Food and Agriculture Organization of the United Nations

Post-harvest management: bridging gaps and embracing innovations

Food and Agriculture Organization of the United Nations

Rome, 2024

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Required citation:
Flores Rojas, M., Houmy, K., Fawole, O., eds. *Post-harvest management: bridging gaps and embracing innovations.* Rome, FAO. https://doi.org/10.4060/cd1185en

ISBN 978-92-5-138863-1

Cover photograph: © FAO/Belty Lokossa

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CHAPTER 2.
Minimizing post-harvest losses: gaps in post-harvest intervention

Abstract

In developing countries, post-harvest losses (PHL), which represent the quantitative, qualitative, nutritional, or economic loss of food commodities from harvesting to consumption, remain an important challenge and affect the food security of millions of people. Despite increased attention to PHL, a structural change in PHL is yet to be achieved. This is partly because PHL is a multidimensional challenge with multiple direct and indirect causes linked to the socioeconomic context. This chapter highlights notable gaps in post-harvest interventions regarding technology, management, finance, capacity building, innovations, and weak data availability. The importance of sustainable business models is also demonstrated as post-harvest technologies need to be profitable in the long term to facilitate adoption and scalability. This chapter also stresses the importance of using a system approach to achieve a sustainable reduction of losses, involving stakeholders from the beginning through a value chain approach. This approach enables the definition of a common vision, identification of gaps from different perspectives, collaborative creation and design of inclusive interventions, and promotion of collaboration, coordination and co-learning. Strong public and private sector investments are needed to achieve a sustainable reduction of PHL. This chapter concludes by reiterating there are no universal solutions to addressing PHL, and the technologies promoted must be adapted to the local context or sourced locally.

Keywords:

post-harvest loss mitigation; technologies; business models; finance; system approach; value chain

Introduction

Post-harvest losses (PHL) are a global issue with a significant impact on food security, livelihoods, and the environment. Post-harvest losses can result in a decrease in the quantity of food available for consumption, which can lead to increased food insecurity and malnutrition. Additionally, PHL leads to a reduction in food quality through deterioration of nutritional quality due to poor food handling and storage practices. This is particularly problematic in developing countries where food and nutrition insecurity is already a significant concern. PHL also has environmental consequences as resources used to produce this food (agrobiodiversity, soil, water, fuel, labour etc.) are wasted. This results in economic losses for farmers and other factors in the food supply chain. Furthermore, improper drying, due to irregular post-harvest dry spells, has led to high aflatoxin infestations in cereals, nuts, and pulses, jeopardizing the health of the consumers and making it more difficult for farmers to protect their crops from post-harvest losses. Minimizing PHL is considered a priority and is aligned with the Sustainable Development Goals (SDGs), particularly 12.3 which aims to halve global food waste by 2030 at retail and consumer levels as well as reducing PHL losses along production and supply chains. This target recognizes the pivotal role that reducing food waste and losses plays in achieving sustainable development, especially in food and nutrition security, reducing greenhouse gas emissions, and improving the use of resources. Achieving this target would mean more food available for consumption, thereby alleviating pressure on already strained food systems, and helping to ensure that food is used efficiently. Food loss and waste also impact other SDGs, such as SDG 2 (zero hunger), SDG 13 (climate action), and SDG 15 (life on land).

The SDGs report of 2022 highlighted that too much food continues to be lost, particularly in sub-Saharan African (SSA) countries, that have the highest food insecurity and the highest percentage of food loss (UN, 2022). A study by the United Nations in 2022 reveals a relatively constant percentage of food loss in SSA since 2016, indicating a lack of structural changes in patterns of food loss. Hanson and Mitchell (2017) revealed that decision-makers are either unaware or sceptical of the business case for reducing food loss and waste.

Delgado *et al.* (2021a) highlighted the challenges in addressing PHL, among them being the lack of accurate data on the amount of food lost (including quantitative and qualitative loss). There is also a lack of evidence on the drivers and root causes of PHL. There is a risk that without understanding the root causes of post-harvest losses, interventions may only scratch the surface and leave the root causes unaddressed. Organizations such as FAO have emphasized the importance of understanding and developing solutions to address these challenges.

The absence of international consensus on terminologies where ‘post-harvest loss’, ‘food loss’, ‘food waste and food loss and waste’ are used interchangeably poses a challenge. Additionally, methodologies used to appraise PHL vary in objectives and scopes adding to the complexity (Delgado *et al.*, 2021a; Kok *et al.*, 2021). The causes of PHL are context dependent and could be associated with different factors including climate, technology and innovations, infrastructure, socioeconomic, environmental, and the type of commodities involved. However, as stated by Rosegrant *et al.* (2018), the reduction of PHL is not a low-cost alternative, it requires large investments and needs to be part of long-term strategies. One important challenge is the lack of evidence of the current level of losses, which is crucial for designing effective and appropriate long-term interventions and policies. In the last decade, efforts have been made to conduct food loss assessments in countries such as Cameroon, Ethiopia, Kenya, and Uganda (FAO, WFP and IFAD, 2019; FAO & Ethiopian Statistics Service, 2023; FAO, 2018a; FAO, 2018b). Following these assessments, efforts were made to introduce technologies aimed at minimizing losses. However, as reported by Stathers *et al.* (2020), these interventions primarily focus on the farm level and mainly limited to cereals, particularly maize storage. There is a notable lack of information on the impact of pre-harvest practices

and other post-harvest operations such as field drying, harvest, drying, threshing, and cleaning.
Even though the mitigation of PHL has become a mainstream topic in the last decade, there is a lot to be done. In this chapter, we have highlighted four important gaps that need to be addressed in any intervention to meet the challenge of PHL:

- Gaps in data readiness;
- Gaps in technical innovations;
- Gaps in sustainable investment for the promotion of post-harvest technologies; and
- Gaps in comprehensive and system approaches to mitigate PHL.

Gaps in data readiness

It is imperative that any solution or decision taken by farmers and those working to reduce PHL is based on data. Unfortunately, in many countries, particularly SSA, data on PHL along value chains is not readily available. As highlighted by (Stathers *et al.*, 2020) there is an "urgent need for a systematic assessment of (post-harvest) interventions across the entire value chain over multiple seasons and sites, targeting stakeholders beyond farmers". With the use of reliable data, it is possible to develop solutions that will better target all PHL occurring along the food value chain. Therefore, FAO advocates that any effort to reduce PHL must be preceded by an assessment of the post-harvest losses along the value chain. An assessment is vital to obtain a clear understanding of the root causes and identify key stakeholders. According to FAO (2018c), the post-harvest loss assessment serves the additional purpose of pinpointing critical loss points (CLP) as well as areas of minimal loss, known as low loss points (LLP). This strategic identification enables the effective direction of resources and effort toward reducing PHL where it is most needed.

Gaps in technical innovations

Generally, PHL interventions are designed to address a specific problem in a given region encompassing potential losses along the chain from harvesting to home consumption. Data from loss assessment studies conducted in different countries have been recently published and highlight various points of loss across value chains (FAO, 2018a, 2018b, 2018c; FAO, WFP, IFAD, 2019; Totobesola *et al.*, 2022). These reports have highlighted harvesting as the most frequently reported loss point while drying, including field drying, and shelling or threshing have been identified as loss points for cereals and pulses. PHL could also occur during packaging, retailing and transportation, particularly for roots and tubers, as well fruit and vegetables.

As the first step of the post-harvest activities chain, harvesting is one of the main stages of PHL. Any damage incurred during this stage can lead to a significant loss of commodities during the later stages. Damage during harvesting could be linked to the timing of harvest or improper handling, including the use of non-adapted tools, equipment and machinery, leading to mechanical damage or product loss. In the case of grain, PHL arising from harvesting timing could also be related to prolonged field drying, creating conditions conducive to insects and fungal infestation. In addition, adverse weather conditions such as high humidity and unexpected rain, stem-

ming from climate variation could exacerbate the situation. Regarding perishable goods, mechanical damage may occur due to improper handling during harvesting or packing due to the use of poor-quality materials and equipment (Yahia *et al.*, 2019).

Harvest related gaps encompass the lack of standard guidelines and training for determining the appropriate harvest date for different crops in different contexts (Dumont *et al.*, 2016). It is important to understand the underlying drivers of losses during post-harvest. Factors such as late or improper harvesting can stem from lack of labour or workforce shortages during peak agricultural activity or bottlenecks in the provision of mechanization services, such as limited access to harvesting machinery. Socioeconomic factors are also indirect causes of PHL. For example, in Southern Africa, farmers may harvest maize early to mitigate the risk of crop loss due to cattle invasion, in doing so, farmers risk further loss through humidity by storing the grain with a moisture level above 18 percent. (Ncube *et al.*, 2021). Other socioeconomic factors contributing to PHL are inefficient marketing systems, marked by lack of communication between farmers and buyers, as well as ineffective supply chains and transportation infrastructures (Yahia *et al.*, 2019).

Other gaps include the lack of small-scale combine harvesters and other post-harvest equipment that smallholder farmers could use to prevent PHL and maintain commodity quality such as dryers, shellers, threshers, sorters or storage containers for grains, harvesters, small-scale refrigerated vehicles, and packaging materials for perishables. In addition, post-harvest technologies are not often readily available locally to meet the demand, and their importation comes with high costs and subject to government regulations, thereby restricting farmers' access to these technologies (Yahia *et al.*, 2019). Adaptation of innovations to local contexts is important for effectiveness. This can be achieved through a co-creation process involving key stakeholders (Figure 2.1). For example, training local artisans in upscaling technology, as seen in the deployment of metal silos in Central America and Africa (Tefera *et al.*, 2011; FAO, 2021). This training should include basic post-harvest and business aspects, enabling artisans to start and successfully run small-scale businesses, thereby contributing to the transfer of post-harvest technologies. Practical training guidelines, such as those developed by Van Loon and Flores Rojas (2022) for machine operators, extensionists, technicians, and mechanics on the operation, maintenance and basic repair of farm machinery are a good example. FAO and CIMMYT (2018) have prepared a training manual on hire services as a business enterprise for small-scale mechanization service providers. Online modules on this topic are available in the FAO e-learning Academy in English and French.

Another important aspect of the technological challenge in mitigating PHL is the capacity development of farmers. As highlighted by Stathers *et al.* (2020), only a few studies have evaluated the impact of training on PHL mitigation. Capacity development programmes in PHL mitigation interventions generally focus on individuals. However, there is a need to consider other levels, such as organizational, cooperation and enabling environment levels. An important gap is the lack of a framework to design and implement a capacity development programme to achieve cumulative effects and strengthen collaborators' organizational and institutional capacity (Woltering *et al.*, 2022). Another aspect that is often overlooked is gender, as women frequently represent the main driving forces behind post-harvest activities. Gender aspects are discussed in Chapter 4.

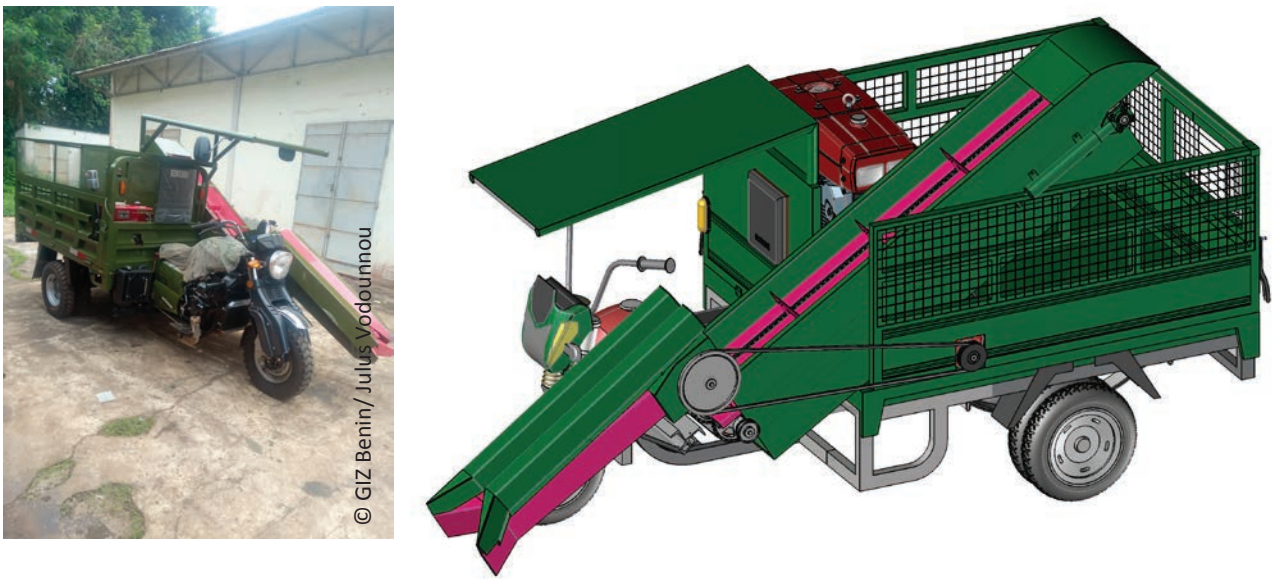

Figure 2.1. Example of a small-scale maize harvester developed in Benin (left) Design of the small-scale maize harvester (right). Source: Vodounnou, J., Ajav, E., Bagan, G., Chegnimonhan, V. 2020. Development and performance evaluation of a small-scale maize harvester for developing countries. Journal of Experimental Agriculture International 42.8 (2020): 144-156)

Gaps in in sustainable investment for the promotion of post-harvest technologies

Despite the existence of technologies for PHL mitigation, many farmers lack access to them due to the scarcity of sustainable investment for their acquisition. Common commercialization of post-harvest technologies involves demonstrating the benefits of the technology to farmers, with the aim of convincing them to invest in it, followed by direct sales. For example, cost-benefit analyses of the use of maize shellers and storage cribs in Uganda, hermetic bags for maize storage in Kenya or plastic crates for tomato handling in Nigeria have demonstrated the profitability of these technologies for smallholder farmers, making them sound investments (Balana *et al.*, 2022; Mwebaze and Mugisha, 2011; Ndegwa *et al.*, 2016). However, the decision to invest in post-harvest technology also depends on socioeconomic factors such as land ownership, the quantity of commodities produced and access to training (Bokusheva *et al.*, 2012). Yet, the profitability of post-harvest technologies depends largely on commodity prices, even though appropriate storage facilities can overcome volatility. In this context, important challenges remain in the initial cost of acquisition, farmers' risk perception, and access to (micro) credit. This is mainly due to the lack of collateral, financial illiteracy, high transaction costs, short repayment schedules unsuitable for farming characteristics and inadequate communication between the supply and demand side. Although there are leasing schemes adapted to smallholder farmers, they are relatively scarce, with one example being AgLeaseco located in Zambia (Box 2.1).

Gaps in comprehensive and system approaches to mitigate post-harvest losses

Post-harvest losses are not confined to a single segment or node within a food value chain, instead, they occur along the value chain. Consequently, effective strategies to address these losses require a varied approach involving both technical and non-technical solutions disseminated along the food value chain. Initiatives that focus solely on a single node within the food value chain are not likely to succeed.

Box 2.1. Leasing schemes in Zambia: accessing credit with small collateral

Established in 2017, AgLeaseco is an agricultural leasing company focused on improving farmers' access to agricultural mechanization by providing access to finance to acquire machinery. The business model is premised on the provision of equipment together with a set of services that include tailored financing, delivery, and training in equipment maintenance and repair. To establish a financing scheme, AgLeaseco partnered with three companies supplying agricultural machinery in Zambia (SARO Agro Industrial Ltd, BHBW Zambia Ltd and AFGRI). The scheme is based on a fixed interest of 28 percent (interest does not change) in which the leased asset (i.e. agricultural machinery or equipment) is the collateral. Farmers and entrepreneurs use them to finance agricultural machinery.

Source: Mkomwa, S., Mutai, W., Kamwendo, M., Mpagalile, J. & Jiang, S. 2020. *What opportunities for investments? Proceedings Sustainable Agricultural Mechanization Hire Service Provision Workshop,* 9–12 December 2019, Kampala, Uganda. 53 pp. Rome, FAO, and Nairobi, African Conservation Tillage Network (ACT).
Houmy, K., Flores Rojas, M. and Side, C. 2021. Agri-hire in sub-Saharan Africa – Business models for investing in sustainable mechanization. Rome, FAO. https://doi.org/10.4060/cb5071en

Typically, post-harvest interventions are generally technology-driven, demonstrating the effectiveness of specific technology in mitigating PHL. Some interventions may include pilot phases, involving the training of farmers and other stakeholders, along with direct support to farmers or cooperatives in acquiring technology. However, these technologies often struggle to reach the intended scale for many reasons, including reliance on external resources and leadership, narrow scope, and limited incentives for scaled or biased collaborations (Woltering *et al.*, 2019). As highlighted by Delgado *et al.* (2021b), PHL origins are multifaceted, which therefore requires an approach that considers the economic, social, ecological, and political dimensions of the PHL challenge. Partnerships and collaborations are also key in achieving the goal of reducing post-harvest losses.

A system approach and consideration of the whole agrifood value chain are imperative for the sustainable integration of technological innovations. Critical loss points (CLPs) in post-harvest losses, also referred to as hotspots of PHL, represent key stages in the value chain where significant losses such as quantity, quality, nutritional, or economical occur compared to other steps in the value chain. (Strecker *et al.*, 2022). However, there are existing gaps in conducting a thorough analysis of critical loss points within a given value chain to identify the most impactful leverage points, which is crucial for effective interventions.

Various methodologies, such as the FAO Food Loss Analysis (FLA) methodology (FAO, 2016) or the GIZ Rapid Loss Appraisal Tool (RLAT) (GIZ, 2021) can be employed to determine critical loss points. These methodologies generally adopt a value chain approach, yet differences in approaches across studies have been reported, making

data comparison difficult (Affognon *et al.*, 2015; Delgado *et al.*, 2021a; Kok *et al.*, 2021). Even if loss data exists at the national or sub-national level (for example, The African Postharvest Losses Information System - APHLIS), detailed knowledge of loss points within a given value chain in a specific region and their economic importance remains unavailable. Without adopting a comprehensive value chain approach encompassing all relevant stakeholders, there is a significant risk of making incorrect investments and misallocating limited resources. Examining the whole value chain, identifying the critical loss points and their economic dimension are important initial steps for deciding on appropriate technologies, innovations and intervention types.

Successful examples of the application of a value chain approach to mitigate PHL in literature are limited. A recurrent flaw encountered in post-harvest interventions is the insufficient engagement of local stakeholders and their relationships in the context of the local food system (Affognon *et al.*, 2015; Rolker *et al.*, 2022). Various stakeholders within the value chain generally have different perspectives and interests. For instance, farmers may place more value on high yields, while marketers value high-quality products with market value and low transaction costs. Therefore, any intervention designed to mitigate PHL should consider these diverse stakeholders from the outset, incorporating them into the design, planning, execution, and evaluation through a participatory approach. It is important to consider the existing PHL knowledge that stakeholders have while favouring a process of co-learning and information sharing (Gardeazabal *et al.*, 2021). Plaisier *et al.* (2019) proposed a framework for designing context-specific solutions to reduce PHL. This framework includes the selection of value chain stakeholders; the mapping of value chains (including information flows); the identification of bottlenecks; the selection of solutions with promising potential; the training of participants; the implementation of a pilot phase; and evaluation of outcomes. This approach was applied to tomato value chains in Nigeria, demonstrating a positive impact, particularly in reducing weight loss with the use of return plastic crates. However, it also highlighted important challenges that need to be addressed for successful scaling.

Scaling up post-harvest technologies, like any agricultural innovation, is a complex challenge with implications in other domains. For example, adopting hermetic technologies to avoid aflatoxin contamination has repercussions in the health domain. Therefore, any scaling intervention needs to consider the complex dynamics of agrifood systems. According to Woltering and Jacobs (2019), scaling aims to increase the use of innovations, encompassing new technologies or practices to impact many people. Therefore, tools like the “Scaling Scan” by Woltering and Jacobs (2019) and “Scaling Readiness” by Sartas *et al.* (2020) can be used to evaluate the scaling ambitions of a specific post-harvest project and devise actions for a sustainable scaling of innovations.

Examples of the scaling of post-harvest technologies are scarce. However, some success stories such as the post-harvest programme in Central America featuring metal silos for grain storage, the promotion of hermetic bags in sub-Saharan African countries, and the Yield Wise Initiative in the United Republic of Tanzania have been reported (Sonka, 2020).

All these examples included a strong and long-term involvement of development partners (USAID, Feed the Future Lab, The Swiss Cooperation and the Rockefeller Foundation) as well as governments and the private sector. Baributsa *et al.* (2014), highlighted the importance of initial financial support for market building when introducing a new post-harvest technology, demonstrating the benefits associated with farmers and other value chain stakeholders. Finally, long-term investments are imperative to achieve structural changes regarding PHL and to achieve the Sustainable Development Goal (SDG) 12.3.

Conclusion

PHL is now part of the international development agenda, particularly in developing countries, prompting investments in the last decade to mitigate them. Despite this, achieving the desired sustainable change remains a challenge, necessitating a continued commitment to reduce PHL. Several gaps have been identified in the post-harvest stages, notably during harvesting, drying, and processing, and are influenced by factors such as inadequate tools, equipment, and machinery, adverse weather conditions, and socioeconomic issues.

Additionally, limited farmer access to proven-profitable post-harvest technologies persists due to challenges like the scarcity of sustainable investment. Post-harvest losses have multiple causes and occur at various stages along the food supply chain, from harvest to retail and consumer levels. Therefore, it is imperative to ensure a value chain approach is adopted. Moreover, we need to consider that even though technologies exist to minimize losses, there are no universal solutions. Promoted technologies must be adapted to the local context or sourced locally. Addressing PHL will require a system approach and the engagement and collaboration of multiple stakeholders, including farmers, governments, the private sector, civil society, and consumers at a local level. Sustainable changes will only occur if all the stakeholders of a specific value chain in a given context collaboratively shape a new configuration that allows sustainable PHL mitigation, considering the three pillars of sustainability: economic, environment and social.

Future investments in post-harvest should prioritize long-term and sustainable changes, focusing on gathering evidence regarding critical points of losses, the direct and indirect causes of losses, and evidence regarding successful interventions using a value chain approach embedded in a conducive environment.

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