A holistic approach to food loss reduction in Africa: food loss analysis, integrated capacity development and policy implications

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Abstract
Food insecurity in the African context is a critical issue; yet total food losses are estimated at 15.9% and 17.2% in quantity and in caloric value, respectively (FAO, 2019). Currently across the continent, there is insufficient funding and the lack of policy mechanisms to support interdisciplinary analytical approaches and data collection systems to better inform the reduction of food loss. This paper highlights the critical need for a paradigm shift of current research and development programs aimed at food loss reduction, as demonstrated by findings of a project implemented in Burkina Faso, the Democratic Republic of Congo and Uganda by the United Nations Rome-based Agencies (RBAs) – The Food and Agriculture Organization of the United Nations (FAO), the International Fund for Agricultural Development (IFAD) and the World Food Programme (WFP). Quantitative and qualitative food loss data generated by applying the FAO Food Loss Analysis (FLA) methodology to identify critical loss points in the supply chains of nationally prioritized staple food crops, informed the development of practical knowledge-sharing tools and policy guidelines on food loss reduction and contributed to the development of a comprehensive approach for mainstreaming food loss reduction strategies and solutions into national strategic frameworks. Furthermore, a holistic approach that integrates multi-stakeholder engagement, and evidence generation through the implementation of pilot activities to shape local and regional policies and strategies proved essential to the realization of beneficial outcomes in the respective countries. The project also recognized the critical importance of integrating gender considerations and particularly the inclusion of women in harvest and post-harvest operations and in decision-making. All of these outcomes have contributed to the advancement of knowledge and strategic approaches toward reducing postharvest loss, achieving SDG target 12.3 and meeting the targets set by the Malabo Declaration. In short, the project effectively translated commitment into action in all three beneficiary countries.

Keywords Multi-sectoral and multi-stakeholder approaches · Post-harvest management policy formulation · Food loss reduction · Malabo Declaration · Sustainable Development Goal12 · Target 12.3
1 Introduction

Global attention to food loss and waste (FLW) reduction is reflected in the 2030 Agenda for Sustainable Development, particularly in the Sustainable Development Goal 12: Responsible Consumption and Production. SDG target 12.3 specifically seeks to “halve per capita global food waste at the retail and consumption levels and reduce food loss along production and supply chains (including postharvest losses) by 2030.” Achieving SDG target 12.3 by 2030 will necessitate accelerating the pace of actions. Reducing FLW will bring about benefits for society as a whole by improving food security and nutrition (SDG 2), contributing to gender equality (SDG 5), reducing greenhouse gas emissions (SDG 13), lowering pressure on water (SDG 14) and land (SDG 15) resources and can increase productivity and economic growth (SDG 8).

According to the FAO flagship publication titled The State of Food and Agriculture (FAO, 2019), “Food loss and waste reduction should be seen not only as a goal in its own right but also as a means toward achieving other objectives.” Food loss reduction must accordingly complement increasing crop productivity toward sustainably feeding increasing populations. This is particularly important in Sub-Saharan Africa where the population is projected to double by 2050 (UNDESA, 2017), and more than one-third of the world’s undernourished (282 million) currently live (FAO et al., 2021c). Based on food loss estimates documented by the African Postharvest Losses Information System (APHLIS) a World Bank study estimated that improved postharvest management to reduce food loss has the potential to avoid food losses equivalent to the food and nutrition requirements of 48 million people in sub-Saharan Africa SSA (World Bank et al., 2011).

Using 2016 data, the FAO Global Food Loss Index (GFLI) – an indicator which focuses on the supply stages of food supply chains, and measures changes in percentage losses between harvest and distribution over time, estimates that globally (FAO, 2018b), 13.8% of food produced is lost from postharvest up to, but not including the retail level (FAO, 2019). On the African continent, when calculated based on physical quantities and calorific value, 15.9% and 17.2% of the food produced respectively, is lost. Losses in cereals and pulses take place mainly during on-farm postharvest operations storage, and during processing and packaging (FAO, 2019).

Effectively reducing food loss necessitates policy frameworks at the national, regional and international levels that promote the coordinated action of all stakeholders. To achieve this, a Voluntary Code of Conduct (CoC) for Food Loss and Waste Reduction that presents a set of internationally recognized, nationally adaptable guiding principles and standards for responsible actions, was developed by FAO through an inclusive process (FAO, 2021a). The CoC includes practices that Governments and other stakeholders can voluntarily apply to effectively reduce FLW while promoting sustainable and inclusive agriculture and food systems.

In the framework of specific actions for food loss reduction in Africa, it is important to underline that one of the commitments made by the African Union Commission (AUC) in Malabo, Equatorial Guinea, in June 2014 was to “end hunger in Africa by 2025” through “halving the current levels of postharvest losses” (AUC, 2014). Subsequently, a number of food loss analysis studies were commissioned and carried out in African countries to contribute toward meeting both SDG target 12.3 and the AUC targets. Due to scarcity of food loss data and challenges with measurements, a methodology was developed by APHLIS to estimate quantitative and nutritional food loss (Hodges et al., 2014). The loss calculation algorithm of the methodology now integrates consideration for economic and nutritional loss for cereals, legumes and roots and tuber crops (Stathers et al., 2018, 2019). In addition to transnational actions, a number of regional and national strategies were launched in Africa to prevent and reduce food losses, with a specific focus on postharvest losses. The key strategy at the continental level, is the African Union Postharvest Loss Management Strategy, launched in 2018, which aims at facilitating and building the capacity of post-harvest actors to reduce post-harvest losses in order to increase incomes and food and nutrition security (AUC, 2018). The distinction between food loss and food waste is important as the causes and the nature of interventions in each case, are different. This paper brings in a concerted focus on food loss.

Low-income countries tend to focus on improving food security and nutrition, in addition to the sustainable management of land and water resources. This calls for a focus on reducing food loss early in the supply chain, including at the farm level, and in traditional food supply chains where impacts are the greatest and losses tend to be the highest. There may be trade-offs between objectives, and choices may have to be made about which objectives to prioritize.

A 2017 IFPRI (IFPRI, 2017) study concluded that most food loss takes place at the farm level, but also observed that the causes often relate to factors beyond the farm, associated with poor food value chain integration – inadequate storage, packaging, transport and processing capacity – leading to poor handling of produce at the farm level.

Inefficiencies at the farm level and unequal access of vulnerable groups and particularly women and youth, to key productive resources contribute significantly to food loss – both qualitative and quantitative – and food insecurity, in Sub-Saharan Africa.
Women play a key role in grain postharvest operations as they are largely responsible for the management of drying, shelling/threshing, cleaning and storage operations as well as the income derived from these activities; yet they are more disadvantaged than men in the context of value chain operations due to gender-based inequalities. The gender disparity particularly applies to labor and income management, and postharvest asset access and ownership (Manda & Mvumi, 2010; FAO, 2018a; APHLIS, 2019). This paper discusses and provides evidence to illustrate how food loss analyses conducted in three African countries (Burkina Faso, the Democratic Republic of Congo and Uganda) using the FAO Food Loss Analysis Methodology (FAO, 2016), contributed to the identification of critical loss points in the food supply chains, promoted a multi-sectoral and multi-stakeholder approach to food loss reduction, and contributed to informing and developing local and regional policies and strategies.

2 Methodology

For the purposes of the work reported in this paper, the following definitions (FAO, 2019) were adopted:

1. Food loss and waste are defined as the decrease in quantity or quality of food along the food supply chain.
2. Empirically, food losses occur along the food supply chain from harvest to, but not including, the retail level. Food waste, on the other hand, occurs at the retail and consumption level.

3 Project locations and crop value chains

Burkina Faso, the Democratic Republic of Congo (DRC) and Uganda were selected as pilot countries for the implementation of field level project activities. These countries present different agro-ecologies (dry and humid), different socio-economic contexts and benefit from developmental support to value chain development from the United Nations Rome-based Agencies (RBAs). Higher impacts in postharvest loss reduction were therefore expected to be achieved due to synergies among on-going projects and opportunities to collaborate with local supply chain actors.

Key criteria for the selection of value chains for the implementation field level activities in the framework of this project, were the scale of production, linkages to agro-food processors and/or urban markets, the level of organization of producers, availability of infrastructure, land availability, regulations and the prevailing business climate in the country.

Data collection in Burkina Faso, took place in Boucle du Mouhoun (for sorghum), Hauts Bassins (for maize) and Nord (for cowpeas); in Kwilu (for maize) and Central Congo (for maize and rice) in the Democratic Republic of Congo; and in Northern Uganda (for maize, sunflower and dried beans). Table 1 summarizes the relative importance of agriculture and the main crops cultivated in each of the three pilot countries.

4 Elements of the multi-dimensional approach taken

The rationale for the development of a food loss management strategy at both the national and continental levels was driven by recognition of the relatively limited attention accorded to postharvest, as compared to crop production in Sub-Saharan Africa, where the impacts of food losses on food security and nutrition are significant. An integrated multi-disciplinary approach was taken to address the complex and often interrelated causes of post-harvest losses toward the identification of solutions that could be feasible from the technical, economic, social and environmental perspectives, involving stakeholders at different levels.

The major causes of loss were identified at micro, meso, and macro levels respectively: the causes at the level of individual value chain actors; those that relate to the level of efficiency of their organizations and the causes that require actions at the institutional level such as investment in infrastructure, policy and, strategy development and regulatory frameworks (HLPE, 2014). The multidisciplinary approach was centered around three main pillars: (i) food loss analysis and the identification of critical loss points, underlying causes of losses, recommendations and feasible solutions; (ii) capacity building of stakeholders at different levels; and (iii) support to the development of food loss reduction policies and strategies and related effective engagement with actors (Fig. 1).

(i) The FAO Food Loss Analysis (FLA) methodology

The FLA methodology applies a case study approach to assess location-specific quantitative and qualitative data (FAO, 2016). The methodology identifies critical loss points along food supply chains. These critical loss points are locations at which food losses have the highest magnitude, the greatest impact on food security and the largest economic impacts (FAO, 2019). The FLA helps to identify the underlying causes of these losses, feasible solutions and ultimately serves to inform strategy and policy development (FAO, 2016) for food loss reduction.
The FLA methodology is based on the sequential application of five steps (i) a **screening method** that provides an overview of the subsector (the actors involved and the product flow, and a pre-identification of possible critical loss points) in the specific supply chain. This step is based on a literature review and local expert interviews; (ii) a **survey method**—that makes use of a questionnaire differentiated for different stakeholders, complemented with additional observations using checklists, semi-structured interviews and focus group discussions—to identify and assess the critical loss points and the possible major causes of food losses at different stages of the supply chain; (iii) A **load tracking and sampling method** to collect quantitative and qualitative data on the commodity “load” as it moves across the food supply chain, to identify the critical loss points and the main underlying causes of losses; (iv) a **synthesis** stage that engages local stakeholders in identifying and assessing solutions that are technically, economically, socially and environmentally feasible for intervention programs to reduce food losses, and to formulate recommendations for policies and strategies that are conducive to food loss reduction, based on the results of all of the analyses.

The FLA methodology includes a strong social, cultural and gender analysis approach that allows for the analysis of gender roles in accessing and controlling key resources, and services, the use and control of strategic resources; cultural practices (beliefs, norms and values) of men and women as economic actors, that may represent social barriers and/or hinder performance of the food supply chain; social position of men and women and their different abilities to have a voice and influence decision-making in...
the food supply chain. The methodology takes into consideration the fact that women play a critical role in harvest and postharvest activities and are normally responsible for ensuring household food security, nutrition and health.

The FLA methodology also integrates consideration for environmental analysis as food losses along the supply chain are expected to have both direct and indirect impacts on the environment and climate change. Key issues include: how food loss reduction would contribute to national climate change mitigation and adaptation objectives; the role of energy and energy access in contributing to food losses; and technology measures available to reduce food losses and to increase the use of sustainable energy in the supply chain.

(ii) **Capacity building of stakeholders**

A multi-disciplinarily team consisting of a post-harvest expert, a socio-economist and a gender and social development specialist was constituted at the national level to carry out the FLA in each of the selected countries. Each team was tasked to train national experts on the use of the FLA methodology and support them in conducting food loss analyses in the selected food supply chains.

In parallel capacity development was conducted to raise awareness on food losses, their causes and impacts, generate evidence and build the capacities of smallholders through the implementation of pilot activities designed to promote good practice at all stages of the value chain (during harvesting, shelling, drying, storage at household and community levels); training on proper use and promotion of storage equipment (hermetic bags and plastic and metal silos).

(iii) **Policy dialogue and formulation**

Data generated on food losses in the pilots conducted, was the basis for policy and strategy development in each of the three countries. These latter processes involved the engagement of policy-makers, donor agencies, and key stakeholders in the development and validation of policy briefs.

Knowledge sharing, networking, and the development of linkages among stakeholders was facilitated by the establishment of a web-based Community of Practice on food loss reduction (FAO, 2014), to share and communicate information pertinent to project activities, and to make available the FLA methodology as a global public good.

5 **Results**

5.1 **Food loss analysis**

Critical loss points were identified in all supply chains mainly at harvest, and during drying, shelling and threshing activities (FAO, 2019a, b, c). Inappropriate postharvest management practices such as failure to protect grains from pest infestations during storage, and lack of knowledge and suitable postharvest technologies were common underlying causes of losses. The peculiarities of specific crops, however, resulted in some differences that needed to be taken into account. The potential for aflatoxin contamination from mold proliferation that could lead to serious threats to human and animal health was also an issue of particular concern.

Differences were also observed in the case of unshelled beans that were brittle and easily shattered, thus influencing the sequence of the postharvest operations carried out. The levels of food losses at critical loss points in each of the three pilot countries are summarized in Table 2.

Results of the food loss analysis carried out in the selected grain supply chains in the three countries showed indicative levels of quantitative and qualitative losses across all countries.

Quantitative food loss refers to food that ultimately is not eaten by people. The main causes of quantitative loss include attack by pests, insects and disease prior to or during harvest; or weather conditions at harvest. Rains at harvest increase the moisture level of the grain, resulting in spoilage by mould during the post-harvest period. Poor handling of harvested grain, also results in spillage which contributes to physical loss.

Qualitative loss on the other hand, refers to food that has incurred a reduction in economic value or nutritional value and may still be eaten by people. This may include broken or discolored grains, insect and pest-infested grain and often include aflatoxin-contaminated grain.

Quantitative losses in maize were more pronounced at harvest, during shelling, on-farm storage, whilst bean and cowpea losses occurred mainly at harvest, during on-farm drying and on-farm storage. The results of aflatoxin tests carried out in Uganda showed that aflatoxin contamination was a major issue, and one that needs to be fully evaluated and addressed to inform stakeholders on the serious health risk that it poses and the dire need for good postharvest handling practice and drying, in particular, to reduce this risk.

Qualitative losses were mainly the result of improper storage practices on farm and at the trader or wholesale level that
resulted in insect and pest damage, rendering the product still edible but of a low quality. Aflatoxin contamination resulting from mold growth during storage under conditions of high temperature and humidity, particularly in the case of maize, sunflower, and cowpeas exceeded the tolerance limit for the safety of grains, highlighting the need for urgent attention to improving storage practices.

In all three countries, producer organizations were engaged in testing and in validating recommended solutions to effectively reduce losses in the supply chains. At the national level, collaboration among the implementing agencies facilitated the identification of support to scale-up successful interventions such as improved storage techniques, drying facilities, threshing machines (Table 3).

### 5.2 Stakeholder capacity building and knowledge-sharing

Stakeholders benefitted from capacity-building and knowledge-sharing in order to effectively undertake technical tasks on food loss prevention and reduction. These learnings allowed them in turn to raise awareness and to analyze the data and evidence generated to inform policy development and practice. At the centre of capacity building were the pilot activities implemented on good post-harvest management practice in all three countries, alongside training activities on the use of more efficient storage technologies (multi-layer sacks, hermetic bags and silos), and post-harvest equipment and technologies (mechanical threshers and shellers and drying technologies). Pilot activities were supported by the provision of mini-grants to producer organizations and value chain actors. In addition to the testing and demonstration of technologies, government employees, universities, and national agricultural research experts were trained to use and assess the recommended solutions to reduce post-harvest loss, based on results of the FLA. Capacities of smallholder farmers were also enhanced through ad hoc community radio broadcasts that addressed post-harvest management issues.

Local capacity building proved to be key for enhancing and accelerating human, institutional, political and infra-

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**Table 2** Indicative data on food losses at the critical loss points in the selected food supply chains in Uganda, Burkina Faso and the Democratic Republic of Congo as determined by load-tracking

|                      | Uganda       | Burkina Faso | Democratic Republic of Congo |
|----------------------|--------------|--------------|-----------------------------|
|                      | Maize        | Beans        | Sunflower                  | Maize | Sorghum | Cowpeas | Maize | Rice |
| **Quantitative loss** (%) |              |              |                            |       |         |         |       |      |
| Harvesting           | 3.3          | 3.6          | 2.5                        | 3.0   | 5.4     | 10.4    | 6.0   | 12   |
| On-farm drying       | 3.0          | 1.8          | 3.0                        | -     | -       | -       | -     |      |
| Transport            | -            | 0.5          | -                          | 1.2<sup>d</sup> | 0.4<sup>d</sup> | 0.3     | -     | -    |
| Shelling/            |              |              |                            |       |         |         |       |      |
| Threshing/Dehulling: |              |              |                            |       |         |         |       |      |
| Yield/Broken         | 4.0          | 4.1          | 2.4                        | 3.7   | 0.6     | 1.1     | -     | 11   |
| On-farm storage      | 10.0         | 6.5          | 2.0                        | 1.6   | -       | -       | -     |      |
| Processing/          | 5.0          | 5.0          | 17.7                       | -     | -       | -       | -     |      |
| Transformation       |              |              |                            |       |         |         |       |      |
| **Qualitative loss** (%) |              |              |                            |       |         |         |       |      |
| On-farm storage      | 40.0<sup>a</sup> | 6.5          | 53.5<sup>c</sup>          | 2.7   | 1.6     | 27.5    | 9.5<sup>c</sup> | 18.3<sup>f</sup> | 19.0 |
| Storage at rural trader (after 4 month storage) | > 70<sup>b</sup> | 0.5          |                            |       |         |         |       |      |

Six supply chains were studied in Uganda (2 maize, 2 sunflower, 2 beans); seven supply chains were studied in Burkina Faso (2 maize, 3 cowpea, 2 sorghum); five supply chains were studied in the DRC (3 maize, 2 rice). Where measurements were replicated over two seasons or two sites in the same country, the numbers represent the mean of the replicates.

- data not available
-<sup>a</sup>% of samples positive with aflatoxin (> 10 ppb)
-<sup>b</sup>% of samples positive with aflatoxin > 30 ppb (the tolerance limit)
-<sup>c</sup>samples collected at bulking points at the village level and from farmers; aflatoxin contamination levels of 30 ppb (using Afla-kits)
-<sup>d</sup>transport to wholesaler
-<sup>e</sup>group storage
-<sup>f</sup>wholesale storage; rice cleaning at retail 4.3 %
Table 3 Summary of causes of food loss at critical points of the supply chain and recommended solutions in Burkina Faso, the Democratic Republic of Congo and Uganda

| Critical Loss Point | Causes | Identified solutions |
|---------------------|--------|----------------------|
| Harvesting          | Improper harvesting techniques due to the lack of/ inadequacy of tools; Late or early rains; Difficulty of harvesting when double cropping | Introduction of improved crop varieties and improved agricultural practices; Improved harvesting equipment and practices; |
| Transportation (of unshelled/ Un-threshed grain on-farm) | Low quality packaging of grain for on-farm transportation; Rough or improper handling and loading of bags on to transport vehicles | Introduction of better quality sacks for transportation; Improved loading and unloading of bags on to vehicles; Improve vehicles and transport systems for grain on-farm transportation |
| Drying              | Inadequate drying practices; Insufficient use of tarpaulins or other drying equipment; Mold growth resulting from insufficient drying | Improve drying practices; Use of tarpaulins as an underlay for grain drying on pavements, to prevent contamination during drying |
| Shelling/threshing, Manual pounding, winnowing/ sorting | Inadequate manual threshing practices; Difficult nature of manual winnowing; Poor performance of equipment; Uneven gender distribution of tasks | Promote the use of mechanical threshing to reduce fatigue; Use tarpaulins to gather the grain and to avoid contamination |
| Storage (at farm level) | Pest infestation; Inappropriate storage materials or disinfestation treatments not used | Apply good storage management practice (e.g. first in-first out, wherein older stocks are used prior to the introduction of new grain into the store); Use of hermetic storage equipment and hermetic bags and silos |
| Transport (at wholesaler) | Rough handling and loading of bags; Traders’ lack of funds; Pilling during transportation; Poor road and vehicle conditions | Use of tarpaulins to protect the bags from rain and moisture; Use of quality bags/sacks for grain transportation |
| Storage (Community level/ Depots/Warehouses) | Poor storage management; No disinfestation treatment of warehouse stock for pests or mold; Low quality packaging; Rough handling | Raise awareness/train warehouse personnel on good storage management practices; Use of tarpaulins to protect the bags from ripping; |
| Storage (at wholesaler) | Hygiene regulations not followed; Overstacking of storage facilities; Poor pesticide application practice | Increase the number of warehouses Ensure proper pesticide and hygienic management of grain; |
| Marketing           | Poor market infrastructure; Contaminated grain resulting from the mixture of spoiled grain with grain of good quality | Support construction of adequate market infrastructure; Control, improve and secure grain quality, equipment and packaging; |
| Processing (into flour or oil) | Inadequate milling and seed oil presses; Untrained or careless operators; Poor maintenance of equipment; Inefficient processing methods | Introduction of more efficient mills and seed oil presses; Carry out preventative maintenance of equipment; Train operators |

6 The food loss—gender nexus

In acknowledging the link between gender and food losses, the FLA Methodology recognized the different roles played by women and men in post-harvest loss reduction. Sex-disaggregated data collected, identified specific constraints and opportunities for women and men in reducing food losses. In Uganda, the scarcity of transportation from the field to the homestead was a key underlying cause of loss, as grains were carried by women through head loading. In DRC and in Burkina Faso, the limited participation of women in decision-making over postharvest tasks led to the adoption of inappropriate practices, that resulted in work-burden and ultimately to food losses. In the case of Burkina Faso, in particular, gender-related post-harvest loss factors identified, included time constraints to control pests, postponement of cutting operations at harvest – due to the need to prioritize other family activities which resulted in the increased exposure of crops to pest damage – and limited...
or no access to processing technologies for cereals. Group discussions conducted in rural villages highlighted the fact that women refused to harvest cowpea, simply because they were unaware of the final destination of the funds obtained by men from selling these products.

Evidence based on gender analysis from the Burkina Faso context, also indicated that there was a greater tendency for teamwork across both genders during maize and sorghum threshing. Women were, however, more involved in the threshing of sorghum (34.5%) and cowpeas (50.4%) as compared to men whose involvement was 17.7% and 32.7% respectively (Table 4). Men were more visible in maize shelling than in any other single category. Women were more widely involved in processing (at least 92%) and in winnowing/cleaning (at least 89%) operations across all commodities (Table 4). Men prevailed in the national trade of cereals as retailers (52.6%), collectors (62.2%), semi-wholesalers (70%), and wholesalers (100%).

The project demonstrated the relevance of gender dynamics and of developing gender-sensitive mapping, a mapping that not only provides information on actors, farms, firms, value-adding activities, and their vertical and horizontal linkages but which can also make visible women’s and men’s different participation, position and contribution in value chain activities.

Based on this analysis, it was recommended that attention be given to the importance of enhancing the access of women to facilities and equipment (such as wheelbarrows and bicycles for transporting their grain), and to increase their participation in decision-making on postharvest tasks. These actions would considerably reduce losses and limit inappropriate practices, which cause increased work-burden and ultimately lead to food losses.

### Table 4 Gender roles in postharvest operations in Burkina Faso

| Postharvest operation | Actor | Involvement by commodity (%) |
|-----------------------|-------|-----------------------------|
|                       |       | Maize | Sorghum | Cowpeas |
| Threshing/Shelling    | Men   | 28.9  | 17.7    | 32.7    |
|                       | Women | 9.4   | 34.5    | 50.4    |
|                       | Other | 1.8   | 2.3     | 0       |
|                       | All categories | 59.9 | 45.4    | 16.8    |
| Winnowing/cleaning    | Men   | 4.6   | 3.7     | 1.3     |
|                       | Women | 89    | 96.2    | 92      |
|                       | Children | 4.4 | 0.2     | 0.8     |
|                       | All categories | 2     | 0       | 5.9     |
| Transformation        | Men   | 2.5   | 0.8     | 0       |
|                       | Women | 97.3  | 98.8    | 92.6    |
|                       | Children | 0   | 0.4     | 5.3     |
|                       | All categories | 0.2 | 0       | 2.1     |

### 6.1 Policy implications

At the national level, policy-makers, donor agencies, and key stakeholders were fully engaged in the development of policy briefs conducive to food loss reduction and the integration of post-harvest management and food losses in national agricultural policies, as well as in supporting strategy development.

A postharvest loss reduction strategy and action plan compiled by the Government of Uganda with support of the project, (FAO, 2021b) brought in a focus on cereals (maize, sorghum, millet, rice and wheat), pulses (beans, peas, groundnuts,) and oil crops (sesame and sunflower). Its overall goal is to ensure that “postharvest losses across these grain value chains are reduced through four strategic objectives: 1: Promote mind set change and awareness on postharvest loss, 2: Improve the knowledge, skills and capacity of producers and key stakeholders in reducing food postharvest loss, 3: Enhance availability, accessibility, adoption and utilization of appropriate postharvest and quality management technologies by the VCA across the grains value chain, 4: Strengthen coordination and collaboration for the efficient and effective implementation of postharvest loss reduction strategic actions.”

The agriculture sector is in the frontline of reforms in Burkina Faso. A number of agricultural policies and strategies have been adopted and implemented, with significant public investment: among these the Sectoral Policy for Agro-Sylvo-Pastoral Production (SP-CPSA, 2018a), the Review of the Action Plan for the Grains and Cowpea Value Chains and the “Country Resilience” Priorities adopted in February 2016 to achieve the objective of halving losses by 2025. This “Country Resilience” document prioritizes actions to build resilience. Actions for the reduction of food losses identified in the context of this work, were integrated into the National Rural Sector Program (PNSR) (SP-CPSA, 2018b) and the National Economic and Social Development Plan (PNDES). National strategies developed highlighted women as core stakeholders, given their crucial role in harvesting and in postharvest activities and household management.

Policy options documented for the DRC, highlighted the need for: strengthening the capacities of producers and professional organizations; popularization and dissemination of knowledge and good practices, support for adaptive research on food losses, support for the transfer and adoption of appropriate postharvest technologies, meeting the specific needs of men and women, strengthening agricultural education programs and support for sector development, including capacity development of stakeholders and investments in infrastructure (transport, markets, etc.). Post-harvest loss reduction standards for different food categories and for the safe use of pesticides were developed and validated by experts.
including CODEX-DRC (on cereals, pulses, oilseeds, nuts; pesticides inter alia).

Findings and recommendations of the FLA studies have also contributed to the development of the AU Continental Post-harvest Loss Management Strategy (AUC, 2018). The strategy aims to improve food security and nutrition in AU Member States by reducing post-harvest losses in grains, horticulture, livestock and fishery products. FLA results have also inspired the development of a postharvest loss reduction strategy by the Intergovernmental Authority on Development (IGAD) (IGAD & FAO, 2019) – in line with the goals of the Malabo Declaration—which focuses on developing and implementing solutions to reduce food losses at various levels (from policy, to improved market linkages and technologies) and which is compiled on the basis of data obtained through the conduct of food loss analysis case studies. At the global level, the results of the food loss analysis studies have contributed to informing the development of the Global Food Loss Index (FAO, 2018b) to track progress in reducing losses toward meeting SDG 12.3, and in building the capacities of member countries in data collection.

### 7 Discussion

The analysis of food losses in the framework of the work reported here, was based on use of a case study methodology developed by FAO (FAO, 2016). The methodology, identified critical loss points along the food supply chain as well as feasible solutions and strategies for food loss reduction.

The innovative aspects of the work undertaken benefited from the multi-disciplinary and holistic approach that embraced multi-stakeholder involvement at all levels; the piloting of activities with stakeholders, shaping of local and regional policies based on data collected, and the understanding of the underlying causes of losses and the identification of solutions. Rather than seeing human labour, food and resources as separate systems, efforts and initiatives at the field level sought to underline their inter-dependencies, and to move beyond national, sectoral, policy and disciplinary silos to identify efficient, equitable and sustainable ways of reducing food losses through a systems approach. The food loss analysis methodology allowed detailed and context-specific insights into the identification of critical loss points and allowed in-depth, multi-faceted and efficient exploration of the complexities associated with food loss-reduction. All of these actions demonstrated how systemic changes in post-harvest loss reduction can be brought about through technological interventions such as the use of hermetic metal and plastic silos and storage bags and emphasized the importance of building local capacities through training, as well knowledge sharing and capacity building across countries, through an online Community of Practice.

The results also highlighted the importance of collecting context-specific data on food losses, thus implying that no one size fits all – that solutions to reduce food loss must be comprehensive, science-based and context-specific. The specificities of the food systems, local conditions of agriculture, infrastructure, transport and distribution as well as “cultural” habits and modes of consumption all impact the estimation of food losses, their causes and potential solutions.

Imbalanced gender relations, due to discriminatory attitudes and practices, often result in diverse constraints faced by women and men in accessing and controlling the resources needed to carry out their activities, thereby influencing the efficiency of food value chains in many ways and subsequently contributing to food losses (FAO, 2018a). Our findings reported here, highlight the importance of integrating gender-based approaches in food loss reduction activities.

Project findings and results served as inputs into the development or amendment of polices, strategies and standards by national governments and generated interest in, and commitment to allocate resources for the implementation of post-harvest loss reduction strategies. By contributing to informing the development of an Africa-wide post-harvest loss reduction strategy, results of this work contributed to advancing progress toward meeting targets set by the Malabo Declaration and to guide and accelerate the formulation of new strategic frameworks. Achievement of the continental commitment of reducing food loss in Africa would also contribute to the realization of SDG target 12.3.1, with positive impacts on food security. Further work would, however, be required to impress upon AU member states, the need to invest in food loss reduction at critical loss points and to generate reliable food loss data which can serve as indicators of progress toward reducing postharvest losses. Alignment of the AU data collection framework with the Global Food Loss Index, is also of critical importance to maximising its use and application.

### 8 Conclusion and recommendations

Reducing food loss plays an important role in ending hunger, ensuring food security and nutrition and assuring the long-term sustainability of food systems. Reducing food loss necessitates the improvement of local food systems, and warrants a thorough understanding of the local conditions
and factors that adversely impact food value chains, as well as greater attention to the barriers that limit investment in improved postharvest handling practices, technologies, and policy.

This paper has highlighted key elements of an integrated approach to address food loss reduction in selected African countries. It sought to map the harvest and postharvest stages of local agri-food supply chains, to identify their components and to rationalize the approaches taken in a coordinated, integrated multi-sectoral, multi-disciplinary and multi-institutional manner. Results of this work highlight the importance of a holistic approach to addressing post-harvest handling toward bringing about systemic change. This holistic approach was built on three pillars: (i) Application of the FLA methodology toward identifying critical loss points and their underlying causes; (ii) Multi-stakeholder engagement and capacity building at different levels; and (iii) Policy dialogue and formulation. This agenda was taken forward, using the FLA methodology and through recognition of the cross-cutting sustainability (social, economic, environmental and political) issues that characterize the food supply system.

Our findings helped to generate a number of recommendations, including practical food loss reduction guidelines and gender-related, policy and knowledge-sharing recommendations. In terms of field-related, practical recommendations, it is important to underline that emphasis should be given to good sanitation and proper management of environmental conditions (temperature and relative humidity) in the initial crop postharvest period, as these conditions are essential in minimizing food safety risks. Users of postharvest chemicals must ensure that dosages and residues conform to maximum allowable levels. The introduction of adequate and efficient equipment and technologies — particularly drying shelling/threshing and winnowing equipment—should be encouraged and made possible through ad hoc investments that recognize the cross-cutting aspects of sustainability.

Knowledge-sharing, the sharing of data and collaborative actions should be promoted. Key success factors and challenges should be documented and shared to support the development of future actions in similar contexts and to enhance replicability and long-term sustainability of interventions. At the country level, awareness-raising and training of supply chain actors in good post-harvest management practice should be promoted alongside research and data collection activities. Departments of postharvest technology should be established in tertiary academic programmes and research and extension activities strengthened to enhance the awareness of available technology for all users. Overall, the project contributed to raising awareness on food losses, their indicative magnitude and causes, economic value, possible solutions and benefits associated with the adoption of solutions to reduce food losses.

Systemic change can only happen if effective and efficient policies that support local advancements in line with the Malabo Declaration targets are developed. Such policies should be integrated with existing agricultural development policies and strategies (when and where they exist). National services and policy makers should be involved and play a pro-active role in promoting post-harvest loss reduction. Policies are in fact part of an enabling environment, where government or private sector investments can be supported and encouraged and laws can incentivize the fight against food losses.

As a follow up to this project, it is now critical that the AU incorporates and encourages the conduct of food loss analyses and the implementation of solutions to reduce food loss among its member countries so that these countries can generate data and track progress toward achieving the Malabo commitments and the SDG12.3 targets. Using the continental postharvest management strategy, the AU intervention may facilitate the commitment of resources in national budgets to support food loss reduction where public funding is needed. Continued capacity development is required to enhance data collection efforts and the implementation of loss reduction measures. This is where collaboration with the private sector is key for the assurance of sustainable action. FLA studies of this nature should not be one-off; they must be conducted on a periodic basis (e.g. every 4 or 5 years) to monitor changes and impacts over time.

Appendix

Case studies illustrating the holistic approach including food loss analyses, capacity building and policy implications

Burkina Faso

The food loss analyses (FLA) carried out on selected maize, sorghum, and cowpea value chains in Burkina Faso (FAO et al., 2019a) identified harvest, threshing, shelling, winnowing, sorting, drying, household level storage, and milling (in the case of maize flour at farmer group level) as critical loss points. The leading causes of losses included poor harvesting practices; gender inequalities and the lack of female labour as well as competing tasks for women who carry out a majority of postharvest activities; inappropriate drying practices and use of poor storage equipment and facilities that result in mould and insect infestation; lack of storage management skills; protracted
storage periods; rough handling of bags and poor transport conditions.

On the basis of these findings and recommended strategies and feasible solutions identified, capacity building activities were piloted with eleven farmers’ organizations producing maize and cowpea, as well as agricultural extension service providers, NGO staff and equipment providers. These activities included:

- Awareness raising on post-harvest losses, their causes, and potential solutions;
- Hands-on training on good harvesting and postharvest practices, and promotion and support for the acquisition of drying, shelling/threshing and winnowing and storage equipment for small farmers;
- Sensitization on improved packaging, storage, and transport practices (including sensitization on good loading/offloading practices);
- Awareness raising on gender inequalities, the participation of women in decision-making, reducing women’s workloads and the equitable management of stock to address related causes of losses.

A considerable reduction of losses was reported as a result of the capacity-building activities, which directly benefitted some 2600 households. Postharvest management solutions piloted included the use of clean cemented drying yards and tarpaulins, improved storage solutions (hermetic bags, pallets, and metal silos) and mechanized shellers. The introduction of improved storage equipment and the use of mechanized shellers promoted through the pilots reduced losses by 67 and 72 percent respectively. Overall, an estimated increase of about 8535 tonnes of maize and 103252 tonnes of cowpea were reported in the communities in which the pilots were conducted.

The evidence generated from the above approaches and a policy brief summarising the key issues and recommended feasible solutions and strategies were used to inform the Permanent Secretariat for the Coordination of Agricultural Sectoral Policies (Secrétariat Permanent de la Coordination des Politiques Sectorielles Agricoles, SP-CPSA) in Burkina Faso on the importance of mainstreaming PHL reduction in relevant policies. The project specifically supported the Secretariat in integrating recommended solutions within the sectoral agricultural policy on agricultural, forest, and pastoral production value chains that was being developed for the period from 2018 to 2027 (Politique Sectorielle—Production Agro-sylvo-pastorale PS-PSAP)(SP-CPSA, 2018b).

As a result, the PS-PSAP the first strategic objective of the sectoral policy (to increase productivity and production of agricultural, forest, and pastoral production value chains and to reduce PHL) now includes an outcome on reducing post-harvest losses by half at the farmer level. To achieve this result the main actions considered include improvement of stakeholder knowledge on the causes of losses, development of tools and instruments to reduce losses, supporting the construction of storage facilities at the community level, and technical capacity building of value chain actors.

**Uganda**

The FLAs carried out in Uganda on maize, sunflower, and beans also revealed that harvesting, drying, threshing and shellng, storage and processing (into sunflower oil and maize flour) at the community level constitute critical loss points, with major causes of losses similar to those observed in Burkina Faso as presented in Table 2.

The recommendations formulated included awareness raising on postharvest losses and the benefits of applying good postharvest management; training of trainers and value chain actors on: postharvest management and the proper use of improved equipment such as tarpaulins, drying cribs, manual threshers, hermetic bags and metal or plastic silos for storage by individual farmers; mechanized threshing machines; as well as on warehouse management for bulk ing, to producers’ groups, associations and service providers. Recommendations also addressed issues pertinent to gender, food safety and health risks due to aflatoxins and the inappropriate use of postharvest chemicals, as well as improving the enabling environment through access to credit and loans to facilitate the acquisition of equipment and enforcement of premium prices for stored grain of good quality.

Further to these recommendations, capacity-building activities were implemented and equipment, including tarpaulins, drying yards, hermetic bags and silos introduced. These activities benefitted 39 sunflower and 40 maize producer groups with a total of about 1600 farmers (men and women), who reported an estimated reduction in post-harvest loss ranging from 48% to about 26% as a result of the improved practices.

These recommendations and results from the FLAs and the pilots informed formulation of the Uganda National Postharvest Loss Reduction Strategy and Action Plan in grain value chains, which is anchored around the following objectives: 1: Promote mind set change and awareness on postharvest losses, 2: Improve the knowledge, skills and capacity of producers and key stakeholders in reducing food postharvest, 3: Enhance availability, accessibility, skills, adoption and utilization of appropriate postharvest and quality enhancing technologies across grain value chains, 4: Strengthen coordination and collaboration for the efficient and effective
implementation of strategic actions to reduce postharvest losses.

The Democratic Republic of Congo

The FLA studies carried out on rice and maize in selected supply chains highlighted high levels of losses at harvest, and during threshing, hulling and storage at the farmer and trader levels (Table 2). The underlying causes of losses included inappropriate harvesting practices (harvest of immature crops), exposure to rodent and insect attack, insufficient drying causing mould contamination of the grain, and poor and inadequate storage structures that do not adequately protect the grains. Losses during storage were also the result of inappropriate handling and drying of crops. In addition, gender inequalities affecting women were also reported to be an underlying cause of losses.

Recommendations from the FLA studies carried out in the DRC included the need for: awareness-raising of producers on postharvest losses; capacity-building of value chain actors and agricultural extension service staff on postharvest management practices; and the promotion of postharvest equipment for smallholder farmers and producers’ groups. Training of actors involved in grain storage at bulk points on good warehouse management and to build the capacity of inspection services to enforce the application of standards for grain storage was also recommended. Based on the results and recommendations of the FLA studies, pilot activities focused on providing hands-on training and the introduction of improved equipment including tarpaulins, dryers, plastic and metal silos, manual threshers and dehullers, to four producer associations having a total membership of about 4,000 farmers (men and women). The beneficiaries reported a reduction in losses ranging from about 30% or higher to 10% or less.

A policy brief documenting lessons and recommendations for policy makers was developed and validated through the conduct of broad stakeholder consultations. Following these consultations and advocacy, support was requested by the DRC Ministry of Agriculture for the formulation of postharvest loss reduction standards for grains and for other food products. Standards were accordingly developed by a team of national experts, supported by the project, for nine food categories as well as for the judicious use of pesticides. The enforcement of these standards across the different food categories is expected to considerably reduce postharvest food losses while ensuring food safety.

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Declarations

Conflicts of interest The authors declared that they have no conflict of interest.

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