Swans are the main partner in this initiative which is being financially supported by the Netherlands Government[Et033].

Financial services: As far as access to finance is concerned, there was unanimity among respondents that local banks do not provide credit to farmers or to fabricators, and service providers for PH related issues. One key informant reported, "*in general, finance organizations require loanees to have some collateral. Private sector actors who have some collateral can get a loan from a bank to invest in PH, but this would not be the case for smallholder farmers or private sector who have no collateral*"[Et021]. One key informant reported having had no success when contacting financial organisations to see if they could finance farmers[Et026].

It was suggested that if farmers do not have direct access to microcredit organizations in their village perhaps they could borrow from farmers' cooperatives. Farmers can get credit to buy inputs or oxen through farmers' unions. A key informant felt there was a possibility that PH technology could be provided through primary cooperatives e.g., if there is a single thresher in that village that could serve many people there. Another key informant felt there was still an opportunity for engaging the private sector in terms of fabricating PH technology and providing services, information and financing. But highlighted that for metal silos, farmers want credit access for 3-4 years, but that "the financial institutions here have their own product and PHM is not included in their products"[Et056].

Kenya

Equipment and input suppliers

Public researchers suggested the private sector was interested in those PHL reduction areas where they could recoup their investments very fast, but that they predominantly focused on the production as opposed to PH inputs. The private sector PH-focused companies mentioned included the hermetic bag and plastic silo/container companies, metal silo fabricators, those pest control companies who fumigate and treat the large-scale grain warehouses, and cold storage enterprises.

Kenya hosted the 'AgResults on-farm improved grain storage pilot' which was an innovative market-pull (results-based management) initiative that aimed to reduce grain PHLs in 14 focal counties in Kenya. The project wanted to incentivise commercial enterprises who manufacture and sell **grain storage solutions** to smallholder farmers. Following identification of which enterprises were selling which grain storage solutions (e.g. different hermetic bag brands from 100 to 1000kg capacity, plastic silos, and metal silos), a financial incentive (cash prize) strategy was set up to reward those that promoted, marketed and sold a certain volume of their solutions to smallholder farmers at full commercial price. Sales thresholds were measured in terms of metric tonnes of improved storage capacity created. The prize money paid out was ~$4.5 million, and this was paid in two phases (mid and end point of project). Within the 4 year project period from 2014-2018, the participating companies created over 400,0000 metric tonnes of improved grain storage capacity at smallholder farmer level, from a baseline of almost zero. This is reported to have avoided an estimated USD$14-23 million of grain PHLs, the project also increased awareness of PHL among farmers and helped to achieved 14% penetration of

[14] https://www.flyingswans.org/projects/ethiopia/cool-port-addis/

these solutions within the pilot counties and supported the development of strong agribusiness relationships that have continued to ensure sustainable supply of PH technologies to farmers. One stakeholder we spoke to suggested that in retrospect, greater market stratification of the private sector companies might have been helpful to recognise the different scales and financial situations of the companies. Greater awareness raising about the PHL technologies being marketed could also have been positive, although this task was intentionally left to the private sector. Also, recognising the range of actors who need to contribute to ensure the success of such a project, a wider package of incentives that address different groups might have encouraged greater ownership and continuity by important non-private sector players such as extension and other officers in local and national Ministry of Agriculture teams.

"Working with the NGOs is a nightmare for private organisations. And to identify which is a good NGO is not easy as they do such excellent presentations. They don't understand marketing or sales, they only know how to get a grant from a donor. Ke050

The AgResults grain storage pilot involved 9 private sector PH equipment companies (three of whom received prize money) who linked with 12,000 agri distributors across the country, and national and local departments of agriculture. This pilot was led by Agribusiness Systems (ASI) (now Tanager) and funded by several government including the UK's FCDO, Australia, Canada, USAID, BMGF with the World Bank acting as a trustee for that consortium of donors.

One of the several hermetic bag brands available in Kenya is AgroZ bags, produced by the Arusha-based company A-Z Textile Mills Limited. The AgroZ bag is a hermetic (air-tight) storage bag composed of one multi-layer liner placed inside an outer woven polypropylene bag. This product only has a single liner, while some other hermetic bags have two inner liners (e.g. PICS bag), which according to A-Z means it puts 50% less plastic into the environment than other brands. The AgroZ bag was one of the hermetic bags that participated in the AgResults initiative and increased its presence and sales in Kenya as a result, and was awarded some of the prize funds. During the competition period they sold 70,000 100kg AgroZ bags, which on the assumption each bag is used three times, equates to 21,000 metric tonnes of improved storage created. PICS, Agro Z and Elite each qualified for the 70,000 bags sold within the specified 2-year period. AgResults had a USD$4 million prize, so each company that reached the threshold of 70,000 bags sold within the 2-year period was awarded USD$750,000, and then they also received further funds based on their percentage share of the increased market. For example, AgroZ bags got USD$2.2 million in total. A-Z view AgResults as being a success in terms of scaling up storage solutions for smallholders. Hermetic bag market development in other countries (e.g. Tanzania) has been much harder, even though there have been big hermetic bag promotional programmes. Apparently NGOs are often funded to promote and market the bags, which the private sector views as their own role and does not feel these other initiatives have resulted in the kind of scale up of the market which AgResults did. Scale up requires awareness raising, promotion, training and distribution which is expensive and difficult to guarantee the amount of return that will be achieved within the first 3 or 5 years, and therefore taking bank loans for this is not attractive, and donor funding at this stage is valuable. The AgResults design saw the initial investment coming from the private sector companies anticipating that if achieved, the prize would help cover that investment.

The A-Z company also produces the AgroZ Plus bag which incorporates a pesticide (alpha cypermethrin) layer in the centre of the five layers of the multi-layer liner, this pesticide layer is claimed to prevent particularly damaging storage insect pests such as the larger grain borer and

bruchids from being able to penetrate or pierce the hermetic liner bag – which is known to be a problem with hermetic bag storage. A-Z have also developed other products such as the AgroZ Aroma bag an ultra-hermetic storage bag for preserving the aroma of arabica coffee during long storage periods, the AgroZ silage bag to help in having feed for cattle during the dry season, small hand-held maize shellers. They also manage the Aflasafe Tz01 plant in Tanzania for IITA, and are involved in helping to scale use of the Aflasafe biocontrol product, which is a non-toxigenic species of fungus cultured on sorghum grain that farmers then broadcast in their fields at different during crop growth, with the idea that the Aflasafe fungal spores then germinate, and the fungus multiplies and outcompetes any toxigenic *Aspergillus flavus* that was present, and in so doing helps to prevent the crop from being infected with aflatoxin producing fungi. A-Z also produce tarpaulins to help farmers dry their crops without contact with soil. Other products include, various nets and shade netting products, crates, twine, and a range of agro-chemicals and knapsack sprayers.

Cold storage provision. The Kenyan cold storage solutions company SOKO Fresh emerged from an issue analysis exercise conducted by Enviu [15]. Working on PHLs in 2017 and 2018 the SOKO Fresh founders concluded key PHL reduction solutions for fresh produce included scaling of reliably powered cold storage and aggregation and market access for smallholder farmers. Their focus is on where there is a business case to support quality management, particularly fresh produce VCs where there is a longer lead time from harvest to off taker. This has mainly been export-oriented VCs where the risks are high if quality is not managed at the farm level during the first 6 hours after harvest, as this produce needs to then withstand up to 30-40 days on a ship to Europe. They have focused particularly on avocado, mango, French beans, and herbs – and the producers of these crops already typically had makeshift cold storage solutions, some had cold trucks, others charcoal coolers, so SOKO Fresh offered a more efficient solution. Produce that does not reach the specifications e.g. avocadoes with black spot may be rerouted to the Kenyan market via local wholesale off takers.

The SOKO Fresh cold storage containers can be leased for periods of 6 months or more at USD$750/month, there are various service packages that cover cold store delivery, set-up, PH handling training, cold store training and hub management including crate cleaning as needed. SOKO Fresh have 50 staff and 21 solar-powered 5,000 kg capacity cold store containers with automated controls enabling storage temperatures from 4 to 15°C. They hope in future to monetize the solar energy they are providing through carbon credits. They have insurance cover that covers the cold storage, panels, damage and theft etc and they inspect the site to ensure it meets their minimum criteria. They have found due to the importance of farming in the areas where they set up cold stores, the farmers involved really guard the cold stores. The cold stores can be moved to the required locations, currently 70% of them are rented by large scale farms, and the rest are used by smallholder farmers. Currently on average, produce is only held for between 1 and 3 days in their cold stores, but they are exploring 3-6 month-long potato seed storage.

Smallholder farmers involved in export value chains can benefit when an aggregator or someone with an outgrower scheme leases a cold storage container for farmers to aggregate their produce in before off-take. Well-organised farmer cooperatives may lease the containers too. SOKO Fresh also run some aggregation cold stores in sites where they see target produce is

[15] Enviu is an 'impact-driven' venture building studio which focuses on long-term issue-driven and entrepreneurial programs to disrupt and drive broken value chains and industries towards a 'new normal'

in abundance, and they will then coordinate the harvesting (and supply harvesting tools as needed and train local youth on correct harvesting methods and specifications[16]), transport, aggregation and cold storage and then when they have sufficient volume push it to an off taker. Each customer has specific harvesting requirements and size, weight, maturity and Brix content etc. specifications which SOKO Fresh teams monitor and manage, providing specialist analytical equipment as needed. They also bring in training resource persons for specific interventions such as biological control solutions etc.

Agricultural seasonality means the cold stores need to move with the harvest seasons, e.g. from mango to French bean areas. SOKO Fresh currently have cold stores operating in about a dozen counties across Kenya, including Tana River, Nyeri, Nanyuki, Kiambu, Muranga, Nakuru, Busia, Kajiado. Customers who have used their cold stores for 2 years report reduced losses, and that the slowing down of ripening times is critical for long shipping routes - the current issues affecting the Red Sea mean longer shipping times. Expansion could include coverage of a wider range of VCs, including meat, or scaling up the high value VC activities. Creating a business case for cooling of low value bulky commodities such as cabbages would be tricky although very high losses occur due to market gluts, "*even the cattle in Nyarandau, won't eat cabbages anymore, and there are anecdotal reports of their milk turning orange due to them eating so many carrots*"Ke078 although in other areas of the country, cabbages cost so much people cannot afford them, highlighting potential aggregation opportunities.

"..even the cattle in Nyarandau, won't eat cabbages anymore Ke078

Within the fresh produce sector, we also heard about private sector plastic crates providers for improved transport of fresh produce, and mention was made of KaFresh a company with an organic solution for extending the shelf-life of different vegetables https://siovalley.tech/.

Financial services

Major banks in Kenya (e.g. Equity, Cooperative, KCB, and Absa Ltd) generally have ag-financing strategies, which will cover PH financing for various VCs, such as maize, some legumes, avocadoes, citrus. Following the recent warehouse financing legislation, banks designed warehouse receipt-related products. However, the drought two years ago affected demand for these products, and although this year's harvest was better, concerns around management of public-sector warehouses is anticipated to negatively affect this scheme. In addition to receipt financing, there has reportedly been some expansion to cover equipment such as drying technologies. Avocado is a rapidly growing sector currently in Kenya with specialists such as Hass moving in and providing grant funding seed capital to help people establish their trees, a few avocado oil producers are also accessing funding directly from the banks. But processing plants, packhouse or cold stores are generally not able to easily access funding until they get to scale. Borrowing costs are currently 20%. While loans of $100,000 may be available for larger scale farmers of high value commodities, smaller loans or bridging or liquidity funds for individual smallholder farmers doing their own grain storage are not common. Finance support for aggregators is rare as they are often perceived by banks as risky due to the seasonality of their operations and their tendency not to stay long in the business. But lending to cooperative groups is increasing, and many smallholder farmers are strengthening their cooperative societies although the focus of the lending is still perceived to be predominantly on production

[16] For example, sufficient length of stem needs to be left on avocadoes to reduce fungal contamination and uneven ripening, which may impact on the entire batch

as opposed to PH technologies. Farmer groups may also have merry-go-round savings groups to help with saving up for small items. When the EAGC surveyed SMEs such as mobile shelling service providers in Kenya and Malawi in 2016, regarding the source of their working capital about 80% reported using savings and borrowing from relatives with little coming from microfinance and banks.

The ACELI project, a results-based financing initiative with similar features to the AgResults grain storage pilot was launched in Kenya in 2017. It aims to specifically incentivise commercial banks and other financial institutions to lend more to agricultural SMEs, e.g. agri-processors. As banks often consider such potential customers to be risky, this project aims to bridge this funding gap for these small businesses by working with groups of banks to collate and analyse de-identified data on their agri-SME lending to help inform the evidence-base behind their lending plans and to catalyse more lending to SMEs in the ag sector. This in turn is hoped to spur production at farm level and spawn other benefits. The banks are offered a financial incentive if they achieve set targets in terms of loans advanced to SMEs. To be involved, the banks agree to share data on their lending – this is used to create the common pool of data to glean insights from. Thus the banks get access to lending performance data from a large group of banks in their own tier to help them in making better decisions, this shared data is a huge incentive. The project does not encourage subsidisation of the loans to SMEs; interest rates are the bank's own business decision, and the cost of capital that SMEs face can be very high. Through targeted training the ACELI project also enhances the financial and managerial capacity of SMEs, which helps in building the confidence of banks to lend to them. This project is funded by an expanding consortium of donors, including the Dutch Ministry of Foreign Affairs, the UK's FCDO, Global Affairs Canada, BMGF, Ikea Foundation, Good Energies Foundation etc. The donors have pushed this project to expand from Kenya to Uganda, Tanzania and Zambia.

> *"If you want the market mechanism to work then you have to leave the commercial decisions to the banks whose core business it is.* [Ke045]

Malawi

Input suppliers, fabricators and other PH equipment manufacturers

There is some fabrication capacity in Malawi [Mw051]. For, example metal silos promoted by the government with funding from FAO are fabricated by in-country artisans. In this case, they were fabricated and then distributed to farmers for free. However, it was reported by a private sector key informant [Mw062] that for production of hermetic bags, the PICS global company partnered with a Tanzanian manufacturing company. Attempts to find a local manufacturer of the bag ran into a lot of issues with quality and timeliness of production. It was commented that if the market for PICS bags in Malawi changed it may be an option to manufacture in Malawi, but the material would need to be imported and it would not reduce the price much, depending on the size of the plant.

Pesticides are being sold by middle men/itinerant traders who move around, as well as in agro-stockists outlets. Agro-dealers are dealing with a number of hermetic storage bag products, as three or four hermetic bag products (different brands and models) are being marketed by different companies and sometimes these companies have their outlets at regional offices or district levels.

The input suppliers are linked to the Pesticide Control Board (PCB) so in major towns they are generally adhering to the regulations. But in rural areas, where PCB staff are less likely to visit, the pesticides are just left out on the verandah in the sun etc. and this will reduce their efficacy. In general, knowledge about and safe use of pesticides was reported to be low. "*The residues from the pesticides are left mixed in with the grains, I think they are consumed, so those issues are really affecting the trade. I was alarmed, recently in the rural area, because I saw fumigants*[17] *being sold like sweets on the open markets.*"[Mw054]

"…I was alarmed, … because I saw fumigants being sold like sweets on the open markets [Mw054]

PICS ESA Malawi have been operating in Malawi since 2019 and are part of the PICS Global LLC company. PICS bags were introduced to Malawi in 2014, through projects funded by USAID and Bill & Melinda Gates Foundation until 2018. The PICS hermetic grain storage bags are being distributed through a number of outlets. For example, famers organisations, ATC, and close to 300 agro-dealers. Some of the agro-dealers are chains, e.g. Farmers World has close to 70 shops throughout Malawi and Agora have around 50 shops.

Financial services

Public sector key informants [Mw081] commented that the "*the finances under PH are on the lower side, so its almost negligible*". The Palladium programme [Mw064] is currently working with a microfinance company known as Community Finance, which is working with village saving and loans groups for them to access hermetic bags, as well as seed and fertiliser inputs. According to their website, Community Finance Ltd (CoFi) is an emerging leader in agricultural financing and sustainable micro-finance services to SMEs and Personal markets. The Company is a wholly owned subsidiary of Tradeline Corporation Group Ltd. CoFi's operations are focused on the development of regulated innovative financial solutions targeted mainly at the un-banked and under-banked sectors of the economy. Their goal is to create opportunities for the people who are economically active but are excluded from the formal lending mechanisms. https://www.cofimw.com/

Other private services

According to one public sector key informant [Mw023] there is no private sector entity working on cold storage in the private sector. The Growth Poles project is working with the private sector in a range of activities, including supporting the communities around the private sector to work with hermetic bags [Mw064]. One of their interventions is aimed at building better relationships between the private sector and the surrounding communities. In Northern Malawi a company known as TROPHA is producing chillies and paprika. Some of the community members are outgrowers for these crops. The project is testing hermetic bags for storage of dry paprika and dry chillies.

Zimbabwe

In the 1990s, farmers were encouraged to produce quite a lot of small grains, particularly sorghum for export to Botswana. The IAE provided quality control- inspecting all the grain,

[17] Fumigants, such as aluminium phosphide can be used to control insect pests in stored grain, but they have high mammalian toxicity and are not supposed to be used within 100m of human habitation and never by operators who are not fully trained and certified in their use.

fumigating, and after the cleaning transported by rail to Botswana. The private company SeedCo contracted some farmers to produce seed, and any surplus was sold and shipped to Botswana.

Another initiative looked at solar driers to dry horticultural produce in a peri-urban area which produced quite a lot of horticultural produce for the public market in the city centre. They needed to dry it to reduce losses. There was a company called Olivine which wanted dry vegetables and dried tomatoes to make soups and powders and so forth. Unfortunately, they needed large and reliable quantities and the farmers could not match the demand.

There are no agro-processing plants near market places that can absorb unsaleable produce, and quite a lot of losses are happening at these aggregation points. Farmers tend to group and sell together and hire trucks, but these trucks are not refrigerated and so they travel overnight using vehicles that are not designed for transporting very sensitive produce and sometimes because the farmers do not trust the drivers they come with the produce, sitting on top of cabbages or tomatoes.

For bananas there are no ripening facilities at their source or at the public markets. There is quite a lot of damage that happens particularly with bananas, they use these huge bags which are very difficult to move around. The effects of all this mishandling are only evident at ripening which is the problem.

There are a number of agro-chemical companies in Zimbabwe and distributors, e.g. one of the biggest distributors was 'Farm and City' which has a number of outlets across the country.

Financial services

Access to finance is reported to be a huge challenge. The AFC has been created to provide finance to farmers, not smallholders but those at a higher level who process soybean etc, the threshing and the combine harvesters. The AFC provides loans for machinery, as well as inputs, fertilisers, pesticides etc. There are farmer groups who are being given loans to purchase or hire threshers or combine harvesters – but it has not worked out very well because the farmers are not paid in time for their grain sales. If hiring the commercial service providers (e.g. for threshing and harvesting), these businesses need to be paid upfront and if the payments to farmers only come 3-4 months down the line, then that creates knock-on problems for the service providers. It is an area that needs further work.

2.4 Public policy

Nigeria

Government's involvement in reducing PHL includes pre-harvest investments, for example, in "*... breeding crop varieties which are easier to handle and/or store better, e.g. tomatoes with thicker coats that help reduce losses*"[Ng013]. This is led by the Federal Ministry of Agriculture and Rural Development (FMARD). Dissemination of information of improved planting materials is mainly through the national extension delivery system.

Nigeria has no PHLMS but there have been some interesting policy and institutional initiatives which have potential to impact on PHL. For instance, in 2002, under the Presidential Initiative on Cassava, Government encouraged 10% inclusion of cassava flour in wheat flour for baking. This created a major opportunity for private investment in production of high-quality cassava flour

(HQCF) for supply to flour mills and in fabricating flash driers for processing cassava roots into HQCF. FUNAAB and NRI spearheaded efforts to boost private investment in the supply of HQCF in Nigeria and other African countries under a project funded by BMGF.

The Government of Nigeria incorporated the Nigeria Commodity Exchange (NCX) to catalyse the development of a formal grain marketing system which will also help to reduce PHL by encouraging grain storage in well-run and well-regulated storage facilities. Though the NCX has not gained much traction in the Nigerian market, a private company which is regulated by Govt (the AFEX Commodities Exchange Limited) was mentioned by one of the respondents as having emerged as instrumental in the development of a formal grain marketing system in the country.

Ethiopia

Government, through the Ministry of Agriculture (MOA), has played an instrumental role in formulating the NPHMS, starting with a focus on durable grains but expanding this to perishable crops. It was developed through active involvement of a platform *"which brought together multiple stakeholders and was supported by government and donors* (including SDC)*"*[Et035]. Government has costed implementation of its Strategy, estimated at over US$266 million for the period 2023 to 2030. Whilst Government is to contribute 50% of the budget, 30% of the required funds is expected to be invested by the private sector. The remaining 20% of the budget is expected to be provided by donors. Though SDC support for PHL reduction is expected to end, there are indications that some support may be provided as PH interventions align with some of their planned strategic investments for 2025-28.

Government has also aligned the NPHMS with other sector-related policy strategies such as the National Agriculture and Rural Development Policy, which focuses not only on boosting productivity but also reducing PHLs and promoting value addition. It is also promoting contract farming as a way of ensuring that smallholders can *"… use common facilities for storage, transportation and so on"*[Et016], thereby reducing losses. It is also investing in cold hub and related logistics, especially at port in order to promote export of avocadoes, flowers, fruits and vegetables, beef, cherry tomatoes, sugar snaps, green peas, and different kinds of herbs.

Kenya

A multi-stakeholder group including government, academia, private sector, farmers and NGOs has through an extensive process including validation with the counties, been leading the development of the Kenyan NPHMS which will be launched very soon. Given the devolved system, budgeting for the strategy's activities will need to happen at county level. Not all PH stakeholders we spoke to were aware of the development of this NPHMS. A previous NPHMS developed predominantly by a consultant in alignment with the AU PHMS did not get recognised or adopted by government. FAO supported both processes.

The Kenyan NPHMS focuses on three key pillars: skills, knowledge and tools for postharvest food management; value chain development services, including value addition; and food waste redistribution framework.

KALRO researchers explained PH aspects were covered in several existing policies. The KIAMIS (Kenyan Integrated Agric Management Info System) is a recently launched data repository, e.g. of what is being grown etc. in Kenya. There is also an act of parliament on warehouse receipt systems. The food and feed safety coordination bill aims to coordinate the various agencies dealing with food, as they cut across different Ministries. Coordination is reported to be difficult, with devolution adding complexity. A multi-stakeholder process, involving the Ministries of

Agriculture and Health, RETRAK, Food Banking Kenya and other stakeholders, in developing guidelines for food redistribution legislation is also ongoing.

Malawi

Key informants explained that while PH management is a big issue, there isn't a policy specific to PHL management in Malawi. [Mw064] PHM used to be one of the pillars of the Department of Crop Development from 2015-2016, but it no longer is. Government is reportedly keen to ensure that the country manages the losses, but the focus is now on improving low production. One key informant commented "*...but if we produce we still have to manage it after harvest and that is why government said let's come in with a campaign to reduce FLW. So it is still a priority. PH management is one of the key activities that the department has and we have resources in our budget set aside for PHM. We have three priority activities - control of migratory pest, monitoring and this PHM*, and at district level they also have PHM as an activity." [Mw033]

"...but if we produce, we still have to manage it after harvest and that is why government said let's come in with a campaign to reduce FLW. [Mw033]

One informant explained, that "*as a project we have been lobbying the Minister as to why do they not they extend this input subsidy to PH? Maybe on insecticides? Or hermetic bags, whichever, to make sure they show that there's a political commitment to address the PH losses. More than 50% of the budget goes to the subsidy programme, but it only looks at the production aspects*". [Mw044]

"...we have been lobbying the Minister as to why do they not they extend this input subsidy to PH? [Mw044]

A private sector key informant commented with respect to hermetic bags "*We have asked Government to remove the VAT because all these chemical pesticides have no VAT because that is for agricultural produce, but for plastic bags they are charging VAT. They say it was a plastic bag. But it is a technology for grain storage. I asked for an exemption for this and have been trying for the last two years but no luck yet. They are giving exemption for the storage chemical protectants. We gave that application to the Agriculture department and they forwarded it to the Ministry of Finance and they are supposed to take that in the budget because it is a policy matter.*" [Mw022]

2.5 Donors/development partners

Interviewees were asked for examples of donors active in the PHL reduction area, and those they mentioned are summarised below. This is unlikely to be a complete list of all donor PHL reduction activities.

Nigeria

Support from development partners include co-sponsorship by the Common Fund for Commodities, the African Development Bank (AfDB) and USAID of projects to promote value addition in the cassava value chain. This was subsequently upscaled under C:AVA with funding by BMGF. Support for some PH-related projects in Nigeria was available through organisations such as AGRA, IITA, GAIN, ICRISAT, AATF and Sasakawa Africa. National research institutions (FCAPT and NAERLS) also benefited from collaborating with WOFAN in a project which was funded by Mastercard and which had a gender focus. While not reported by in-country KIs,

Nigeria has received significant funds from USAID under the FLW accelerator to establish new PPP[18].

Ethiopia

FAO: has been working on PHL-reduction initiatives since 2013, the focus being mainly on promoting use of hermetic bags and small-size metal silos for storage of grains (e.g. maize, wheat, sorghum and haricot beans). The initiative originally targeted 14 major grain producing regions but has reached 12 as a result of the ongoing conflicts in two of the target regions. The main promotion activities include the following[Et046]:

a) Supporting the Government of Ethiopia in preparing a national Postharvest Management Strategy (NPHMS).
b) Capacity building for extension personnel, including aligning the dissemination approach with the FAO's tried and tested FFS methodology. That methodology involves engaging farmers in experimenting with innovations; observing results in comparison traditional and/or existing practices and inputs; and evaluating the results as basis for decisions on uptake of the innovations. This process may take months as it allows the participating farmers to observe loss levels at different times after harvest. It is reported that the Ministry is already replicating this "*… successful model and their own funds*".
c) Awareness creation, especially targeting middle to senior level government officials at the Ministry of Agriculture.
d) Strengthening technical and research capacity of universities and other education institutions (e.g. TVETs) in postharvest management issues as well as related research and piloting of postharvest solutions.
e) Jointly promoting institutional structures that foster engagement by different actors to address postharvest challenges. For instance, the FAO supported the establishment of the Ethiopia Society for Postharvest Losses Management, a platform to discuss and share experiences on postharvest actions, including contributing to the NPHMS.

Swiss Agency for Development and Cooperation (SDC): has been the main funding agency for the FAO project, especially in PHL reduction interventions, building on "*a good history in PHM [focused on metal silo use] in Latin America … and working in three other (focal) countries: Uganda, Congo and Burkina Faso"*. Their programme in Ethiopia includes working with universities such as the Jimma University.

SDC has also, through FAO, supported Youth Groups with seed capital to enable the youth artisans to buy small welding machines, and get trained and engage in fabrication of PH equipment. Farmers who are interested in equipment such as metal silos pay a small advance enabling the artisans to buy materials for fabrication. Finance for such youth enterprises remains *"… a key problem"*.

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[18] Under the initiative, ReelFruit, Nigeria's largest dried fruit processor, produces a range of dried fruit, coconut snacks, and coconut inputs for food manufacturers sold across Nigeria, the United States, the UK, Kuwait, Saudi Arabia, and Switzerland. The company is majority women-owned and sources from a network of over 250 smallholder farmers and aggregators. Fruit value chains face post-harvest loss levels of 40% or higher in Nigeria. In partnership with MSP, ReelFruit seeks to mitigate at least 1,303 MT of FLW in the coconut, banana, pineapple, and mango value chains by expanding processing capacity at its facility to incorporate three new product lines, adding 40MT of cold storage, and providing training designed to mitigate pre-and post-harvest losses to at least 500 smallholder farmers. This partnership will strengthen the Nigerian fruit processing sector, introducing three new products to the Nigerian market, and helping to connect hundreds of Nigerian smallholder farmers to new premium markets.https://agrilinks.org/post/food-loss-and-waste-flw-accelerator-partnering-private-sector-mitigate-flw

SASAKAWA AFRICA ASSOCIATION: has been focusing PHL reduction in cereals value chains because of the history of involvement by SKG2000 in these subsectors. It has been promoting hermetic solutions, training farmers and service providers as well as aggregators in enhancing grain quality standards in the domestic market. They have been funded by the Nippon Foundation, BMGF and AGRA (though Nippon remains their major funder).

Other donors supporting PHL reduction initiatives include: BMGF, Sasakawa Africa Association, GIZ, USAID (Feed the Future), JICA, Dutch Government, and South Korean Development Agency AGRA-Ethiopia. In addition, collaboration with e.g. a UK university made it possible for a local university to leverage resources for PHL research.

Kenya

In Kenya, many different donors have supported PHL reduction interventions over the years. Here we just mention those donors and the PHL reduction activities they are currently or have supported in Kenya, that were mentioned by respondents during the interviews.

A range of initiatives focused on technologies for PHL reduction in perishable fruit and vegetable value chains. **The Korean government** supported work exploring how plastic packaging crates can reduce tomato losses during transport and handling and the optimisation of banana ripening using locally available materials. The **World Bank** has supported public researchers to develop training materials for different crops which cover their PH stages and management needs**. USAID** is supporting value addition and shelf-life extension of indigenous vegetables using solar driers. The USAID horticultural innovation lab is collaborating with the University of Nairobi, and plan to ship cold storage from USA for installation in Kenya next month**. Rockefeller Foundation** YieldWise programme supported an initiative in Kenya focused on improving mango PH management and value addition to support mango loss reduction and access to higher quality markets. Rockefeller Foundation supported the EAGC and others to work on smart markets of the future, which involved solar power for cold storage and drying facilities and electric vehicles.

Rockefeller Foundation are also supporting technology solutions for surplus food redistribution by Food Banking Kenya. Food Banking Kenya also receive funding from the Global Food Banking Network, Bloomberg, PIMCO, Beiersdorf, Nivea, and Cargill among others.

Focused on loss reduction in grain crops, the **multi-donor funded AgResults** on-farm grain storage pilot in Kenya used a results-based approach to incentivise private sector investment in supply and distribution systems and sales of improved on-farm storage solutions (in this case particularly hermetic bags and plastic or metal silos). This was funded by the governments of Australia, Canada, the United Kingdom, and the United States, and by the Bill & Melinda Gates Foundation, and managed through a Financial Intermediary Fund operated by the World Bank as trustee. USAID have also supported hermetic bag promotion in the country. SDC have supported research work on effective grain management, focused on efficacy and economic returns of hermetic storage solutions, particularly metal silos. FCDO and SDC have supported the EAGC in developing standards in collaboration with the institute of standards development.

For animal-source foods, **GIZ** is funding work with the University of Nairobi on FLW reduction in meat.

FAO have been helping the government develop their soon-to-be-launched NPHMS using a multi-stakeholder approach. FAO also hosted an initial stakeholder meeting in Kenya to talk

about food waste and Solidaridad supported a workshop to develop the first draft of the food redistribution guidelines. The Danish Embassy, COLEAD, IAC and IISD are among donors supporting deeper exploration of retail-level food waste occurrence in Kenya and potential solutions from elsewhere.

While not reported during the interviews by in-country informants, Kenya has recently received significant funds from **USAID** under the FLW accelerator to establish new PPP[19].

Malawi

"*There is no development partner who has really been focused on PHL"* [Mw051], but the following were reported.

GIZ have been showing some interest in PHL reduction, for example working on groundnut quality (aflatoxins), also on hermetic storage.

USAID and Irish Aid Feed the Future (FtF), through Palladium, have been working on hermetic storage and on reduction of aflatoxin in groundnuts.

The Food Systems for Nutrition Innovation lab of TUFTS University in collaboration with FtF hosted a meeting in the US in June 2023. Three people from the continent were invited, including one from Malawi.

FAO. Over the years they have involved certain department and brought some experts to work on certain activities. For example, they had trials with FFS in Phalombe and Kasungu districts.

World Bank – supporting shellers and also building warehouses for farmer cooperatives. they are also trying to link them to companies operating the Warehouse Receipt System. [Mw004]

IFAD funded project – also has some PH handling work – training, as well as the provision of storage facilities like warehouses, just like AgCom but doing it in different locations.

Zimbabwe

SDC: Markets and seed project (MASEP). Supporting a multi-institutional initiative looking at primary processing, including food safety and also recipes to get delicious food prepared locally.

FAO: Has driven some PH work.

Rockefeller Foundation: Has tried to initiate a PH working group coordinated by the Ministry.

[19] Under the initiative, Regen Organics, a circular economy company, collects and upcycles organic food and sanitation waste and transforms it into regenerative agriculture inputs, namely organic fertilizer and insect-based animal feed. Regen Organics is currently able to upcycle 35,000 MT of organic waste annually at its existing facility at Kinanie outside of Nairobi and recently opened a second facility in Kakamega. Through the partnership, MSP will support Regen Organics to establish and then scale waste processing at Kakamega and further increase waste processing at Kinanie, leading to a 20,000 MT or 57% overall increase in waste processing and Evergrow fertilizer production capacity, reaching a total capacity of 55,000 MT annually. .https://agrilinks.org/post/food-loss-and-waste-flw-accelerator-partnering-private-sector-mitigate-flw

2.6 Multi-stakeholder arrangements

Key informants were asked if there was a multi-stakeholder arrangement of any kind working on PHL reduction.

Nigeria

There is no ongoing national PHL multi-stakeholder platform. However, arrangements mentioned included:

a. Postharvest Connect – annual event bringing together stakeholders in the PH space and initiated by the Head of NSPRI.
b. The Organisation for Technology Advancement of Cold Chain in West Africa (OTACCWA) has been responsible for promoting cold chain solutions especially for perishables value chains. With support from GAIN it has conducted over 15 business-to-business mentorship events and *"... with success"*.

One interviewee reported attending a number of multi-stakeholder events: an EU funded Value Chain for Agricultural Development (VC4AD) event in Kano (2022) which discussed maize PH aspects; one with GAIN and Harvest Plus; one on biofortified cassava [Ng034]. The same informant reported that on-going platforms would have benefits. For example, they could then keep track of some of the losses and some of the issues involved in the mishandling of pesticides. A further suggestion was to establish a PH databank on PHLs or on adulteration of those chemicals (particularly in Kano market).

Ethiopia

There is a PHM Platform that was initiated by FAO, and it is still running. There is an annual meeting where participants discuss what has been done and major issues requiring attention. It was suggested that this provides an opportunity for stakeholders to provide policy inputs and intervention support.

The Ethiopia Society for Postharvest Management: was established in 2016[Et041]. It brings together scientists and other stakeholders, providing a platform for policy advocacy etc. It works with other professional organisations, e.g. the Ethiopia Crop Protection Society and the Ethiopia Horticultural Society. It has been supported by the SDC and played a key role in the formulation of the NPHMS and accompanying manual for implementation. The SDC supports the Secretariat of the Society, including organisation of its biannual meetings. One of the successes achieved by the Society is advocating for Government removal of taxes on PH equipment. The Society was founded by Jimma University and chaired for two rounds by one of the key informants. A private sector key informant also noted the Ethiopia Society for PHM, as a professional association and in which they represent the private sector.

Different commodities also have their own platforms, e.g. pulses, oilseed and spices platform, a wheat platform, and an avocado platform for producers and exporters will be established – but very few are focused on PHL reduction. Only the PH Society and the PHM platform really do that[Et033].

A private sector key informant reported that the Ministry of Agriculture, together with FAO, organise quarterly platforms and they represent the private sector in those. In them they bring up broader issues about PH, not only in the context of grain but also for fresh products too[Et052]. They share information on critical bottlenecks they are facing in terms of the private sector or for the extension or for product availability into the market[Et082].

Kenya

Various multi-stakeholder platforms were mentioned in Kenya. A reportedly extensive and expensive multi-stakeholder process has been employed in developing the new Kenyan NPHMS and validating it with the 47 counties and putting it out for public consultation and then revising it based on the feedback received. This involved government, academia, private sector, farmers and NGOs, was supported by FAO and is about to be launched. It is envisaged that the multi-stakeholder team will be involved in tracking what progress has occurred against the planned strategy implementation in about two years' time. An earlier NPHMS had been developed by an FAO consultant working with the AU, but engagement with national government had not occurred and so the document never got signed. Early drafts of the new NPHMS were also rejected as too academic and not practical enough. Budgeting for the strategy's activities has to happen at county level. However, not all PH stakeholders we spoke to were aware of the NPHMS or that a multi-stakeholder platform existed.

The need for the platform to support greater coordination of FLW related activities had been identified. Within the NPHMS there is a national coordination unit with a national focal person, this is not the CAADP person who reports on loss reduction progress to the AU biannually, and that CAADP person did not attend any of the NPHMS meetings. Within each county there is a focal person responsible for coordinating FLW work.

The EAGC is another platform that brings various stakeholders from across the VC together. The food trade coalition for Africa https://ftcafrica.org/ is a regional level multistakeholder platform. There are also various public-private policy, dialogue and business to business forums in which PH management features.

The technical committee on food waste reduction in Kenya, involves RETRAK, Ministry of Health and County Government, Solidaridad, FAO, University of Nairobi, four supermarkets, and horticultural crops development. The NPHMS process has helped raise awareness of individual level food plate waste even among their team.

Malawi

There is no on-going multi-stakeholder PH platform or arrangement. There are some sub-sector related platforms, so if there are PH issues about legumes they can also be addressed in that platform. But they are not given much prominence because they combine production and other issues. So PH issues are not given much prominence [Mw034].

A public sector key informant noted that "*We work together but not as a formal network, we do work together with research, Department of Extension, the Universities that do agriculture (Livingstonian University, LUANAR), so there is that collaboration when need arises, when there are issues we do collaborate. That kind of a multistakeholder structure would be useful because it will assist us to at least network easily. As when you have issues you have to call this one, write to that one, but when you have a network it's easier to manage the situation.*"[Mw053]

Zimbabwe

The concept of coordinating at national level has been tabled a number of times, but it hasn't happened. Rockefeller tried to initiate a PH working group coordinated by the Ministry. It exists but has not really actively happened. However, "*there is a very strong consciousness of the need for that and the people are there and it is critical that it happens to enable co-learning and efficient use of resources.*"[Zw041]

3. Perceived Drivers Influencing PH Systems

A range of different drivers continually influence, interact and shape food systems and the postharvest (PH) elements of those systems. These drivers vary by context and over time, and to understand PH systems it is important to identify which key drivers are influencing PH systems and in what ways they are responding. The stakeholders we consulted identified a wide range of drivers. Using the conceptual framing of groups of drivers from the HLPE (2020) sustainable food system framework, in this section we summarise the drivers mentioned by country and group.

Biophysical and environmental drivers include climate-related changes impacting on production levels, produce perishability, crop drying, storage quantities and pests.

Technology, innovation and infrastructure drivers include increased use of ICTs for learning and information sharing, cold chain investment, while storage and handling technologies exist so do access and affordability challenges, high yielding varieties with poor storage characteristics, and poor roads and stores which result in high PHLs.

Economic and market drivers include poverty leading to consumption of low quality or contaminated produce, growth of quality sensitive markets and structured trading, high intra-seasonal price variation incentivising grain storage for food and sales, increasing imports of food, increasingly stringent export food safety regulations, crop exports as important source of hard currency, Forex instability affecting price of imported equipment, limited access to credit by farmers and SMEs.

Political and institutional drivers include the dominance of the focus and expenditure on production/pre-harvest activities by government and other actors, growing awareness of scale and cost of PHLs particularly in relation to imports, internal and international conflicts affecting and/or lengthening trade routes resulting in higher loss, absence of VAT exemption for most imported PH technologies, creating of youth employment opportunities in PH systems, emerging multistakeholder PH strategies.

Socio-cultural drivers include increasingly quality-aware consumers' concerns about food safety aspects such as aflatoxin contamination, Gen Z driven healthy living movement influencing food handling, increasing theft of crops in field driving earlier harvesting and affecting drying.

Demographic drivers include rapid population growth and associated increased food demand, the high proportion of youth and high youth unemployment and varying interest levels for engagement in food production and PH systems (e.g. mobile mechanised service provision), an emerging consumer class prepared to pay premiums for higher quality produce. Differing rates of urbanization influencing the type and form of food demanded.

Perceived drivers for each country are set out below.

Nigeria

Biophysical and environmental drivers identified include

- climate warming increasing losses in perishable produce, e.g. tomatoes, and leading to increased need for cold storage
- increasing unpredictability of seasons, unexpected rains leading to losses during drying
- heavy rainfall triggering release of water from Lagdo dam in Cameroon with flood waters washing away the fields of crops, homes, infrastructure and lives of Nigerian farmers.

Technology, innovation and infrastructure drivers identified include

- launch and promotion of 'NSPRI dust' grain protectant and other PH technologies
- influence of smart phones and social media on increasing demand for quality produce
- investment in cold chains and cold chain hubs.

Economic and market drivers identified include

- current economic challenges are leading to people eating deteriorated produce that should be discarded, and to retailers cutting produce (e.g. yam tubers) into small pieces and leaving them exposed/uncovered to meet the demand for different prices
- growing presence of quality sensitive markets linked to Gen Z healthy living movement
- market gluts causing high losses (e.g. tomatoes) leading to training inputs for farmers
- aggregation and warehouse receipting systems that require certain quality standards
- agriculture becoming very lucrative in Nigeria as food demand outstrips supply – this then drives investment in production and cold chains, hermetic bag and Aflasafe sales.

Political and institutional drivers mentioned include

- introduction of a value chain approach by Minister of Agriculture to address overfocus on production
- internal insecurity making transport from North to the South slower, costlier and riskier and produce is no longer being handled carefully leading to it deteriorating faster
- insurgency in North can lead to people fleeing their villages and staying away for months, roads may be blocked by bandits causing produce to deteriorate, or if 20 extra checkpoints are added it causes produce to spoil as trucks to spend extra time on road
- Ukraine - Russia war price rises provided an impetus for storage facilities to store produce and profit
- Presidential ban on import of certain food products drives more lucrative production
- need to import food, leading to focus on how much of the food we produce is being lost
- political actors' interest in quantified efficacy of PH technologies and testimonials
- Government investing in dry season farming for wheat and rice made a difference
- slow food safety regulation procedures for processed products adds cost/time barriers for SMEs
- some politicians supporting value addition and PH management training for constituencies
- some policies to reduce PHLs are on paper only, and not active in practice on the ground

Socio-cultural drivers mentioned include

- education leading to people getting trained and capacity being built
- new healthy living movement being pushed by Gen Z and particularly the young coming back from the west with their MScs and PhDs who control the social media space and question everything from the food they eat to the political system, and this is changing the way our food is handled, moved and consumed – leading to improved PH management.

Demographic drivers include

- youth getting into agriculture if it can be lucrative

- urbanisation pulling demand for large quantities of food to be produced and retailed, but economic challenges driving hunger satisfaction as opposed to demand for quality.

Ethiopia

Biophysical and environmental drivers identified include

- climate change and variability, with drought affecting production levels leading to an increasing prioritisation of PHL reduction activities
- erratic rain increasing shallow water irrigation and entrepreneurs expanding mobile thresher services from rainfed to irrigated and wheat growing areas, particularly when the land is too wet for combine harvesters to operate
- climate change is perceived to be affecting pest and disease incidence, with increasing spread of the larger grain borer insect pest across Africa, and more aflatoxin challenges.

Technology, innovation and infrastructure drivers include

- poor roads and stores leading to higher PHLs of fresh produce and grains.

Economic and market drivers identified include

- Forex instability making imported PH technologies (or those requiring imported raw materials (e.g. hermetic bags)) expensive
- increased cost of imported inputs impacts on productivity which then leads to people being more inclined to manage their PH activities better
- the lack of access to credit by farmers and SMEs hinders adoption of technologies
- a quality sensitive middle class(market) is emerging, who are prepared to pay better prices for better quality fruit, vegetables, and grains
- increasingly stringent food quality and safety regulations (e.g. aflatoxin thresholds, pesticides residues, false codling moth) for export markets for coffee, avocado, mango etc. which are a key source of hard currency in Ethiopia
- escalating (i.e. doubling) costs of cereals and pulses bringing huge problems to consumers, improved grain storage is seen as part of the solution to support food security, but the Government's focus is mainly on increasing food production to reduce food insecurity.

Political and institutional drivers identified include

- dominant focus and investment by Government on increasing productivity through widening access to improved seed and fertilisers plus agricultural extension, while PHL reduction not receiving the same attention, although it would be cheaper to save PHLs
- increasing recognition that food security cannot be ensured unless PH systems are invested in
- concerns around managing a large population of jobless youth with the Government keen to see youth having technologies they want to work with, and mechanised mobile threshing/shelling, drying and harvesting businesses are attracting youth participation
- the internal security/conflict situation is impacting on productivity, agricultural service provision, transport and market access routes used by farmers resulting in higher PHLs
- geopolitical issues disrupting Red Sea trading routes have even led to airfreighting instead of shipping of some coffee exports, which is a crucial source of hard currency.

Socio-cultural drivers identified include

- the level of awareness and understanding of PH-related food safety aspects (e.g. sufficient grain drying, handling and storage hygiene, safe pesticide application, safe storage including risks of traditional underground pits and stores)
- the scale of impact of PHL on production-focused investments and activities
- increasing sales of draught-power-oxen by farmers to supply the expanding domestic market for meat consumption is accompanied by the increasing replacement of the traditional oxen-trampling threshing method by mechanised threshing by farmers.

Demographic drivers identified include

- rapid rate of population growth in the country and the challenges for production systems to cope with this increased demand for food, particularly given the extent of PHLs
- efficient use of resources is thus a key element of government policy, including PHL reduction
- the emerging middle class is driving the development of quality-sensitive markets, which can also help in reducing losses
- the high proportion of youth in the rapidly growing population, and their attraction to operating mechanised PH threshing/ shelling etc. businesses.

Kenya

Biophysical and environmental drivers identified include

- unexpected rains during harvesting, can lead to high mycotoxin levels, government delivered driers but farmers did not take their grain, so farmers were trained on drying and on checking grain moisture
- El Nino (2024) caused rains that prevented farmers from drying their grain, in response Government purchased solar driers for breadbasket counties using emergency funds
- climate-related challenges mean it is becoming harder to produce, that should translate to wanting to preserve the little that you harvest, but connecting it is not simple
- climate change brings diverse changes and triggers pests to change their behaviour, e.g. crop failures, emerging pests, rats invading Mwea rice irrigation scheme
- some grain storage pests are becoming more difficult to control ('superbugs'), this can discourage farmers from producing surpluses because they will lose it due to pests
- development of products that do not contribute further to GHG emissions, e.g. ozone fumigation in central stores, and need for recycling of hermetic bags.

Technology, innovation and infrastructure drivers include

- although "climate smart" technologies exist (e.g. hermetic bags, solar driers), accessibility and affordability are issues, and not all farmers like working in groups to access them
- some technologies need to be introduced in combinations, e.g. solar driers + moisture metres + in situ aflatoxin test kits, so aflatoxin levels checked and action taken if needed
- limited access to finance for agricultural sector SMEs
- launch of online data repository (KIAMIS) to better understand farmers outputs
- circular economy growth - black solider fly (BSF) and making compost from fruit & veg loss.

Economic and market drivers include

- agriculture is the biggest contributor to GDP and largest employer in Kenya, given the high unemployment rate jobs are likely to come from ag., ag. output needs to be optimal
- the significance of agriculture to our economy, means all PHL reduction initiatives are relevant; other sectors, e.g. manufacturing, tourism have less impact on the economy
- food deficit creates a situation whereby grain contaminated with aflatoxins or weevils, gets consumed because of food shortage, disincentive to comply with standards
- structured markets (e.g. commodity exchanges, G-SOKO) data shows increasing use trends for commodities and actors, all traded from warehouses that handle the grain
- emergence of forward contracts and institutional purchases, the process reduces PHLs
- increased policy attention on how food is transported etc. from farm to market
- increasing importation of food
- higher paying buyers' preferences are more stringent, to improve their income farmers have to work with buyers wanting a premium product
- when farmers can connect PH management with a more profitable business, they start to integrate cold chains and better transport, then can see improvements.

Political and institutional drivers include

- major focus is on production and yields, not on ensuring this is not then lost, showing decision makers the scale and USD value of losses, led to support for PH strategy development
- lack of subsidy for PH technologies, e.g. hermetic bags, Aflasafe, which could increase use
- declining opportunities for participatory research where farmers would compare traditional storage methods for example with new methods to see which worked well
- devolution has reduced national-level overview of agricultural issues including PH issues, adds complexity, the counties are in charge of all agricultural extension activities
- public food storage/ central food reserves if operating effectively and efficiently directly impact on PHLs as grain moves quickly from farm to central store and is then kept well
- adoption of warehouse receipt system (WRS) is growing across the region, this leads to more grain moving into professional hands for storage, which will reduce PHL
- political interest in local livelihoods, e.g. with governors in Makueni investing in a mango factory, and in Kisumu County putting up cold storage for fish
- lack of evidence comparing maize imports with PHLs to show deficit could be met
- lack of evidence on loss levels to convince people
- Increased political awareness that we lose as much food as we import, and political goodwill to support farmers' access to information and technologies to reduce losses
- limited awareness around agricultural recovery food banking models
- multi-stakeholder initiatives for food redistribution guidelines and national PHM strategy
- new waste management bill approved
- public health crisis which is not being discussed and '*poor-quality produce (e.g. full of aflatoxin) still ends up on a shelf and is consumed by ourselves and our children*'[Ke028]
- awareness creation by non-profits working on food systems and focusing on how to deal with PH management increase awareness of potential solutions, e.g. cold stores
- current red sea issue means longer fresh produce export shipping times with higher deterioration risks.

Socio-cultural drivers include

- farmers want to see yield gains resulting from products they purchase, and so ask, '*if they buy Aflasafe, will it result in more food on their table?*'
- addressing food insecurity/inequality by redistributing surplus produce to the vulnerable
- desire for no one to go to bed hungry, leads farms to donate their surplus, business to support and volunteer at Food Banking initiatives
- an awakening around sustainability leading more people to think about losses.

Demographic drivers include

- newly employed youth demographic will limit waste and drive sustainable consumption
- population growth has and is increasing demand for food, we have a food deficit, imports are increasing, but we lose as much as we import.

Malawi

Biophysical and environmental drivers identified include

- rainfed food production systems require storage of food for 8 months between harvests
- climate change is causing farmers' food production and storage levels to fluctuate, reduced storage quantities and durations may reduce investment in PH systems. Large companies purchase grain, and store and sell it during the year to meet food needs
- arrival of new pests, less availability of timber and thatch for granary building influence farmers' storage systems, grain now stored inside, shelled and admixed with pesticides
- variable climate, dry spells, flash floods and degraded soils are reducing production levels, this leads to increased management (good drying and storage) of the reduced harvest
- climate-related changes in PH activity timing, e.g. rains disturbing the drying process
- climate change will be affecting PH systems, but not clear what the subtle changes are
- increased concerns around aflatoxin risks and health impacts due to changing climate.

Technology, innovation and infrastructure drivers include

- improved maize varieties are high yielding but more susceptible to storage pest damage
- more people are being educated and information flow is increasing with WhatsApp etc., e.g. 7% of farmers in 4 districts now continuously using hermetic bags
- PICS bags kept crop safe and dry during heavy rainfall, but water got into other bags.

Economic and market drivers include

- drive for export as opposed to food security is shaping the limited PH activity happening
- intraseasonal price variation so farmers want to store for 4 months to access high price
- cheap imports of crops by processors, e.g. soyabean, undermining local production
- grain storage in PICS bags in urban households to avoid buying grain when prices rise
- sale of cheap low quality hermetic bags can damage future market for good products.

Political and institutional drivers include

- production focus still dominates government thinking, although growing PH awareness

- strengthening of extension system through donor funding, has improved the extension to farmer ratio and changed the level of agricultural support received by farmers, including PH messages
- sudden import bans on certain crops (e.g. maize) can undermine traders' business
- no VAT exemption for hermetic bags, although storage-chemicals are exempt.

Socio-cultural drivers include

- increasingly quality aware consumers concerned about aflatoxins and other risks
- consumers (especially urban) are now prepared to pay more for better quality foods
- increased risk of theft of crops in field, leads farmers to harvest early and then dry it at their homestead, but then it is at greater risk from unexpected rains during drying
- the youth prefer soft foods (e.g. rice, potatoes) to maize but most are unemployed so not yet driving a big shift in diets and PH systems.

Demographic drivers include

- population is young, youth unemployment is high, government are trying to attract them into farming
- increased population density, food insecurity and other factors have in the last 10-20 years driven change from outdoor cob storage in granaries to indoor storage of shelled maize grain admixed with pesticide.

Zimbabwe

For Zimbabwe, the following drivers were identified by the stakeholder we spoke to. *Biophysical and environmental drivers* identified include climate change causing food security concerns and meaning many people are reluctant to sell their grain, and extreme events, (e.g. a cyclone in northern highlands) destroying structures and grain. *Technology, innovation and infrastructure drivers* include ICTs increasing market information access and being important for negotiating time-sensitive horticulture prices. *Economic and market drivers* include money not always being able to provide access to food, e.g. during COVID-19 only those connected to farmers survived. *Political and institutional drivers* include geopolitical issues leading to increases in global wheat prices and to the Government investing in national wheat production.

4. Outcomes of PHL Reduction Interventions

Stakeholders were asked for any information regarding the outcomes of PHL reduction interventions.

Nigeria

There is a dearth of information on the outcomes and impact of PH interventions. However, one notable initiative appears to be a private sector-led market-based cold storage investment, 'Cold Hubs'. Key characteristics of this initiative include being driven by a socially aware private entrepreneur who saw an opportunity to address a major challenge in value chains of perishables crops – which to date has not been a PHL reduction investment area attractive to development partners. The Cold Hubs are outside the more familiar grains subsectors and are not driven by available outputs from in-country research organizations. Instead, the businesses developed was driven by an interest in finding a better solution for preserving fresh produce by traders than the *"traditional method of sprinkling water on fresh produce"* – something that has proved to be largely ineffective. So far, the company has established 58 three-tonne capacity cool stores in urban markets. Another 45 of these stores are under construction and they have occupancy rates of close to 100%. They also have two 100-tonne cold stores in major markets, for example in Zaria. The average occupancy rate in these is about 50%.

The facilities are run by young women (who the entrepreneur identified as being the most capable) and their main clients are small/micro-scale aggregators as well as wholesalers and retailers in the urban markets. Major challenges include accessing land at the markets on which to install the cool stores, and getting specialised skills for their personnel who handle the cold storage facilities (most come from a background of artisanal training in refrigeration). Studies are beginning to emerge about the impacts of these cooling technologies[20].

Hermetic storage technologies targeted at smallholder farmers and processing equipment for both durable and perishable crops have also proved highly popular. The technical efficacy of these equipment has been demonstrated during public exhibitions and this has reportedly driven uptake, led in part by politicians acquiring and distributing these technologies and equipment in their constituencies[Ng012, Ng065]. However, informants confirmed there is currently a dearth of evidence on assessment of the financial, economic, social and environmental outcomes of the PH interventions[Ng003]. Financing for acquisition of such equipment is largely inaccessible.

Ethiopia

The rate of adoption of PH technologies and practices by smallholders has become an important measure of success for many development partners. Based on this criterion, it is apparent that the introduction of hermetic bags for grain storage far outstrips the other

[20] For example, Takeshima et al., 2021 in a study in northeast Nigeria, found using cold-storages significantly increased horticulture sales volumes and revenues of market-agents. Back-of-the-envelope calculations indicate that increased net revenues for market-agents may be sufficiently large to recoup the investments and operating costs of cold-storages within a reasonable time frame. Using cold-storage also reduced the share of food loss and lengthened the products' shelf-life, while raised prices received by both market-agents and farmers, which were associated with improved product quality, expanded value-adding activities by market-agents, and increased use of advance payments. No evidence was found of negative spillover effects inside horticulture markets.

technologies. Indeed, reports from a local researcher indicate that dissemination of information on and uptake of the other PHL-reducing innovations is quite low. In contrast, about 3.5 million hermetic PICS bags were manufactured and sold in Ethiopia in 2023. This is in contrast to a total of about 9,000 bags bought by farmers in 2014. Annual supply is currently about 4 million PICS bags for Ethiopia, Sudan and Somalia combined per year. Domestic demand in Ethiopia is growing by an annual rate of about 20% and it is projected that total uptake will reach over 10 million bags per year by 2030. Only 12-15% of hermetic bags manufactured in Ethiopia are exported into subregional markets e.g. Somalia and Sudan. In contrast, uptake of solar driers developed by a local university is rather low as *"… they remain on the shelf"*.

The use of threshers is growing as the number of service providers and the scale of their operation expands. For instance, it is reported that some micro-entrepreneurs who started with one mechanical thresher have acquired 25. However, the reported number in use (about 3000) is still seen as rather low and well below reaching *"… even 10% of target farmers"*. This is despite evidence from the NGO on the comparative benefits of using threshers. For example, it was mentioned by the NGO that produce quality is much higher because mechanical threshing is done on plastic mats and avoids foreign matter such as *"… animal excreta, mud and straw in the produce when the traditional method of trampling on the bare ground is used"*. Mechanical threshing is also much quicker and requires less labour. To illustrate, *"it takes 12 oxen and 4-5 people about 3 days to thresh tef from one hectare of land, but a mechanical thresher will do same in 4-5 hours only"*[Et054]. However, women-headed households faced challenges in acquiring oxen for threshing.

An independent evaluation of the PICS bag in Ethiopia by 60 decibels in 2020 confirmed some of the economic and social benefits. Households that were able to adopt some of these technologies said their quality of life had improved. Women who stored produce in hermetic bags rather than in traditional mud storage facilities avoided the drudgery involved in constructing and cleaning the structures as well as in loading and offloading grains into those structures. Farmers also avoided chemical control of weevils and rodents, which sometimes posed health and safety risks for them and their livestock. The risk of moulds and mycotoxin contamination was also minimised. It is anticipated that more robust enforcement of grain quality standards on pesticides residue will further boost demand for quality grains and the use of such equipment. The assessment further concluded that the perceived benefits were spurring demand for the new PH technologies. However, limited credit made it difficult for a large number of farmers to acquire the equipment.

Reports evaluating PHL reduction projects financed by SDC in Burkina Faso, Uganda and DRC (Guenat and Mengel, 2020) and a capitalisation of experience (CAPEX) report on the SDC Africa Postharvest Management Portfolio in Benin, Mozambique and Tanzania (Felber and Witteveen, 2019) were shared by the SDC team in Ethiopia. These cover learning on implementation of pilot interventions, establishment of a FLW community of practice, the continued need for PHL reduction support by the international development community, a better understanding of farmers' PHM decisions as well as the long-term perspective of an improved policy and regulatory framework, systemic change in PHM markets, institutionalisation of PHM in training and advisory services, effective advocacy and shaping of PHM policies, knowledge management and dissemination.

Kenya

There appeared to be limited study of available evidence on, or independent evaluation of the outcomes from PH initiatives that had occurred in Kenya. KALRO researchers were not aware of any impact assessment of the promotion of plastic as opposed to wooden crates for tomato handling and transport study that had occurred, but they were aware the introduced plastic crates were cheaper than existing wooden crates. No assessment of the changes occurring as a result of any of the work on the hermetic bag, solar drier, or ripening chambers work KALRO researchers were doing was reported. The independent evaluation reports written in 2020 on the outcomes from the AgResults on-farm grain storage initiative in Kenya had not reached the Kenyan grain storage experts prior to our interviews.

Respondents confirmed there is no system that is tracking outcomes of PHL initiatives in the country. While the AU Malabo Declaration Kenyan Biennial Review report has submitted data each time and is apparently surpassing the loss reduction targets, many are unclear where that data was taken from.

It was reported that the new NPHMS will aim to support the tracking of and reporting on loss levels (with loss assessment work currently underway in Kakamega and an Eastern province county with funding from FAO). WRI is also about to start tracking FLW in selected VCs, to then action their '*target, measure, act*' model through working closely with influencer companies. The NPHMS is also designed to increase awareness of what PHL reduction work is occurring and to support greater knowledge sharing and lesson learning around it. The EAGCs systems can collect data on quality aspects along the VC, and the interviewees thought it could be interesting to compare losses in structured and unstructured trade. KALRO researchers are part of the APHLIS network and in the absence of measured loss data from Kenya, they use APHLIS PHL estimates data. As network members they also supply production and other data to APHLIS; devolution meant this required obtaining production data from the counties, which was difficult.

Ministry officers reported that the Aflasafe and maize sheller interventions had brought big changes. Following the death of 100 Kenyans in 2014 from aflatoxin, the country sourced Aflasafe from Uganda and after farmers in aflatoxin-prone areas applied it, the data from samples showed the aflatoxin levels came down. IITA and KALRO have since developed an Aflasafe plant in Katumani in Kenya and product demand is increasing. They have done surveys in farmers' fields and by the second round of the survey, farmers that had used Aflasafe saw average aflatoxin levels reduce from 15ppb to 2ppb, bringing them within the Kenyan acceptable contamination levels for aflatoxin.

Where mechanised maize shellers and tarpaulins to catch any grains that scatter during threshing have replaced stick beating of maize cobs it has reduced breakage and contamination which reduce grain quality. Hand operated as well as mechanised shellers are available. Storage of this higher quality grain could then be done in hermetic bags. However, there are concerns by some where the stored grain is to be used as seed, as some farmers reportedly perceive that storing seed in hermetic bags results in reduced rates of germination[21]. This has led the Ministry to also promote pesticidal grain protectant dusts.

[21] In contrast, results of published research studies report improved germination from hermetic bag storage. Although if grain is stored at too high a mc in hermetic bags this can affect germination levels.

There was no awareness among respondents of the economic returns to farmers from sales of grain stored in hermetic bags versus the usual woven polypropylene bags, although the importance of this was recognised. Similarly, no independent evaluation of the gender dimensions relating to uptake of these interventions was reported. The role of women being responsible for use of food stocks and being involved in threshing/shelling and winnowing, was mentioned alongside the drudgery of these tasks and the opportunity to look for women-friendly technology enabling shelling of the harvest to be done in an hour as opposed to a week.

Following market linkage difficulties faced by an earlier mango aggregation centre project, a subsequent project is working with young 'agro-preneurs' in Kisumu looking at aggregating African leafy vegetables and off take and linking them to urban markets, these agro-preneurs are actively following up on branding, markets in Nairobi and with the diaspora outside Kenya.

The earlier mango capacity building and PHL reduction project worked end-to-end, from covering the use of maturity indices, to harvest practices, to storage, to value-added products (e.g. juice, wine, dried products), and valorisation of waste from mango. But social and other outcomes of this project have not been looked at. A different mango farmer group in Embu has exploited the use of the dryer to the maximum, drying mangoes and other produce for niche markets. They have even managed to get an export market. According to one researcher, impacts from the Embu group's work are apparently easy to see.

The AgResults Kenyan grain storage pilot was perceived as a successful initiative by private and public sector stakeholders in terms of widening SHFs use of hermetic bags and in developing distribution networks of improved grain storage solutions, particularly for hermetic bags, and for having saved 400,000 metrics tonnes of grain from insect damage during storage. The AgResults grain storage pilot was independently evaluated, although the evaluation report did not appear to have reached several key stakeholders. Various actors (e.g. AGRA) have been interested in replicating something similar to the AgResults grain storage initiative. From the private sector perspective, the AgResults initiative's prize - for those companies that did manage to sell at least 70,000 hermetic bags (each 100kgs capacity) in the two-year period - provided an incentive for them to make investments in awareness raising, promotion, capacity building and distribution networks in Kenya. Without that incentive being present in other countries, it has been reportedly harder for them to develop markets there.

EAGC collect data in terms of the volume and quality of grain traded, which could potentially provide interesting trend analysis of different quality aspects. However, they do not usually have the bandwidth available for such analyses or for exploring social or economic outcomes. One of their hermetic bag members is keen to work with them on a study exploring and quantifying the reduction in fumigation and in chemical residues the use of hermetic storage could bring.

Cold store service providers work with their export-oriented clients to understand and track produce quality, especially during the currently extended shipping times through the Red Sea. The particular focus of the cold chain in Kenya has been on high value perishable export VCs, e.g. avocado, mango, French beans, spices, as it is not currently possible to get the business model working for bulky low value products such as cabbages.

Food Banking Kenya reported seeing a shift in public attitudes towards redistribution of surplus, or out-of-spec food, with greater understanding that some of it is rejected just due to minor aesthetic blemishes. Initially there was stigma associated with the idea of 'rescued food', and suggestions that it was not fit for consumption etc. Some of the food being redistributed is

exotic for domestic Kenyan food systems, e.g. patty pans (cucurbits). They were unsure how their activities have changed the practices of the farmers from whom they collect surplus produce.

Malawi

According to those consulted there appears to be little independent assessment available about the outcomes of PHL reduction interventions in Malawi.

Funding structures and incentives often reinforce the situation of organisations using adoption rates as a metric to substantiate their claim to success. One respondent suggested 15-20% of people are using PICS bags in Malawi.[Mw072] LUANAR conducted a study earlier this year to try and understand how many people are still using hermetic bags. In the four survey districts, only 7% were continuously using hermetic bags, and they also discovered that 20-23% had never heard about hermetic bags.

Another respondent reported, “I've never seen any evaluation of interventions and I have never heard of such an initiative from the crops department. But you have raised a very good point as we need to also evaluate the effectiveness of their interventions”.[Mw035]

One respondent explained, “almost all interventions have advantages and disadvantages and it’s the way we take the initiatives to the farmers [that matters].”[Mw022] For example, there was an initiative in the past where the government subsidized PH grain storage pesticides and “we saw a jump in uptake of those pesticides by a lot of farmers who opted to use them. That was the time of LGB in the country so to safeguard the produce, government thought alongside the seed and fertiliser maybe we should also subsidise the pesticides and there was high demand for them from farmers. But then we ended up having a lot of pesticides because some of them expired in the process, so we ended up accumulating a lot of pesticides in stores. So there are advantages and disadvantages and it depends on how you handle such things”.[Mw013] This respondent went on to explain, “another initiative is grain banks, which are the same as warehouses, where government would construct a structure for the community who could then store their produce and then start using the produce during the main period for their consumption and they can also store for sale if they have excess. For that one, what is needed is to do a lot of sensitisation, so farmers understand the use of those structures”.[Mw023]

It was suggested, particularly by public sector actors, that more needs to be done to understand farmers’ and other stakeholders’ perspectives on PHL and what is preventing the use of PHL reduction technologies.

5. Enablers and Disablers for PHL Reduction

The key informants were asked to identify factors enabling and disabling PHL reduction in their country's context. The aim was to base this on what is actually happening on the ground. There were both similarities and differences in responses between countries and stakeholders. In many cases the disabling factors reported were the flip side of the enabling factors. An overview of the factors identified by the different stakeholder types (i.e. public, private, third sector) by the themes that emerged is provided in Tables 5.1 and 5.2, and a narrative summary is given below.

Enabling factors

Government awareness of and engagement with PHL reduction, supportive public policies and regulations (e.g. export standards, tax exemption for PH equipment) and the recent development of national PH management and other complementary strategies (e.g. food safety, horticulture) – these tended to be identified more in Ethiopia and Kenya and by public sector rather than private sector actors.

Public sector research organizations working on PHL technologies, knowledge and practices were identified mainly by public sector actors and in Nigeria, Ethiopia, Kenya.

Product (e.g. hermetic bag standards) *and food handling standards* were mentioned by a public and private actor in Kenya.

Private sector investment in areas such as tomato processing factories and agro-dealers supply and sales of grain protectants to farmers was mentioned by public sector actors in Nigeria, Malawi and Zimbabwe, and private sector organizations' technologies was reported by private sector in Kenya.

Knowledge and awareness of PHL aspects was reported in terms of university curricula in Ethiopia and Malawi by public sector actors. In Kenya a private sector actor reported increasing awareness of aflatoxins and increasing consumer awareness /demand for quality food products which were considered to support more adoption of PHL solutions.

International and regional bodies and initiatives - e.g. the UN Food Systems Summit providing an opportunity to integrate PH in country-level food system road maps; SDG12.3 and the AU Malabo Declaration and IGAD at East Africa level, and regional bodies such as the East African Grain Council's promotion of PHL reduction strategies. These were only mentioned by public sector actors.

Good collaboration/ relationships/ partnerships - these were reported by public sector and private sector actors referring to a number of different contexts, for example, collaboration between a training college and the Dawanau International market in Nigeria; Farmers Union members aggregating produce based on quality in Ethiopia; a Nigerian social entrepreneur and German researchers co-developing solar powered cold rooms outside a project context; maintaining close relationships between the technology supplier and agro-dealers in Kenya.

Development partners support and NGO initiatives – these were reported by public and private sector actors. Examples include the AgResults grain storage project mentioned by public and private sector in Kenya; USAIDs Feed the Future Programme, donor support for PH loss assessments, and WFPs PH farmer training were mentioned by private and public sector in Malawi; donor funding and support assessing PHL in Malawi reported by the public sector.

Markets and prices that reward quality such as supermarkets, export markets and rising prices in domestic markets were reported as PHL reduction enablers by public, private and other actors in Nigeria, Kenya, Malawi and Zimbabwe.

Other enablers mentioned included electrification and rural roads increasing market access (Ethiopia); access to finance for SMEs (Kenya, Nigeria); existence of PH government officers at different levels (Ethiopia); access to online PHL reduction information, e.g. on cold room engineering (Nigeria); data collection, access and sharing between financial institutions for more informed learning and lending (Kenya) and on PHL levels for informing food security planning (Malawi); improved processing technologies for climate resilient crops (e.g. enset); national campaigns on managing FLW (Malawi); flow of information due to good average literacy levels and interest in seeking information (Zimbabwe); increasing storage of grain crops in urban areas (Zimbabwe); recognition of women's roles and skill sets in managing food (Nigeria); investments built through contract farming (Ethiopia); and the demand for and price of food (Kenya).

Disabling factors

Public policies and legislation and government investment – particularly around lack of VAT exemption on PH equipment, and government focus on production (pre-harvest) investments as opposed to postharvest were reported as disabling factors.

> Examples from the public sector: inconsistency in VAT exemptions for agricultural products and money not being budgeted at the political level to address PHL (Kenya); a focus on production stages and lack of integration of PHL reduction aspects in government policy or actions, and weak farmer engagement processes in government investments (Malawi).
>
> Examples from the private sector: high import duty on all cooling unit parts, and the need for PHM agencies to be separate from Ministry of Agriculture as PHM is so cross-sectoral (Nigeria); high import duty of 16% - 25% on PH inputs and infrastructure, many other taxes including those at both national and county level on movement of high value chain products and changeable and high taxes which can deter investment (Kenya); lack of VAT exemption on hermetic bags (Malawi).
>
> Examples from stakeholders from other sectors: government and other partners prioritise areas/topics other than postharvest (Ethiopia); much of Government debt is domestic and owed to businesses who have provided goods and services to government, inadequate legal and policy frameworks leading to ambiguity and lack of incentives (Kenya); VAT and Import duty on hermetic bags makes them quite expensive (Malawi).

Public sector research organizations working on PHL technologies – disabling factors reported by the public sector in Nigeria were that such organisations were not sufficiently focused on end-users' ability, but were more like academic research projects, while the private sector identified a lot of need for research capacity enhancement on this topic arising from the view that most researchers from these research institutes and universities, do not seem to have a depth of understanding around the gaps that really exist in PH systems.

Product and food handling standards and certification cost concerns were reported by public sector actors in Kenya, where standards apply for export markets, but the local market does not demand any quality, and in Nigeria where there are complex, time-consuming and costly certification processes for processed food products.

Concerns on private sector investment were mentioned by public sector actors in Zimbabwe - hermetic bag supply chains are not well enough developed; the private sector needs to be incentivised to market their technologies, and the private sector is unwilling to invest in research as returns on the investment are uncertain. For Ethiopia, a weak private wing in the PH sector is a big challenge.

Knowledge, skills and awareness of PHL aspects was a concern reported by public and private sector actors in Nigeria, Ethiopia, Kenya. Comments from public sector in Nigeria were that PH management needs scientific knowledge and skills and this is not available to farmers due to their level of literacy; there is a need for training and manpower around PH management in Kano market. Ethiopia reported a human training gap in PH and that the University needs to train PH experts. Kenya reported knowledge gaps as technologies have been developed but not cascaded to the farmers for use because the "in between channel" may be lacking. Agricultural devolution means extension staff are solely under the county government and they are not actually employing the extension staff, so agricultural extension in Kenya is currently in a coma and needs reenergising. Concerns by private sector actors in Nigeria were lack of awareness of the importance of cooling to reduce losses, and the need to market cool storage amongst retailers and others; Malawi reported a lack of PH awareness; Kenya pointed to a lack of acknowledgement that there is waste and a shortage of capacity and expertise, although there is a certification scheme for traders and warehouse operators, some people doing sampling and the experts are trained through the grain business institute. Other sector actors in Ethiopia also mentioned a lack of knowledge and awareness.

Infrastructure concerns, specifically the limited availability of good infrastructure which creates storage and transportation challenges, were reported by public, private and other sector actors in Nigeria, Ethiopia and Kenya. Public sector actors in Nigeria acknowledged that although a few grain silos may be present, "when it comes to the fruit and vegetables we hardly have anything; poor road networks are a critical disincentive even if you have cheaper storage, to get the produce to market the transport cost alone will be 60% of all your profit". Also mentioned was the poor electricity supply, "the national grid failed almost 3 or 4 times in a month". Additional comments from Ethiopia were that distances are long; there are no cold chain facilities for the crops which is very challenging for horticultural crops. Private sector actors in Nigeria reported poor infrastructure in food markets (all food markets are owned by government), particularly the lack of provision for cold storage areas, "there has to be storage for cold and dry produce in each food market". Private actors in Kenya noted that the energy tariff for milling is lower in the residential estates than in the industrial parks, which is a disincentive for formal millers. Other actors in Ethiopia mentioned poor access to roads, market and information.

Access to finance concerns were reported by the public sector actors in Nigeria and Ethiopia. In Nigeria, access to credit involves 24% interest which is not conducive for farmers, with some commercial banks having up to 34% interest. Both Nigeria and Ethiopia public sector actors face challenges in accessing operational funds and finance for equipment/technologies. "Most of the money we get from Federal state just covers the overhead, fuel etc. We need more funding for equipment, tools and resources so we can perform and do a lot more activities in PH". "We are just a college although we are into research, so funds are limited as we are not under tertiary education funds." (Nigeria). Ethiopian public sector actors stated, "only recently the government is trying to open opportunities for foreign banks to come in and invest here". Access to finance was also a challenge for private sector actors in Kenya: "Businesses like us are figuring out how to finance their business as capital expenditure is expensive." Accessing

the foreign exchange needed for importing materials, and their crop export activities to help manage that was an issue for private sector actors in Ethiopia. Other sectors in Ethiopia reported a lack of loans for PH machines or technologies which would help people get into these businesses. The challenges around *the cost of technologies* being unaffordable for many (particularly given *high poverty levels* in the countries) were raised across sectors (e.g. cost of cold rooms, aflatoxin testing) and the importation of most of the materials involved in producing the technologies resulting in their higher costs.

Collaboration/ relationships/ partnership concerns were reported by public and other sector actors in Kenya. They cited political issues and lack of coordination "so no one knows what the other is doing PH wise across the country. FAO are now mapping all PH work in Kenya to try and overcome that." The private sector in Nigeria commented, "We have stakeholder engagement that brings government and private entities together, but those present are low calibre government staff who can't bring change, the right people are rarely in the room; these staff come and write their report, submit it to the Permanent Secretary and nothing happens or changes".

Concerns about development partners support for PH and NGO initiatives were reported by the public sector in Malawi. "Donors focus on production stages and can't see the point of having PH initiatives so then preach about production". They commented that resources will always be limiting to enable NGOs to continue to do enough sensitisation to raise public awareness. A view from the private sector in Kenya was that grants require so much administrative time and data that little time is left for project activities. Also identified were mission/role creep issues when NGOs start distributing private sector products.

Markets and price concerns were reported by public sector actors in Zimbabwe. They cited cases where contractors don't show up so farmers lose confidence in the marketing systems, long delays in payment, e.g. by the Grain Marketing Board, which is a major blow to farmers, and many middlemen taking off produce at lower prices. Public markets are less sensitive to quality unless the produce is crushed/damaged. For Nigeria, the lack of decentralised markets and aggregation centres was highlighted, while for Kenya, public sector actors said that market can be the hindering factor. It there is no quality-based pricing and no demand for quality in local markets then no one will go the extra mile. Other sectors in Kenya reported market volatility and in Ethiopia, they also reported a lack of quality sensitive markets.

Social and cultural factors reported by the public sector in Nigeria include cultural beliefs. "It is difficult to convince famers that loss is not just part of the business. We keep trying to convince them that you can actually get 100% of what you grow to the consumers table, [but the] cultural belief is that a certain % has to go back to nature". The private sector in Nigeria reported that when you come out to present an innovation to Nigerians, you need to be very, very confident. In Malawi the private sector noted that 70-80% of people are poor so cannot afford to buy expensive technologies.

Climate change reported by the public sector in Nigeria and Ethiopia as another big obstacle which is increasing the number of pests and accelerating the rate of deterioration. Other sector actors in Kenya mentioned that global warming is leading to extreme weather patterns and events.

Security concerns were reported by the public and private sectors in Nigeria. "Security systems are required to keep investments such as cold stores and solar panels safe, and we have

needed to install monitoring systems for cold store conditions but also cameras to prevent misuse of the stores by staff often trying to make extra money by loading too many containers, but that then affects the cooling". Other sector actors in Ethiopia reported that security issues in some project sites, mean that people (e.g. FAO and Ministry teams) are not ablet to go and support farmers, so they can't get support or inputs.

Other disablers mentioned included global crises, e.g. conflicts such as the Russian invasion of Ukraine and Israel-Gaza conflict which have affected export/import routes and options, making it harder for some countries to sell their products, (i.e. they need to airfreight as opposed to ship coffee from Ethiopia). Other issues related to technology acquisition and distribution, for example, importation of machines such as threshers without sufficiently checking their specifications, and weak distribution networks for technologies to reach intended end-users. Technical constraints raised included timeliness of harvesting and reduced efficacy of chemical pesticides. There is an absence of PHL data and uncertainty on how it is being used if it does exist. Economic and social constraints mentioned were the absence of insurance for agricultural loans, poor uptake of mobile money in Nigeria in comparison to countries such as Kenya, population drift to urban areas and lack of an outlet to help with redistribution of food.

Table 5.1 Factors ENABLING PHL reduction in the focal countries from the perspectives of public, private and other sector key informants

Factors	Sector	Details
Government awareness/ engagement	Public	• Govt is engaging but it depends on the crop, they are engaging more for the grains but not for the F&V. Ng011 • Good awareness among the policy makers of the contribution PHL reduction makes to food security, health and nutrition, due to export product recall because of mycotoxins. Et021 • Political awareness exists now of the need not to lose produce PH. Et023 • Govt is willing and has policies that allow for the private sector to assist, even the NGOs. Mw033
	Other	• Ministry is on board with PHM and they are the champion of NPHMS. Et055
Government policy and regulations	Public	• Tax exemption for PH equipment. Et021 • We have standards that apply for export markets - harvest in a certain way etc, but the local market does not demand any quality. But in Kenya less than 5% is exported, we have standards, but no one cares about standards. People just want affordable. So, no one will buy unless you have a niche market. Ke071 • Incentives provided by the govt in terms of tax waiver for PH technologies. Et063 • Investors can produce and sell produce either domestically or abroad. So it is creating a good opportunity for foreign direct investment to come and invest in Ethiopia. Et053 • Policies enabling the promotion of these technologies initiatives. *The only thing is how to access the credit mechanism for farmers to access some of these technologies?* Ke022
	Private	• For maize, the Warehouse Receipt legislation has been passed. Ke019
	Other	• Policy interventions that have been supportive. For example, there has been policy work happening with the two main regulators we have and the banking sector in Kenya. Ke075
National PH strategies/ complementary strategies	Public	• The NPHMS is a good one and once resourced and actioned will bring positive change. Et011 • The new PHM strategy is already very interesting and was designed over years, revised and revalidated many times & has now been launched by MoA even with a promise of budget from the govt. Et001 • Complementary strategies e.g. food safety and horticulture development strategy. Et061 • A very good PHM strategy plan was developed for 2018 to 2025 and contained very good aspects on how to drive PH issues within the country. *Unfortunately, it requires quite a healthy amount of money to fund it*. Ke032
	Other	• The Ministry of Ag is on board with PHM and they are the champion of NPHMS. Et065

Factors	Sector	Details
Public organisations introducing PHL technologies, knowledge and practices	Public	• There are institutions introducing technologies to tackle PHL. There seem to be a lot of players who are interested in PHL reduction funded by govt institutions. [Ng075] • Research centres now have a dedicated system for that. [Et051] • Research project trying to promote storage practices including hermetic bags plus other methodologies. Although not sure whether the impact of that project for farmers was assessed. [Ke032] • Breeding seems to have now brought in those flinty varieties that are now available in the market and are less susceptible to storage pests. But often farmers go for the high yielding varieties and then use the pesticides. [Zw081]
	Private	• We have very good ag research institutes here and I think our farmers need to be guided more on which are the best types of crops to be grown, what is the best variety of potato or bean etc. Just as we have done for tea and coffee. We need to leverage that knowledge and make sure that we are growing the best possible crops we can have here. [Ke069]
Product and food handling standards	Public	• Kenya developed a standard for hermetic bags to ensure all hermetic bag brands being sold met basic quality standards. [Ke022]
	Private	• The food handling standards, as we have a list of standards for how different products should be managed, recommendations from govt, it outlines what should be happening between hour 0 and 6 after handling. That creates at least a blueprint for how best practices should be. It is not always followed, but at least there is that awareness. [Ke008]
Private sector investment	Public	• Private investment, Dangote is an investor in Nigeria and recently invested in a processing outlet in the north to process tomato in the peak period. He buys from the farmers and the factory produces tomato paste and puree. That helps in reducing losses. [Ng011] • Agro-dealers who assist us through supply of pesticides for use by farmers. [Mw043] • Zimbabwe has a strong agro-chemical industry, so there is a lot of support especially in terms of pesticide use and we have aggressive salespeople and a range of pesticides available which farmers can use. [Zw061]
Private organizations developing technologies	Private	• Technology development solutions that are now becoming available that 5-6 years ago did not exist. If 5 years ago you talked about decontamination or ozonation, people would think you were coming from a different planet, but [now]we have those things. This is private sector led technology although the Canadians bought the first two, private sector developed them. Not public financed. [Ke066]
Knowledge and awareness	Public	• There are 6 Universities that are teaching students on PH aspects, so a lot of trained human power to address PH systems. [Et031] • Universities like Jimma, Haramaya, Bahada, Mecha Universities and others who are now working on PHL reduction. [Et053] • The curriculum changed recently and they have tried to talk more about PH in some disciplines. [Mw051]
	Private	• Another thing that has helped us a lot is awareness and knowledge as people have continued to be trained and to understand the challenges of aflatoxin and PH handling that has had a very positive impact. [Ke046] • Another enabler is consumer awareness and we are seeing a lot more around that consumer demand for quality and that supports much more adoption of PHL solutions. [Ke076]
	Other	• Awareness and knowledge increased. [Et045]
International and regional initiatives, policy and bodies	Public	• International initiatives: the UN Food Systems Summit provided an opportunity to integrate PH in the FS road map in the country; SDG12.3 and the Malabo Declaration and IGAD at East Africa level are push factors. [Et031] • Policy regulation and legislation and trying to anchor them to the Malabo AU plus those other global policies. Once we have one that is speaking for Kenya, we'll ensure that the issue of coordination, collaboration and ensuring that people align themselves within the required standards. [Ke034] • Bodies such as the East African Grain Council (EAGC) and Cereal Growers Authority who promote strategies to reduce PHLs. [Ke032]
Good collaboration / partnerships	Public	• We have good collaboration with Dawanau International Market, there are a lot of F&V markets here in Kano and the Chadian, Niger and Benin people patronise this produce. *If we could help train the market people on good handling of agricultural produce, then I am sure we could achieve a lot*. [Ng034]

Factors	Sector	Details
		• Farmer Unions and aggregation of farmers produce based on quality that is coming and may bring opportunities. [Et071]
	Private	• Online research paper on solar cooling written by the Institute for Air Handling and Refrigeration in Germany that using German Govt funding built a solar powered cool room in 1999 but that was never commercialised. I downloaded the paper, read it back-to-back, found the Research Institute's website, wrote to them and someone responded and connected me with that research team. I saved some money, flew to Germany and met them. [Ng026] • I presented what I had done in Nigeria to them and they took me to the back of the Research Institute, and I saw the solar powered cold room built in 1999, and they switched it on. It came on, and I was blown away and wanted to take it home. My excitement made them understand the need for the technology. They took the research that we did and redesigned it, they really improved on the design and they've been our technical and scientific partners to date. [Ng046] • Maintaining close relationships between the technology supplier and the agro-dealers: helps ensure agrodealers understand the technology, display and promote the merchandise well in their shops and are supported with funds and incentivised to sell the product, and that the private company is aware of customers questions and experiences, *but meeting the agro dealers each month is expensive*. [Ke020]
Development partners support	Public	• Most development partners are happy to work on PH aspects. [Et031] • AgResults project being funded by USAID. They were giving a reward for those who had sold so many improved storage devices within the farmer community. Through the extension services of the private companies, through selling and adoption by the farmers it did have an impact because they appreciated that actually you could use them and prevent losses. [Ke042] • Donor funding and support to conduct PH loss assessments. [Mw025]
	Private	• Conditions around donor grant funding: Projects (eg SUED) where the grant funding is only provided if certain things are in place, such projects then become increasingly influential in terms of guiding policy and making sure things are done the right way. [Ke039] • Results-based improved grain storage donor programmes that incentivised the private sector: AgResults did a fantastic job of supporting the development of the hermetic bag market in Kenya incentivising private sector companies to really invest in promoting and distributing their product through the potential of winning a share of a ~USD$4 million prize. [Ke040] • Development projects raising awareness about private sector products: While doing the AgResults, two other programmes, one was USAID KAVES programme promoted the hermetic tech and so that was an add on that helped and then there was a programme known as cereal enhancement programme KACEP '10 bags and one tarp to all the farmers in a county', and that has run for more than 6 or 7 yrs in Kenya. We used CGA to help us launch in the rift valley counties with road shows in each county, so thousands of farmers came and directly learnt about the hermetic bags. [Ke010] • USAID-funded Feed the Future (FtF) project and also WFP are doing a lot to reduce these PHLs as they are going and giving classes to the farmers, and NGOs are helping and recently Government are going and giving some awareness as well. Government, NGOs etc – if we can cover more than 70-80% of farmers then would see a big change in food security. [Mw082]
NGO initiatives	Public	• Some of the initiatives that some NGOs are putting in. [Mw021]
	Private	• WFP are doing a lot to reduce PHLs as they are giving classes to farmers, and NGOs are helping. [Mw052]
Markets and Prices	Public	• Quality is being driven by private sector cos they supply big supermarkets where quality is a big issue. [Zw021]
	Private	• For avocado it is the end market, which is quite well structured and the critical thing is getting yourself integrated into that market. [Ke029]
	Other	• Inter-seasonal price variation: in a few months down the line there is a big price change so that offers an incentive for farmers to hold their commodities till the price improves as they can get higher profits if they keep the grains and maybe sell them in around November/December when the prices are high. That is a general trend that is affecting the hermetic bags and an incentive. [Mw064] • The quest for getting the price that food product commands in the market right now and you want to ensure you get your food products in the right form so you can reduce

Factors	Sector	Details
		losses from your yield so you can get more money. The economy is biting hard now, so if you are harvesting 10 tonnes of maize, you want to ensure that if you are keeping 2 tonnes for your household consumption, you have 8 tonnes going into the market and you don't want to lose anything. So people are motivated by the price of food stuffs in the market now and farmers are asking how can I get Aflasafe and PICS bags so I can store. Others are doing what is not good practice, but hoarding food products till there is scarcity and they can get a higher price so they need to be able to store properly and are beginning to consider PH storage equipment so they can command a higher price in the market. It's actually money that is a motivating factor as nothing has changed in terms of enabling environment with the government, no new it's just the motivation that they are going to make more money and so they want to adopt PHL mitigation measures. Ng047
Infrastructure – power, road networks	Public	• Last June they unbundled the monopoly of the govt in power provision Ng033 • Rural electrification and rural road network programme which connects Kabele to Kabele increasing the possibility for farmers to sell their produce to the local market. Et091
Access to finance	Public	• Trainees access to finance from financial institutions in Kano state to help them invest. There is a SME development agency of Nigeria. If they are registered with Corporate Appeals Commission of Nigeria. They can now go and access some funds e.g. up to 250,000 or 500,000 Naira depending on the proposal submitted and the project they are engaged in. Ng024
	Private	• For finance – particularly export finance - some countries are supporting their private sector with export finance schemes to sell driers, shellers etc. From a policy perspective we have been pushing to get more tax concessions to get storage tech and quality infrastructures. We've not been very successful, but we think we will when we start getting some incentives around quality storage. Ke046
Government staffing	Public	• Government has allocated structures focused on PH, e.g. PH officers at diff levels. Et031 • Extension staff across the country who can help in enumerating surveys on PHLs. Mw065
Online information	Private	• Availability of YouTube videos on cold room engineering. Ng076 • Research paper online on solar cooling written by the Institute for Air Handling and Refrigeration, located in Germany that built a solar powered cool room in 1999 as German government funded research but that was never commercialised. So I downloaded the paperwork online, read through it back-to-back, found the Research Institute's website, wrote to them and after a while someone responded and connected me with the team that did that research. I saved a little bit of money, flew to Germany and met the team. Ng096
Role of data	Public	• PHL assessment data being used to inform food balance sheet and food security assessment. Mw035
	Other	• The role of data in making some of these projects successful is probably not appreciated. If we didn't have this data from various financial institutions and analysing it and presenting it to all the market players then the project would not have made the strides it has today. So ability to collect data and analyse it is critical. Ke075
Other	Public	• Contract farming which brings together investors and smallholder farmers Et023 • Enset is a climate resilient crop, its processing was very difficult and was totally done by women. Now thanks to Universities, they have developed machineries that can easily facilitate processing, packaging etc. Et063 • Started a campaign on managing FLW. Mw083 • General literacy – that people seek information in various ways, they have contacts in urban areas and that facilitates information flow they do not just rely on the radio programmes etc. Zw021 • We have seen an increasing trend in urban grain storage; people produce in their pieces of land, buy grain from farmers and then come and store in urban areas. Zw031
	Private	• Women seen as better managers of food in this part of the world and easier for women traders to come and be attended to by women. Ng046 • The fact people need food. Ke023 • Even as waste it is considered as an income stream. Ke003

Table 5.2 Factors DISABLING PHL reduction in the focal countries from the perspectives of public, private and other sector key informants

Factors	Sector	Details
Government policy and legislation	Public	• Inconsistency in VAT exemptions for agricultural products. Pesticides are exempted but not hermetic bags which have VAT and import duty added. Although efforts have been made to ask for VAT exemption on PH inputs. When it was examined for metal silos, there were challenges distinguishing between metal sheets coming in for metal silos fabrication and those for other uses. [Ke072] • Focus on production stages by Govt: The food insecurity situation makes us focus on the production. [Mw031] • Lack of integration of PHL reduction aspects in policy or government actions. People are preaching about those issues, so now it is for the policymakers or government to take it on and that is where we are having problems. [Mw021]
	Private	• Import duty on all cooling unit parts. Companies within the cold storage space, pay 20% import duty on all their condensing unit evaporator fans, which is a huge cost. Government could remove that as an incentive to enable companies to bring in their equipment. Most of the equipment is manufactured in Europe, America and Industrialised Asia. We still do not have the capacity to manufacture in this part of the world, so that kind of incentive can help companies grow. [Ng056] • Policy – the incentives are not yet available, particularly for the PH infrastructure all consumables are hit with a 25% import duty and many other taxes. [Ke026] • Fiscal policy e.g. the tea industry: by introducing a certain 'packaging tax' it has now resulted in tea packaging not happening in Kenya so there is billions of shillings worth of stock of low grade tea in Mombasa which has not been sold. So farmers have not been paid for their tea countrywide. [Ke079] • Tax policies can risk damaging the whole agricultural sector. [Ke009] • Price control or price decontrol, or any interference on imports or taxes etc, and because of devolution the taxes can be at national level and then also at county level on movement of high value chain products which can be taxed again and then it damages the whole industry. [Ke039] • Government policy is resulting in larger players disengaging, e.g. a big German coffee player with 400 employees left at the end of last year (disinvestment). [Ke069] • High taxes on imported PH inputs: 18% tax in Tanzania and 16% in Kenya if that was removed it could help, but not much. We would like to see VAT exemption for PH products. [Ke039] • Lack of VAT exemption on PICS bags. [Mw042]
	Other	• Govt and other partners prioritise other areas/topics. For example, if you look at the wheat initiative and the grain legacy initiative by the Prime Minister this then diverts the attention of people to particular topics, and this may have implications on PHM although some PH issues may be within the wheat initiative, but people are looking at the production aspects. Lots of actors at ground level so that attention can have positive and negative impacts. [Et065] • Government debt is a handicap businesses face. Ksh0.7trillion is owed to businesses who have provided goods and services to government. If that domestic debt was paid today by government to those businesses that are owed that money that would be a huge stimulus to the economy and would turn the fortunes of those businesses around significantly. [Ke025] • VAT and Import duty on hermetic bags make them quite expensive. [Mw024] • Inadequate legal and policy frameworks leading to ambiguity and lack of incentives. [Ke057]
Government investment	Public	• People are not walking the talk, as there is investment that is required by national or county govt. It costs and there are limited resources, so prioritisation of what is important is needed. E.g. to convince counties to put cold storage in a market to reduce losses. If you put a cool store in the market it makes a lot of difference cos so much loss happens there, especially with perishables. If you can figure out how to operationalise it. So not sure if someone hasn't shown the evidence of what impact it will have, you can't know why the investment is not there. [Ke031] • At a political level money is not budgeted to address PHLs. It's diverted to other priority areas based on what level government needs. So it is our priority setting that is not conforming to the needs of where losses are being highly incurred. [Ke082]

Factors	Sector	Details
		• Resources will always be limiting for government to continue to do enough sensitisations to raise public awareness. [Mw033] • Government has also through projects constructed some structures but it depends on how we take these initiatives to the farmers and we may need to improve on that going forward. [Mw033]
	Private	• Need for government to play a greater role in PHM; we should have PHM agencies as separate entities from the Federal Min of Ag. PHM is cross cutting -crops, livestock, aquaculture, and even artisanal fisheries. [Ng056]
Public organs introducing PHL technologies, knowledge and practices	Public	• Not enough focused on the end user ability more like academic research projects. [Ng055]
	Private	• A lot of need for research capacity enhancement in this topic. Most of the researchers that from these Research Institutes and Universities, don't seem to have a depth of understanding around the gaps that really exist in PH systems. So, it is really important to enhance their capacity around PH, to make them more focused. [Ng036]
Product and food handling standards	Public	• We have standards that apply for export market - harvest in a certain way etc, but the local market does not demand any quality. But in Kenya less than 5% is exported, we have standards but no one cares about standards. People just want affordable. So no one will buy quality produce unless you have a niche market. [Ke011]
Certification costs	Public	• Certification challenges, it took 5 months to get certification for products and involved a lot of money, we had to take the produce to Lagos and pay a lot of charges. It required patience. For those people we trained it would take even longer to get certified, but may cost less for individuals applying vs us being a college. [Ng024]
Private sector investment	Public	• Private sector involvement e.g. hermetic bags supply not well enough developed. [Zw061] • Private sector need to be incentivised to market their technologies. [Zw001] • Private sector not willing to invest in research as uncertain there would be a return on the investment. [Zw021] • Weak private wing in the PH sector is a really big challenge. [Et053]
Knowledge, skills and awareness	Public	• PHL needs some scientific knowledge and skills and this is not available to the farmers due to their level of literacy. I suggest the HEI agriculture graduates should be mobilised to go into modern farming. So they do 'cool farming' not necessarily agriculture. We need to mobilise that. We had something like that previously called empower it was supposed to engage our youths. I think we should go for our University and Polytechnic graduates, put them together and give them a starter pack, they will do a better job than current field actors. [Ng033] • Need training and manpower as we can't achieve a lot when we look at the market and produce in Kano. Very high levels of PHL on orange, banana and other perishables etc and the stench, and number of lorries offloading those perishables is huge. [Ng064] • Human training gap in PH. Maybe our University needs to train PH experts. [Et031] • Knowledge gaps – as technologies have been developed but they are not cascaded to farmers for use, that channel may be lacking, that person playing the in between role. [Ke084] • When agriculture was devolved, extn staff became solely under the county govt and the govt are not actually employing the extn staff, so agricultural extension in Kenya it is in a coma currently we need to reenergise that. [Ke094]
	Private	• Lack of awareness of importance of cooling to reduce loss, and the need to really market it amongst retailers and people. [Ng026] • Lack of awareness. [Mw052] • The lack of acknowledgement that there is waste here. If we don't acknowledge that there is waste we continue wasting, e.g. the fact we can sell off fruit to pig farmers or BSF farmers so I may not consider that I have waste so if we redistribute all this food waste we will then be creating a challenge for the pig farmer and economically denying someone an income as someone already makes an income out of buying that fruit waste. [Ke043] • Shortage of capacity and expertise is a challenge, we have come up with a certification scheme for traders and warehouse operators and some people doing

Factors	Sector	Details
		sampling but the experts are those trained through our grain business institute so the shortage of skills becomes another disabler. [Ke006]
	Other	• Lack of knowledge and awareness. [Et016]
Infrastructure	Public	• We hardly find good infrastructure around, you may find a silo here and there but when it comes to the fruit and veg, we hardly have anything. Only the private sector are trying to help people out. [Ng021] • Infrastructural facilities e.g. road network etc is a critical disincentive no matter what you want if you have cheaper storage, then to get produce to market the transport cost alone is still 60% of all your profit. [Ng072] • Electricity supply is another problem. Within a month the national grid fell almost 3 or 4 times. The national infrastructural support is just not there. [Ng002] • Infrastructure is not well developed. [Et031] • Long distances. [Et051] • No cold chain facility for the crops. [Et001] • The huge problem is infrastructure that is very limiting, we have poor roads, we don't have cold chain which are very challenging for horticultural crops. [Et063]
	Private	• Infrastructure for food markets. All the food markets are owned by government. There is no design, no impute, no architectural markup for cold storage areas in the markets. There has to be storage for cold and dry produce in each food market. A position should be marked out for private sector to come and take, that would reduce the time frame it takes us to negotiate and lock down on land. [Ng086] • Energy tariff for milling is lower in the residential estates than in the industrial parks. [Ke036]
	Other	• Lack of/poor infrastructural capacity that leads to storage and transportation challenges. [Ke027] • Poor access to roads, market and other information. [Et066]
Collaboration/ relationships/ partnerships/ coordination	Public	• Political issues and lack of coordination so no one knows what the other is doing PH wise across the country, and FAO are now doing a mapping of all PH work in Kenya to try and overcome that. [Ke021]
	Private	• We have stakeholder engagement that brings government and private entities together. But these are low rank government staff who can't bring change, they rarely bring the right people in the room, the staff come and write their report, submit it to the Permanent Secretary and nothing happens. So that's why it is difficult to make the changes. [Ng016]
	Other	• Poor coordination among public and private stakeholders, coupled with information asymmetry. [Ke077]
Access to finance	Public	• Access to credit - the 24% interest is not conducive for farmers. Some commercial banks have up to 34% interest now. The govt has a Bank of AG, it is supposed to be single digit interest rate for farmers. Need a single digit interest rate. [Ng033] • Need a lot of equipment and tools. Most of the money we get from federal state just covers the overhead, fuel etc. we need a lot of funding and eqpt and resources so we can perform and do a lot more PH activities. [Ng024] • We are just a college although we are into research, so funds are limited as we are not under tertiary education funds which would bring funding for research in Nigeria, if we were incorporated into that we could achieve and sort a lot of issues in terms of PH. [Ng064] • Financial access for the technologies. [Et051] • Limited access to finance, only recently the govt is trying to open opportunity for foreign banks to come in and invest here. There is a law being prepared to allow foreign banks to come in. Local banks don't have much strength to provide credit for SHFs, fabricators and manufacturers, so far their credit is for lease banking only for the big equipment importers while SHFs don't have that opportunity. [Et023]
	Private	• The other one is also for businesses like us. They're figuring out how to finance their business as capex is expensive. So looking at the financing options available we are still dealing with people who want the product but may not be able to pay the premium price, so what is the availability of capital that is well priced for such business model. [Ke078]
	Other	• Financial issue – there is no loan for PH machines or technologies which would help people get into these businesses. [Et014]

Factors	Sector	Details
		• Poor financial access. Et046
Cost / Affordability of technology	Public	• There are financial challenges as well, e.g. the cold room, how many farmers can afford them? Unreachable for them. But there are some financial houses coming up with opportunities for them but the interest rates are sometimes unbelievable. Ng031 • Production cost of the technologies is very high currently, as most of the materials are imported, and exemptions are in and out they say it is and then they say now Ng002 • No one is sure how many of these techs are reaching the end user, some are too expensive for the rural community. Ng055
	Private	• High cost of aflatoxin testing: how will you know if your grain is safe if cost of testing is prohibitive? Ke036
	Other	• High cost of agricultural inputs coupled with limited access to credit for farmers. Ke027
Poverty	Private	• 70-80% of people are poor so cannot afford to buy expensive technologies. Mw012
Foreign exchange	Private	• Foreign exchange is the biggest headache. Unfortunately, we came out of all the subsidies so currently I don't have any grant or any subsidies when it comes to PICS bags (and we are profitable), but we have to pay a big price for foreign exchange so we are into export in Somalia and Sudan. And we also export beans and spices to India and Asia just to cater for our foreign exchange needs. Et022
Development partners support	Public	• Focus on production stages by Donors: Donors who are coming in with their resources can't see the point of having these PH initiatives that is why they then preach about production. Mw051
	Private	• Grants that require so much administrative time. Projects that end up asking private sector for so much data and then you end up just doing that (i.e. admin) as opposed to focusing on the project. Ke039
NGO initiatives	Public	• Resources will always be limiting for the NGOs to continue to do enough sensitisations to raise public awareness. Mw063
	Private	• Mission/role creep by development players: NGOs getting involved in the distribution of private sector products e.g. hermetic bags, Aflasafe – as they don't have experience of commercialisation, but they have the money and the art of writing reports which private sector can't do perfectly. Ke060
Markets and Prices	Public	• Cases where contractors don't show up so farmers lose confidence in the marketing systems. Zw021 • Very long delays in payment, e.g. by GMB (Grain Marketing Board) so that is a major blow to farmers. Zw051 • A lot of middlemen going out there to off take produce at lower prices. Zw011 • Public markets are less sensitive to quality unless you are talking about crushed produce. Zw031 • Lack of decentralised markets and aggregation centres. Ng022 • Market can be the hindering factor, if no quality-based pricing, then no one will go the extra mile. Ke061 • We have standards that apply for export market - harvest in a certain way etc, but the local market does not demand any quality. But in Kenya less than 5% is exported, we have standards but no one cares about standards. People just want affordable. So no one will buy unless you have a niche market. Ke031
	Other	• Market volatility. Ke027 • Lack of quality sensitive markets. Et056
Cultural beliefs	Public	• There are cultural beliefs. It is difficult to convince famers that loss is not just part of the business. We keep trying to convince them that you can actually grow 100 and get 100% to consumer table, that cultural belief believes that a certain % has to go back to nature. Ng011
	Private	• when you come out to present an innovation to Nigerians, you need to be very, very confident. Ng026
Climate change	Public	• Climate Change. Ng055 • Climate change is also another big obstacle and it is increasing the number of pests and accelerating the rate of deterioration. Et023
	Other	• Effects of global warming and climate change leading to extreme weather patterns and events. Ke077
Security	Public	• Security. Ng035

Factors	Sector	Details
	Private	• Security systems are required to keep investments such as cold stores and solar panels safe, and we have needed to install monitoring systems for cold store conditions but also cameras to prevent misuse of the stores by staff often trying to make extra money by loading too many containers but that then affects the cooling. [Ng026]
	Other	• Security issues mean in some project sites, people (FAO and Ministry guys) can't go and support farmers. Peace building issues, and so they can't get support or inputs, so this is connected. [Et075] • Security. [Et086]
International crises	Public	• General global economic crisis due to Russia Ukraine conflict, creating a huge challenge for exporting and importing items, restrictions that have created a huge problem for Ethiopia. Then recently the conflict in the Red Sea, so selling our products has become a huge challenge, we recently had to export coffee by flight instead of by the Red Sea. [Et093]
Role of data	Public	• Absence of PHL data: Lack of information is a big issue, because we don't have PHL data. Maybe the data is there, but maybe it doesn't speak to policy makers and the stakeholders. [Mw011] • Not sure how or if the Ministry are using the PHL data to inform their decision-making and intervention programmes. [Mw035]
Technology distribution networks	Public	• The distribution network of technology to the end user is another problem. [Ng032]
Other	Public	• Timeliness of harvesting. [Zw021] • Threshers are often imported and without checking their specifications. [Zw061] • Agricultural insurance for any loan in the agri-sector can help vs. PHL but is still very weak in Nigeria currently. [Ng043] • Population drift to urban areas. [Ng035]
	Private	• In Nigeria unlike in Kenya mobile money has not taken off here. [Ng086] • Lack of recognition that FW is happening and lack of the logistics, e.g. an outlet for FW redistribution to enable FW reduction. [Ke023] • Informal sector appears to be thriving at the expense of the formal sector [Ke046]
	Other	• Effectiveness of chemical pesticides has gone down. [Mw024]

6. What Needs to be Done to Support PHL reduction, and How can Investors best Support this?

The key informants' suggestions of **what** they would like to see being done to support PHL reduction to meet their country's needs are described in this section by country and stakeholder group. These suggestions cover a range of different types of interventions which we can group following the categories of technology/tool/equipment, handling practice change, training/extension, support /organisation, finance, market access/support/linkage, supply chains, alliance building, policy, regulations, infrastructure, investment and coordination type, described in Stathers et al., (2020). These interventions can then be categorised by the level they can be applied at, e.g. *micro*, *meso* or *macro* level[22] as discussed by Pedrotti and Verschoor (2022). Table 6.1 illustrates which of the intervention types typically connect with which of levels, although some are applied at multiple levels. The key informants' responses to what they would like to see being done have been synthesised using this framing and discussed and presented by country and stakeholder type in Tables 6.2-6.5.

Information on interesting **PHL reduction ideas or initiatives from other countries** that these informants knew about and which they thought might have potential in their own country was also captured. Finally, we asked them about **how** investors should best support PHL reduction to meet their countries need, and why.

Table 6.1 Types of postharvest interventions applied at *micro*, *meso* and *macro* levels

Micro	Meso	Macro
• **Technology/ tool/ equipment** • **Handling practice change**	• Training/ extension • Support/ organisation/ aggregation • Finance • Market access/ support/ linkages • Supply chains • Alliance building/ multi-stakeholder processes	• Policy • Regulation and standards • Types of focal systems • Infrastructure investment • Coordination

6.1 What key informants think is needed to support PHL reduction

Those we consulted had many suggestions of **what** they would like to see being done to support PHL reduction in their country with some being applied at *micro* (e.g. local fabrication or

[22] The *micro* level looks at individual links in a particular food supply chain, like an intervention that aims at improving the handling of the food product on the farm to reduce food loss. A *meso* level intervention considers the relation between different actors of the supply chain, so no longer a one-on-one relation but larger groups and different stakeholders. For example, the training and education of farmers groups by local extension officers on postharvest practices can be considered a meso-level intervention. Finally, *macro* level interventions focus on FLW as a more systematic issue to enable investments and the adoption of good practices. Interventions to extend the network of paved roads, tax-reduction measures for certain technologies, or the facilitation of extension services with content, material and finance are all examples of macro level interventions which involve governmental bodies, affecting the entire supply chain and/or an entire group of actors. This structure facilitates the logical mapping of causes, solutions, and actors that should be involved, and recognises the cascade effects where dynamics at one level can also affect other levels.

manufacture of small and medium sized drums, hermetic bags, threshing machines), others *meso* (e.g. PH training for extension workers, learning visits between stakeholders and countries, solutions supporting farmers and SMEs in accessing finance to purchase PH equipment), and others *macro* (e.g. VAT exemption for all imported PH technologies, implementation of the NPHMS) levels. The expected application levels are shown in the final three columns of the tables.

Key themes which emerged were the need for:

- **PH capacity building** this was particularly suggested for extension workers and farmers, but also for other VC actors, and policy makers.
- **greater coordination among those working on PHL reduction** to share learning and prevent duplication of efforts.
- **evaluation and sharing of learning on the outcomes of PHL reduction interventions** - including (but not limited to) understanding the return on investment - to inform future work and investments.
- **more participatory research processes** designed and implemented in partnership with farmers and other VC actors.
- **access to finance for SHFs and SMEs** to be able to access PH technologies. The need for de-risking support for private sector players as they invest to develop their supply and distribution networks, and VAT exemption to be extended to all imported PH technologies and their raw materials.

Technology interventions mentioned included the installation of appropriately sized processing plants in rural areas for products such as sunflower oil, and in marketplaces for buying off and processing of overripe tomatoes, solar powered packhouse, mobile packhouses, refrigerator trucks, cold chains, simple affordable labour-saving technologies and hermetic bags. These were particularly mentioned by the public sector respondents. The need for greater local manufacturing of PH equipment with opportunities for reverse engineering were raised. No specific examples of handling practice changes were suggested.

PH training and awareness raising for farmers, extensionists and other stakeholders was mentioned frequently across the countries and by public, private and other sector stakeholders. The need for training in PH systems thinking was flagged by the public sector in Ethiopia. The need to strengthen farmer associations and cooperatives so they could play a greater role in PH information sharing, and the need for aggregation and logistics to help farmers reach economies of scale and further scaling to support their access to PH equipment was voiced.

The need for financial access at affordable interest rates for SHFs and for SMEs to enable them to buy PH technologies was stated by public sector in Nigeria and Ethiopia and had been discussed elsewhere by Kenyan private sector stakeholders. The private sector stakeholders were keen to see VAT exemption expanded to cover all PH technologies, and for early-stage de-risking financing to support market and supply chain development for private sector companies. The AgResults on-farm grain storage pilot was mentioned as a project with opportunity for replication in other countries to help incentivise private sector investment as had occurred in Kenya. No specific mention of market access or linkage interventions was made, although the need for Government enforcement of produce quality aspects of market linkage was. The desire to develop and work in alliances was raised by public, private and other stakeholders, with particular emphasis given to recognising and supporting the role of the private sector in PHL reduction.

Macro level interventions mentioned included implementation of the NPHMS, and recognition of it by high level government members (e.g. Prime Minister), harmonisation of standards across regions to facilitate trade, removal of VAT on PH agricultural imported inputs, infrastructure investments such as roads, market facilities and food reserves, the greater enforcement of pesticide regulations particularly for safe use of fumigants. The need for coordination between PH stakeholders to ensure they each knew what the other was doing and shared learning was mentioned by public sector stakeholders. Only from Zimbabwe was there mention of the need for increased support for small grains.

Table 6.2 What key informants would like to be done to support PHL reduction in Kenya

What stakeholders want to see being done to support PHL reduction to meet their country's needs	Level		
	Micro	Meso	Macro
Public sector actors' perspectives			
Evaluation of and **sharing on the outcomes** of existing PHL interventions		X	
Coordination of PHL reduction activities within the country		X	X
Participatory adaptive research and investment in innovations		X	
Implementation of the national PH management strategy (NPHMS)			X
Standards being harmonised within the EAC, to simplify trade			X
App-based data collection to support data access and use at all levels		X	
Awareness raising about **individual food waste behaviours and changes needed**	X		
Private sector actors' perspectives			
Greater **analysis** of the causes and options for addressing **gluts** and losses		X	
An environment where **farmers can access training** programmes		X	
Donors supporting the building up of **farmers' cooperatives**		X	
Aggregation of farming enterprises to reach **economies of scale** to support investments in PH equipment		X	
Shared **learning visits** between countries and stakeholders		X	
Solutions supporting farmers & SMEs in **accessing finance to purchase PH equipment**		X	
Forward contracts to support production for what the market wants		X	
Regulation that enables and does not disable **trade and safe food** provision			X
More policies and regulations that **incentivise structured trade**			X
Harmonisation of grain PH approaches, practices, standards and laws		X	
Private sector managing some of the **huge cooling infrastructure** that was set up by a donor then abandoned due to not being maintained - this will reduce losses	X	X	
Taxes kept lower to allow **freedom of movement of produce** to ease farmers lives			X
Truck for organisations redistributing food e.g. Food Banking Kenya for moving food	X		
Adoption of guidelines for food redistribution encouraging retailers to donate surplus food - with good Samaritan laws, *e.g. as I hand over this food in good condition the liability moves to you to store it safely, so it does no harm to the end user*		X	
Retailers **using their data to support food waste reduction**	X		
Increased **consumer acceptance of discounted food items** and labelling	X		
Other sectors actors' perspectives			
Creation of stronger VC, whether storage or aggregation as we have seen a lot of success when it comes to aggregation in terms of helping to reduce PHLs		X	
Sorting the **legislative framework** around food loss and waste redistribution.			X
Development of the **infrastructure**			X

Table 6.3 What key informants would like to be done to support PHL reduction in Nigeria

What stakeholders want to see being done to support PHL reduction to meet their country's needs	Level		
	Micro	Meso	Macro
Public sector actors' perspectives			
Capacity building in PH management, and this should be of **actors all along the VC** not just farmers, as transporters also need to handle produce carefully	X	X	X
Shared learning PH study tours – e.g. to Vietnam, India, Thailand and Brazil		X	
Ensure **end users are involved** in design of PHL reduction interventions		X	
Greater coordination between researchers and other stakeholders to enhance learning and progress		X	
Farmer associations and cooperatives playing key role in PH information sharing		X	
Improved **processes for PH knowledge sharing across Africa** – perhaps through the AU, AATF, AFAAS, or FARA			X
Affordable simple labour-saving technologies made available to support uptake	X		
Focus on equipment for small and medium-sized enterprises, e.g. small/ medium silos, hermetic drums and bags, not 500,000t silos that will never be >60% full	X		
Support **local production** and awareness raising **of equipment, if fabricators and researchers collaborate** we can reduce the importing of it	X	X	
Reverse engineering to **copy and locally fabricate effective technologies at an appropriate scale for commercial farmers, and SHFs** (e.g. driers, onion stores)	X		
Investment in the cold chain can reduce a lot of PHLs	X	X	
Support **alternative energy** solutions to enable machines to be run on solar energy	X		
Train women, youth and men farmers in their use of technologies which can reduce PHLs without large cost implications, and cascade this to trainee agricultural extensionists so they can then work with farmers on them		X	
Show **how expenditure can be recovered** and profit made by investing in PHL reduction	X	X	
Access to funds for PH innovation facilitated at a **highly reduced interest rate**		X	
Other sectors actors' perspectives			
PHL reduction **training and awareness creation all over the country**, not just in a small pilot space. It is already in secondary school curriculums, but delivery may vary		X	
A **PH alliance** so we know what every team, intervention and donor is doing across the country. So we work together and do not keep doing scattered interventions and reinventing the wheel. New donors and actors could then join the alliance to learn, 'what have you done in terms of this aspect of PHL, where did you get to, let's continue from here'. We were developing this before the Director at Ministry of Agriculture retired		X	X
Scaling, so PHL reducing interventions (e.g. use of returnable plastic crates during tomato truck transporting reduced PHLs from 40% to 10%) can be scaled to all parts of the country		X	

Table 6.4 What key informants would like to be done to support PHL reduction in Ethiopia

What stakeholders want to see being done to support PHL reduction to meet their country's needs	Level		
	Micro	Meso	Macro
Public sector perspectives			
Training on **PH systems thinking**, as the system is not working from the bottom up		X	
Capacity building at different levels so that PH interventions happen in synchrony		X	
Strengthening of our innovation and research system so they can **generate and adapt affordable PH technologies**, and we do **not just import technologies**		X	
PH **infrastructure** and **the technologies**	X		X
Systems for **financial access for SHFs,** so they can buy affordable technologies		X	
Solar powered packhouses, mobile packhouses, refrigerated trucks	X	X	
Cold chain systems powered by **renewable energy** being introduced to Ethiopia, we are already collaborating to achieve this		X	
Work on **logistics** as it is so important for cold rooms and aggregation centres		*X*	
More attention being given to **storage and threshing**	X		
Warehouse services and huge national grain and feed **reserves** as we do not have them		X	X
National **coordination systems** for PH aspects across grains, horticulture and livestock			X
Private sector perspectives			
Early-stage de-risking to support market and supply chain development for private sector companies - development cooperation to share product development risks is key		X	
Participatory action research, currently the research is too theoretical		X	
Creating **positive platforms** between development partners, public and private sector to explore what can help		X	
Digital information platforms to share understanding and track progress and outcomes		X	
Other perspectives			
Further **awareness raising** of stakeholders of the **PHL happening in Ethiopia**		X	
Improve market facilities and infrastructure, e.g. roads		X	X
Support Government on **enforcement mechanisms for market-linkage** to support quality			X
Help Government **recognise the role private sector could play** in minimising PHLs		X	
PHL reduction policy being **recognised by high levels in Government**, e.g. Prime Minister			X

Table 6.5 What key informants would like to be done to support PHL reduction in Malawi

What stakeholders want to see being done to support PHL reduction to meet their country's needs	Level		
	Micro	Meso	Macro
Public sector perspectives			
Firstly, **recognition that PHLs as well as low production is a problem**		X	X
Better **understanding of how the existing PHL interventions are and are not working**, and **why**, and what neighbouring countries are doing to address PHLs		X	
Strengthening of the **capacity of our extension system on understanding PH issues**		X	
Investment in PHL reduction in fruits and vegetables as little has been done on that in Malawi and we lose a lot, e.g. could test cold storage or processing of them	X		
Farmers could **test the very big hermetic bags** as well	X		
Target loss reduction training and activities at grain harvesting and storage stages, where data shows most grain losses are happening		X	
Reduction of taxes on imported PH technologies			X
Greater **enforcement of pesticide regulations**, e.g. fumigant use only by qualified personnel		*X*	*X*
Private sector perspectives			
Awareness raising on PHLs and interventions by NGOs and Government		X	
VAT exemption for all imported PH technologies			X
Other sectors perspectives			
Strengthen the extension service starting with the tertiary education curriculum which should include PH management, **as PH capacity is low in government** which means it does not get addressed during farmer training		X	
Private companies buying from farmers **also need to invest in knowledge transfer** to improve the quality of their raw materials, the farmers and the companies would benefit		X	
Greater **awareness of importance of monitoring crop moisture** at SHF level during grain drying and storage, this could drive investment in equipment by buying companies		X	
Greater **monitoring and enforcement of standards by regulators** as this would drive greater attention to produce quality through the system			X

6.2 PHL reduction ideas or initiatives from other countries

Those consulted listed a range of PHL reduction **initiatives from other countries** which they thought might have potential in their own country. These included impressive grading practices, well-structured and functioning aggregation and regulation processes, centres that sold PH equipment, market-located pay-as-you-store cold stores, a market-located processing plant that buys offs and processes overripe tomatoes, the ACELI Africa project which is incentivising lending to SMEs. A description of these is given in Table 6.6.

Table 6.6 Interesting PHL reduction initiatives key informants knew about from elsewhere

Country	Public sector	Private sector	Other sector
Kenya	ColdHubs market-located cold stores [Nigeria] Kenyan hermetic bag standards adopted across EAC 'Doggy bag' culture for taking home meal leftovers	Government investment in potato cool stores which can then be used as collateral [India]	-
Nigeria	Good farmer capacity building & voice [Kenya] A centre that sells PH tools [Kenya] Well-structured & functioning aggregation and regulation leading to export of yam [Ghana] Good agricultural extension system [Ethiopia] Good PH equipment [Thailand, Vietnam] Export fish smoking [Thailand], mushroom [Vietnam] Small-scale mobile harvesters [China] Pre-cooling systems [Ethiopia] Ventilated onion structures [Ethiopia/online] Mobile grain stores [online]	-	Mechanisation – e.g. harvesters [YouTube]
Ethiopia	Dairy handling and distribution [Kenya] Fruit handling [Uganda] PH incubation centres for professionals [Tanzania, Uganda, Kenya] Cold chains that reduce PHLs [Kenya, Nigeria] Strong regulation systems [Kenya] *Further study would be needed to see if these interventions would work in Ethiopia*	-	Tax exemption for PH machinery [Uganda] *(*now happening in Ethiopia too)* ACELI Africa project incentivising bank lending to agricultural SMEs, with additional incentives is supporting more vulnerable people [Kenya, Rwanda, Tanzania, Uganda]
Malawi	APHLIS for loss estimates data and information [online]	-	Serious grading and grade associated pricing [Kenya] Packing groundnut in jute bags to support airflow [Rwanda]
Zimbabwe	Processing plant in market which buys off overripe tomatoes [Zambia]	-	-

6.3 How investors should support PHL reduction

When it came to **how** investors (public or private) should best support PHL reduction to meet their country's needs a wide range of opportunities were suggested. These highlighted the importance of getting stakeholder buy in and engagement in any prioritisation decisions, the need for public-private partnerships from the start, grant financing for private sector companies to be able to afford to investment in the development of their supply and distribution networks. Two results-based financing initiatives were suggested as interesting models of how the investment might be done, 1) the AgResults on-farm grain storage initiative but with an expanded definition of PHLs to include food safety and a focus on a different country, and 2) the ACELI Africa project which incentivises finance institutions to lend to agricultural SMEs, and something similar could specifically look at incentivising lending to PH SMEs. Table 6.7 summarises the different key informants' suggestions by country and sector on how investors should support PHL reduction.

"It is very risky to experiment with money from the banks, because they will surely come for you, and even before they give you the money they've already asked for the details of all your ancestors, but public money has a lower entry barrier. [Ke028]

"... last time, we asked [the bank] to come and try running a cold store for a week and see whether they could pay 35% interest rates. [Ng036]

Table 6.7 How investors (public or private) should best support PHL reduction to meet their country's needs

Country	Public sector informants' perspectives	Private sector informants' perspectives	Other sector informants' perspectives
Kenya	Study drivers of loss in specific VCs to enable targeting of loss reduction Get stakeholders decisions on priorities Beware of 'white elephant' investments e.g. cold storge for farmers without market linkage PPPs, private have technology and public can facilitate adoption	Public money can support pilots and testing of infrastructure that has PHL reduction promise Provide guarantees for private companies that need debt financing or co-funding Organise learning and development forums to discuss challenges and form partnerships Invest in circular economy As in the SUED project look at investment viable product and provide seed funding grants to get them to scale up PHL solutions Use an approach similar to AgResults on-farm grain storage pilot but with a broader definition of PHLs to include food safety Do not support NGOs to play private sector roles	Use a results-based mechanism to incentivise markets to address development issues
Nigeria	Prioritise strengthening the private sector in any intervention PPPs and tripartite arrangements (tech provide, private sector, finance provider) R&D fund for national agencies to develop PH solutions	Extend grant financing to companies as sector is very young and many technologies not market-ready enough to attract equity Support medium/large ticket financing to get existing entities	Ensure the right stakeholders are on board and channel investment to VC actors Use a VC approach as some VCs have higher losses

Country	Public sector informants' perspectives	Private sector informants' perspectives	Other sector informants' perspectives
		to come to scale after that they can borrow commercially. Bank interest rates are 35% currently.	
Ethiopia	Involve key stakeholders along the VC Recognise importance of access to finance for VC actors Locally fabricating affordable equipment Quality sensitive aggregators – grading, washing, packaging and transporting in refrigerated trucks Value addition of perishable produce		As in the ACELI Africa project incentivise lending to PH SMEs Understand importance of addressing financial access issues for PH Invest in dependable long-lasting quality PH machines (e.g. German combine harvesters) Use multi-stakeholder processes Build linkage with private sector from start Do not let NGOs replace private sector roles Involve CSOs to support community involvement Recognise the restrictions of large organisations' systems
Malawi	Focus investment on public, private and NGO sectors not just public sector Development partners can show government PHL reduction is important, then government will follow Recognise multi-sectoral nature of PHL, e.g. transport, health, agriculture PPPs into viability of cold storage or processing of fruit Encourage private sector investment through mega farmers or outgrower aggregations Ensure resources for regular loss assessment, particularly more objective measurement of actual losses	Invest to grow distribution networks – linkage to more input stockists	Public investment can improve PH policies to create an inducive environment for PHL reduction Government should avoid intervening in commodity prices, which can scare private sector investment
Zimbabwe	Entry point will depend on if targeting hardware, software or institutions Start with consultative analysis of what government wants, and what private sector can do, and what other players can bring in Get stakeholder buy-in at start, and engage people in prioritisation of the challenges Look at - which VC, where geographically, how does it influence which communities, infrastructure issues Make the interventions visible		

7. Knowledge Gaps and Opportunities for Enhancing Learning

7.1 What are the important knowledge gaps for PHL reduction that still exist?

Public, private and other sector actors were asked to identify important knowledge gaps for PHL reduction. Their responses are provided in Table 7.1 organized by theme and stakeholder group and where identified the actors associated with a knowledge gap are shown. An overview of these range of knowledge gaps identified by actors from the different sectors is shown below.

Public sector actors' perspectives included:

- Improving PHL awareness, understanding of its importance and knowledge of options for management by farmers
- Improving farmers' access to information such as weather services and commodity prices
- Understanding farmers' perceptions and reasons for their decisions around uptake of interventions by actors providing services or promoting technology and knowledge to farmers
- Assessment of the viability of PHL reduction interventions for particular value chains/ systems for various actors
- Developing holistic approaches to PHL management for various actors
- Crop drying, including solar drying technologies, for farmers and other actors.
- Crop PHL data to inform decisions by a range of actors
- Food safety and safe pesticide handling for various actors
- PH equipment and infrastructure assessment
- Policy processes – are policies appropriate, are they being implemented and what are the outcomes for policy makers and other stakeholders
- Funding aspects
- Gender and other social dimensions of PHLs

Private sector actors' perspectives included:

- Postharvest loss data to inform companies investment decisions
- Understanding the causes of PHL within the context of the wider food system
- Skills for solar refrigeration for technicians and engineers
- Understanding food waste and re-cycling particularly for urban dwellers
- Localized protocols for PH management for particular contexts, VCs and systems
- Provision of access to PHL reduction finance – for both financial providers and users.

Other sectors actors' perspectives included:

- Postharvest loss data to inform decision makers
- Pesticide safety for farmers
- Recycling knowledge for hermetic bag providers and users
- Appropriate PHL learning methods to reach rural poor

Table 7.1 What are the important KNOWLEDGE GAPS for PHL reduction that still exist?

Theme	Sector	Details of important KNOWLEDGE GAPS that exist	Actors *(if identified)*
PHL handling practices	Public	• People should know how to handle their produce, but we still have to tell them how to identify maturity indices. There are practices that can be better done. Ng071	Actors handling produce
	Public	• Good agricultural practices after harvest Ng033	Farmers
	Public	• New innovations that can attack PHL at farm gate level Ng005	
	Other	• In our work with smallholder farmers, we have identified a need for capacity building on proper farming techniques and best practices that not only increase yield but also reduce PHL and FLW. This includes education/training/capacity building on pesticide use, preservation, and storage. Ke027	Smallholder farmers
Possibilities to reduce losses and how they can do that	Public	• Farmers need to know that there are possibilities to reduce the losses and how they can do that. Mw013	Farmers
	Private	• Awareness is not there, people don't understand the value of the product Mw042	Farmers
Understanding the importance of PHL management	Public	• In general terms there is need for farmers to understand why PHL management is important and how they can do it depending on the VC they are dealing with, and different categories of farmers may need different capacities. But generally, there is a need for farmers to understand, why PHL management is important and how they can do it. How they can handle produce so that we reduce the loss. Mw053	Farmers
Appropriateness of PH technologies	Public	• Even the technologies, are we having the appropriate technologies and how best can we adapt the technologies to suit? Mw031	Various
Commodity prices	Public	• Middlemen go to rural areas and buy at very low price, so if the farmers can get real time commodity prices, they can then tell the traders what price they want. Ng055	Farmers
Uptake of knowledge and practices	Public	• Why uptake of PH technologies and knowledge is limited? Ng061 • Adoption of PH technology is a big gap Ng022 • Understanding farmer adoption better, so that the effective technologies we have can reach farmers Ke072 • What is preventing the use of these PH technologies Mw031 • What is preventing the penetration and the information flow? Mw021 • Where are we getting it wrong? E.g. for this case (hermetic bags) we have not even moved, from the past initiatives the Palladium Initiative, why did it not proceed the way it should have? Mw081	Actors promoting tech and knowledge
Farmers' perspectives on PHL management	Public	• Why are farmers not caring? Mw051	Various
Economic viability of interventions	Public	• Viability, stability, economic viability of some of these PH interventions. Ng022 • Willingness-to-pay for any of the adoptable technologies. Ng042	Various
Weather information	Public	• Weather reports could be very important so they don't lose their crop. Ng035	Farmers
Pre-processing and adding value	Public	• Need to encourage farmers to pre-process their products, and add small value e.g. tomatoes to puree. Ng045	Farmers
Crop drying	Public	• Drying is a big issue, but the management is quite tricky. The driers themselves – maybe you can bring in solar driers and all that, but there are large quantities to dry. Some semi-commercial farmers – tricky to dry large quantities, sources of energy become an issue, and mobility of the dryer as many people need to be accessing the same equipment and expertise when the drier is not functioning well, but you cannot afford a sedentary drier. Because of the huge investment in it, and drying only occurs during a very short period of time. So the down time is quite long unless you provide the service to other people. So you	Various

Theme	Sector	Details of important KNOWLEDGE GAPS that exist	Actors *(if identified)*
		want mobile driers and you can use these driers for many other types of crops e.g. chilli and sweetpotato, apart from the usual grains. Zw061	
Solar drying technologies	Public	• There are different solar drying technologies for different products so options to share experience through different partnerships. Et031	Solar drier actors
Post Harvest Loss data	Public	• Scale of losses occurring: If we would have a big project on updated loss assessment of all crops in the country that would help to inform the region so when we share that information that would help us improve. We have the common market. So I think when we share that information, it will help us improve on areas where we are very weak. Ke052	Actors in the region
	Public	• There are also data gaps in terms of PHL occurring, that is our song, the fact we don't have data to even make our case for anybody. Ke061 • We need to address that so when we talk about the impacts of loss on the nutrition or environment we can work back with data and not estimates. So, I was telling the Food Bank we need figures on FLW. Can we really have figures for Kenya, that would really change the narrative – having our own narratives. Asking the Food bank – how much food is now being used to feed hungry people. So, we can have concrete evidence and targeted interventions. Ke031	Actors to whom a case is made to address PHL
	Private	• There's also a knowledge gap on knowing the right volume of PHLs. You know, just this week I started reading the state of food insecurity. I think we need to have the state of PHL too. It will help companies like ours to point us to where we are supposed to make our financial investments. You know, it will help to point us to where we should think about building new business. I think there is a huge knowledge gap in countries on the volume of PHLs and there should be annual reports by University or Research Institutes that look at that volume and really identify that this is the level of PHL and publish 'State of PHLs in Nigeria 2024'. Ng036	Companies to guide their investments
	Other	• The biggest knowledge gap exists in the availability of data (or lack thereof). While stakeholders involved in PHL and FLW reduction/management have internal data from their respective fields, there is significant information asymmetry. For example, although there are ballpark figures for FLW in Kenya, these estimates are not accurate and are based on the limited data available to the public. Ke027	Various actors
Demand for PHL data to be collected	Public	• Maybe to have these surveys done regularly as that is lacking in Malawi. In Malawi, we plan to do it every 2 or 3 years but sometimes we miss because there is no funding. Mw055 • But also good to have some demand for the data. We get it and they use it currently. But I have never felt the demand from the management that we need the PHL data, it is just my own initiative and then they use it. I would like to feel it is being demanded a bit more. But they do use it when I produce it. Mw045	Actors producing data and decision makers
Gender perspectives on PHL issues	Public	• Aspects such as the gendered perspectives, it's not something we have thought about, but it would be nice to know how the different demographics or genders are affected and how they can affect if we build their capacity for example. Ke011	
What is and has been done on PHL	Public	• Finding out what has been done on PHL in the country and coordinating and sharing the results from that Ke014	Actors with an interest in PHL
	Private	• Coordination between different development actors is weak, so they don't know what each other are doing and so resources are not efficiently used as result, better coordination is needed Ke061	Development actors
Interventions applicable for farmer's VC	Public	• Farmers should understand what intervention is applicable for his or her VC and how to ensure that integrates with what they have, as knowledge of the intervention can come with some challenges. For example, farmer is not doing the right thing and is trying to incorporate their system, then along the way, if they miss out the whole process, so you'll find knowing the right thing at the right time becomes important. Ke034	Farmers

Theme	Sector	Details of important KNOWLEDGE GAPS that exist	Actors *(if identified)*
Crop variety susceptibility to PHL	Public	• Varietal selection, in Kenya we have many varieties and some are more susceptible to PHL, in case good agricultural practices were not applied, then at the end of the day you will send problem from your farm to your stores. Ke064	Various actors
PH pests and diseases	Private	• Understanding of various pests and how they operate in conditions that accelerate them. Very poor level of understanding of the various solutions and variable understanding among people. I would say that the knowledge gaps are massive and that's one of the biggest intervention areas. E.g. aflatoxins you can't see or smell them. Ke036	Farmers and other actors
Holistic approach to PHL management	Public	• It is a holistic change, not just specific. Ke064 • We want to reduce on the chemical so the chemical advisory services must come into play, that's like when you are using Aflasafe, at what stage are you using the Aflasafe, so that it gives you the best when you are using hermetic bags and at what mc you should you store your produce when you are taking your crop to the solar drier, and then on the other side of the machine how are you supposed to ensure that you monitor your maize so that you don't over dry it? Ke074	Various actors
Policies and policy instruments	Public	• Are the policies and policy instruments in place? Where are the gaps? Why are we not caring about this? Mw021	
Funding	Public	• Are we having enough funding towards this? Mw011	Various
PH infrastructure	Public	• The assessment of the PH infrastructure in the country, all these are learning opportunities. Mw031 • Learning from the warehouse investments and what is and isn't working in them so that you don't repeat anything that isn't working and keep on improving always. Mw053	Various
Food safety	Public	• Food safety in terms of mycotoxins is not yet fully understood as these are invisible. Zw021	Various
	Private	• Is there sufficient understanding of safety aspects of disintegrating aflatoxins with ozonation? Or the costs of transporting grain to and from a disinfestation plant? Ke040	Various actors
Safety in terms of pesticides	Public	• Safety in terms of pesticides, cos people go and buy tomatoes, and no one worries about pesticide residue analysis only if exporting do the pesticide residue issues become critical, but for local markets there is no incentive. This is why it is difficult for organic farming to take off, because there is no immediate evidence of impact between the two products, pesticide treated and other. People look at the aesthetic appearance and avoid the blemished ones. So safety is a big gap. Zw051	Various
	Other	• In terms of how to handle chemical insecticides and application, or the way farmers mix the pesticides 40g of Actellic plus/ 50kg bag and farmers may not be able to measure those quantities. Some packets have certain containers, but they are not that effective. Increasing farmers' understanding of the dangers of these chemicals so that they can easily understand the impact on the food chain. Mw074	Farmers
PH equipment repair and maintenance	Public	• The other big gap is technicians who can maintain these machines, out there when they break down, and to service this equipment. Some of the equipment is imported and used and made to work till it just breaks down and we don't have strong enough cadres of technicians with these capacities Zw041	Technicians
Urban food security and PH systems	Public	• At some point we wanted to explore that; how is urban food security supported by PH systems and the movement between the rural and the urban? Zw021	Various
Skills for solar refrigeration technology that are needed to drive the cold chain	Private	• Solar cooling is a very new technology no one has really studied it before, last time we checked no university has an offering in solar cooling as a discipline, so we have been able to identify most of our solar technicians, either they are solar electricians and then we build in refrigeration on them, or refrigeration technicians and then we build in solar technology on them. So, lots of knowledge gap around the skills for solar refrigeration tech that are needed to drive the cold chain. Ng066	Technicians and engineers working on solar refrigeration

Theme	Sector	Details of important KNOWLEDGE GAPS that exist	Actors *(if identified)*
		• A lot of work to be done to usher in the right refrigeration technicians. What we have now is nothing that can drive the cold chain sector, we need expertise, a lot of expertise, we need really qualified people who have ideas around industrial cooling to solve large scale cooling centres that use industrial scale condensing unit**s**. What we have is technicians who are specialized in repairing fridges. That's not what we need. [Ng036]	
Understanding what is waste; what is surplus	Private	• How to deal with it, when it is just a surplus and not waste? I am also working very hard at not calling it waste, when it can't be sold I don't want to call it waste as people will ask why are you giving me waste so I want to call it surplus. [Ke023] • Understanding what is waste is a gap, and how to deal with the surplus and the real waste as I guess we can't have 0% waste. [Ke053] • Here the easy answer is always pig feeding, or BSF but that knowledge is not out with everyone. [Ke043] • Waste is more an issue in urban areas than in non-urban areas, even out of Nairobi you notice there is less garbage thrown through the window and less littering. Cos in rural what is not eaten is fed to the animals, so you automatically reduce that. In rural there is more separation of waste, e.g. paper for lighting fire, containers for re use happens. So, this menace of waste is more of an urban than rural problem, as in an urban area I don't have a cow or a goat and don't light fires in my electric kitchen. [Ke063]	Urban dwellers
Recycling knowledge	Private	• Education on segregation so that whoever is collecting plastic is can get clean plastics for recycling. [Ke073]	General population
	Other	• From an environmental perspective, hermetic bags contain plastics and in other countries I think those plastics are recycled. In Malawi, we have been silent on that. This is something we need to look into seriously as that can be a very serious environmental pollution if we do nothing about those plastics. [Mw024]	Hermetic bag users
Understanding the different causes of and types of PHL within the context of wider food system	Private	• Understanding the various commodities and the grains and what leads to the PHL. It is a very big gap even some regulators said they don't understand why maize and not maize flour should be exported out of their country. So they don't have an understanding of what is maize they were shocked to learn that the tablets they take is starch. It comes from maize and flour milling has various level of extraction from whole grain to 75% extraction and left with something so fine and then like glucose so if you eat that you have a spike of sugar in your food that almost knocks you down. And the food that has no nutrition apart from carbohydrates you've extracted and removed. [Ke016]	Various actors
Localised protocols for PH management	Private	• In potato, we often don't find localised protocols for PH management that take into consideration our varieties, the temperature and settings of our harvest. Some of the supply chains here use recycled seeds that behave very differently from proper seeds in terms of the PH management. Developing protocols specific to our circumstances is one of the knowledge gaps, so for farmers to find low-cost solutions where they are experiencing modern infrastructure, still some gaps in how to do this and maintain food safety standards. [Ke078] • Financial institutions and people for whom PHL should be one of their key concerns how do they support bigger farmers or people trying to sort this issue. PHL is one of the biggest causes of indebtedness of SHFs, because you borrow for inputs it but then you are hoping to pay with your harvest, and if you lose half your harvest you can't pay. If there was a PH solution for these groups, it could help them to honour the financial obligations that they get into. [Ke028]	Farmers
Provision of and access to finance	Private	• One of the key agricultural financing gaps is still finance access for people who might want a loan of less than USD100K. I think it is a bank capacity problem, as the banks look at processing cost of a USD100K loan and a USD1,000 loan it takes the same amount of time, so it is a volume game for them, and clearly less risk at the higher end, and	Financial providers and users

Theme	Sector	Details of important KNOWLEDGE GAPS that exist	Actors *(if identified)*
		probably higher risk at the lower end. But Coop bank has been good at getting farmers into groups, so they can sort of subcontract the lending mechanism, so give them the 1.5millionKsh and then Coop society divvies out the 100,000Ksh on its own. So, learning how to aggregate finance is also a way forward. [Ke069] • The Banks also need to understand the returns required when you buy some of this equipment, e.g. What return on investment (ROI) when you buy a cold storage unit, so their lending programmes sort of match the ROI on some of these equipment. I don't think they understand the ROI and how long it takes to get your money back and not just applying a generic sort of return to it by saying we are going to classify it like any other asset class we give you a maximum of 3 years. So cold storage, 3 years, but actually it could take longer to get a return. [Ke029] • Investments that would benefit grain trade in Kenya. They are already doing it for maize, they could do it for other crops e.g. onions. Some of the biggest maize producers in Kenya have moved to Uganda and are now supplying us maize in Kenya, in 5-6 years I think we will import all our maize which is why we need to move to other crops like potato. [Ke059] • Onion does not attract financing, which is surprising, I think it is due to a lack of understanding of the seasonality of the produce. And then we don't produce enough. Big demand for onion lots of trucks come in at harvest so rapidly off taken and very little PHL. [Ke029]	
PHL and the environment	Private	• Reintroduce environment as a teachable subject in school. [Ke043]	Teachers & School children
Appropriate PHL learning methods	Other	• Most agricultural activities carried out by rural people and they lack education, so one challenge we faced when we carried out our campaigns, is on the level of their education and that affects their understanding. So, on technology you have to keep explaining, so that is one gap. Language is not a barrier as we bring people who speak the vernacular but their understanding is. [Ng067]	Actors working with rural poor
PHL information to inform policy	Other	• Without clear policy frameworks for managing PHL and FLW, there is little incentive for stakeholders to participate due to the lack of cohesive data, coordination, or compliance requirements, leading to minimal investment in this area. That being said, the development of the NPHM strategy, together with the ongoing development of the Food Redistribution Guidelines for food waste reduction at the retail level, are steps in the right direction. [Ke077]	Policy makers

7.2 How could PHL reduction learning opportunities be enhanced?

Stakeholders were asked how PHL reduction learning opportunities could be enhanced (see Table 7.2 for details).

Public sector actors' suggestions included:

- Supporting farmer learning through their organizations (e.g. Farmer associations, Farmer Field Schools)
- Supporting other actors learning through their organizations (e.g. Retail Traders Association of Kenya)
- Strengthening public agricultural extension services
- Online / virtual learning
- Traditional media
- Collaboration, partnerships, sharing and synergy between actors within and between different countries or regions
    - Multi-stakeholder FLW/ PH learning platforms
    - Learning with decision makers
    - Conferences and meetings
- Formal training
    - PHM training programmes for technical vocational education centres
    - FLW taught in schools
    - FLW and PH in higher education
    - Continued professional learning and tailor-made courses for different practitioners/actors
- Learning programme considerations: Coordinating body for each PHL topic; Resources to support learning; Coordinated learning programmes of sufficient duration; Capacity needs assessment to prioritise learning; Specific tools e.g. PHL/ FLW Training guides

Private sector actors' suggestions included:

- Supporting other actors learning through their organizations - often the VCs have associations which are good places/ways to bring everyone together, e.g. in Kenya the avocado VC will organise a seminar on cooling in which companies providing cooling and other solutions can participate
- Online / virtual learning. For example, "Portals such as Research Gate have many published articles, information from them can be used to conduct pilots to see if we can get something that works".[Ke048]
- Traditional media, e.g. in Kenya, Government officials and all kinds of media should talk about waste – if there was a budget a running conversation or advert could be made to reach a lot of people
- Collaboration, partnerships, sharing and synergy between actors within and between different countries or regions. "For example, in Nigeria, several of our actors could also look at what the industrialised West are doing, not necessarily to copy, but to see what works and then refine a couple of 'what works there' to suit our environment" [Ng076]. "Actors should organise study trips, professional exchange visitor programmes would be very useful for us to interact with colleagues from the other side and then learn, exchange, refine in our own local context." [Ng036] "A PHL professionals exchange physical

programme would be useful. Also, lesson learning within the continent and others in the Global South."[Ng022]

- Private sector working with researchers to do assessment and analysis of their rich data and come up with learning modules that can be used.
- Consumer learning

Other sectors actors' suggestions included:

- Supporting farmer learning through their organizations -Farmer Field Schools (FFS) - the FFS is based on the adult learning principal. In addition, the visualisation methods, e.g. posters, charts are really very helpful. Also the field day activities and exchange visits
- Supporting other actors learning through their organizations
- Strengthening public agricultural extension services e.g. Malawi Extension curriculum on PH management; the Agricultural Development Programme in Nigeria. In Ethiopian woredas there are development agents for animal science, crops, and natural resources but no mechanisation experts. These people need to be hired by some organisations and get secure jobs. This issue has got some level of acceptance and Government started to send middle level experts. But this needs to be continued.
- Traditional media e.g. in Ethiopia Radio and TV is good for disseminating to the public
- Collaboration, partnerships, sharing and synergy between actors within and between different countries or regions
- PHM training programmes for technical vocational education centres, e.g. in Ethiopia through crafting curriculum in learning institutes, especially providing training from technicians up to higher level is very important. We have to come down from the University to the middle level education at college level, so that people really understand PHL reduction in the teaching institutes, may need supporting with some kind of curriculum.
- Targeted learning events e.g. in Ethiopia we have postharvest week, before the harvest we have tried to organise an event, a brief discussion and then take the extension workers and farmers to an area where there is some experience to be shared. The metal silo fabricators are there and usually by the end of the week the farmers are interested in making a down payment on the metal silo, so good linkage between artisans and SHFs.
- Resources to support learning. In Kenya, the project expanding into those countries, is driven by the funders, e.g. GAC, BMGF etc. So as a strategy in terms of rolling out a project in the region, one of the things is to lobby the funders by showing them that these are the results of what has happened in a particular country setting.
- Consider the role of the private sector and the market in learning.

Table 7.2 How could PHL reduction LEARNING OPPORTUNITIES be enhanced?

Theme	Sector	Details of how PHL reduction LEARNING OPPORTUNITIES could be enhanced
Supporting farmer learning through their organizations -Farmer associations	Public	• Generally, for the **VC actors learning needs to be improved**. The good thing is most of them are already organised and belong to associations. We still have the extension officer/agent to link across to the group to get them properly trained. Because of associations we don't need to approach them individually, and the associations function OK. [Ng031] • Through **strengthening the farmers' association**. In Ethiopia, there are farmer training centres that can finance training on agricultural technology training. [Et041] • It is not straight forward, it is not easy. Usually what I have seen working is if there are existing initiatives within communities. For example, **Farmer Field Schools are a strong entry point** where technologies are tested and they kick out what they don't want and they can demand for services from extension staff. [Zw051] • Also, where the lead farmer system exists, each lead farmer is in charge of 10-15 famers, **demos are set up** with the lead farmer and then they go and practice. [Zw061]
	Other	• **Farmer Field School approach** is based on the adult learning principle. In addition, the visualisation methods, e.g. posters, charts are really very helpful. As are the field day activities and exchange visits. [Et066]
Supporting other actors learning through their organizations	Public	• For example, the Retail Traders Association of Kenya wanted to develop something on food recycling. [Ke014]
	Private	• Often the VC has an **association** so that is a best place to bring everyone together, e.g. avocado VC will organise a seminar on cooling in which companies that are providing cooling and other solutions participate, sometimes a county government has an interest in reducing PHL and they organise forums to bring stakeholders together to help advise their farmers e.g. cooling as a service. [Ke038]
Strengthening public agricultural extension services	Public	• Agricultural extension in Nigeria and their ability to extend PH information and their own PH training. Nigeria's extension community is very sad. They have effective and functional human capital, they are employed, and each state has a solid network to reach to the grassroot. BUT the only problem is **they are not funded for mobility**, so once they give you the small fraction of salary anyway to survive they do not care. The little they give cannot buy petrol for the officers. We demonstrated in C:AVA project when we met the ADPs we asked for the truth and they said we had to provide mobility and then we will deliver, and when we did they did deliver for 14 years. [Ng022] • Some state governors are deviating away from the extension agriculture education programmes that the World Bank supported, some have created the entrepreneurial development agency. But those are makeshift. The agricultural extension agency as it was created should not be touched. When working they have a technical section, agri-business section, socio-economic etc. [Ng062]
	Other	• **Extension curriculum on PH management**. [Mw074] • Opportunities are there. I discussed with the Commissioner of Agriculture in one of the States about the Agricultural Development Programme. It has been there a long time and the extension workers live and work there, **using community extension agents** is an opportunity. We need to empower the extension agents to take this message to the farmers. But they can't do their work as they don't have mobility. They want motorcycles, so they can go to the communities. The **government needs to empower these extension officers, so they can help us bridge this knowledge gap and help us explain these tech innovations in a language and ways farmers understand**. Government needs to do much in terms of agricultural extension services. [Ng087] • In woredas there are development agents, (animal science, crop and natural resource) **but no mechanisation experts**. These people need to be hired by some organisations and get secure jobs. This issue got some level of acceptance and government started to send middle level experts. But this needs to be continued. [Et044] • In 2007, I visited China and the Chinese have 100,000 agricultural engineers in 25,000 centres, and that is how they are mechanising the labour. If you are a farmer and have 1/5th of an acre of land, you have the technology for that land, to cultivate or harvest etc. and these 100,000 people are raising the technologies. There are a lot of different machine manufacturers and they bring them to the centre and farmers can then select. So the human resources is just working for them to export,

Theme	Sector	Details of how PHL reduction LEARNING OPPORTUNITIES could be enhanced
		to Europe, to any other countries, good quality agricultural products. Here at woreda level there is no mechanisation technician. Probably in the future they will correct that. Et054 • Competition between extension workers, **rewarding those who perform well**, not financial reward, just acknowledging their performance and good practice Et066
Online / virtual Learning	Public	• Learning about innovations from Ethiopia and Kenya via **YouTube**. **Direct collaboration** with NSPRI. Ng024 • Also to enhance PHL issues to use media platforms. Et011 • We need to do a lot of advocacy and sensitisation and then a lot of collaboration so these things I saw in Kenya and Ethiopia via YouTube could be more widely adopted. Ng024
	Private	• We **also look at secondary research** that has been done in that VC e.g. portals like research gate that have lots of published articles. Then use that info., have our team conduct pilots and see if we can get something that works Ke078
Traditional media	Public	• **Radio programmes** would be more impactful, and if we could have group messaging using the networks, and TVs would help for urban dwellers who in many cases make decisions for people in rural areas; as they will buy varieties or speak to people out there and say, 'no, this is the chemical which is working'. Zw031
	Private	• Government officials should talk about waste, and we could use all kinds of media and TV – if there was a budget – to make a running conversation or advert we would get to a lot of consumers Ke023
	Other	• **Radio and TV** is good for disseminating this to the public Et056
Collaboration, partnerships, sharing and synergy between actors within and between different countries or regions	Public	• Synergy, **collaboration** between West African countries or with Southern African countries, or **between regions or continents** can help a lot and can help in reducing losses. So there is a need to have a lot of collaboration, sensitisation, tech transfer, training and improvement from one area to another which can help in reducing losses, e.g. for some of the Evaporative Cooling Systems how can we improve them, e.g. the ZECC or charcoal cooler which are a little complex for farmers unless they are in coop groups/clusters. But if some of those techs are ones that SHFs can adopt then I think they can go a long way in mitigating PHLs. Ng034 • Let us work together, let us promote and collaborate with effective PH solutions, and not just South-South collaborations. Ng072 • E.g. the RELOAD project was very good for **cross country learning** within East Africa Et031 • If you conduct a **workshop that involves different stakeholders talking about PH issues** that is an opportunity to share knowledge and experience from other countries. And colleagues from different institutions are working on different topics e.g. a colleague in Kenya is working on solar based drier and others on fish drying etc. Et071 • There are different solar drying technologies for different products so options to share experience through diff partnerships Et081 • **Exchange programmes** could help. I remember when working on a problem of promotion of metal silos and scientists would come from Malawi, Zambia and Zimbabwe and we learnt a lot from that. Ke022 • **Conferences** for sharing that information. Ke042 • **Joint project** to look into those issues. Ke052 • Annual meetings would be an event for exchanging lesson plans and ideas Ke022. • We do have other models which are **expensive, e.g. the learning tours or exchange programme**s. For example, in the seed bank we have had farmers coming from 400km away crossing to another district to see how they keep their seed and the actual seed varieties so those are some of the initiatives. Zw081
	Private	• Several of our actors could also look at what the industrialised West are doing, not necessarily to copy, but to see what works and then refine a couple of what works there, to suit our environment. So I think actors should **organise study trips, professional exchange visitor programmes** would be very useful for us to interact with colleagues from the other side and then learn, exchange, refine in our own local context. You know, there is nothing like a **PHL professionals exchange physical programme** or whatever and those are the things that are useful. Ng086 • **Lesson learning within the continent** and with others in south Ng046

Theme	Sector	Details of how PHL reduction LEARNING OPPORTUNITIES could be enhanced
		• We have rich data and you (NRI) have abilities to do assessment and analyses so I see a big opportunity for us to partner and do insights etc and come up with learning modules that can be used [Ke026]
Multi-stakeholder FLW/ PH learning platforms	Public	• We have platforms where we do awareness creation and now we have an **official day where we bring stakeholders together** to raise awareness about the impact of FLW. [Ke091] • Multi-stakeholder platform, this must bring on board relevant academics, development partners, researchers, ministers, and ministry departments and agencies, then they sit together, and develop a training guide to go and re-tune or re-tool the county technical teams. Then we supply them with those guidelines which they follow as they continue training. So we are going to use the county technical teams at the TOTs. But now we as the MIT seated at the national level we are now there. They're master trainers of the entire problem. [Ke024] • The Rockefeller Foundation tried to establish PH learning processes in Zimbabwe. [Zw011] • We do have other models which are **expensive, e.g. the learning tours or exchange programmes**. [Zw051]
Learning with decision makers	Public	• We need a **mechanism in which we can publicise the effect of these PHL to the policy makers and even the donor community,** once we convince those actors then we might see some resources trickling down to these activities and only then we see something can happen. [Mw061]
PHM training programmes for technical vocational education centres	Public	• Skill training is very important, I designed a **PHM training programme for a technical vocational education centre** and if implemented that would be a very smart thing to do. Capacity in technical vocation (TVs) should not be at all TVs, it could be at selected TVs. We need to train skilled labour that can fit into the extension system and agri-business. So that they can become also entrepreneurs, service providers by some sense. This is really my wish. [Et033]
	Other	• **Through crafting curriculum in learning institutes**, especially providing training from technicians up to higher level is very important. So we have to **come down from the University to the middle level**, education at college level, so that people really understand PHL reduction in the teaching institutes, may need supporting with some kind of curriculum. [Et074]
FLW taught in schools	Public	• When we talk about learning, it is **unfortunate that nothing on FLW is taught in schools**, if children actually get to learn about these things they grow up knowing it's not right to throw food away and there is something you can do with your leftovers. [Ke081]
FLW and PH in higher education	Public	• Even at BSc we just teach a little bit on PH at the end of first year, and **we don't have specialised courses in PH**. [Ke091]
Coordinating body for each PHL topic	Public	• Need a body that coordinates technology development per topic, and then people can see what has been created and can pick out what they need. [Ng025] • In the past we used to see little books that would tell you what IITA had done etc, but now that doesn't exist. [Ng035] • If I want to develop a solar drier, I should be able to see what NSPRI has done so I can visit it and not repeat it but can learn from it. [Ng005]
Resources to support learning	Public	• Resource wise, with the government that is a process and so when we convene meeting as the national government we must facilitate, and if it is the donors interest, then the donor will say, 'this is my budget, this is how I want it to happen, this is the report I want to get at the end of the day', we have it as a Kenyan, not as a donor. But you'll have the opportunity to get what you want for the country [Ke064].
	Private	• Do you charge for your training? No, we provide it for free, but we can't do our business without that service as it prevents substandard product ending up with the buyer. [Ke078]
Coordinated learning programmes of sufficient duration	Public	• We need a very coordinated programme, and it has to be l**ong enough**. [Mw021] • Learning is only possible if there is a programme that is **long enough and not a project** and if it has **all the elements of awareness raising, training** and everything and then out of that you learn things. [Mw081] • We have donors coming in and then they go, we **need something continuous on the ground**. Resources for production/pre-harvest work are coming in. Since starting my job, I have never seen a 'dry period' when resources are not available for production issues, never. But with PH it is dry spells here and there. [Mw041]

Theme	Sector	Details of how PHL reduction LEARNING OPPORTUNITIES could be enhanced
Capacity needs assessment to prioritise learning	Public	• There is a **need to do needs assessment, capacity needs assessment.** Because I could assume we need a training on X when actually it is not that important so there is a need to do at least the training needs assessment for staff and those staff would then inform us of the needs of the farmers when they are doing training. [Mw033] • For our country we also need specialised capacity for the staff. We are just looking at what the government can manage, but if donors or other development partners see our training needs they can then come in and assist. [Mw013] • That would also mean they **need to bring in experts for PHM**. As I said **we know we are losing food, but we can't quantify it as of now**. So, we may need experts to assist us to do that. [Mw053]
Continual professional learning	Public	• We could also enhance the PH learning through different **continued advance learning** so the PH expertise who are teaching and conducting research could get **update PH training** and then that could cascade and disseminate through the extn workers [Et011]
Targeted learning events	Public	• We could think about **tailor-made courses for different practitioners/actors**, and even for policy makers. There is a discussion around how do we do some training that policy makers could make [Ke061]
	Other	• **Postharvest week-** before the harvest we have tried to organise an event, a brief discussion and then take extension and farmers to an area where there is some experience to be shared. Metal silo fabricators are there and usually by end of the week farmers are interested in making a down payment on a metal silo so good linkage between artisans & SHFs. [Et036] • The artisans are interested in **displaying the metal silo in the market** area to raise interest. [Et066]
PHL/ FLW Training guides	Public	• When we designed that training guide, we had to call for that multi-institutional team and they still exist. They come from different institutions within the country. So we still have them on board and in case of anything about PH we've been falling back on to that group. [Ke074]
Resources to support learning	Other	• The project expanding into those countries, that is driven by the funders, by the donors, e.g. GAC, BMGF etc. So as a strategy in terms of rolling out a project in the region, one of the things is to lobby the funders by showing them that these are the results of what has happened in a particular country setting. [Ke085]
Conferences and meetings	Public	• **Conferences** for sharing that information. [Ke022] • Annual meetings would be an event for exchanging lesson plans and ideas [Ke052]
Consumer learning	Private	• I am a firm believer that the greatest change-maker will be the consumer [Ke023]
Role of the private sector and the market	Other	• Most of the things are market driven. When we tell farmers this is an area to be strengthened the incentive is access and better prices. So I am for more private sector participation, in all these interventions we leave to NGOs and donor funded projects and perhaps government. But **these should be owned by the real players who benefit from the interventions**. This is the private sector (the hermetic bags companies) as they have a vested interest in that intervention. And of course farmers themselves are at the end of the chain. But it looks like we are leaving a lot to government and NGOs who are there for projects for a specific time period, and then leave. But **if private sector were more actively involved in these interventions, then sustainability will be very high**. Maybe it is like a chicken and egg situation whereby private sector will be saying no the demand for this product is not that high, so we cannot invest, but the demand cannot be high unless it is accessed by the users. So, there is a need to balance things, but I think private sector or the market should drive these interventions. [Mw064]
Learning from others' experience	Private	• We start by looking at which development agent has worked on those topics and we speak to them to learn about the VC and the behaviour of that community [Ke058]

8. Conclusions and Recommendations

The conclusions follow the structure of the report. This study is based on a consultation with key informants rather than a full stakeholder survey process. The interviews were conducted virtually and we were unable to consult with all the stakeholder types, particularly farmers.

8.1 Conclusions

What are different actors doing in PHL reduction and why?

Farmers

Farmers are perceived by other actors to be mainly continuing to use their traditional PH practices, some of which may be associated with health and safety risks and PH reductions in quality and quantity of their own food and the products they are intending to market. However, there is also change happening within their PH systems in response to a range of drivers (see Drivers section). Many respondents interpreted this question of what farmers are doing to be about the extent to which there had been uptake of 'improved' technologies. They reported that there has been some uptake of hermetic bags, mobile threshing/shelling and harvesting services, improved handling practices and packaging of fresh produce intended for markets. Barriers to uptake of these PH interventions are perceived to be the cost of interventions, poverty levels of farmers, with less mention of the absence of understanding by most stakeholders of cost: benefit and any other outcomes linked to adoption of these recommended PH interventions. Opportunities to improve farmer and other VC actors' engagement in, design and testing of and ownership of PH interventions were recognised. There appears to be limited understanding of what farmers are doing to reduce PHLs currently and why. The heterogeneity of situations, knowledge and aims among smallholder farmers needs recognition alongside the recognition of much-larger commercial and mega-farmers and the interactions between these groups.

Traders, aggregators, transporters

The importance of traders, aggregators and transporters in influencing the levels of quantity loss and quality loss occurring in both fresh and dry produce VCs was clear. Where traders are supplying quality sensitive markets, required PH practices are passed back along the chain to farmers. Given the seasonal rain-fed nature of most food production in the focal countries, serious market gluts of produce occur, resulting in high nutritional and economic losses for producers and consumers. There is very limited data about the actual levels of loss occurring in different commodities during transport and trading in many VCs, other than for tomato. Improved packaging, e.g. returnable plastic crates, was shown to be able to reduce transport and handling losses of tomato from ~40% to ~10% on trade routes from the north to the South of Nigeria. Solar-powered 'cooling as a service' is a rapidly growing and emerging business customised by fresh produce wholesalers and retailers in marketplaces in Nigeria, with significant demand emerging from other countries for similar services, and from traders of other perishable commodities, e.g. fish and meat. Small- and large-scale grain traders exist in all the countries, and their interest in the quality of the grain they purchase and handle is driven by their markets, and particularly by fears of mycotoxin contamination which consumer awareness is rapidly increasing, accompanied by the emergence of more quality sensitive markets with associated price differentials. Linkage between the traders, transporters and the PH research and other PH public sector actors appears limited currently.

Public sector

A range of public sector actors were consulted, many of whom were PH specialists. All the countries have PHL reduction / FLW research taking place in Ministry organizations or public universities, although there is strong emphasis on agricultural production. Much of the PHL reduction work has been on grains, but there is increasing interest – and to varying degrees action - in relation to perishables and root crops. All the countries have publicly funded and implemented agricultural extension services. These services are all to varying degrees decentralized and reportedly demand-led. These organizations have a strong focus on agricultural production, with varying levels of PH-related work. Stakeholders reported various capacity issues (see other sections of the report) including access to financial resources. Much of the funding for public sector PHL reduction work is coming from international donors/ development partners, rather than governments' budgets. This has raised questions about the continuity of PHL work and the extent to which it is able to respond to stakeholders' priorities. The development of national PH strategies (Ethiopia and Kenya) has been on attempt to address these concerns.

NGOs

Stakeholders identified a range of different types of NGOs ranging from international research centres, a regional agricultural development entity, and more traditional international NGOs who have played important roles including supporting R&D by national research institutions. This includes funding for the R&D and actions to promote uptake. They have also been involved in knowledge (technology) transfer, which sometimes includes collaboration with national researchers and equipment manufacturers to modify transferred technologies to suit local conditions. A notable case is the role Sasakawa played in modifying an IITA thresher (which had originally been used in Nigeria for rice) for threshing tef and other grains in Ethiopia. They have also supported local NGOs and public extension agencies in training local equipment fabricators and disseminating information on new PH equipment and practices, especially to smallholders. Subregional organisations such as EAGC have been instrumental in articulating critical PH issues at national and subregional levels and been partners in piloting and promoting upscaling of some PH innovations, including structured trading systems which rely on PH handling actions that reduce losses. They have also led efforts to institutionalise standards for produce and storage infrastructure across Eastern Africa.

Local NGOs continue to complement public extension services in disseminating relevant PH management information in the countries studied. This is often not because PHL has been prioritised by the local NGOs but rather that it fits with the agenda of the international organisations (NGOs and donors) or public agencies with which they collaborate. They are emerging as important players in organising smallholders and micro/small-scale processors to collaborate with the research community and in setting an agenda that focuses on addressing the PH challenges which are relevant to them (e.g. WOFAN in Nigeria). Their role in validating proof of new technology concepts is being shown as important in helping researchers as well as in fostering subsequent uptake of proven technologies.

A new role for local NGOs, which is contributing to reduction in PHL in Kenya and is likely be replicated in other countries, is that of redistribution of 'surplus' or 'out-of-spec' produce particularly from commercial export-oriented farms. The allied role of contributing to policy and legislative reforms in relation to this specific activity is something which is also likely to be replicated by others in the wider context of PHL actions.

What is apparent is that the NGOs (local and international) tend to be reliant on funding from various donors. Therefore, the sustainability of their funding and related capacity to independently define their own PH agenda poses a challenge. Collaboration with public services also poses some challenges, for instance where local/international NGOs often have limited extension and therefore tend to rely on public extension services which, in most cases are overstretched in terms of personnel and resources.

Private sector

Private sector companies focused on PH activity stages exist in all the focal countries. The products they supply include sacks, hermetic bags, plastic drums, storage pesticides, crop threshers and harvesters, plastic crates and cold storage solutions. PH private sector service provision includes mobile crop threshing and drying for grain farmers, 'pay-as-you-cool' services in marketplaces for fresh produce wholesalers and retailers, and cold store hire for export-oriented commercial farmers and farmer groups. While some of these products and services are seeing rapid uptake, for others it is very slow. Access to affordable finance by SMEs and their potential smallholder farmer client is limited which hinders expansion of purchasing and of supply and distribution network development.

Development partners

Several international development organisations have been involved in PH activities, including those mentioned by interviewees e.g. FAO, SDC, the World Bank, the African Development Bank, FCDO, USAID, GIZ etc. The actions are driven in part by global and continental PH commitments and initiatives (e.g. SDG 12.3 and Malabo). Also identified are international private philanthropic organisations including Rockefeller Foundation, BMGF and Nippon.

In most cases the support of these donors is either through funding projects which have PH components or supporting local and international NGOs and governments to undertake PH activities. The activities funded include R&D by research institutions; knowledge transfer; supporting the formulation of national PHLM policies and strategies; awareness creation, including for policymakers/other decisionmakers; capacity development, especially for knowledge transfer to target beneficiaries (not only users but also equipment fabricators/manufacturers); and facilitating access to finance and grants to private sector though a substantial gap in supply remains.

Policy

Some of the countries (e.g. Ethiopia, Kenya and Zimbabwe) have developed NPHMS, these have been done through multi-stakeholder processes and are at different stages of being launched. While implementation guidelines are being developed, funding for these strategies is yet to be attained. However, due to the complexity and multi-sectoral nature of PH systems, many other agricultural, health, transport, industry policies affect PH elements of food systems. One challenge mentioned by most countries was that of coordination between PH actors and initiatives with that being a major role of the NPHMS.

Multi-stakeholder arrangements

These have taken different forms across the countries studied and have included short-term engagements during the formulation of NPHMS and/or implementation of specific PH projects. Some multi-stakeholder arrangements are also emerging triggered by the interest of key actors in maintaining networks for sustained PH actions in particular to address identified challenges

including missing enabling factors or prevailing disabling factors. There is evidence that these actions can make a difference. For instance, the EAGC has been notable in its role in driving some PH activities in the grains subsectors.

What is becoming apparent is the need to ensure that the networks are sustained, involve as broad a range of key actors as possible and in addition to addressing local needs and priorities, are also informed by and aligned to global and continental PH initiatives. National, continental and global processes should be informing and supporting each other. Lesson-learning, including through subregional exchanges, needs to be explored.

Drivers

Postharvest agriculture exists within a wider development context involving multiple drivers of change which continually shape food systems and the postharvest elements of those systems.

The stakeholders we consulted identified a wide range of drivers which we summarised and grouped using the conceptual framing of drivers from the HLPE (2020) sustainable food system framework (*Biophysical and environmental drivers, Economic and market* drivers, *Political and institutional* drivers, *Socio-cultural* drivers, *Demographic* drivers).

These drivers vary by context and over time. The drivers identified exert influence on a particular population, place (e.g. rural or urban) or system (with social and ecological attributes) at various scales (local to global). The internal attributes of the population, place, or system affect their relative vulnerability, adaptive capacity and resilience. The interactions between the external drivers and the internal attributes lead to actual outcomes and impacts.

Development interventions (e.g. capacity strengthening, investment in technologies, regulation, institutional change) may influence the attributes of the population, place or system and the drivers over time.

Decisions about future PH interventions aiming to achieve development outcomes should be informed by an understanding of the food and PH systems' drivers in a particular context.

Outcomes of the PHL reductions interventions

Relatively little assessment has been made of the changes brought about through PHL reduction interventions. Funding structures and incentives often reinforce the situation of organisations being tied to the promotion of specific technologies and innovations, and competing to demonstrate the relative advantage, often using adoption rates as a metric of success that reinforces their claim to success (Sumberg et al., 2012; Hermans et al., 2021). There has been an increasing critique of this. In the context of small-scale farming systems, how should agricultural development professionals conceive of technological change and how can it be most meaningfully and effectively documented, measured and evaluated? Glover et al. (2019) contend that the concepts and methodologies most commonly used for this are flawed conceptually and operationally, and increasingly unfit for purpose. Specifically, the dominant concept of technology adoption provides a poor basis for understanding processes and consequences of technological change (Glover et al., 2019).

With the above in mind, we asked a deliberately open question about what the outcomes of their PHL reduction interventions had been, to allow the respondent to frame their response in the way they thought best.

Where there has been assessment of PHL reduction interventions it has been mainly focused on individual technologies. Hermetic bags have probably received the most attention. For example, in Ethiopia there appear to have been a number of technical and economic assessments, which suggest positive outcomes for farmers who are able to access the bags. Environmental and social outcomes appear to have received less attention.

Many stakeholders commented on the need for such assessments to be done. This raises the question of how best to assess the contribution of PH interventions to development outcomes.

Postharvest systems are complex and require a multi-stakeholder and multi-sectoral understanding and approach to work with them. The use of a (food) systems approach can support a more holistic appreciation of the dynamic, complex and multi-dimensional nature of the relevant issues and interconnections. It also highlights the involvement of stakeholders who may hold diverse views and experiences but whose interactions are necessary in order to bring about the changes required for transformation of food and postharvest systems. Co-learning approaches can bring together these diverse players to contribute to developing and testing practical solutions and skills for contributing to these transformations.

Postharvest innovation is frequently embedded in a wide set of relations and contexts, with key research areas spanning engineering, food science, pest and disease management, marketing, and socio-economics. The associated diverse set of agendas make its management and assessment challenging (Stathers et al., 2013).

Enabling and Disabling Factors for PHL reduction

Enabling factors

The enabling factors identified by the stakeholders interviewed include growing awareness about PH issues among public policymakers (in government), private sector actors, education and research institutions as well as farmers, micro/small-scale processors and traders who actually experience losses at different stages in food value chains. Rising consumer awareness of food safety hazards (including effects of aflatoxins) stimulating demand for quality food produce/products is perceived to be an enabler for adoption of PHL reduction solutions.

Other enablers encouraging prioritisation of PH actions include global and subregional initiatives, e.g. SDG12.3, the AU Malabo Declaration and the UN Food Systems Summit, which provided an opportunity to integrate PH in countries Food Systems roadmaps. These may have contributed to commitments by development partners and international NGOs to support PH actions, for example, the AgResults grain storage project mentioned by public and private sector actors in Kenya; Feed the Future Programme mentioned by private and public sector actors in Malawi; and donor funding and support for PHL assessment surveys in Malawi.

The existence of public sector research organizations which work on PHL technologies and other PH interventions is identified by private and public sector actors as an important enabling factor. There is also apparent interest by the private sector to invest in viable PH solutions, especially when there is market demand and/or the solutions help in meeting market demand for quality produce and products.

Good collaboration/relationships/partnerships have also emerged/been developed which are catalysing R&D in PH solutions as well as uptake of the proven solutions. Examples include networks which involve researchers and policymakers on one hand and on the other technology manufacturers/fabricators, farmers, traders, aggregators, NGOs and development partners.

Some of these networks have emerged through specific project/programme-related activities and some through multi-stakeholder processes.

Disabling factors

The identified disabling factors include public policies and legislation as well as government investment. Most notable among these are enabling fiscal policies which are skewed in favour of pre-harvest stages and excluding PH activities. For instance, whilst inputs for production are imported duty-free and are exempt from taxes/VAT, these benefits are not applied to PH equipment and materials required for producing them. It is a situation that is found in all the countries with the exception of Ethiopia which recently carried out required tax reforms.

A common disabling factor is under-resourcing of public research organizations, which are leading in R&D in PHL technologies. This is a critical issue because there is limited private investment in R&D in PH solutions due uncertainty regarding return on the investment. Furthermore, the food quality standards which encourage investment in PH handling activities that tend to reduce losses are not applied in the predominant informal local markets where, quite often consumers do not demand any quality. Where structured, quality-sensitive formal markets are dominated by public sector agencies, delays in payments and other activities tend to discourage market participation by private actors and smallholders. It was also noted that some interventions by governments, donors and NGOs tend to frustrate the private sector, including where specific action has been taken to encourage youth investment in activities such as providing PH services (e.g. fee-based threshing services), or when NGOs or other actors start acting as distributors of private sector products.

Knowledge and skills gaps are major disablers. The importance of involvement of senior level personnel to ensure PH networks inform decision-makers was noted.

Severe physical infrastructure constraints are major disablers. Many respondents highlighted the poor state of rural roads but some also mentioned unstable power supply as a major challenge. This is being addressed through use of solar energy by some emerging initiatives e.g. cold storage. In Nigeria, respondents explained how access to land for construction of cold storage facilities at local markets is also problematic.

Access to finance is a concern across all the countries and affects manufacturers/distributors as well as users of PH tools. In particular, local financial institutions are averse to financing private sector PH actors and some of those who have obtained funding did so from grants and debt funding from donor-funded projects and/or impact investors.

Climate change is reported to be accentuating PHL and may therefore be driving demand for PH solutions. Physical security and its effects on actors, their investments and transport routes and durations are also highlighted by respondents in Ethiopia and Nigeria.

What needs to be done to support PHL reduction and how can investors best support this

Interviewees perspectives on **what** they would like to see being done to support PHL reduction at the **micro level**, included promoting uptake of proven harvesting, transportation, storage and processing technologies. The focus should not only be on staple grains but also on the perishables value chains where PHL levels appear to be higher than in the grains subsectors. To drive this agenda, there is need to build/strengthen local fabrication/manufacturing capacity, e.g. of small and medium-sized hermetic storage drums, hermetic bags, threshing machines

and processing equipment. Other examples include installation of appropriately sized processing plants in rural areas for products such as sunflower oil and in marketplaces for buying off and processing of overripe tomatoes, solar powered packhouses, mobile packhouses, refrigerator trucks, cold chains, simple affordable labour-saving technologies and hermetic bags. Smallholders, micro/small-scale traders, aggregators and processors will be the main targets for uptake of these technologies.

The desire for more participatory research processes designed and implemented in partnership with farmers and other VC actors was highlighted. There is need for robust evaluation of any innovations (assessing technical, economic, financial, social and environmental impacts of these) before any wide-scale uptake promotion. Target users, including smallholders, have to be involved in the assessment process.

At the **meso level** the key areas for investment suggested include PH training for extension workers, learning visits between stakeholders and countries, solutions supporting farmers and SMEs in accessing finance to purchase PH equipment. Also stressed is awareness raising for farmers, extensionists, *policymakers* and other stakeholders such as private sector stakeholders. The need for training in PH systems thinking was flagged by the public sector in Ethiopia.

Incentivising private investment in PH solutions can benefit from lessons from projects such as the AgResults on-farm grain storage pilot. This may be replicated in other countries. Unlocking access to finance for suppliers and users of proven technologies, and at affordable interest rates is a critical challenge. The desire to develop and work in alliances was raised by public, private and other stakeholders, with particular emphasis given to recognising and supporting the role of the private sector in PHL reduction.

Macro level interventions mentioned include formulation and/or implementation of enabling policies such as NPHMS, which also need to be well-funded. Institutionalising, harmonising and enforcing quality standards (e.g. greater enforcement of regulations on use of pesticides and fumigants) across regions to facilitate subregional trade is also expected to enhance application of handling practices which contribute to PHL reduction. Removal of import duties and taxes on PH agricultural inputs and government investment in infrastructure such as roads, market facilities are some of the macro-level interventions which are suggested. In addition, the way food reserves are managed should be integrated in marketing systems which help to reduce PHL by offering predictable incentives for adopting appropriate loss-reducing PH practices and technologies.

Knowledge gaps and learning opportunities

A long list of **important knowledge gaps for PHL reduction**, were identified by public, private and other PH stakeholders. These included: 1) farmers' awareness of PHLs, 2) farmers' access to information on weather services and commodity prices, 3) limited understanding by various actors of: farmers' perceptions and reasons for their decisions around uptake of interventions for PHL reduction services and technologies, 4) the causes of PHLs within the context of the wider food system, 5) gender and other social dimensions of PHLs, 6) the scale of losses actually occurring in order to inform targeted loss reduction decisions by various actors, 7) the viability of PHL reduction interventions, 8) PH finance provision, access decisions and needs, by both financial providers and users, 9) more knowledge is needed on holistic approaches to PHL

management and appropriate PHL learning methods to reach rural poor, 10) food waste and recycling, particularly for urban dwellers.

Greater knowledge is also needed around a) crop drying, b) solar refrigeration technical and engineering skills, c) safe handling of food, d) localized protocols for PH management of specific VCs and contexts, e) safe use of pesticides, f) PH equipment and infrastructure that could reduce losses, g) reducing the environmental footprint of PH interventions, e.g. recycling of hermetic bags.

Many ideas for increased PH learning opportunities were suggested including greater collaboration and sharing of activities and learning between stakeholders particularly around linkages with the private sector and from professionals in other countries, supporting PH learning within existing organisations (e.g. farmer field schools, VC associations etc) and strengthening public sector extension services. Suggested learning approaches ranged from posters, radio, TV, online courses, special events, farmer field schools, study tours, and increasing the profile of PH issues in the curriculums of schools, technical vocational education centres and higher education courses.

Synthesising the findings from this study and the different framings we worked with, we developed a set of 12 recommendations (section 8.2) and a draft framework (Appendix 3) to support actors in conceptualising their decision-making around PHL reduction interventions.

8.2 Recommendations

Recommendation 1: Interventions should be informed by what stakeholders and systems are doing and why

Those planning and/or implementing interventions, appear have limited recognition and understanding of what focal stakeholders are or are not doing currently to reduce PHLs, and why.

1.1 Planners and implementers of interventions should explore in more depth the PH-related activities of stakeholders (e.g. farmers, traders, transporters etc.) whose decisions and activities directly influence PHLs. This includes stakeholders' reasons for these decisions and their sphere of influence.
1.2 Measure and collect data on losses from different activity stages across a range of VCs, to deepen understanding of the scale, types and causes of loss occurring.
1.3 Recognise the heterogeneity of situations, knowledge and aims between and among stakeholders (e.g. farmers, traders, transporters etc.).

Recommendation 2: Recognise and address the complex and dynamic nature of agri-food systems

Postharvest agriculture exists within a wider development context involving multiple drivers of change that continually shape agri-food systems and their postharvest elements (see section 3). Postharvest systems are complex and working with them requires a multi-stakeholder and multi-sectoral understanding and approach.

2.1 Build on this and other analyses of postharvest systems to understand the complex and dynamic relationships between actors, drivers, place and PH system attributes and outcomes to help prioritise interventions at micro, meso and macro levels within the existing system.
2.2 Explore scenarios for how agri-food systems might or should change in the future and the implications for the management of PHL reduction within wider development contexts.
2.3 Support multi-stakeholder learning processes in the development, implementation and assessment of PHL management strategies and interventions, within a framework of contribution to sustainable and equitable farming and food systems transitions.
2.4 Understand the enablers and disablers (see examples in section 5), the degree of consensus around them, the proposed actions, and the trade-offs and potential winners and losers.
    - Where there is consensus between stakeholders utilise this to potentially achieve early wins.
    - Where there is no consensus on forward actions, create and maintain a safe space to support dialogue and deliberation by diverse stakeholders to inform decision-making.
2.5 Integrate the well-established lessons for managing multi-stakeholder processes.
2.6 Explore with governments how multi-stakeholder processes can be sustained beyond specific projects and initiatives.

Recommendation 3: Recognise the diverse roles and support effective, fair partnerships among stakeholders in PH interventions

In development interventions, stakeholders are not always playing the roles for which they have appropriate strengths. When interventions require bringing stakeholders together, issues around power imbalances often emerge.

3.1 Recognise the importance and strengths of different actors in roles relating to PH systems and support them in ways that enable collective use of their strengths. For example:

- Support actors who can facilitate processes which address power imbalances
- Sustain capacity to engage in PH actions by going beyond promotion of new technologies and practices, to also actively empower smallholders and micro/small-scale actors to participate in R&D processes for PHL reduction
- Ensure that PHL reduction initiatives entailing eventual commercialisation of technologies or handling services, involve appropriate private sector partners from as early as possible to build ownership and sustainability. Care should be taken to avoid other stakeholders (e.g. NGOs, researchers, government) crowding out the private sector and vice versa.

Recommendation 4: Support appropriate research, innovation and learning processes

Although a number of researchers recognise the importance of how they work and interact with farmers and, perhaps to a lesser extent, other stakeholders (e.g. traders, private sector), extending this more widely requires appropriate skills, confidence and resourcing.

4.1 Increase involvement of core actors (such as farmers, traders and transporters) and their associations in PHL reduction programmes.

4.2 Increase use by researchers and other stakeholders, of more participatory research and learning processes which support engagement and ownership by farmers, farmer organisations and other actors, to enable the co-design of accessible PHL reduction interventions that address their needs.

4.3 The social, economic and environmental outcomes of PH interventions alongside the technical outcomes, should be co-investigated with farmers and other actors to inform decisions on further promotion and investment in each PH intervention.

Recommendation 5: Embed appropriate learning, monitoring and evaluation approaches in PH intervention processes

Several interesting PHL reduction interventions were identified, but key informants felt there had been little social, economic and environmental assessment of the changes they had brought about. Many stakeholders commented on the need for such assessments to be done. This raises the question of how best to assess the contribution of PH interventions to development outcomes.

5.1 Together with farmers and other food systems actors, investigate the social, economic and environmental outcomes of PH interventions alongside the technical outcomes, to inform decisions on further promotion and investment.

5.2 Support the development and implementation of appropriate outcome and impact assessment approaches and tools to guide evaluative learning around PHL reduction strategies and actions.
5.3 Embed sustained monitoring, evaluation and learning in PH investments to enable prompt modifications where needed, e.g. as a result of unanticipated challenges/risks.

Recommendation 6: Support research on widening access to finance by key PH stakeholders

The key informants highlighted how lack of access to finance limits both the supply-side capacity of fabricators/manufacturers, distributors and service providers to sustainably deliver innovative PH tools, equipment and services, and the end-user uptake capacity of farmers, traders and SMEs in agri-food systems. Some examples of potential financial products (e.g. blended finance products) were identified but were not assessed in depth in this study.

6.1 Evaluate existing innovative finance products, e.g. de-risked financing products, result-based financial incentives, to understand their potential in catalysing private sector development of supply and distribution networks, and in stimulating financial organisations' PH-focused lending to SMEs and different types and groups of farmers.
6.2 Explore well-structured market relations and the ways in which they create or expand opportunities to de-risk and improve access to finance for different actors.

Recommendation 7: Greater focus on equity and social inclusion

The study illuminated the limited knowledge of the broader outcomes of PH interventions beyond the technical outcomes, and a dearth of knowledge around the relationships between PH interventions and systems and their gender and diversity aspects and implications. In line with national government priorities this would include consideration of opportunities for youth.

7.1 Ensure that equity and social inclusion dimensions of PH systems and PHL reduction interventions are given prominence in PH programmes, projects and other investments. This requires a ground-truthed understanding of the heterogeneity of situations and actors (e.g. farmers and traders), and their involvement in PH systems. Attention should be given to how different forms of social exclusion (e.g. gender, age, poverty) can interact and further disadvantage particular groups.
7.2 Support the involvement of PH actors, including SMEs, in co-designed equity-focused PH investments to enable women and youth and people living in extreme poverty to participate and benefit from PHL reduction interventions.

Recommendation 8: Ensure continuity, financial sustainability and coordination of actions

Development partners' role in highlighting the issues and supporting PH interventions has been important in the countries studied. Continuity, coordination and financial sustainability of PHL reduction interventions were identified as issues that need to be addressed with short-, medium- and longer-term perspectives in mind.

8.1 Support the embedding of PH systems thinking in agricultural public sector organisations.

8.2 Support co-development, ownership and embedding of PH interventions in local systems/organisations to enhance the likelihood of their continuity following project end dates.
8.3 Strengthen public sector organisations' capacity to coordinate and secure diverse streams of resources for sustained PH actions, including funding of national PHMS.
8.4 Co-design longer term programmes and opportunities for actors to have continuity of funding within them.

Recommendation 9: Invest in capacity strengthening approaches to support PHL reduction in existing and future systems

The public, private and other sector stakeholders all reported capacity issues at different levels. At individual level these encompass capability, motivation and opportunity. Key informants identified a range of approaches and opportunities for enhanced learning, including formal training at a range of levels, experiential learning, virtual learning, professional exchange and collaboration, sharing and synergy between actors within and between different countries or regions (see sections 6 and 7).

At organisational level, much of the operational budget for public sector PHL reduction work is funded by international development funding through projects, rather than from governments' budgets. This has raised questions about the continuity of PHL work and alignment of stakeholders' priorities.

9.1 Support public sector agricultural service organizations in ways which strengthen capacity of individuals (capability, motivation and opportunity) and organizations (strategies, operational ability, reflection and learning practices, culture etc.) to respond to PH stakeholders' needs. This involves the public sector working with other key actors to consider holistically the agri-food systems, the drivers of change, the nature and causes of PHL under existing systems, and transitions towards more sustainable and equitable systems.
9.2 Support the development and implementation of PH learning and training strategies at different levels (e.g. national, sub-national, regional, sub-regional) and in different institutional contexts (e.g. school, extension programmes, farmer field schools, vocational and university curricula).
9.3 Strengthen capacity in farmer-centred, experiential learning extension approaches such as Farmer Field Schools, and participatory action research.

Recommendation 10: Deepen understanding of how markets influence PH actions

Some key informants mentioned that certain markets, especially formal market segments which offer price rewards for quality, can incentivise uptake of practices and technologies which reduce PHL.

10.1 Support transdisciplinary teams in exploring the barriers and facilitators to accessing PH products and services by disaggregated market segments.
10.2 Research is needed to understand the relationships between market factors (including quality standards and reward systems) and PHLs, the related incentives to use PHL-

reducing interventions and the varied impacts of such emerging markets on the livelihoods of poorer and more vulnerable sections of the population.

10.3 Increase understanding of the context and conditions under which structured marketing systems - that offer predictable/transparent rewards for compliance with relevant standards – function, and the economic, social and environmental impacts.

Recommendation 11: Recognise technology is just a part of the change process

A few PHL reducing technologies, such as hermetic storage containers, mechanised threshing, plastic crates, solar-powered cold chains, were mentioned by key informants, along with a desire for increased local production of these technologies. However, several challenges were also mentioned, highlighting the need to understand the role of technology and its co-relationship with other types of interventions, to avoid further 'white elephant' type investments.

11.1 Within the change process, support the exploration of existing technology options with key stakeholders, the co-development of new technology options, and assessment of their efficacy, affordability and acceptability and impacts at the appropriate contextual scales, while ensuring responsible innovation and just innovation are taken into consideration.

11.2 Support the necessary training and access (e.g. through supply and distribution systems, finance, local fabrication and renewable energy opportunities) for any selected and tested technologies.

Recommendation 12: Support research and learning to address wide-ranging knowledge gaps for PHL reduction

Public, private and other sector key informants identified a range of PH knowledge gaps (see section 7). Some related to the knowledge among specific actors, such as farmers' awareness of PHLs. Others were more general in nature (e.g. the scale and causes of PHLs within the agri-food system; the social, economic and environmental outcomes of PHL reduction technologies currently being promoted) and others were more specific (e.g. crop drying, solar refrigeration, food safety). Many ideas for improving PH learning opportunities were suggested.

12.1 Support research and learning to address the important knowledge gaps (e.g. scale, causes and awareness of PHLs, social, economic and environmental outcomes of PHL reduction interventions, changing PH risks and opportunities) identified by key informants, following prioritisation with shorter and longer-term considerations and validation by stakeholders in context.

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10. Appendices

Appendix 1. List of Key Informants Interviewed

The research team would like to extend their gratitude to the individuals interviewed for sharing their time and experience to inform this study.

Name	Country
Prof Kumela Dibaba, Jimma University	Ethiopia
Prof Ali Mohammed, Ministry of Agriculture	Ethiopia
Mr Yared Sertse, Shayashone	Ethiopia
Mr Oumer Taha, Sasakawa Africa Association Ethiopia	Ethiopia
Mr Amsalu Andarge, Swiss Agency for Development and Cooperation (SDC) Ethiopia	Ethiopia
Mr Aresawum Mengesha, FAO	Ethiopia
Dr Tola Yetanet, Jimma University	Ethiopia
Dr Paddy Likhayo, KALRO	Kenya
Prof Jane Ambuko, University of Nairobi	Kenya
Ms Joy Muya, Food Banking Kenya	Kenya
Mrs Wambui Mbarire, Retail Trade Association of Kenya (RETRAK)	Kenya
Mr Mganda Doncarlos, Ministry of Agriculture and Livestock Development, State Dept for Agriculture, Directorate Plant Protection and Food Safety	Kenya
Mr Andrew Gathecha, Global Development Incubator	Kenya
Mr Gerald Masila, East African Grain Council EAGC	Kenya
Mr Denis Karema, SOKO Fresh	Kenya
Mr Simon Karunditu, Ag Finance Consultant	Kenya
Mr Kimondo Mutambuki, KALRO (retired)	Kenya
Mrs Jacinta Mwau, East African Grain Council EAGC	Kenya
Dr Charles Singano , Chitedze DARS	Malawi
Mr Shelix Munthali, USAID Feed the Future - Palladium Initiative	Malawi
Mr Emmanuel Mwanaleza, Ministry of Agriculture, Planning Department, Statistics Unit	Malawi
Mr Pradeep Purushothamam, PICS Global Malawi	Malawi
Mrs Ida Mwato, Department for Crop Development (DCD)	Malawi
Prof Limbikani Matumba, LUANAR	Malawi
Dr Olubukola Odeyemi, FUNAAB and PEF	Nigeria
Prof. Lateef Sanni, Nigerian Stored Product Research Institute (NSPRI)	Nigeria
Prof. Ikani, National Agricultural Extension and Research Liaison Services (NAERLS)	Nigeria
Prof. Bashir, Federal College of Agricultural Produce Technology (FCAPT) in Kano	Nigeria
Prof. Bola Asiru, Federal industrial Research (FIRO)	Nigeria
Mr Nnaemeka Ikegwuonu, Cold Hubs	Nigeria
Mr Godwin Ehiabhi, GAIN - Global Alliance for Improved Nutrition	Nigeria
Mr Bhuphinder Singh, A-Z Textile Mills Limited Arusha, Tanzania	Kenya/ Tanzania
Prof Brighton Mvumi, University of Zimbabwe	Zimbabwe

Appendix 2. Semi-Structured Interview Guide

FOOD LOSS REDUCTION - SEMI-STRUCTURED INTERVIEW GUIDE

Date	
Location	
Interviewer Name	
Interviewer Gender	
Interviewee Name	
Interviewee Gender	
Organization	
Role in organization	
Start time	
End time	

Introductory text

Thank you for assisting us in this exploration of PHL reduction initiatives and opportunities by participating in this interview.

We would like to interview you to hear your views on and experiences of initiatives, lessons and opportunities to reduce PHLs in your country.

These interviews are to ensure evidence and experiences from a range of key stakeholders, such as yourself, as well as evidence synthesised from the literature is integrated to inform, design and align FCDO's forthcoming PHL reduction investment plan in sub-Saharan Africa.

We do not know which country FCDO will be focusing this investment in, but we do know they will be focusing the investment in sub-Saharan Africa.

Confidentiality
We will use the information you share to help understand more about PHL reduction initiatives and their successes and challenges. Your interview responses are confidential, and will only be shared among team members, for analysis. While we aim to use the information and perspectives that you provide, should information from your interview be used in any report or publication, all identifying information would be anonymized. This would ensure that you or your organization would not be individually identifiable in any way. Your name will only be listed as a person interviewed in the report annex, if you state at the end of this interview that you are happy for that to happen.

Consent and voluntary participation
Your participation in this interview is completely voluntary. If you agree to participate, you can choose to stop at any time or to skip any questions that you do not want to answer.

A. Do you have any questions for me on the above before we start?
B. **Are you happy to give your oral consent to participate in this interview: YES | NO**
C. Do you consent to the interview being audio recorded and transcribed?

☐*Switch on the transcription if consent is given*

BRIEF Introductions by All Who Are Present

Context and details of their involvement in PHL reduction work

1. a) **What** PHL reduction work have you/your organisation been involved in and **why**?

Probes:

☐Which crops did this focus on and why?

☐Which PH activity stages did this focus on (e.g., harvesting, drying, threshing, transporting, storing, retailing etc), and why?

☐Which groups in the community and other stakeholders were involved

and how/in what ways? (what approaches used?)

☐Which types of interventions has this involved, and why?

☐technology/tool/equipment; ☐handling practice change; ☐training/extension; ☐awareness raising; ☐support/organisation; ☐finance; ☐market access/ support/ linkages; ☐supply chains and their development; ☐alliance building; ☐policy; ☐regulations/ standards/ quality sensitive markets; ☐physical infrastructure (which ones?); ☐types of focal systems; ☐coordination; ☐investment

☐Where and for how long did this work happen?

☐Who funded this work?

1b. What examples or ways are there that could lead to the **wider use and spread** of these PHL reduction initiatives?

2. What **other stakeholders/actions/initiatives** are you aware of in your country that are trying to reduce PHLs? And **who** is involved and **what are they doing**?

2a. **What** are **farmers** doing and **why**?

☐How does this differ between different types of farmers (intersectional)?

2b. What is the **private sector** doing?

☐What are different value chain actors doing to reduce PHL and why e.g., aggregators, traders, transporters, processors, retailers?

☐What are the equipment and input suppliers doing?

☐What are finance lenders and groups doing?

2c. What is the **public sector** doing?

☐What are government extension doing?

☐What are government research institutions doing?

☐What is being done by means of government policy and regulation doing?

☐What are universities doing?

2d. What are **NGO's** doing?

2e. What are **donors** doing?

2f. Is there a multi-stakeholder arrangement of any kind working on PHL reduction, e.g., platform, working groups?

3. For the interventions you mentioned, which one(s) have had the **most influence** and what are/were the **outcomes** (the changes resulting) from them? Has there been an assessment of these outcomes? If yes, what were the findings? And is there a report you can share with us?

    Probes:

    ☐Any technical outcomes (i.e., in terms of reduction of quantity or quality losses?)

    ☐Any social outcomes (e.g., health and well-being in terms of gender, wealth, age, ethnic group)

    ☐any economic/financial outcomes?

    ☐any environmental outcomes?

4. What **systems** are in place **to track and share/scale the outcomes** of PHL reduction initiatives in the country, and how effective are they?

5. What **drivers** are PH systems having to respond to currently and in what ways is this happening (and how do you think this will evolve in future)?

    Probes:

    ☐What social drivers? ☐What environmental drivers? ☐What economic drivers? ☐What political drivers?

6. What are the factors that are **enabling and supporting** PHL reduction in your country's context?

7. What are the factors that are **disabling and preventing** PHL reduction in your country's context?

8. **What** would you like to see being done to support PHL reduction to meet your country's needs and why? What would the **challenges** and the **facilitators** be? What **interesting PHL reduction ideas or initiatives from other countries** have you seen, heard or read about that you think could have potential in your country?

   Prompt: ☐which crops, ☐which PH activity stages, ☐which target groups, ☐where and ☐why

9. What important **knowledge gaps** for PHL reduction still exist, and for who?

10. How could PHL reduction **learning opportunities be enhanced**?

11. How should **investors** *(public or private)* **best support** the PHL reduction to meet your country's needs, and why?

12. Are there any **key reports or strategies** on PHL reduction for your country or the region which you think we need to be aware of?

Snowballing

13. **Who else** do you think it would be particularly **useful for us to talk to** regarding crop PHL reduction in your country?

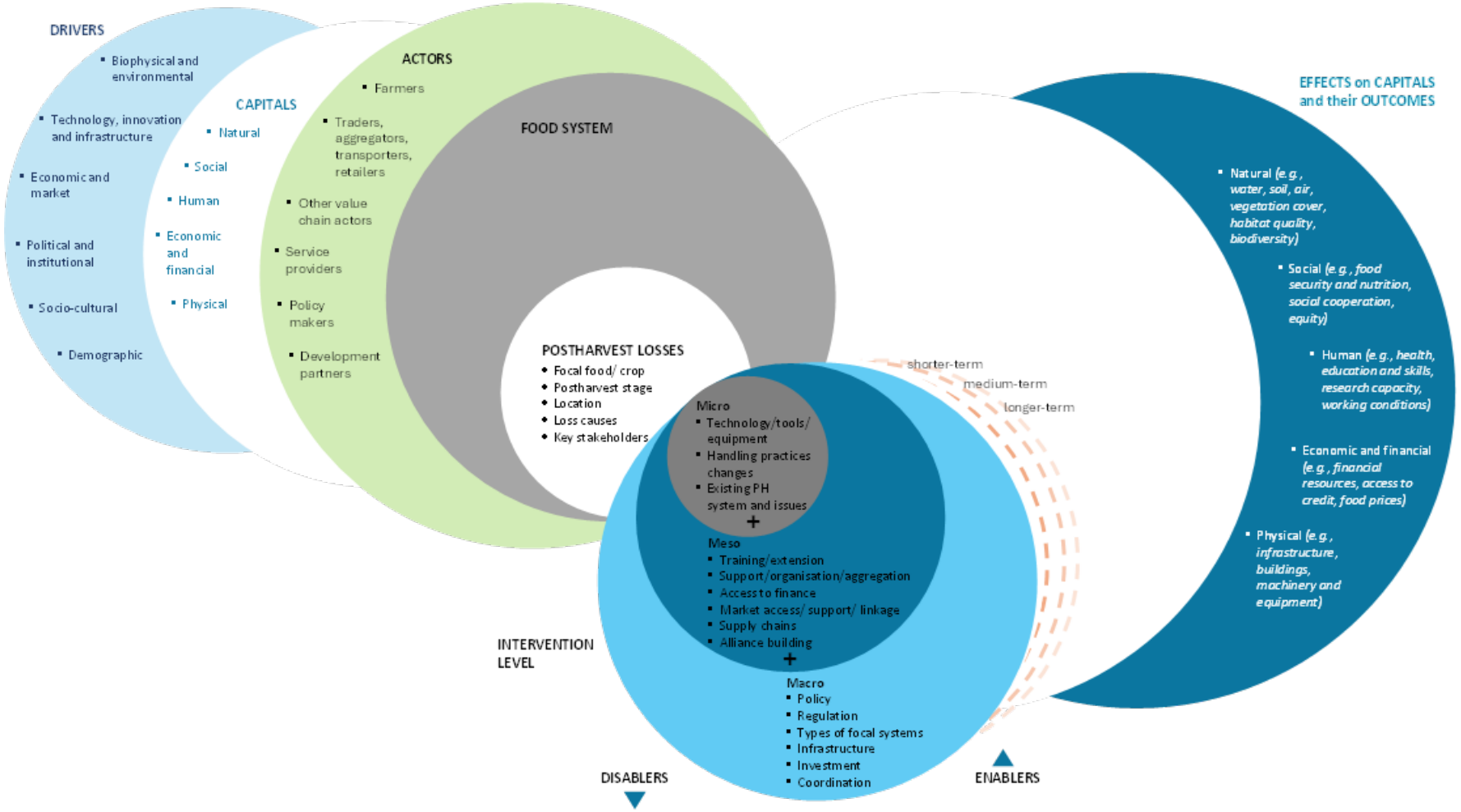
    Probes:

    ☐NGOs? ☐Government? ☐Farmer organisations? ☐Research? ☐Stockists? ☐Other private sector? ☐Policy?

14. This has been an incredibly rich interview and of course we would like to recognise your name and information and credit you for this, but we realise that there may be information you would not want to share, so we would like to just check that you are **happy for your name to be listed** as a person interviewed in our report annex, or would you prefer that we just state your stakeholder type and country name?

Thank you!

Appendix 3. Framework to support actors in conceptualising their decision-making around PHL reduction interventions



Source: Authors' work

Appendix 4. List of Acronyms and Abbreviations

ACDI-VOCA	Agricultural Cooperative Development International/ Volunteers in Overseas Cooperative Assistance
AATF	African Agricultural Technology Foundation
ADP	Agricultural Development Programme
AFAAS	African Forum for Agricultural Advisory Services
AfDB	African Development Bank
AFEX	African Exchange
AU	African Union
ARI	Agricultural Research Institute
BMGF	Bill & Melinda Gates Foundation
BSF	Black Soldier Fly
CASSCOM	County Agricultural Sector Steering Committee (Kenya)
C:AVA	Cassava: Adding Value for Africa
CFC	Common Fund for Commodities
CGA	Cereal Growers Association (Kenya)
COLEAD	Committee Linking Entrepreneurship-Agriculture-Development
EAC	East African Community
EAGC	East African Grain Council
F&V	Fruit and Vegetables
FARA	Forum for Agricultural Research in Africa
FCAPT	Federal College of Agricultural Produce Technology
FCDO	Foreign and Commonwealth Development Office (UK)
FIIRO	Federal Institute of Industrial Research Oshodi
FLW	Food Loss and Waste
FMARD	Federal Ministry of Agriculture and Rural Development
FPC	Fresh Produce Consortium
FtF	Feed the Future (USAID)
FW	Food Waste
FUNAAB	Federal University of Agriculture, Abeokuta
GAIN	Global Alliance for Improved Nutrition
GIZ	German Development Agency
GMB	Grain Marketing Board
Govt	Government
HLPE	High Level Panel of Experts
HQCF	High Quality Cassava Flour
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICTs	Information Communication Technologies
IDRC	International Development Research Centre
IGAD	Intergovernmental Authority on Development
IISD	International Institute for Sustainable Development
IITA	International Institute of Tropical Agriculture
JICA	Japan International Cooperation Agency
KALRO	Kenya Agriculture and Livestock Research Organisation
KI	Key Informant

LGB	Larger Grain Borer (*Prostephanus truncatus*)
L&MICs	Low- and Middle-Income Countries
LUANAR	Lilongwe University of Agriculture and Natural Resources
MASEP	Markets and seed project
mc	moisture content
MITT	multi-institutional technology teams
MOA	Ministry of Agriculture
MSPs	Multi-stakeholder Processes
NAERLS	National Agricultural Extension and Research Liaison Services
NAFDAC	National Agency Food and Drug Administration and Control
NCRI	National Root Crops Research Institute
NCX	Nigeria Commodity Exchange
NGO	Non Governmental Organisations
NIFST	Nigerian Institute of Food Science and Technology
NPHMS	National Postharvest Management Strategies
PH	Postharvest
PHL	Postharvest Loss
PHM	Postharvest Management
PHMS	Postharvest Management Strategies
PPP	Public Private Partnership
R&D	Research and Development
RCC	Research Commissioning Centre
RETRAK	Retail Trade Association of Kenya
ROI	Return on Investment
RPC	Returnable Plastic Crates
SAA	Sasakawa Africa Association
SDC	Swiss Agency for Development and Cooperation
SDG	Sustainable Development Goal
SHF	Smallholder Farmer
SME	Small Medium Enterprises
SKG2000	Sasakawa Global 2000
SSA	Sub Saharan Africa
ToT	Training of Trainers
TVET	Technical and Vocational Education and Training
VC	Value Chain
WOFAN	Women Farmers Advancement Network
WRI	World Resources Institute