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REPORT

Food loss and waste in maize, potato, fresh fruits, and fish value chains in Kenya

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Foreword

By 2050, the global population is projected to exceed 9 billion. This poses a major challenge and raises an important question: how can the world secure a sufficient food supply while fostering social and economic development and reducing strains on ecosystems, climate, and water resources? One key solution is reducing food loss and waste (FLW).

In Kenya, approximately 15 million people—28 percent of the population—face food insecurity. Yet, 30–40 percent of food is being lost or wasted between production and consumption. These losses have significant economic, social, and environmental impacts – depriving farmers of income, increasing household financial strain, worsening food insecurity, and contributing to climate change through greenhouse gas (GHG) emissions. As such, tackling FLW presents a triple-win opportunity: feeding more people without increasing production, enhancing livelihoods by strengthening value chains and cutting costs, and reducing environmental impacts, including lowering GHG emissions.

Despite these clear benefits, many farmers, businesses, and government entities struggle with limited capacity to accurately measure, analyze, and report FLW. This challenge makes it difficult to not only justify investments but also track progress toward reduction goals. Furthermore, weak policy coordination and implementation hinder effective action, with existing government strategies often lacking targeted incentives to drive FLW reduction.

This report urges agribusinesses, governments, research institutions, and other value chain stakeholders to adopt the "Target-Measure-Act" approach to reduce food loss and waste by half by 2030. It is a proven strategy that works because (1) setting clear targets fosters ambition, which drives action, (2) measuring FLW enables better management, and (3) impactful change is achieved through concrete action. This report provides insights into the extent of food loss and waste across key value chains, identifies critical loss points and root causes, highlights possible interventions, and examines policy gaps. To scale up FLW reduction efforts, it outlines seven actionable interventions that public and private sector actors in Kenya can implement.

The findings in this report are based on an extensive review of published and grey literature, key informant interviews, and market observations. The analysis focuses on the maize, potato, fresh fruit (mango, banana, avocado), and fish value chains—selected for their dietary/economic role as staple foods (maize, potato, banana), nutrient-rich sources (fruits and fish), and commercially significant commodities (mango and avocado).

Reliable and consistent data are essential for shaping interventions, informing policy decisions, and tracking progress in FLW reduction across the country. Our hope is that this report inspires collective action toward a more sustainable and food-secure future.

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Executive summary

Food loss and waste in Kenya exacerbate food insecurity—currently affecting more than 15 million people—lead to economic losses of an estimated KES 72 billion ($578 million) a year, and worsen environmental challenges. Critical resources like land, water, and energy go to waste while also contributing to climate change through greenhouse gas emissions. Despite Kenya's commitment to reducing FLW under the 2014 Malabo Declaration and SDG 12.3, a lack of robust monitoring, standardized measurement methods, coordination, and financing hinders progress. Without clear data and accountability mechanisms, stakeholders struggle to implement effective solutions and set meaningful reduction targets.

HIGHLIGHTS

- Food loss and waste (FLW) reduces the quantity and quality of food available for consumption. It contributes to economic loss—US$578 million annually in Kenya — and methane emissions due to anaerobic decomposition in dump sites and landfills.
- Losses, especially for fruits, are significantly higher in produce destined for domestic markets compared with export markets (e.g., 35 percent vs. 15 percent in avocado).
- With investments in innovative solutions, economic, social, and environmental returns would be substantial.
- There is high variability in FLW estimates: 20–36 percent for maize; 19–22 percent in potato; 17–56 percent in mango; 15–35 percent in avocado and 7–11 percent in banana. Losses in fish at Lake Turkana are estimated at 34 percent.
- The variability in estimates could be explained by complex supply chains with overlapping interactions between actors and value chain stages and failure by most studies to account for waste and destination for food removed from the supply chain.
- There is need for adoption of contextualized national protocols for measuring FLW to inspire stakeholders to set targets and act against the problem.
- There is a need to put in place institutional arrangements for the coordination of FLW reduction interventions and efforts.

Context

Food loss and waste (FLW) is exacerbating food and security, livelihood, and environmental challenges. In a country where an estimated 15 million Kenyans (28 percent of the population) face severe food insecurity, FLW is substantial and an unfortunate reality. FLW implies reduced availability of food to feed the hungry population and a direct loss in income for producers and traders. FLW accounts for KES 72 billion ($578 million) loss annually in Kenya. In addition, it is a wastage of scarce resources—land, water, and energy—when food is lost or wasted. FLW not only puts pressure on the constrained resources but may drive expansion of food production into fragile ecosystems to meet demand. FLW also contributes to climate change through greenhouse gas (GHG) emissions released when the discarded food decomposes.

Kenya is a signatory to the 2014 Malabo Declaration calling on the African Union (AU) member states to reduce postharvest losses by 50 percent by the year 2025. The country has also made a commitment to address FLW under Sustainable Development Goal (SDG) 12.3, which aims to halve the per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including postharvest losses by 2030. To address food loss and waste, a three-pronged approach called Target-Measure-Act has proved to accelerate results and has been widely promoted for adoption. But Kenya lacks a robust mechanism for monitoring FLW, which presents bottlenecks to understanding the extent of FLW and underlying causes and drivers, as well as solutions and priorities for its reduction. Existing estimates in Kenya are often based on nonstandardized methods and primarily focus on quantity losses, while paying little attention to quality loss and waste. This undermines the credibility of the estimates and reduces their comparability. These gaps limit stakeholders—the government, businesses, and farmers' associations—from effectively setting their own targets for reducing FLW and addressing demand for solutions. Additionally, the lack of coordination mechanisms and limited financing have constrained the implementation of interventions aimed at reducing FLW.

About this report

This report is a collaborative effort between World Resources Institute Africa (WRI Africa), the Food and Land Use (FOLU) Coalition, Kenya, and Jomo Kenyatta University of Agriculture and Technology. The report seeks to bridge the gap in available knowledge on the issue of FLW in Kenya, placing emphasis on the gaps in the

evidence of the magnitude, critical points of loss and waste, underlying causes and drivers, available FLW reduction interventions, and policy limitations to tackle the problem. The report provides actionable recommendations for public- and private-sector actors in efforts to address the challenges of FLW in Kenya.

Informing this report was an extensive scoping review of published and gray literature covering the topic of FLW in Kenya. To triangulate the findings from the scoping review and gather additional relevant information, 24 key informant interviews were conducted, along with observations in food retail markets. This issue focuses on maize, potato, fresh fruits (mango, banana, and avocado), and fish value chains. These commodities were selected because of their role as main staples in diets (maize, potato, banana), commonly consumed nutrient-dense foods (fruits and fish), and market orientation (mango and avocado).

Key findings

We find that the FLW estimates in the literature are scanty, fragmented across and within value chains, and less comparable, leading to a gap between research results and what policymakers and other stakeholders need to set as targets for reducing food loss and waste. The existing literature focuses on quantity loss with less attention to quality and nutritional loss and waste. There are also wide variations in estimates even within the same value chain, which could be explained by the differences in the stages of the value chain reported. In fact, some studies only report on loss, suggesting that the magnitudes may be higher if waste estimates are accounted for.

There are gaps in the evidence on the critical points of loss and waste and interventions to tackle the problem across the selected value chains:

- **Maize:** Estimates in the literature are only available for loss and not waste. There is a wide variability of estimates of quantity loss from 20 to 36 percent. Except for the Food and Agriculture Organization (FAO), all the other studies only report loss at storage, suggesting that the estimates could be higher if the studies considered all the other stages. While the storage losses account for at least 70 percent of total losses, there is lack of distinction between losses occurring at on-farm and off-farm storage. Despite having significant economic and public health impacts, the assessment of loss due to aflatoxin contamination has received limited attention in the literature. There is also a lack of clear approaches for adjusting or standardizing data drawn from experimental studies with those collected on non-intervention or treatment settings. While there are several FLW reduction technologies being promoted in maize, uptake is limited. Similarly, evidence of the effectiveness and economic feasibility of various FLW interventions is limited.

- **Potato:** Based on the limited number of available studies, the quantity loss in the value chain is 19–22 percent and 9 percent quality loss. However, there are several gaps that limit comparability of the findings. First, there are differences across the studies on what constitutes food loss and waste. Some studies consider all the deteriorated potato as loss; while others consider the reduced value arising from the damage. Second, the reviewed studies focus on loss with limited attention to waste (at the retail and consumption stages). Even for the studies that report the retail stage, there is limited disaggregation across the retail outlets, particularly supermarkets. Last, there is limited understanding of the suitability of the interventions in different contexts.
- **Fresh fruits:** The reviewed studies show a wide variability in reported estimates within and across different fresh fruits. Mango has the highest FLW (17–56 percent), followed by avocado (15–35 percent) and banana (7–11 percent). Although the retail stage is the most critical point of FLW, some studies do not report estimates for the stage, which might explain the lower end of the range. Despite the rising importance of supermarkets in the supply of fresh produce, there are few studies which pay attention to this retail channel. Similarly, there are few studies which report on loss at processing. While there are efforts to demonstrate the feasibility of FLW reduction interventions in fresh fruits (mainly through experimental studies), understanding of their viability at commercial scale is limited.
- **Fish:** There are few studies documenting FLW in fish, and the results indicate differences among species and across fishing sites. While the quantity losses are minimal in Lake Victoria (2–4 percent), the magnitudes are much higher in Lake Turkana (34 percent). This

is associated with higher ambient temperatures and poor infrastructure in Lake Turkana. For silver *cyprinid*, locally called omena, quantity losses range from 6–7.5 percent but only account for harvesting, transportation, and processing. This suggests that the magnitude may be higher if all the stages of loss and waste were accounted for. Quality losses are higher in tilapia (up to 28 percent) compared to omena (9 percent). Based on the studies reviewed, evidence of magnitude and critical points of loss is not sufficient to enable identification of appropriate technologies to target and reduce FLW in the value chain.

Kenya lacks a coordinated policy framework to support the reduction of FLW. Despite being a signatory to global and regional commitments with set targets for FLW reduction, and recently launching the Post Harvest Management for Food Loss and Waste Reduction Strategy, Kenya lacks a clear mechanism for measuring and reporting any progress toward these targets.

To address the gaps, there is need to develop holistic food strategies that will facilitate the shift from sectoral to systemic thinking, covering, among others, FLW. The process for putting in place the required policy changes will need to be evidence-based, considering several aspects, including detailed measurement of the extent of FLW along food supply chains, context-specific drivers of FLW, private and social cost-benefits of potential interventions, and how to target those interventions, including the unintended and undesired (trade-offs) implications of reducing FLW.


CHAPTER 1.

Background

Kenya faces severe food insecurity, with 15 million people affected. Yet, 40 percent of food produced is lost before consumption. Measuring and addressing FLW through the Target-Measure-Act approach is crucial for sustainable food systems, yet knowledge gaps and inconsistent data limit effective policy and intervention strategies in the country. This report seeks to bridge these gaps by providing actionable recommendations for local stakeholders to reduce FLW.

An estimated 15 million Kenyans (28 percent of the population) face severe food insecurity (FAO et al. 2024). The growth of more than a quarter of the children under the age of five is stunted (UNICEF 2023), underscoring the severe problem of the inability of many families to access a healthy diet. In 2021, about 39 percent of the Kenyan population could not afford a healthy diet. Notwithstanding these challenges, it is reported that up to 40 percent of the food produced for human consumption in Kenya is lost before it reaches the table (Liebetrau 2019; TechnoServe 2023). Furthermore, based on the 2021 Food Waste Index Report by UNEP (2021), every Kenyan throws away an average of 99 kilograms of food annually, amounting to 5.2 million tonnes of food being wasted nationally. This is a regrettable loss, which, if tackled, would not only alleviate the pain of hunger and malnutrition in the country, but also enhance livelihoods and ensure sustainability of local food systems. There are various possible causes of FLW, including poor harvesting practices, inadequate postharvest handling, and a poorly coordinated food supply chain. However, the exact causes vary significantly across different regions and time periods, largely depending on the specific local conditions and circumstances in each country (FAO 2014).

FLW implies a direct loss in income, especially for producers and traders. It is estimated that Kenya loses KES 72 billion ($578 million) annually due to FLW (Axmann et al. 2022). In a country where more than 70 percent of the population relies on the agri-food sector for a livelihood, this is dire. Moreover, amid increased calls for sustainable food systems in development policy and practice (Blay-Palmer 2016; Marsden and Morley 2014), it is critical to recognize FLW as a major threat to the sustainability of local food systems. It is a waste of scarce resources—land, water, and energy—when food is lost or wasted. This is happening in a context where the pressure put by a growing

population, declining arable land, and water constraints are threatening the viability of local food systems (Muraoka et al. 2018; Mulwa et al. 2021; Jayne and Muyanga 2012). FLW may also drive expansion of food production into fragile ecosystems (Affognon et al. 2015). For example, Searchinger et al. (2019) indicate that the extra land needed for food production results in either deforestation or a lack of opportunity to reforest. Furthermore, at a global level, it has been proved that FLW contributes to climate change through GHG emissions released when the food is thrown away (UNEP 2021). This is true for the Kenyan context.

To guide governments, businesses, farmers, and other stakeholders in their efforts to address FLW, a three-pronged approach—Target-Measure-Act—which has proved to accelerate results, has been widely promoted for adoption (Flanagan et al. 2019).[1] By setting targets, governments and companies show ambition and motivation to act. Kenya is a signatory to the 2014 Malabo Declaration, continuing as the commitments to the CAADP Kampala Declaration 2025, which targets a 50 percent reduction in postharvest losses by 2025,[2] and SDG 12.3, which aims to halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including postharvest losses, by 2030. Despite these commitments, there is limited information on the extent to which the goals have been cascaded to other stakeholders, such as businesses and farmers' associations, to enable them to set their own targets and take action. Reducing FLW requires stakeholders to measure FLW to identify critical points of loss and waste and underlying causes and drivers, share results to inspire others, and monitor progress over time.

Some subnational studies have been carried out by several scholars and development entities, estimating the postharvest losses of select crops (such as maize, fresh fruit, and potato) in select stages of the supply chain (Chikez et al. 2021; Kaguongo et al. 2014; Ndegwa et al. 2016; Njoroge et al. 2019). Measuring FLW is complex due to various stages in a value chain, methodological challenges [e.g., lack of uniformity in the definition of FLW (Box 1)], and spatiotemporal factors [e.g., locational differences and seasonality (Kruijssen et al. 2020; Luo et al. 2021)]. As such, FLW data and knowledge (magnitude, critical points of loss and waste, causes, and drivers) are often not well documented, especially in developing countries, Kenya included. While several interventions or innovations are mentioned in policy and project documents for reducing FLW, the level and scale of adoption cannot be ascertained. Evidence built on reliable and consistent data is critical for informing policy, development, and implementation of strategies (action) toward FLW reduction.

BOX 1 | Definitions

Food loss: Decrease in quantity or quality of food occurring along the food supply chain from harvest or slaughter or catch aggregation, handling, transportation, storage, and processing but excluding retail, food service, and consumption stages.

Food waste: Decrease in quantity or quality of food at the retail, food service, and consumption stages,

Quantity loss: Losses in weight and/or value when food is entirely removed from the food chain from harvesting to processing,

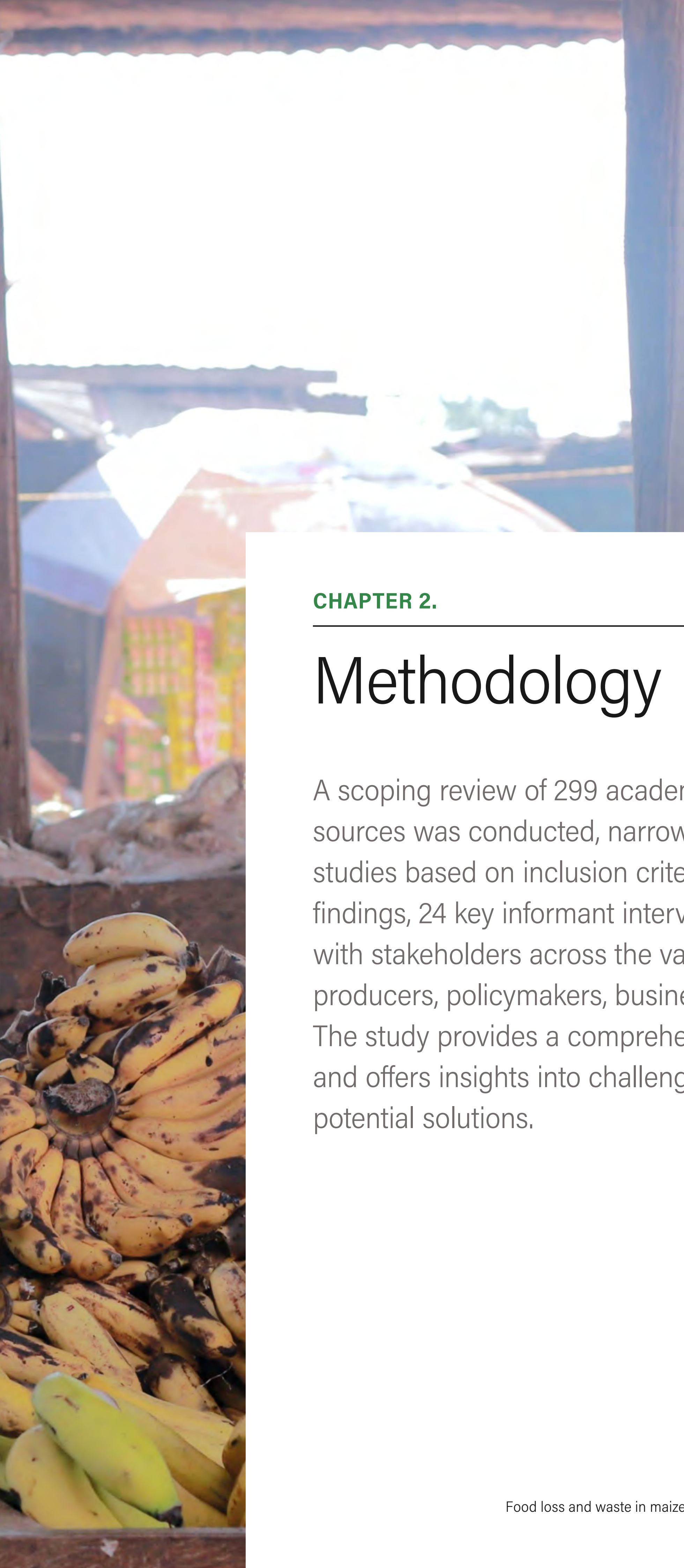
Quality loss: Losses associated with physical evidence of deterioration of the product due to damage, infestation, mycotoxins, and mold. The quality can be affected by abiotic factors such as temperature, humidity, and rain.

Economic loss: Losses in monetary value associated with the food loss or waste. This type of loss is therefore usually expressed as the difference between the initial value of the food that is lost or wasted and the current market price.

Monetary loss: This type of loss is therefore usually expressed as the difference between the initial value of the food that is lost or wasted and the current market price.

Sources: FAO 2019; UNEP 2021.

This report seeks to bridge the gap in the available knowledge on FLW in Kenya. It places emphasis on the gaps in the evidence of the magnitude, critical points of loss and waste, and the solutions available to tackle the problem. We go beyond previous studies by documenting the existing knowledge on underlying causes and drivers, available FLW reduction interventions, and policy limitations to tackle the problem. The report provides actionable recommendations for the public- and private-sector actors in the efforts to address the challenges of FLW in Kenya.



CHAPTER 2.

Methodology

A scoping review of 299 academic and gray literature sources was conducted, narrowing to 30 relevant studies based on inclusion criteria. To complement these findings, 24 key informant interviews were conducted with stakeholders across the value chains, including producers, policymakers, businesses, and researchers. The study provides a comprehensive analysis of FLW and offers insights into challenges, opportunities, and potential solutions.

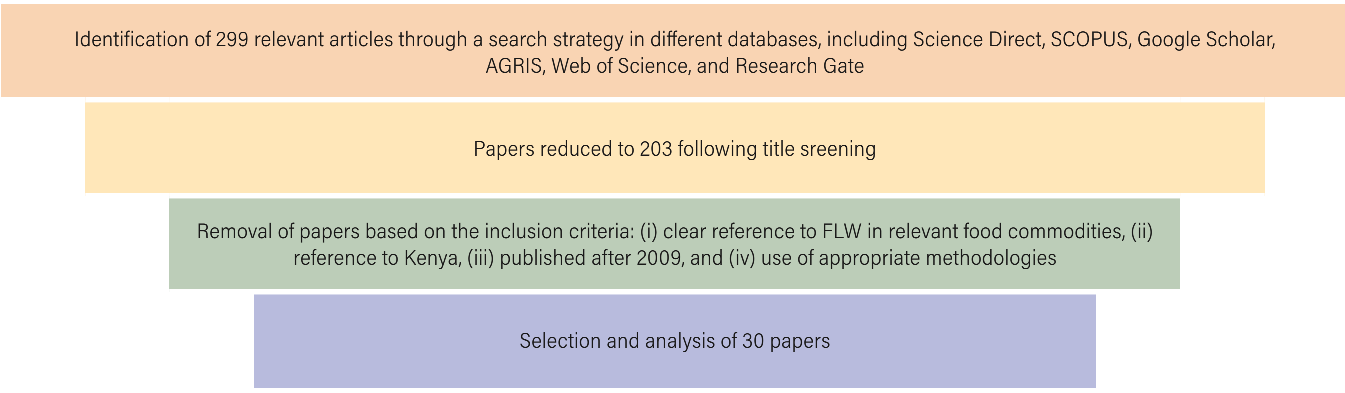
This report focuses on maize, potato, fish, and fresh fruit value chains. Maize was selected because it is the most important staple food crop, providing 36 percent of the total caloric intake in Kenya (Ekpa et al. 2019; Mohajan 2014). Potato is the second most important crop after maize for food and nutritional security in Kenya (RoK 2021). Fresh fruits were selected because they experience the highest estimated losses. Fresh fruits are also associated with the highest GHG emissions (Axmann et al. 2022). The study focused on mango, avocado, and banana because of their growth potential in terms of market share and their important role in local or export markets or both (AFA 2022). Last, fish, a highly perishable commodity, is also nutrient-dense and scarce (Kruijssen et al. 2020).

We conducted a scoping review of peer-reviewed and gray literature covering the topic of FLW in Kenya. Scoping review helps '[…] to map the extent, range, and nature of the literature, as well as to determine possible gaps in the literature on a topic' (Mak and Thomas 2022: 565). The review followed Tricco et al.'s (2018) guidelines on preferred reporting items for systematic reviews and meta-analyses. To meet the objective of this study, three major steps were followed: identification of relevant studies, screening or selection of studies, and synthesis and reporting of findings. The academic literature was obtained through scanning of common journal articles' databases, including Science Direct, SCOPUS, Google Scholar, Web of Science, Research Gate, and the International System for Agricultural Science and Technology (AGRIS). In addition, we retrieved gray literature from the top 10 pages of Google Scholar results. These included technical reports, working papers, and conference proceedings. Development partners and relevant government databases were also scanned. Search terms included keywords such as *food loss, food waste, food safety, postharvest losses, small-holder farmer*, and *innovations or solutions to address FLW*. We also consulted the FAO database on FLW for cross-referencing (FAO 2023).

The literature search yielded 299 papers from various databases based on inclusion and exclusion criteria. Articles were included if they contained FLW data or information; had explicit reference to Kenya and selected value chains; were published from 2010 onward; covered postharvest losses, including harvesting; and contained descriptions of FLW assessment methods. The period beginning in 2010 coincides with the time FLW started receiving increased attention (FAO 2011, 2019; UNEP 2021). Those that were not focused on Kenya, covered pre-harvest losses, or had limited description of how FLW was estimated were excluded. Following initial screening for relevance, the articles reduced to 203. A further review of the abstracts and summaries reduced the relevant papers to 96. A rapid full-text screening found only 52 papers to review. Excluding duplicates, the selection yielded 30 studies (Figure 1). In the review, we considered that a study applied an appropriate method of FLW assessment if a credible methodology for data collection and analysis was used, based on whether the methods used were anchored in the literature and data were analyzed and interpreted using appropriate statistical techniques. The key findings are organized around the status of FLW magnitudes (reported amount of losses or waste), critical points of loss, causes of FLW, and interventions employed to tackle the problem as reported in various sources. A subsection covers the policy environment for tackling FLW in the country.

To triangulate the findings from the scoping review and gather additional relevant information, 24 key informant interviews were conducted, along with observations in food retail markets. Key informants were identified from among stakeholders that have a direct role in implementing interventions within the selected value chains. The informants included producers, research and academia, business entities, and key actors across the selected value chain, policymakers (national government, county government, state agencies), development organizations, and consumer associations. The interviews collected information on status of magnitudes, critical points and causes of FLW, innovations seeking to reduce FLW, and challenges and opportunities. We also consulted the FAO global database on food loss and waste (FAO 2023). Data were recorded, transcribed, and organized along with each interview question. The emerging findings were then summarized along the main themes.

FIGURE 1 | Outcome of the journal articles selection process from various databases



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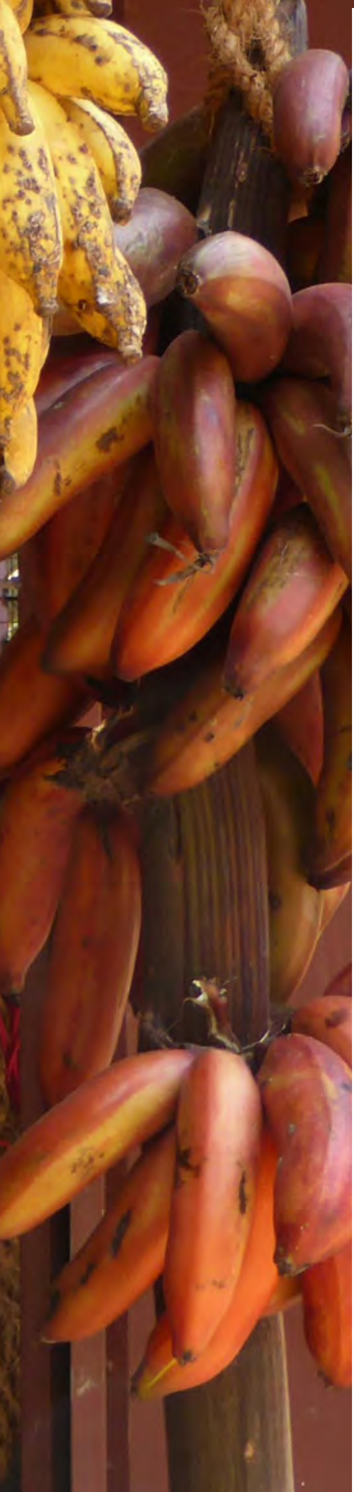


CHAPTER 3.

Key findings on food loss and waste in Kenya

This chapter examines the available evidence on food loss and waste across four key value chains in Kenya – maize, potatoes, select fruits, and fish – to determine the extent, key loss points, underlying causes, and ongoing interventions aimed at addressing the issue. The analysis highlights significant gaps in assessment methodologies and the scope of studies within these value chains, exposing a critical challenge that hinders efforts to effectively combat food loss and waste. Additionally, the chapter reviews the policy landscape related to food loss and waste reduction.

Maize value chain

Maize is an important food security crop in Kenya, accounting for providing 36 percent of the total caloric intake, which is about 65 percent of the total caloric intake that comes from food staples (Mohajan 2014). The crop is planted in 2.1 million hectares, an area that constitutes 40 percent of total arable land in Kenya (RoK 2019b). Despite the importance of maize, the country has experienced substantial demand—supply gaps in recent years associated with declining yields,[3] high levels of FLW, and high exposure to aflatoxin, a common fungal toxin associated with adverse negative health consequences (Mutiga et al. 2015; Okoth and Kola 2012; Sheahan and Barrett 2017). Kenya`s estimated demand for maize was about 4.34 million tons per year (T/year) compared to the local supply of 2.88 million MT.[4] The demand-supply gaps often lead to increased food prices, making it more difficult for vulnerable populations to access sufficient quantities of nutritious food.

Status, critical points of loss, and causes of FLW in maize in Kenya

FLW in maize is associated with different production and postharvest handling activities, including drying, shelling, sorting, grading, transportation, and storage (Figure 2). Although pre-harvest losses can be significant, they are normally not included in FLW estimations based on the assessment criteria by FAO (2019) and UNEP (2021).[5] However, activities happening at the pre-harvest stage can have implications for FLW (Mahuku et al. 2019).

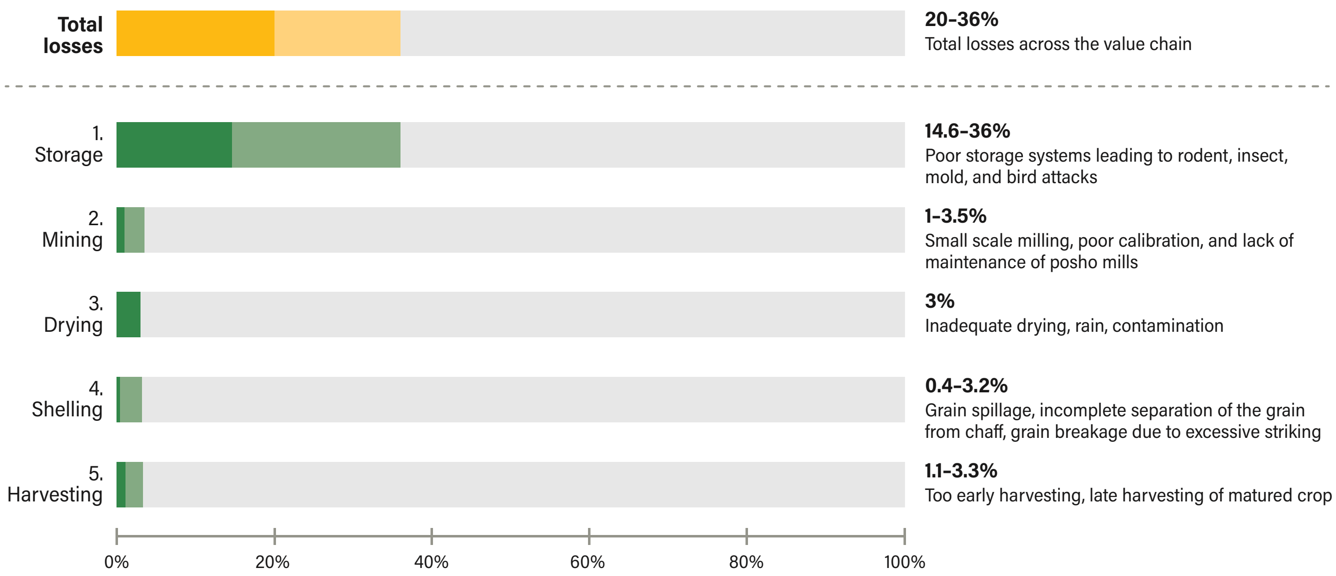
Twelve studies meeting the methodological criteria set out in the "Methodology" section were reviewed. Of the 12 studies, only 5 reported on status of loss in maize (Affognon et al. 2015; FAO 2014; Mutungi and Affognon 2013; Mwangi et al. 2017; Ognakossan et al. 2016; Ognakossan et al. 2018) with the rest reporting on the impact of loss reduction interventions (George 2011; Gitau et al. 2024; Makinya et al. 2021; Mutambuki and Ngatia 2012; Ndegwa et al. 2016; Nduku et al. 2013; Njoroge et al. 2019). Four of the five studies only report on loss at storage, with only FAO (2014) reporting losses for the pre-storage activities (drying, shelling, and harvesting). The FAO (2014) study covered two leading maize-producing regions in western Kenya, Kakamega and Trans Nzoia. Three of the five maize loss studies were implemented at the national or subnational scale (De Groote et al. 2023; Mwangi et al. 2017; Ognakossan et al. 2016) covering the country's main maize growing agro-ecological zones. As a robustness check, we reviewed systematic studies by Mutungi and Affognon (2013) and Affognon et al. (2015). We show the levels of loss reported in the studies at the different nodes of the value chain (Figure 3). Based on the five loss studies, we estimate the overall loss to be in the range of 20 to 36 percent. Storage losses account for at least 70 percent of the total losses. Other losses in the milling, harvesting, shelling, and drying account for at most 3.5 percent of the total losses. The variability in the reported estimates could be due to the differences in assessment methods, the influence of storage time, and contextual issues related to location, region, and farmer practices.

The key causes and drivers of loss at storage include infestation by insects, rodents, weevils, and molds (*Fusarium* spp.), associated with storage of grain with high moisture content. High moisture content (>13 percent), which is linked to early harvesting and the lack of equipment to measure grain moisture at the point of harvesting, increases the drying cost and makes the maize susceptible to mold, insect infestation, and low milling yields (Angelovič et al. 2018; Kumar and Kalita 2017). Maize should be harvested when the dry matter content is between 30 and 35 percent to ensure optimal yield and quality—reflected in high starch content and fiber digestibility (Kumar and Kalita 2017). The way farmers harvest and handle produce can also be explained by socioeconomic factors, such as the scale of production, fear of pilferage, how quickly farmers want to utilize the crop, availability of labor, and availability of postharvest equipment (Kaaya et al. 2005; Mutungi et

FIGURE 2 | Stages of the maize value chain where loss and waste occur in Kenya

Source: Authors.

FIGURE 3 | The state of food loss and waste in the maize value chain at different stages based on various studies in Kenya



Source: Authors' compilation.

al. 2019). Mature crops, however, can result in losses from birds, rodents, or rain. Most of the studies reporting loss at storage show the percentage of loss associated with the different causes and drivers (Table 1) (De Groote et al., 2023; FAO 2014; Mwangi et al. 2017; Ognakossan et al. 2016; Ognakossan et al. 2018).

Grain spillage, incomplete separation of the grain from chaff, and breakage due to excessive striking of the grain are the key sources accounting for loss during shelling (Kumar and Kalita 2017). This process is also linked to grain contamination with foreign materials like stones, sand, and chaff. The magnitude of loss reported at shelling was 0.4–3.2 percent (FAO 2014). The FAO study estimated the loss at drying (at the farm) to be about 3 percent, attributed to rain; contamination from soil, dust, and other particles; and attacks from rodents. Most farmers in Kenya rely on sun drying to attain the required moisture content (below 13 percent). Stooking, a process of leaning maize stalks against each other into a tee-pee-like structure, is also used where the maize must be left on the ground for further drying. The study also reports losses of up to 3.5 percent at milling because of poor calibration and lack of maintenance of small scale (posho) mills (FAO 2014).

Comparatively, the estimates obtained from the review are a bit lower (except for storage) than those found in the FAO FLW database (Figure 4). The database is the largest online collection of data on FLW (FAO 2023) often reported in scientific journals, academic publications, and gray literature, among others. Based on estimates from the database, losses significantly dropped from 31 percent in 2010 to 19.6 percent in 2014. The figures reported in 2014 are the same for the next eight years, raising questions about the accuracy of the data. Further, magnitudes of loss for the milling stage are missing, which might explain the lower end of the range. Some of the studies used to model the magnitudes in the FAO database are based on experimental studies, and it is not clear how they are adjusted or standardized with those collected in non-intervention or treatment settings. The interpretation and reporting of the data also reveal several inconsistencies. For instance, the losses in maize at storage for 2012 and 2016 are off range, going beyond 100 percent. The failure to report on causes and drivers is also a key gap. We raise similar concerns for the African Postharvest Losses Information System (APHLIS), the data from which show that the total maize loss dropped from 25 percent in 2013 to 16.7 percent in 2014. The same figure (16.7 percent) is reported for the next eight years (2014–2022). APHILIS is based on postharvest loss data derived from peer-reviewed literature (the most recent for maize is from 1986), and contextual factors provided by a network of agricultural experts from about 40 countries in sub-Saharan Africa (although Kenya is not represented in the network).

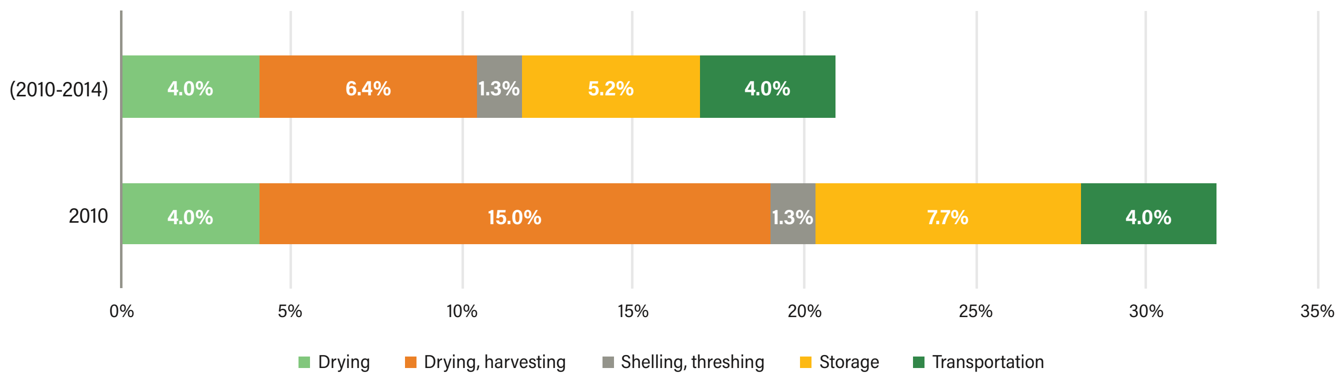
From the review, we find that the assessment of maize loss associated with aflatoxin contamination (considered to be quality loss with implications for food safety) is limited, despite its significant economic and public health impacts

TABLE 1 | Estimated food loss and waste in the maize value chain from different causes and drivers at storage level in Kenya, according to various studies

STORAGE	CAUSES AND DRIVERS
17.6± 2.3[a]	Insects (7.2± 1.0%), molds (5.7± 2.1%), moisture loss (3.4± 0.5%), rodents (2.0± 0.5%), spillage (0.50 ± 0.0%), and birds (0.10± 0.0%).
15.5 ± 0.6[b]	Rodents accounted for up to 30–43% depending on the storage method. Rodent damage was higher when maize was stored on cobs.
36[c]	Represents storage losses at farm level reported in farm maize storage due to maize weevils and larger grain borers
9.4[d]	Infestation by weevils reported as major driver
18.3[e]	Molds and aflatoxin contamination, which was higher in rodent-damaged grains

Note: For a comprehensive review of food loss and waste in the maize value chain in Kenya, please refer to the references listed at the end of this document.
Sources: Authors' compilation; a. Mwangi et al. 2017; b. Ognakossan et al. 2016; c. De Groote et al. 2023; d. FAO 2014; e. Ognakossan et al. 2018.

FIGURE 4 | Estimated food loss and waste in the maize value chain at different stages in Kenya, based on FAO FLW database



Source: Authors compilation.

(Affognon et al. 2015). Acute exposure to aflatoxins can cause hepatitis, liver failure, and death (Kang'ethe 2011; Okoth and Kola 2012). In 2005, a severe outbreak of aflatoxicosis caused the death of 125 people who had consumed highly contaminated home-processed maize (Daniel et al. 2011). A study by Mutiga et al. (2015) also reports aflatoxin contamination above the acceptable limits, even in areas not commonly considered to be hot spots. Key informant interviews (KIIs) with large millers, who account for 40 percent of the maize flour market, indicated aflatoxin contamination to be a frequent challenge for maize sourced from the southeastern counties of Kenya. However, the interviews did not reveal any specific magnitudes associated with aflatoxin, which suggests a gap in understanding. Using data from 1,500 maize samples and consumer surveys collected from clients of small-scale hammer mills in rural Kenya, Hoffmann et al. (2021) found no correlation between price and indicators of aflatoxin, implying an absence of market incentives to manage this aspect of quality loss. As observed by a key informant, there is potential to leverage existing platforms to measure FLW, including the incidences of aflatoxin.

The Eastern Africa Grain Council (EAGC) estimates FLW in maize at 30–40 percent, but we do not have our systematic data collection mechanism to support this claim. We have established a regional agricultural trade intelligence network (RATIN)—a platform that collects data on prices, and market changes, but little data is collected on FLW. We can leverage such systems to improve data collection on FLW, including the incidence of aflatoxins—Monitoring and Evaluation Official, EAGC.

Interventions to address FLW in maize in Kenya

Several interventions for reducing FLW in maize are reported in the literature. Most of these interventions are targeted at the management of storage losses and include the use of hermetic bags, warehouse receipt systems (Coulter and Onumah 2002),[6] artificial insecticides, natural insecticides, and metal silos. A study by Nduku et al. (2013) found differences in the level of loss (more than 12 percent) reported by farmers, depending on their choice of storage method.

Polypropylene bags are the grain storage method most used by small-scale farmers in Kenya (Ndegwa et al. 2016) because they are effective in reducing losses. Hermetic bags are also effective in controlling losses, but they are relatively more expensive (KES 250 for a 90-kg bag compared to KES 30 for a polypropylene bag of a similar capacity). Ndegwa et al. (2016) found that farmers using hermetic bags had 2.3 percent damaged grains by the second month, compared to 6.5 percent for those using polypropylene bags. The differences increased to 10.7 percent by the fourth month. The implication is that longer storage can increase losses when polypropylene bags are used, especially if the maize has high moisture content and lower temperatures (Angelovič et al. 2018). Providing tax rebates to make the hermetic technology affordable could be a key intervention for promoting their uptake.

Building on numerous studies (Owach et al. 2017; Shiri 2019; Soethoudt et al. 2021; Viola 2017), we assessed the key interventions for FLW reduction in maize against nine criteria for their appropriateness in the Kenyan context. The analysis considered five widely disseminated interventions available for use on a commercial scale in the country. An intervention got a positive (+) score if it was considered desirable or appropriate, or a negative (-) score if otherwise. The sign -/+ was adopted where the appropriateness or desirability was uncertain. The scoring was based on findings from the literature review (Owach et al. 2017; Shiri 2019; Soethoudt et al. 2021; Viola 2017) and with five KIIs (Table 2).

TABLE 2 | Criteria and scoring for identifying suitable food loss and waste reduction interventions in the maize value chain

CRITERIA	DESCRIPTION OF INTERVENTION Score: + = positive - = negative -/+ = neutral/uncertain	KEY INTERVENTION				
		Hermetic bags	Warehouse receipt system	Artificial insecticides	Natural insecticides/ biocontrol agents	Metal silos
Affordability	Intervention is affordable for users with low purchasing power.	-	-	+	-/+	-
Availability	Products or services are available for immediate use with minimal complications for value chain actors.	+	-	+	-/+	-
Acceptability	Intervention has higher acceptability by the users, which requires compatibility with the existing culture, social norms, and values.	+	-	+	-/+	-
Awareness	People are aware of the existence, benefits, and shortcomings of the innovation.	+	-	+	-	+
Technical feasibility	Intervention is simple and technically feasible to implement among farming households.	+	-	+	+	-/+
Adaptability	Intervention is adaptable to suit the local environment in the value chain.	+	-/+	+	+	-/+
Scalability	Intervention has potential to achieve widespread adoption.	+	-/+	+	+	-/+

TABLE 2 | Criteria and scoring for identifying suitable food loss and waste reduction interventions in the maize value chain (cont.)

CRITERIA	DESCRIPTION OF INTERVENTION Score: + = positive - = negative -/+ = neutral/uncertain	KEY INTERVENTION				
		Hermetic bags	Warehouse receipt system	Artificial insecticides	Natural insecticides/ biocontrol agents	Metal silos
Resource availability	The existence of physical and technical resources for the technology is available at the local level.	+	-/+	+	+	+
Sustainability	Intervention is aligned with environmental considerations.	-/+	-/+	-	+	+

Source: Author's compilation based on Owach et al. 2017; Shiri 2019; Soethoudt et al. 2021; and Viola 2017.

The results suggest that, except for affordability and environmental sustainability, hermetic bags have a positive score in all domains, indicating potential for success. Some studies report environmental sustainability challenges of hermetic bags associated with the carbon footprint at manufacturing, estimated at 1.1 to 1.7 kg CO_2eq per bag (Ignacio et al. 2023). Addressing issues of affordability, environmental sustainability, availability, and awareness can also help scale up natural insecticides, especially in circumstances where artificial insecticides score positive in 9 out of 10 domains. In contrast, warehouse receipt systems and metal silos appear less preferred and hold a lesser potential for FLW at scale. In practice, there are business models that combine one or more interventions. Box 2 provides private-sector solutions in Uganda and Rwanda that allow farmers to sell maize with cobs withthe firms performing most postharvest processes and therefore minimizing losses. This model is amenable to small-holder systems in Kenya and could help address maize losses. Across East Africa, the Eastern Africa Grain Council (EAGC) is supporting the production and trade of grain through Grain Trade Business Hubs (G-Hubs), where small-holder maize farmers access inputs, storage services, and market linkages, potentially minimizing maize loss (Box 3).

On food safety, Pretari et al. (2019) evaluated the impact of a package of postharvest technologies (training, plastic sheets for sun-drying, hermetic storage bags, and mobile maize drying services) appropriate for use by small-holder farmers on contamination of maize with aflatoxin through a randomized trial in rural Kenya. The results reveal that the intervention reduced aflatoxin contamination by over 50 percent. Most of this reduction appears to be due to training and the use of drying sheets, the lowest cost of all the technologies offered. Similarly, Migwi et al. (2020) reported that 96 percent of the maize met the European

BOX 2 | Maize Cob Model by Grain Pulse Limited (Uganda) and Africa Improved Foods (Rwanda)

The Maize Cob Model by Grain Pulse Limited and Africa Improved Foods is an arrangement where farmers sell their maize at harvesting and do not need to do any postharvest handling. The firm works through cooperatives and farmer groups, buys dry maize cobs with 26 percent moisture right at the farms, and performs processing from transportation to drying, storage, and marketing the maize while on the cob. The firm has trained village agents to aggregate grain from different farmers. Overall, implementers have seen a rise in quality, efficiency, and incomes for small-holder farmers in Uganda and Rwanda. Also, aflatoxin contamination is minimized. However, the model could limit the ability of farmers to participate in temporal arbitrage. Furthermore, the model's uptake in the Kenyan context has not been tested.

FIGURE B-1 | Maize on the cob

Source: Muhammad Shehu

BOX 3 | Grain Trade Business Hubs (G-Hubs) Model in East Africa

The Eastern Africa Grain Council (EAGC) is supporting the production and trade of grain through G-Hubs. EAGC has developed a G-Hub system for registration and profiling of small-holder farmers and offers services that include access to agricultural inputs, post-harvest handling equipment, machinery and services, grain storage and warehousing, capacity building and training, market information and policy advocacy, as well as market linkages. Once the grain is harvested, EAGC ensures that farmer groups aggregate, bulk, and store it in certified warehouses. Eventually, these stakeholders are linked to buyers through EAGC's trade platform called the G-Soko system.

Union regulatory threshold of 4 nanograms per gram (ng/g) of aflatoxin contamination when they used Aflasafe, compared to neighboring farms where almost 50 percent of the maize did not meet the Kenyan regulatory threshold of 10 ng/g aflatoxin content. Aflasafe is a biological control product developed to reduce aflatoxin contamination in crops, particularly in maize and groundnuts. The study also found that farmers were willing to pay KES 113–152/kg of Aflasafe, which was within the range of other comparable products, suggesting that biocontrol agents may be viable.

> *Drying is a big challenge as small holder farmers do not have good facilities. Poor drying exacerbates the problem of aflatoxins and weather damage of maize. While the National Cereals and Produce Board (NCPB) has capacity to support drying, warehousing, and storage of grain for farmers, it is not suitable for small farmers. Collective action mechanisms might improve access to these services*
>
> *—Manager, NCPB*

Overall, the available literature reveals a wide variation in the quantity loss estimates reported, for maize, ranging from 20 to 36 percent. The wide variability in the estimates could be due to the differences in assessment methods; the influence of storage time; and contextual issues related to location, region, and farmer practices. Several gaps limit the comparability of the findings. First, the reviewed studies only focused on loss. All the studies reviewed, except for FAO (2014), only undertake assessment of loss at storage while omitting the other stages, including harvesting, shelling, drying, and milling. The implication is that losses could have been higher if the studies had accounted for losses at other stages. Similarly, none of the papers reviewed reports on quality losses stemming from diminished nutritional value. Despite having significant economic and public health impacts, the assessment of loss due to aflatoxin contamination has received limited attention in the literature. While the storage losses account for nearly 70 percent of the total losses, there is lack of distinction between losses occurring at on-farm and off-farm storage. This is also a key gap because the differences have implications for FLW. There is a lack of clear approaches for adjusting or standardizing data drawn from experimental studies with those collected on non-intervention or treatment settings. In addition, the evidence base is weak on FLW at the transportation, processing, retail, and consumption stages. Although some of the studies assess the effectiveness and economic feasibility of various FLW interventions in the maize value chain, understanding is still limited.

Potato value chain

Potato is the second most important crop after maize for food and nutritional security in Kenya (RoK 2021). The crop contributes about one-third of overall dietary energy consumption in Kenya (FAO 2008). The value chain employs more than 3.5 million actors, contributing over KES 50 billion to the economy (RoK 2021). In 2023, more than 2.3 million metric tonnes of potato were produced on over 200,000 hectares of land (KNBS 2024). Over 70 percent of potato produced in Kenya is marketed while the rest is used for home consumption or seed by producing households (Maingi et al. 2015). However, potato suffers from losses or waste as it moves across the life-cycle stages from the farm through the markets and processing facilities and finally to the consumption stage.

Status, critical points of loss, and causes of potato FLW in Kenya

We report FLW in potato based on three studies (GIZ 2016; Kaguongo et al. 2014; Scollard et al. 2022). The studies reported FLW based on weight reduction, which ranges from 19.4 to 23 percent (Table 3). The differences could be because not all studies consistently collect FLW data on potato across all the stages. For example, despite evidence that potato is damaged during harvesting, Kaguongo et al. (2014) did not measure loss at this stage. Similarly, GIZ (2016) only reported losses (from the farm to the wholesale stage) and none on waste (retail and beyond). Furthermore, while Kaguongo et al. (2014) and Scollard et al. (2022) considered the damaged potatoes to be marketable or part of doing business, GIZ (2016) considered the damaged potatoes as loss for the farmer. Scollard et al. (2022) reported quality loss of 8.9 percent (figures in parentheses in Table 3) because of deterioration of potato at various stages of the value chain. These inconsistencies make the findings less comparable.

Only one study estimated the economic loss of FLW (Kaguongo et al. 2014). The study reported that on average, 200 kg for every harvested tonne was lost or wasted, which accounted for about KES 12.9 billion (€109 million) annually.[7] The FAO FLW database reports potato FLW to be a high of 38.7 percent in 2012 and 59 percent in 2014, which is much higher than the three studies we reviewed. These extreme figures may be due to computational errors in the data. Affognon et al. (2015) did a comprehensive meta-analysis of post-harvest loss in six sub-Saharan African countries: Benin, Ghana, Kenya, Malawi, Mozambique, and Tanzania. The authors reported that the estimate for potatoes based on three studies in the region was 21.6 percent. The existing studies show that the critical points of loss are harvesting (6–12 percent) and transporting to the market (0.5–8 percent), while the retail stage is the most critical stage for waste (9.3 percent). However, despite increased sourcing of fresh foods from supermarkets, especially among the middle-income households (Rao and Qaim 2015), the understanding of FLW from this retail segment is limited. The leading causes of loss are poor harvesting techniques and poor handling during transport. On the other hand, poor storage facilities, especially at the retail stage, explain most of the waste in the potato value chain.

Interventions to address FLW in potato in Kenya

Several interventions have been tried to reduce FLW in potato (Stathers et al. 2020). Use of digging tools that reduce harvesting damage, use of improved storage containers, ventilated storage, evaporative cool storage, cold storage, sprout suppressants, and use of maturity indices have been shown to reduce losses in potato. Stathers et al. (2020) have demonstrated that quantity and quality losses were less than 15.5 percent and 8.5 percent, respectively, when the tubers were stored in improved pits, cold rooms, storerooms, evaporatively cooled, or well-ventilated structures. However, the use of improved storage structures in Kenya is constrained by farmers' behavior of wanting to sell immediately after harvest (Ateka and Mbeche 2023), high investment costs, limited integration of interventions

TABLE 3 | Estimated food loss and waste across different stages in the potato value chain in Kenya from various studies

POTATO LOSS OR WASTE	DATA COMPILED FROM KAGUONGO[A] (% OF VOLUME)	DATA COMPILED FROM GIZ[B] (% OF VOLUME)	DATA COMPILED FROM SCOLLARD ET AL.[C] (% OF VOLUME)	CAUSES OF LOSS
Left in the field	2.1	1	-	Poor harvesting practices. The labor hired to undertake harvesting is mainly paid by volume harvested, and so there is limited incentive to pick all the potato.
Damaged at harvesting	-	12	5.8 (3.3)	Harvesting tools cause damage or cut potato, premature harvesting, or harvesting in wet weather.
Storage loss (farm)	0.8	1	2.5 (3)	Lack of appropriate storage infrastructure.
Transportation from farm to market	6	8	0.5	Poor handling: Extended bag becomes heated, affecting sugar content.
Wholesale market damage		1	0.5 (.01)	Lack of appropriate storage infrastructure.
Retail level damage	9.3	-	9.3 (3.9)	Poor handling, lack of appropriate storage infrastructure.
Processing	0.8	-	0.4 (1.6)	Inappropriate varieties for processing; greening of potato due to exposure to sunlight.
Total FLW	**19.4**	**23**	**21.7 (8.9%)**	

Note: For a comprehensive review of food loss and waste in the potato chain in Kenya, please refer to the references listed at the end of this document; a. Kaguongo 2014; b. GIZ 2016; c. Scollard et al. 2022.

with existing practices, and limited awareness and training among farmers and other value-chain actors (Stathers et al. 2020). Evidence is also limited on the costs and benefits of the promoted interventions. Kenya's National Potato Strategy also promotes institutional innovations for collective action and contract farming to improve access to markets and therefore reduce losses. However, as observed by a key informant, contracting firms are very strict on quantities, which results in high proportions of yields rejected or off-taken at lower prices.

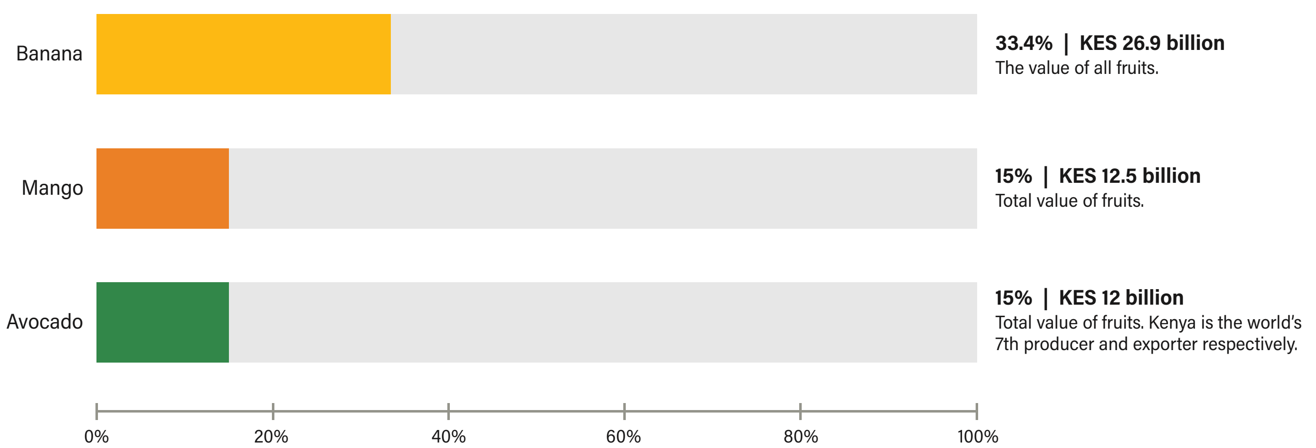
Overall, based on the limited number of studies available, quantity loss and waste in potato range from 19 to 22 percent and about 9 percent in quality loss, based on deterioration of the potato and eventually reduction in market price. However, several gaps limit comparability of the findings. First, there are differences between the studies on what constitutes food loss and waste. Some studies consider all the deteriorated potato as loss, while others consider the reduced value arising from the damage. Second, not all studies consistently collect FLW data on potatoes across all the stages. The reviewed studies focus on loss with limited attention to waste at the retail stage. But even when all studies report on the value-chain's retail stage, there is limited disaggregation across the retail outlets, particularly supermarkets. There is also limited understanding of the suitability of the interventions in different contexts.

Selected fruit value chains

Globally, fresh fruits and vegetables incur the greatest percentage of FLW (approximately 52 percent of production per annum) compared to other food crops like cereals and grains (20 percent) and roots and tubers (44 percent) (FAO 2023). We focus on three fruits (dessert and plantain banana, mango, and avocado), which collectively account for over 60 percent of the value of all fruits in Kenya (Figure 5). The fruits are also highly susceptible to loss or waste due to their perishable nature. Similarly, fresh fruit value chains have long and inefficient marketing arrangements that rely on informal networks (Deloitte 2015; Snel et al. 2021).

To assess FLW in fresh fruits, eight studies were reviewed: five for mango (Affognon et al. 2015; Chikez et al. 2021; Githumbi et al. 2024; Ridolfi et al. 2018; Snel et al. 2021), one for avocado (Snel et al. 2021), and two for banana (FAO 2014; Ronoh et al. 2022). All studies reported quantity losses or waste except for FAO (2014), which reported loss in quality or value. None of the studies report on nutritional loss, despite the nutritional significance of fruits. Some of the reviewed papers include pre-harvest losses in their estimation (Githumbi et al. 2024; Ridolfi et al. 2018), which makes comparisons between studies difficult. Although all the papers report on interventions that can be used to reduce FLW, only two studies (Deloitte 2015; FAO 2014) assess the economic feasibility of FLW mitigation options. We document the understanding of the status of FLW among the selected value chains. In addition, we present an understanding of the critical points of loss or waste, causes, and existing interventions to reduce FLW and the existing gaps.

FIGURE 5 | Economic value of banana, mango, and avocado in Kenya



Source: Authors compilation based on AFA 2022.

FIGURE 6 | Photos of mango quality loss in a retail market in Nairobi, Kenya

Source: Authors.

Status, critical points of loss, and causes of Mango FLW in Kenya

As stated earlier, we report FLW in mango based on five studies. Based on the studies, the magnitudes of quantity FLW in mango was in the range of 17 to 56 percent (Table 4). The two studies that compare FLW estimates with or without interventions (Affognon et al. 2015; Chikez et al. 2021) show that the lower end of the range reflects improved treatments.

The variability in the estimates may be due to different methods used to conduct the FLW assessments and differences in adoption of promoted loss-reduction technologies among the surveyed mango value-chain actors. Two of the studies reported FLW based on review of the literature (Affognon et al. 2015; Ridolfi et al. 2018), while the other three undertook survey-based assessments. The studies are also not consistent in how they report loss or waste estimates across the mango life-cycle stages. For example, Ridolfi et al. (2018) report only loss estimates, which might explain the lower end of the range. The FAO database for FLW reports whole supply-chain estimates of 25 percent in 2012 and 13 percent in 2015 (FAO 2023). In 2012, there are estimates available in the database on mango destined for export (1.5 percent) and for processing (32.5 percent). Overall, the inconsistency in measurement—methods, stages, treatments, or interventions—makes it difficult to compare the FLW estimates across the data sources.

The FLW estimates across the different studies reveal that the retail (18–23 percent) and wholesale (9–15 percent) stages are the critical loss or waste points. However, Chikez et al. (2021) showed that the extent of mango FLW varied, depending on the market destination. Mango FLW estimates were highest for mango destined for processing (35 percent) and the local domestic market (31 percent), compared to the export (18 percent) and supermarket destinations (26 percent). The lower FLW magnitude for the export segment could be because measures to mitigate FLW, such as proper handling and storage, are widely used in export supply chains (Owuor 2020). Alternatively, two KIIs indicated that processing facilities received overripe mangoes, which could be the reason for high levels of loss at this stage. However, understanding is limited as to how retail level waste varies depending on market destination.

The main causes behind mango losses are poor production and harvesting techniques, limited access to inputs like pesticides, and poor linkages to markets. Although the fresh mango market is growing (estimated at 47 percent), the growth in processing (8 percent) and export markets (2 percent) has not matched the growth in production (Grant et al. 2015). Consequently, at the marketing stage, oversupply during peak season and improper handling are also key sources of FLW (Githumbi et al. 2024). In some cases, farmers simply do not harvest at all because they have nowhere to sell, due to market glut. Use of plastic crates to improve handling and use of fruit fly traps are some of the effective loss-mitigation strategies. Chikez et al. (2021) reported statistically ($p = 0.005$) lower FLW for users of plastic crates (18 percent) to transport or store mangoes

TABLE 4 | Estimated food loss and waste across different stages in the mango value chain in Kenya from various studies

VALUE-CHAIN STAGE	DATA COMPILED FROM AFFOGNON ET AL.[A]	DATA COMPILED FROM RIDOLFI ET AL.[B]	DATA COMPILED FROM CHIKEZ ET AL.[C]	DATA COMPILED FROM SNEL ET AL.[D]	DATA COMPILED FROM GITHUMBI ET AL.[E]
Harvesting	-	-	5	7	-
Transportation, packaging, and storage	-	7	1	9	-
Wholesale markets	-	10		15	9.1
Retail market	-	-	23		18
Processing	-	-	2	5	-
Whole value chain	55.9±25.4 (24.8*± 15.6)	17	31 (27*)	36	27.1

Note: *Estimates for treated or where interventions to reduce FLW are reported. For a comprehensive review of food loss and waste in the mango value chain in Kenya, please refer to the references listed at the end of this document.

Source: Authors compilation from: a. Affognon et al. 2015; b. Ridolfi et al. 2018; c. Chikez et al. 2021; d. Snel et al. 2021; e. Githumbi et al. 2024.

compared to nonusers at 25 percent. In addition, the study observed that users of fly traps had an FLW of 20 percent compared to 26 percent for nonusers. The use of fruit fly traps and plastic crates was more effective in reducing FLW than the use of harvesting tools, cold stores, and ground tarps. While quality loss (reflected in price discounting, nutritional value loss, or volume of downgraded produce) is prevalent, none of the reviewed studies specifically focused on this dimension of FLW.

Status, critical points of loss, and causes of banana FLW in Kenya

Banana is one of the staple food crops for both rural and urban populations in Kenya, and it is grown by small-holder farmers. Most banana farmers grow dual-purpose cultivars that can serve as cooking and dessert varieties (Wahome et al. 2023). Bananas are marketed through informal arrangements that are often associated with FLW. Interviews with banana cooperative leaders indicate that the majority (95 percent) of the bananas are sold through street vendors and retailers in residential areas with 5 percent sold through supermarkets and other formal outlet arrangements.

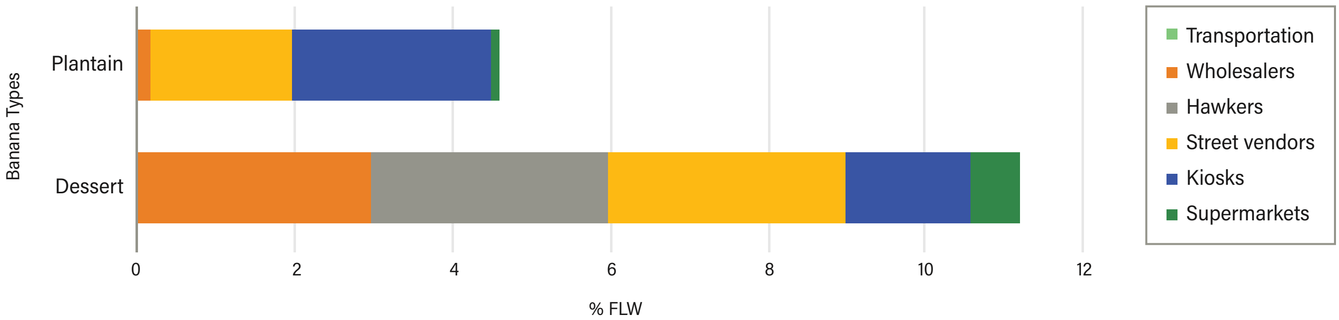
We report FLW estimates based on two studies (FAO 2014; Ronoh et al. 2022). The FAO study reported a weighted average of quantity and quality FLW of 11.2 percent and 4.6 percent for dessert and plantain banana, respectively. A recent study (Ronoh et al. 2022) estimated FLW in the banana value chain to be about 5 percent. However, the study did not report losses or waste across the stages of the value chain. A study in Uganda estimated that 14.9 percent of the produced volume of cooking bananas was lost or wasted. This translated to 1.1 million tons per year lost in terms of physical or economic losses along the value chain. A study by Kikulwe et al. (2018) showed that 7.2 percent of the bananas deteriorate completely and have no residual value, while 7.7 percent deteriorate partially and are sold at discounted prices, mostly affecting retailers.

The critical loss points were reported to occur at the whole-sale and retail stages (Figure 7) mainly because of lack of appropriate handling and storage facilities. Traders often rent rooms or stalls that they use for storage, display, and ripening with unregulated parameters, such as temperature, ethylene, and humidity. These results are consistent with the findings by Kikulwe et al. (2018) that the retail stage was the most critical, accounting for quantity losses of 9.8 percent and economic losses of 11.9 percent, resulting in a 60 percent discounted selling price per damaged bunch.

The study by FAO (2014) also reports the occurrence of quality losses associated with deterioration of banana due to poor handling practices (70 percent), banana thrips (30 percent), harvesting of immature fruits (10 percent), and bananas having fingers decaying at the pedicel with signs of splitting off from the crown (15 percent).

The key causes of FLW (quantity and quality losses) for the dessert banana are poor handling and placement of bananas on motorbikes and trucks, which causes physical injury to the bananas. In most cases, banana loads are dragged into the truck and piled one on top of the other, resulting in further damage or squashing. Poor display and storage facilities at the markets (except supermarkets) increase enzymatic reactions that hasten senescence (IITA 2010).

FIGURE 7 | Comparing estimated food loss and waste in dessert and plantain banana value chains at different stages



Source: FAO 2014.

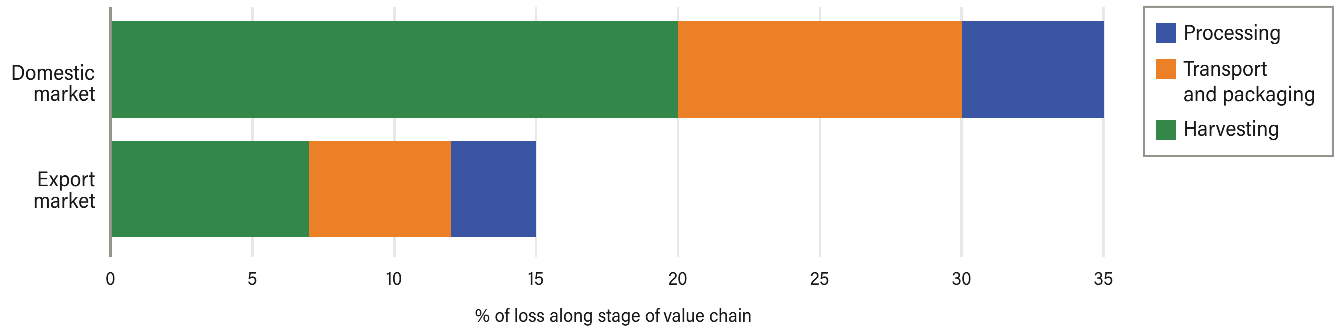
For plantain bananas, the causes of FLW include moisture loss due to less than ambient storage conditions and mechanical damage. In addition, transportation and storage are often done in combination with ethylene-producing products like avocado and passion fruit, which initiates softening and ripening of the bananas and reduces shelf life. Because consumption of green ripened banana is not popular, the softened bananas end up being wasted. Similar findings have been reported in Uganda where quantity losses for cooking banana at farm level were associated with theft and ripening, while the causes of economic losses were mainly selling of immature bananas and poor post-harvest handling and ripening. Selling immature bananas is attributed to the demand in the market that cannot be met by the available farm production during times of scarcity (Kikulwe et al. 2018).

Status, critical points of loss, and causes of avocado FLW in Kenya

In Kenya, over 70 percent of avocado is produced by small-scale farmers whose production is from 5 to 20 avocado trees dispersed throughout their landholdings (Akbarpour et al. 2017). We report the status of FLW based on studies by Snel et al. (2021) and Okech (2022). The study by Snel et al. (2021) found that about 35 percent and 15 percent of harvested avocado is lost between farm and the consumer in the domestic and export market, respectively. These stark differences can be explained by the fact that measures and investments to minimize losses in the export supply chain are common, while that is not the case for the domestic supply chain. Export markets have, in most cases, more efficient aggregation systems and cold-chain infrastructure for storage and transportation of fresh produce. Cooling within hours can extend the shelf life of many fresh products from weeks to months, providing additional flexibility on export schedules, improved consistency and quality, and reduced vulnerability to volatility (Karumba and Nderitu 2022). Across the supply chain, FLW is highest (20 percent) at harvesting and transportation and packaging (10 percent), while 5 percent is rejected during processing (Figure 8). Although the study did not report FLW at wholesale or retail markets, key informant interviews indicated that losses or waste at these points are significant. The major causes of FLW are improper handling, pests and diseases, and product deterioration due to lack of temperature-controlled storage and precooling. As observed by Kassim et al. (2013), FLW in avocado are attributed to pulp softening, rotting, physiological disturbances, and improper temperature management, with fungal attacks being the main cause of rotting.

Defining the system boundary can significantly influence the accuracy of reported quantities of FLW. Many studies, including Snel et al. (2021), tend to focus on losses at postharvest stages—harvesting, picking, field storage, packaging, loading, and processing—while overlooking unharvested, yet edible, crops left in the field. Ideally, the FLW boundary for assessment should begin at the point when raw materials for food are ready for harvest—specifically, when they are prepared to enter the economic and technical system for food production or home-grown consumption. Examples of what qualifies as “ready for harvest” include crops that are harvest-mature or suitable for their intended purpose, as well as mature fruits and berries. Okech (2022) revealed that on-farm losses in the avocado value chain accounted for over 90 percent of the total FLW (45 percent) based on estimates in Nandi County, Kenya. Key contributing factors include market dynamics during both off-peak and peak seasons.

FIGURE 8 | Comparing estimated food loss and waste in the avocado value chain at different stages and between the export and domestic market in Kenya



Source: Snel et al. 2021.

Interventions to address FLW in fruits in Kenya

A range of interventions for reducing FLW in fresh fruit value chains is reported in the literature. Those widely disseminated and available for commercial use in the country can generally be classified into two categories: product or equipment-based solutions and process-based innovations. Product-based solutions include improved harvesting equipment, cold-chain technologies, low-energy cooling, and drying systems and are aimed at improving harvesting, handling, and shelf life. In contrast, process-based innovations focus on improving supply-chain efficiency by connecting farmers with potential buyers, thus linking producers to reliable market demand and creating a more dependable supply for buyers. Examples of initiatives being piloted in Kenya's fresh produce market include the establishment of aggregation centers, contract farming, and the use of Information and Computer Technology (ICT)-based supply chain platforms such as Twiga foods and Soko Fresh (Deloitte 2015; Githumbi et al. 2024).

Using the nine criteria presented in Table 5, we assess potential of these interventions for FLW reduction in fresh produce value chains in the Kenyan context. An intervention got a positive (+) score if it was considered desirable, or appropriate, or a negative (-) score if otherwise. The sign -/+ was adopted where the appropriateness or desirability was uncertain. The scoring was based on findings from a literature review (Deloitte 2015; Githumbi et al. 2024; Karumba and Nderitu 2022; Owach et al. 2017; Shiri 2019; Soethoudt et al. 2021; Viola 2017) and complemented with five KIIs (Table 5).

The analysis reveals significant potential for using improved equipment in the harvesting and handling of fruits. Such equipment can minimize damage during the harvesting process, whereas traditional methods often result in bruising and spoilage, significantly reducing the marketability of produce. However, the widespread adoption of these tools hinges on proper training for farmers in using new technologies. Often, traditional harvesting methods are deeply ingrained, and farmers may be hesitant to change practices that they have used for generations (Chepwambok et al. 2021; Stathers et al. 2020). The appropriateness of cold-chain and cooling facilities is constrained, among other things, by the high cost of investment and lack of electricity connectivity or reliability is some places. Githumbi et al. (2024) indicate that actors were focused on cost-effectiveness, the technology's ability to minimize losses, and its impact on profitability before adopting any loss-reduction practices. Consequently, enhancing existing low-cost technologies to improve user-friendliness is crucial. This would ensure that these technologies are efficient during harvest and that they enable traders to transport optimal quantities, ultimately leading to profit maximization.

Although the establishment of aggregation centers is highly prioritized by the current Kenyan government, their potential for reducing FLW is low. The national government, alongside the Ministry of Investment, Trade and Industry; county governments; and development partners like the United Nations Industrial Development Organization, are working to create county aggregation and industrial parks in each county. However, despite funding for produce-handling facilities aimed at minimizing postharvest losses, these facilities often remain idle as target farmers show little interest in using them. This underutilization stems from facilities being initiated by donors and later handed over to farmer groups to manage under preset models.

TABLE 5 | Criteria and scoring for identifying suitable food loss and waste reduction interventions in fresh fruit value chains

CRITERIA	DESCRIPTION OF INTERVENTION Score: + = positive - = negative -/+ = neutral/uncertain	KEY INTERVENTION				
		Harvesting and handling equipment	Cold chain	Low-energy cooling or drying technologies	Aggregation centers	Contract farming/digital supply-chain platforms
Affordability	Intervention is affordable to users with low purchasing power.	+	-	+	-	+
Availability	Products or services are available for immediate use with minimal complications for value chain actors.	+	-	-/+	-/+	-/+
Acceptability	Intervention has higher acceptability by users, which requires compatibility with the existing culture, social norms, and values.	-/+	-/+	-/+	-	-/+
Awareness	People are aware of the existence, benefits, and shortcomings of the innovation.	-/+	+	-/+	+	+
Technical feasibility	Intervention is simple and technically feasible to implement among farming households.	+	-	-/+	-	-/+
Adaptability	Intervention is adaptable to suit the local environment in the value chain.	+	+	+	-	-/+
Scalability	Intervention has the potential to achieve widespread adoption.	+	-/+	-/+	-	-
Resource availability	Existence of physical and technical resources for the technology to be available at the local level	+	-	-/+	-	+
Sustainability	Intervention is aligned with environmental considerations.	+	-	+	-	-

Source: Authors' compilation, based on Deloitte 2015; Githumbi et al. 2024; Karumba and Nderitu 2022; Owach et al. 2017; Shiri 2019; Soethoudt et al. 2021; Viola 2017.

Lack of involvement of farmers in the decision-making process for these facilities reveals a mismatch between the donors and local communities. Similar challenges apply to processing facilities promoted by local government programs, often producing goods that are less competitive in quality and pricing (FAO 2014).

Furthermore, the contract farming model has faced challenges in Kenya, primarily due to farmers' lack of trust stemming from issues like side selling, negative past experiences, and inadequate enforcement mechanisms. Although information, communication, and technology (ICT) systems have been piloted in donor-funded projects, they often lack sustainability after the project cycle ends. The scaling up of these initiatives is hindered by insufficient investment in digital skills; farmers and aggregators need foundational digital training before advancing to more sophisticated software and equipment. Additionally, barriers such as limited network connectivity, low awareness, and entrenched reliance on brokers and middlemen, further impede adoption. Box 4 presents an example of value addition efforts for the mango value chain in Kenya, especially training in fruit processing, packaging, and branding while Box 5 shows the role of traceability mechanisms in fruit value chains in enhancing access to markets.

BOX 4 | Value addition and processing in Kenya

Value addition through low-cost food processing and preservation methods is considered a crucial strategy for reducing FLW. Key informant interviews (KIIs) reveal that various small-scale mango value-addition initiatives have been set up in Kenya, particularly in Murang'a, Mbeere, Meru, Embu, and Makueni Counties. Examples include Chuluni Horticultural Enterprise, Kitui County Fruit Processors, Gikindu Quality Mangoes, and Malindi Farmers' Cooperative Society. In 2020, a project led by UN Women in collaboration with Jomo Kenyatta University of Agriculture and Technology, the Stockholm Environment Institute, and TechnoServe, with funding from the Rockefeller Foundation, trained 100 farmers, half of whom were women, from Meru, Makueni, and Tana River counties in fruit processing, packaging, and branding. KIIs suggest that these initiatives could significantly reduce fresh fruit losses.

However, despite the growth of these small-holder processing initiatives, high marketing costs and limited market penetration often hinder them from surviving at commercial scale, sometimes resulting in their closure. Currently, many processing facilities remain idle with farmers showing little interest in using them. A significant downside is that these facilities are often established by donors and then handed over to farmer groups to operate with predetermined models. As a result, they are frequently underutilized and associated with products that are less competitive in quality and pricing (FAO 2014). A similar situation exists with processing facilities promoted by local government programs. Other factors constraining their impact include inadequate adoption or participation by farmers in target communities, challenges in attracting sufficient long-term financing, and governance issues due to unclear ownership structures.

To achieve impact at scale, it is essential to address governance challenges, consider financial interventions to de-risk investments, and facilitate adoption of technologies, linking small-holder farmers to consistent market demand and ensuring that farmers have access to appropriate training.

BOX 5 | Fresh fruit and vegetable traceability system in Kenya

In Kenya, the supply chains for fresh fruits are underdeveloped and complex, involving numerous actors and diverse interactions, along with various institutional and marketing arrangements. Produce is primarily marketed as fresh through informal networks, including brokers, middlemen, and rural assemblers, and sold at informal retail outlets such as stalls in wet markets, kiosks, and groceries. The informal nature of the supply chains means that most traders lack access to cooling, handling, and storage facilities for produce, contributing to high levels of losses. Additionally, the handling of produce is often rough, which accelerates deterioration, while infrastructure and technical capacity for preserving surplus produce are insufficient.

Traceability mechanisms can help to track and trace the history and flow of food products throughout the supply chain by using different technical innovations like radio-frequency identification, block chain, food-sensing technologies, barcoding, and 'smart packaging' that changes color as food spoils (Benyam et al. 2021). This has implications for increasing the efficiency of the food supply chain and therefore reducing FLW (Gupta et al. 2023). Due to stringent export requirements, Kenya has progressively implemented traceability measures through international standards such as Global Gap and development of internationally recognized local standards, such as Kenya Gap (Chemeltorit et al. 2018). KIIs show that the leading traceability standards in Kenya are eprod, Farm Force, and the National Horticulture Traceability System. To ensure that horticultural produce is produced and handled in a responsible way, fresh produce stakeholders in Kenya have developed an industry code of practice, the KS 1758. The standard specifies the requirements for safe production, handling, and marketing of fresh fruits, vegetables, herbs, and spices in Kenya for both export and domestic markets. While KS 1758 has been in force since 2016, KIIs affirm that uptake is limited to export-oriented supply chains with limited adoption among food operators in the domestic markets. This is associated with limited awareness, the capacity of stakeholders, and the high cost of implementing such systems.

Overall, the studies show a wide variability in reported estimates of FLW within and across different fresh fruits. The reported FLW for mango is the highest (17–56 percent), followed by avocado (15–35 percent) and banana (7–11 percent). Some studies report only loss estimates, which might explain the lower end of the range. It is also the case that these differences are due to normal variability among value chains. Despite the rising importance of supermarkets in the supply of fresh produce, few studies pay attention to this retail channel. Similarly, few studies report on loss at processing. The review has also shown that, while there are several FLW interventions, their uptake is limited. Further, some studies have been done, based on experiments in research stations, to demonstrate the feasibility of FLW reduction interventions in fresh fruits (Mujuka et al. 2020). However, studies to validate these findings at field level are lacking. The lack of comparable FLW estimates and associated causes limits the selection of suitable interventions to reduce FLW in fresh fruits. Equally, the evaluation of FLW in fruits and vegetables is also confounded by other factors, such as seasonal variations in production, variety difference, and regional contexts for fruits like mango, which are produced in various agroecological conditions.

Fish value chain

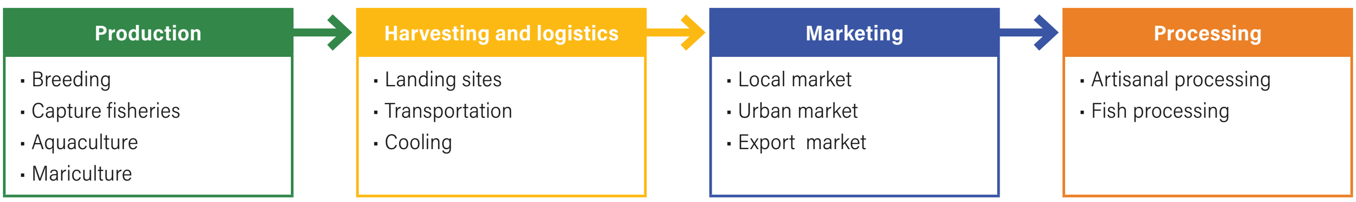
The fish value chain comprising inland capture, marine, and aquaculture is a source of livelihood for over 2 million people and makes an important contribution to Kenya, economy. In 2023, the country produced 161,300 tonnes of fish, a decline of 7.1 percent from 2022, with the total value decreasing to KES 35.9 billion ($225 million) (KNBS 2023). Most of the fish production in Kenya is from inland capture fisheries dominated by Lake Victoria. An estimated 43,653 fisherfolk operate in Lake Victoria, which accounts for 73 percent and 65 percent of the total quantity and value of the national fish catches in the country, respectively (Onyango et al. 2021). Fish is highly perishable and has a high-risk of exposure to loss and waste associated with a wide array of factors, including poor fishing skills and techniques, inadequate storage, deficient infrastructure, inefficient processing, and lack of coordination in the marketing systems. These translate into losses in the nutritional contribution of fish to people's total diet and health (Kabahenda et al. 2009). The loss and waste of fish can occur at various stages of the value chain, which includes harvesting and logistics, processing, distribution, and consumption (Figure 9). However, robust assessments of FLW in the value chain, especially in the low-income country context, are limited (Kruijssen et al. 2020).

Status, critical points, and causes of loss and waste in the fish value chain

We reviewed seven papers that report on fish loss in Kenya (Akande and Diei-Ouadi 2010; FAO 2014; Muma 2015; Obiero et al. 2021; Odoli et al. 2013; Odoli et al. 2019; Wawiye et al. 2021). These papers applied different methodologies— questionnaires, laboratory analysis, load tracking—and scopes—fish species, stages of the fish supply chain considered and locations—hampering comparisons across the studies. Consequently, the available estimates are widely variable, lack representativeness, and yield inconclusive evidence about the extent of fish loss and waste in Kenya. None of the reviewed studies had undertaken nutritional loss assessments, which are often done through experimental rather than field-based methods, making them costly.

Six of the seven studies report on tilapia (caught) and silver cyprinid (*R. argentea*), locally called omena or dagaa, which are species of commercial importance for small scale fisheries in Kenya. The only study of marine gill-net fisheries (Odoli et al. 2013) reports higher quality losses for marine gill nets (28 percent) and much lower quantity loss (5 percent). In Table 6, we report magnitudes of fish losses with a focus on tilapia and omena, based on three studies the estimates of which could be compared (Akande and Diei-Ouadi 2010; FAO 2014; Obiero et al. 2021).

FIGURE 9 | Stages in the fish value chain where loss and waste occur, according to the analysis of various studies



Source: Authors compilation.

The existing literature shows that fish across the two types suffer much higher quality than quantity loss. Quality loss in tilapia was much higher (25–28 percent compared to omena (9–16 percent). Although the reported quantity loss in tilapia was minimal in Lake Victoria (2–4 percent), it was much higher in Lake Turkana (34 percent). The studies only reported on fish loss, suggesting that the magnitudes may be higher if waste was considered. KIIs indicated that the quantity losses for tilapia in Lake Turkana may be lower due to the practice of selling deteriorated fish to unsuspecting customers in neighboring towns.

Based on the reviewed literature, harvesting is the most critical stage across the supply chain, accounting for up to 22 percent of the quality loss in tilapia (FAO 2014; Obiero et al. 2021). While Akande and Diei-Ouadi (2010) did not disaggregate the losses based on the various supply chain stages, they report that harvesting contributed to about 10 percent of the quality losses reported. The losses at this stage are attributed to fish falling from nets, dry runoffs (fish spending too much time in nets), fishing nets entangling the fish by gills, water accumulation in leaking boats, absence of chilling on board, inappropriate fishing techniques, pests, and diseases. As shown in Table 6, processing is the critical stage of loss for omena (FAO 2014). A study by Muma (2015) also reported that processors rejected 10 to 25 percent of omena due to quality deterioration, which led to a 24 percent price reduction. Quality loss at processing is mainly because of the use of more traditional smoking and drying techniques for preservation and lack of cooling (cold-chain) facilities (Kruijssen et al., 2020; Odoli et al. 2019). The other drivers of loss at processing include poor water quality for cleaning fish; infestation by insects, birds, and rodents; spillage; and limited processing capacities (Muma 2015). None of the studies reported nutritional loss, which is often done through experimental rather than field-based methods. For fish, the nutritional loss could be estimated using the country's food composition database, which provides information about macronutrients, such as vitamins and minerals, and other components, such as fiber and water content, found in various foods. However, the lack of guidelines to model and estimate the same in terms of nutritional loss (e.g., lost calories, protein, essential fats, etc.) is also a key limitation.

While quantity losses for omena reported in Table 6 are low (6 to 7.5 percent), KIIs indicated that quantity losses for the species can be as high as 80 percent during processing due to surface runoffs during storms. This is mainly because omena is sun dried on the ground. Due to the poor drying infrastructure, rain washes away the drying omena at the shore or it deteriorates in quality due to delayed drying. A study by Wawiye et al. (2021) also reported losses of 1–4 troughs of 35kg/fisher during harvesting and processing. However, the study did not provide data on the quantity of omena catches in the landing sites studied to allow for estimating the proportion of loss. Harvesting is also the critical stage for quantity losses in tilapia. As observed by a key informant, Lake Turkana is associated with high-quantity losses for tilapia (especially at harvesting) compared to Lake Victoria.

TABLE 6 | Estimated magnitude of fish losses and waste in Kenya across different stages from various studies

	TILAPIA (LAKE VICTORIA)		TILAPIA (LAKE TURKANA)		SILVER CYPRINID (OMENA)
Stage	**Data compiled from Akande and Diei-Ouadi[a]**	**Data compiled from FAO[b]**	**Data compiled from Obiero et al.[c]**	**Data compiled from Akande and Diei-Ouadi[a]**	**Data compiled from FAO[b]**
	Quantity(%)	Quantity (%)	Quantity %	Quantity (%)	Quantity (%)
Harvesting	-	2.0 (22)	18.0	-	-
Transportation & handling	-	2.0 (3.5)	2..0	-	-
Processing	-	-	9.0	-	6.0 (16)
Storage	-	-	5.0	-	-
Total losses (whole chain)	2 (28)	4 (25.6)	34	7.5 (8.9)	6.0 (16)

Note: Figures in parentheses show quality losses. For a comprehensive review of the magnitude of food loss and waste in fish value chain in Kenya, please refer to the references listed at the end of this document.

Source: Authors' compilation from: a. Akande and Diei-Ouadi 2010; b. FAO 2014; c. Obiero et al. 2021.

> *Compared to Lake Victoria Fisheries, there are high quantitative losses for tilapia in Turkana due to the long beach with poor infrastructure. The losses are also associated with long distances between the landing sites and the main market in Lodwar and also high ambient temperatures. Turkana has limited or nonexistent icing infrastructure. This is made worse by the fact that communities along the lake are not fish eaters.*
>
> *—Key informant*

The key sources and drivers of loss during transportation and handling are inappropriate storage infrastructure; rough handling during transport; fish falling from containers during handling; inappropriate packaging during transport; and infestation by insects, birds, and rodents (Akande and Diei-Ouadi 2010; FAO 2014; Odoli et al. 2013, 2019; Obiero et al. 2021; Wawiye et al. 2021). The other key causes include size discrimination, species preferences, operational loss (fishing gear), and animal predation (dogs, storks, cormorants, and crocodiles) (Abelti and Teka 2024).

Interventions for reducing FLW in fish

Development in the marketing and consumption of fish products in recent decades has been accompanied by growing interest in food quality and safety, nutritional aspects, and waste reduction. This has led to considerable investment in fish postharvest management by governments, donors, and other stakeholders in the small-scale fisheries subsector in least- and middle-income countries (Odoli et al. 2019). These innovations, which have been implemented in Kenya, are summarized in Table 7. An intervention got a positive (+) score if it was considered desirable or appropriate, or a negative (-) score if otherwise. The sign -/+ was adopted where the appropriateness or desirability was uncertain. The scoring was based on findings from the literature review (Akande and Diei-Ouadi 2010; Karumba and Nderitu 2022; Kruijssen et al. 2020; Obiero et al. 2021; Odoli et al. 2019; Owach et al. 2017; Shiri 2019; Soethoudt et al. 2021; Viola 2017) and complemented with three KIIs.

TABLE 7 | Criteria and scoring for identifying suitable food loss and waste reduction interventions in the fish value chain in Kenya

CRITERIA	DESCRIPTION OF INTERVENTION Score: + = positive - = negative -/+ = neutral/ uncertain	KEY INTERVENTION				
		Appropriate fishing gear	Cold chains/ storage/ transportation	Improved processing techniques (drying racks)	Improved market infrastructure	Improved hygiene practices
Affordability	Intervention is affordable to users with low purchasing power.	-	-	+	-	-/+
Availability	Products or services are available for immediate use with minimal complications for value-chain actors.	-	-	-/+	-/+	-/+
Acceptability	Intervention has higher acceptability by the users, which requires compatibility with the existing culture, social norms, and values.	+	+	-/+	-/+	+
Awareness	People are aware of the existence, benefits, and limitations of the innovation.	+	+	+	+	-/+
Technical feasibility	Intervention is simple and technically feasible to implement among farming households .	+	-/+	-/+	-/+	-/+

TABLE 7 | Criteria and scoring for identifying suitable food loss and waste reduction interventions in the fish value chain in Kenya (cont.)

CRITERIA	DESCRIPTION OF INTERVENTION Score: + = positive - = negative -/+ = neutral/ uncertain	KEY INTERVENTION				
		Appropriate fishing gear	Cold chains/ storage/ transportation	Improved processing techniques (drying racks)	Improved market infrastructure	Improved hygiene practices
Adaptability	Intervention is adaptable to suit the local environment in the value chain.	+	-/+	-/+	-/+	+
Scalability	Intervention has potential to achieve widespread adoption.	+	-	-/+	-/+	+
Resource availability	Existence of physical and technical resources for the technology to be available at the local level.	-/+	-	-/+	-	+
Sustainability	Intervention is aligned with environmental considerations.	-/+	-/+	+	+	+

Source: Authors' compilation based on Akande and Diei-Ouadi 2010; Karumba and Nderitu 2022; Kruijssen et al. 2020; Obiero et al. 2021; Odoli et al. 2019; Owach et al. 2017; Shiri 2019; Soethoudt et al., 2021; Viola 2017; and KIIs.

Table 8 shows several interventions that have also been developed to reduce fish losses. These interventions range from improved infrastructure and equipment across the value-chain stages and strengthening fisherfolk and other stakeholders' participation in collective action through beach management units. However, to date, infrastructure is poorly developed, and, where developed, it targets international markets. Of 557 landing sites in Kenya, only 25 (4 percent) have cold rooms installed, of which only two can be used for storage. Only 13 percent have ice availability (72 sites), and just 20 percent (111) have access to electricity. In addition, there is limited capacity among users in managing and maintaining the facilities (Obiero et al. 2021).

Lack of appropriate processing technologies continues to be associated with high losses at processing. Improved drying technologies, such as raised drying racks, enable fish to be dried off the ground faster and in a cleaner environment, reducing loss and improving quality of the fish. However, raised dying racks require lots of space to allow adequate passage for people and good air circulation. Similarly, some traders have been known to revert to drying on the ground, in part because there are not enough drying racks to serve all the traders (Obiero et al. 2021). While the fish losses at storage and marketing are lower than at other stages of the chain, there have been efforts to improve preservation, such as refrigerated trucks and packing technologies. However, the adoption of these facilities is limited by high costs. Similarly, ICT systems that offer comprehensive stock tracking along the supply chain (Kruijssen et al. 2020; Odoli et al. 2019) have been employed in countries like India with considerable success. As one KII indicated, the Electronic Fish Marketing Information System (EFMIS) project that was piloted in Lake Victoria in 2011 has suffered from low uptake, in part because of low Internet connectivity in landing sites and fisherfolk's unwillingness to pay for the information. EFMIS is a system for generating, packaging, and disseminating key market information from fish landing sites around the lakes and marine sources and inland markets in major urban areas (Aura et al. 2019). The system contains information on prices at landing sites and inland markets, quantities of fish at landing sites and inland markets, number of fish trucks at landing sites, and basic weather information. Through the system, fisherfolk can get more competitive prices and offload their catch to potential customers.

Block-chain technology in food-supply chain management has also been used to track movements of food products and, as a result, reduce labor costs and food waste in case of a recall (Kshetri 2021). The technology's application is at infancy in Kenya (Moturi and Kosgei 2021). Scaling up block-chain technology in the food-supply chain will require formulation of standards and policies, establishment of appropriate mechanisms for training and skills enhancement, and creating the requisite infrastructure and implementation mechanisms to promote its update (Moturi and Kosgei 2021).

Overall, few studies document loss in fish. The results indicate wide differences in magnitudes of loss between species and location. The literature shows that for tilapia, the quantity losses are minimal (2–4 percent) in Lake Victoria but much higher magnitudes (34 percent) in Lake Turkana. This is associated with higher ambient temperatures in the area and poor infrastructure. For omena, quantity losses range from 6 to 7.5 percent but only accounting for harvesting, transportation, and processing. This suggests that the magnitude may be higher if all the stages of loss and waste were accounted for. A critical gap remains in the assessment of fish waste and nutritional losses. Based on the studies reviewed, the evidence on magnitude and critical points of loss is not sufficient to enable identification of appropriate technologies to target and reduce FLW in the fish value chain in Kenya.

Policy environment for FLW in Kenya

FLW is well recognized in the SDG 12.3 target where countries have committed to halving the per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including postharvest losses, by 2030. Kenya is also a signatory to the 2014 Malabo Declaration, which targets a 50 percent reduction in postharvest losses by 2025. Despite these commitments, the nation has yet to establish a comprehensive framework for measuring and driving FLW reduction. While Kenya reports progress on FLW reduction at the African Union under the Comprehensive Africa Agriculture Development Programme's biennial review reporting cycle, there are uncertainties regarding the credibility of the reported status in the absence of a strong evidence base and reliable FLW data, such as causes, critical points of loss, and magnitude.

Notwithstanding the stipulated gaps, various policies recognize the importance of reducing FLW in Kenya. These include Kenya's Vision 2030 through Third Medium Term Plan—MTP III, (RoK 2018), the Agricultural Sector Transformation and Growth Strategy—ASTGS 2019–2029 (RoK 2019b), the Agricultural Policy of 2021 (RoK 2019a), and the Kenya Climate Smart Agriculture Strategy 2017–2026 (RoK 2017), among others. Kenya is also a signatory to the National Food System Transformation Pathway plan, an initiative that seeks to strengthen the design of national food system transformation pathways.[8] The nation is now in the process of developing holistic food strategies that will facilitate the shift from sectoral to systemic thinking in Kenya`s food system.

Collectively, the existing policies seek to minimize FLW through several measures, including enhancing food system infrastructure, promotion of FLW technologies and approaches, and public-private partnerships for FLW, among others. The policies recommend increased investments from both national and county governments to support FLW mitigation strategies. These include the construction of postharvest and transportation infrastructure; strengthening capacity of value-chain actors in FLW management; and adoption of appropriate technologies that reduce FLW and ensure reliable energy supply for postharvest processing, handling, and storage. A notable development is the launch on October 18, 2024, of the Kenya Post Harvest Management on Food Loss and Waste Reduction Strategy (2024–2028) (RoK 2024), aligned with the Africa Union Post Harvest Loss framework. This strategy is intended to address policy-level challenges hindering FLW reduction efforts.

Our analysis of the policy environment was based on an in-depth review of documents and KIIs to assess the suitability (strengths, opportunities, and challenges) of existing policies and institutional mechanisms (strengths, opportunities, and challenges) for FLW reduction in Kenya. From the policy review, the following gaps and opportunities were identified.

1. FLW reduction has not been recognized as a mechanism for achieving Kenya`s food-security and climate-change goals. Reducing FLW can help achieve the triple benefit of saving money, feeding more people without increasing production, and decreasing pressure on the environment, including reducing Kenya's GHG footprint. Reducing FLW has positive impacts on climate as it lessens the use of production resources and expansion into fragile ecosystems to produce food that will not be consumed (Affognon et al. 2015). However, the potential of FLW is not well integrated in the country`s food-security and climate-change policies. For instance, FLW reduction is not featured among the nation's National Climate Change Action Plans for achieving the Nationally Determined Contributions (NDCs).

2. FLW strategies are not based on measurement and identification of hotspots. The suggested policy actions to minimize FLW are not based on measurement and identification of hotspots, given the lack of consistent data on magnitude of loss, causes, and critical points of loss. There is considerable heterogeneity in FLW along value chains, suggesting that these policies need to be informed by accurate FLW estimates. WRI, FAO, and the US Agency for International Development, among other organizations, have developed protocols to measure FLW; but these have not been contextualized to the situation in Kenya.
3. A coordination mechanism reducing FLW is absent. Existing policy frameworks specify the role of different stakeholders in reducing FLW, including the national and county governments. Equally, there is poor involvement of the private sector and other stakeholders in coordinated action on FLW. The Kenya Post Harvest Management on Food Loss and Waste Reduction Strategy, launched in October 2024, proposes setting up a national committee on FLW management to coordinate the strategy. However, KIIs observed delays in setting up institutional structures for implementation of policies and strategies in Kenya. The absence of a coordination mechanism and limited financing would challenge implementation because FLW is highly multi-sectoral in nature. A past effort to develop a national framework for FLW in India is yet to be finalized but can offer lessons for Kenya.
4. There are limited incentives for FLW reduction programs. State or local grant and incentive programs (e.g., tax credits or deductions, supporting targeted improved infrastructure expansion and providing technical assistance to marketplace stakeholders) can be important catalysts for expanding food waste reduction activities. However, the existing policy framework does not explicitly provide targeted incentives to promote uptake of FLW reduction interventions.
5. There are no organics disposal bans or mandatory recycling laws. Laws and regulations on disposal of organics and mandatory recycling have been shown to be an effective means of achieving FLW reduction, including via prevention and other strategies across the hierarchy (Flanagan et al. 2019). By limiting the amount of organic waste that entities can dispose of in landfills or incinerators, organics disposal bans and waste recycling laws compel food waste generators to explore more sustainable practices like waste prevention, donation, composting, and anaerobic digestion. In 2022, Kenya enacted the Sustainable Waste Management Act. However, the act does include any obligatory provisions on disposal bans or mandatory recycling.
6. Policies, regulations, and incentives for food donations are absent. Waste of food products at supermarkets and other points of sale is on the rise. KIIs with Retail Traders Association of Kenya officials indicate a willingness of large supermarkets to donate food, which currently is wasted in substantial amounts. There are similar efforts in other countries, such as Nigeria and South Africa (Moon 2020). Typically, food banks are established to receive donations and recovered food for distribution to consumers. Already, a nongovernmental organization called Food Banking Kenya is supporting food donation initiatives in the country. However, the existing legal and regulatory framework does not explicitly support food donations.
7. Food systems laws in Kenya are mostly contained in the Public Health Act (PHA), and the Food, Drugs, and Chemical Substances Act (FDCSA). There is no mention of food donations or guidance on food safety for donated food in either the PHA or the FDCSA. As a result, food donors (including international donors, hotels, supermarkets, and households) may avoid donating surplus food, and food recovery organizations may refuse to accept food donations that may otherwise be safe. Interviews with retail associations indicated that a sizable portion of edible food is converted to pig feed. Consequently, potential donors are often uncertain about the steps necessary to safely donate food in compliance with applicable regulations. The uncertainty could also include how date labeling applies to donated food. Date labels, such as "sell by" affixed to food products, can play a significant role in FLW with many consumers interpreting them as indicators of food safety.

Overall, our review has revealed that Kenya has not strongly mainstreamed FLW in the food system–related policies. Key opportunities for policy change include awareness creation and educating consumers through private and public food waste behavior change campaigns and formally recognizing the potential of FLW reduction by making it a part of the NDCs. Other opportunities are investing in the improved infrastructure to measure, rescue, and recycle waste and expanding incentives to institutionalize surplus food donations. The policy changes would need to address evidence gaps in measurement of the extent of FLW along food-supply chains, cost-benefit analysis of FLW interventions, and trade-offs for reducing FLW.

CHAPTER 4.

Conclusions and recommendations

This report highlights gaps in data on FLW magnitudes, critical loss points, causes, and interventions, as well as policy limitations. Existing studies show inconsistencies in FLW definitions, a lack of focus on waste beyond the retail stage, and limited analysis across supply-chain stages. Additionally, the effectiveness and feasibility of FLW reduction interventions remain unclear. Reliable and consistent data are urgently needed to inform targeted policies and actions for reducing FLW in Kenya.

Reducing and preventing FLW has gained global attention with countries committing to achieve a 50 percent reduction in the per-capita FLW (SDG 12.3) along the supply chains. Our synthesis shows that while Kenya has made a commitment to address FLW under SDG 12.3, the evidence to help stakeholders—government, business, farmers' associations—to sets such targets is lacking. This report focused on the gap in the available knowledge on FLW in Kenya. It placed emphasis on the gaps in the evidence on the magnitude, critical points of loss and waste, underlying causes and drivers, available FLW reduction interventions, and policy limitations to tackle the problem.

Our synthesis shows that the evidence on FLW in Kenya is thin with wide variations in estimates even within the same value chain. This is explained by several reasons. First, there are differences between the studies on what constitutes FLW. Some studies consider all the deteriorated food as loss or waste while others consider the reduced value arising from the damage. Second, the reviewed studies focus on loss with limited attention to waste (except for the retail stage). But even for the studies that report on the retail stage of the value chain, there is limited disaggregation across the different retail outlets, in particular, supermarkets. Similarly, the existing literature is not consistent in reporting across the different supply-chain stages. The implication is that the magnitude may be higher if all the supply-chain stages are considered. Third, there is limited attention in the existing literature on causes and underlying drivers to inform the selection of suitable interventions in different contexts. Although several FLW reduction technologies are being promoted in the various value chains, uptake is limited. Evidence on the effectiveness and economic feasibility of various FLW interventions is limited.

There is an urgent need to ensure that interventions and policy actions toward FLW reduction, as well as toward tracking progress in Kenya, are informed by reliable and consistent data. We suggest the following recommendations to target, measure, and act on FLW reduction in Kenya:

- To improve the quality of FLW estimates, the government, non-state, and other development actors should support the contextualization of existing global protocols for measuring and targeting FLW reduction efforts. The contextualized protocols will provide guidance for measuring and reporting FLW within the context of local conditions and realities (including fragmented production systems, seasonality, and complex supply chains). In addition to the protocol, value-chain-specific guidelines are needed to tailor measurement approaches to the different nuances of each value chain.

- To track progress in addressing FLW, there is need for the government and other actors to integrate FLW measurement in national statistics such as the census, economic surveys, and household budget surveys. Similarly, partnerships among actors in the National Agricultural Research Systems can help embed FLW in the country's national research agenda.
- To promote uptake of various capacity-building interventions in postharvest handling, pre-harvesting checks, harvesting methods, drying, storage, hygiene and transport and aggregation, and leverage of existing models in the value chains (e.g., maize-cob and grain business hub models in maize) can help reduce FLW. Lessons from export-oriented value chains (contract farming, aggregation, cold chain) can also be cascaded to domestic value chains. Traceability systems that combine use of ICT in tracking foods from farm to table can assure food freshness, efficient routing, and monitoring of FLW.
- There is a need to enhance awareness of FLW among food-system stakeholders and embed FLW reduction in the country's food system, climate change policies, and NDCs. The National Food Systems Transformation Pathways could help address the multisectoral nature of FLW in policy formulation.
- There is a need to develop policies and incentives that aid in the development of improved and context-appropriate infrastructure for FLW reduction. These include improved infrastructure for harvesting, handling, and storage and even facilities to help recycle and prevent organic waste from entering dumpsites and landfills. These could include infrastructure for composting or biogas generation for generated food waste, which helps get some additional revenue.
- To improve the targeting of suitable intervention, there is a need to prioritize assessment of the existing and new FLW reduction approaches to determine technical and economic feasibility and their appropriateness to local contexts. The assessment of FLW interventions should also recognize and consider the trade-offs that come with the solutions.
- In view of the recognition of the potential of food donations in addressing food waste, the government should develop relevant policies and legislation to promote redistribution of excess food and establish food rescue partners—food banks, cold-chain infrastructure, among others— that facilitate infrastructure for food donations.

Endnotes

1. A three-step approach, the "Target-Measure-Act" approach is a proven way to achieve rapid results adopted by the Champions 12.3 coalition of the SDG. See more at https://champions123.org/publication/call-global-action-food-loss-and-waste.

2. The Fourth CAADP Biennial Review (2015–2023) indicates that Kenya is not among the countries in Africa (Egypt, Gabon, Madagascar, Mali, Mozambique, Namibia, Sierra Leone) that are on target toward achieving this continental target. https://au.int/sites/default/files/documents/43556-doc-EN_4th_CAADP_Biennial_Review_Report-COMPLETE.pdf.

3. Kenya has one of the lowest productivity levels in Africa at 1.5 MT/ha compared to South Africa (5.4MT/ha), Ethiopia(4.2MT/ha), and Nigeria (2.1MT/ha) (FAOSTAT, 2023)

4. The estimate is based on KNBS, KIPPRA, and CMA data and includes all demand maize as food whether or not formally processed. For instance, Kenya needed 52.8 million bags or 4.7 million MT. The consumption has been shifting to changing diets, but demand has remained stable, above 4 million MT. (See KIPPRA 2021.)

5. On-farm losses, which include losses at harvest, farm storage, transportation, or processing, are included in the FLW estimation. (See WWF-UK2021).

6. This involves issuance of warehouse receipts, which are documents issued by warehouse operators as evidence that specified commodities of stated quantity and quality have been deposited at locations by named depositors

7. One Euro was equivalent to Ksh. 118 at the time of the study.

8. Kenya is among more than 100 countries that have signed up to develop national strategies for transforming food systems. See the report at https://www.un.org/en/food-systems-summit/news/more-100-countries-sign-develop-national-strategies-transforming-food-systems.

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About WRI Africa

WRI Africa envisions an inclusive transformation where both people and landscapes thrive. We generate actionable knowledge across four strategic pillars: vital landscapes, thriving and resilient cities, energy, and climate, economics and finance.

Our work supports sustainable society whose communities and ecosystems flourish together.

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