THE CRITICAL MIDDLE



Unlocking Prevention and Reduction of Food Loss and Waste within the Processing and Manufacturing Sector

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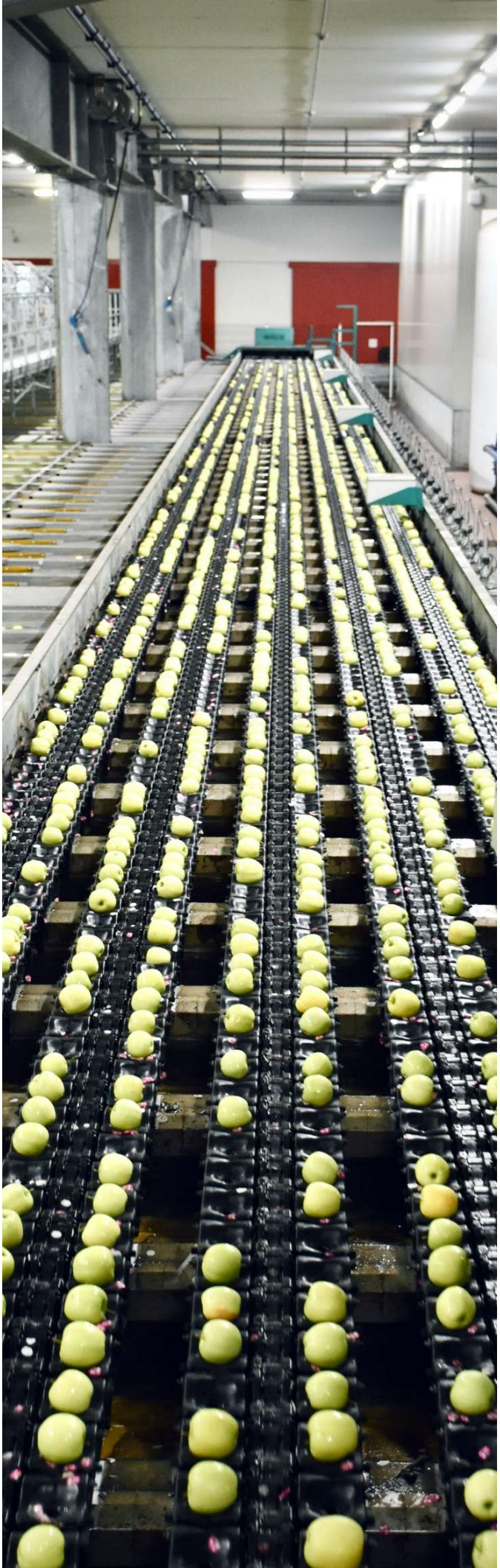
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Key Messages

Food loss and waste is widely recognized, but action and data still lag. Food processors are uniquely placed to close that gap across the whole value chain.



- Food loss and waste (FLW) is now globally recognized as a significant issue by both countries and companies, but **action has lagged behind this understanding**. Many significant data gaps still exist, most globally-available data is based on older estimates, and much of the available data does not reflect waste levels at the processing stage.
- **Data gaps on FLW in the processing stage can be attributed to unclear expectations and insufficient coordination between global monitoring initiatives**. Alignment on frameworks for measurement could improve synergies among stakeholders.
- Because of their position within the food supply chain, companies involved in processing are uniquely able to affect what occurs both upstream and downstream from their own operations. **They serve as a "hinge" point within the supply chain** that most food passes through as it moves from production to consumption. They are therefore well-placed to not just reduce losses within their operations, but to reduce losses throughout the full food value chain, from farm to fork.
- Access to processing can reduce upstream losses by providing opportunities for agricultural producers to **extend the shelf life of products** and avoid losses due to overproduction or higher than anticipated yields. In addition to extending shelf life, processing adds value to agricultural goods and provides further revenue streams for agricultural producers.
- **Processing can also extend the shelf life of highly perishable products**, thus reducing losses for end users and avoiding losses associated with shipping delays and insufficient access to cooling.
- **Businesses within the processing sector need to commit to reduction of food loss and waste across the entire value chain**, and governments need to provide the enabling environment that sets them up for success.



Global Context on Food Loss and Waste

Food loss and waste drives more than $1 trillion in losses and 8–10% of global emissions each year. The world has committed to halving it, but outdated data is holding action back.

Overview

A significant amount of food intended for human consumption is never eaten. In 2011, the Food and Agriculture Organization of the United Nations (FAO) launched a landmark publication, Global Food Losses and Food Waste: Extent, Causes and Prevention (FAO 2011), with the headline finding that one-third of all food is lost or wasted between the farm and the plate. More recent estimates that include losses at the farm level find that 40% of the world's global food supply is lost or wasted (WWF-UK 2021).

This huge level of inefficiency has significant impacts. Consider food security. Food loss, which occurs closer to the farm can affect the ability of farmers to live above the poverty line and, at times, feed their families. Food waste, which occurs near the end of the food value chain, can affect household nutrition and food-related spending. Regardless of where the food loss and waste occurs, in a world where nearly 1 in 3 people faces moderate or severe food insecurity, it is a travesty that two and a half billion tons of food each year never gets consumed (WWF-UK 2021).

Consider the economic costs. Food loss and waste results in more than US$1 trillion in economic losses globally per year. Recent estimates from the Consumer Goods Forum (CGF) indicate that the global costs of food loss and waste are 25-50% higher than previously estimated, in part because of greenhouse gas emissions (GHGs) from food loss and waste. And although the direct effect of food loss and waste on food prices has not yet been directly measured, the costs of higher resource use and business inefficiencies are reflected in growing food prices. Therefore, investing in food loss and waste reduction efforts can reap significant economic benefits.

Consider the environment. The production of food that is ultimately lost or wasted requires a land area greater than that of China (FAO 2013). Moreover, food loss and waste generates about 8–10 percent of global greenhouse gas emissions annually (IPCC 2019). When food is lost or wasted, the land, water, and fertilizer used to produce that food goes to waste as well. A more circular approach to our food system is needed in order to reduce this environmental impact and make better use of what is already being produced without putting additional strain on planetary boundaries.

Considering these impacts, reducing food loss and waste can generate a triple win:

- It can help feed more people.
- It can increase savings for farmers, businesses, and households.
- And it can reduce the food system's pressure on the environment and help mitigate climate change.

Box 1. Definitions

Some organizations distinguish “food loss” and “food waste”. When making this distinction, the following definitions apply:

“Food loss” is defined as all the crop and livestock human-edible commodity quantities that, directly or indirectly, completely exit the post-harvest/slaughter production/value chain by being discarded, incinerated or otherwise. Losses that occur during storage, transport and processing are therefore all included (FAO 2022).

“Food waste” is defined as food and the associated inedible parts removed from the human food value chain (UNEP 2024). It is often used especially to refer to such waste that occurs at the food service, retail and consumer stages of the human food value chain.

“Circularity” refers to the reuse and repurposing of resources within a system, as opposed to a linear model where resources are discarded after use (McKinsey & Company 2024). Prevention and repurposing of food loss and waste therefore increases circularity within the food system. For the purposes of this work, the authors use “food loss and waste” or “FLW” as a term encompassing all food that exits the human food value chain, regardless of the stage of the value chain where it occurs.

We use this combined definition to reflect the way that food loss and waste span the entire food value chain, as well as the interconnectedness of the value chain.

Additionally, some sources make a distinction between processing and manufacturing in discussion of the human value chain. In these instances, the distinction is that food processing refers to turning raw materials into value-added products that would be used later in the food value chain (e.g. processing of tomatoes into tomato paste). Manufacturing, then, would refer to the assembly of processed goods into a “finished” food product (e.g. using tomato paste with other ingredients to create a ready-to-use pasta sauce).
The authors have also combined the processing and manufacturing sectors. The first reason is that many of the interventions for reducing FLW among both processing and manufacturing are duplicative and thus warrant discussion across both sectors. The second is that most data sources reporting FLW among these sectors consider processing and manufacturing as a whole, rather than separating them. Finally, many companies who engage in processing by these definitions also engage in manufacturing, and vice versa. Therefore, for the purposes of this report we consider both processing and manufacturing in tandem.

The world has united around the importance of food loss and waste reduction. In September 2015, at the United Nations General Assembly, countries around the world formally adopted a set of 17 Sustainable Development Goals (SDGs) as part of the 2030 Agenda for Sustainable Development: Global goals to end poverty and hunger, protect the planet, and ensure prosperity for all populations and generations (UN 2017). SDG 12 seeks to "ensure sustainable consumption and production patterns."

The third target under this goal (SDG 12.3) calls for halving per capita global food waste at the retail and consumer levels and reducing food losses along production and value chains (including post-harvest losses) by 2030. The importance of food loss and waste in addressing global sustainability goals has been further reiterated since then, in works such as the EAT-Lancet bundle which identifies reducing food loss and waste as a key strategy for reducing the environmental impact of our food system, alongside shifting to healthier diets and improving food production practices (Sundiang et al. 2025).

How much food is lost or wasted and where does it occur?

To date, global estimates of food loss and waste have tended to reflect the notion that FLW is experienced differently in different parts of the world (Lipinski et al. 2013). These estimates show that in lower-income countries, FLW occurs more frequently toward the start of the food value chain, nearer to the production and handling and storage stages. Conversely, in higher-income countries FLW tends to occur at higher rates at the retail and consumption stages of the value chain. FLW at the processing stage tends to be more consistent, typically less than 10% of overall FLW throughout the entire food value chain. This data is based on 2011 FAO analysis and reflects 2007 data, however, which represented the last major undertaking to measure global FLW within one study.

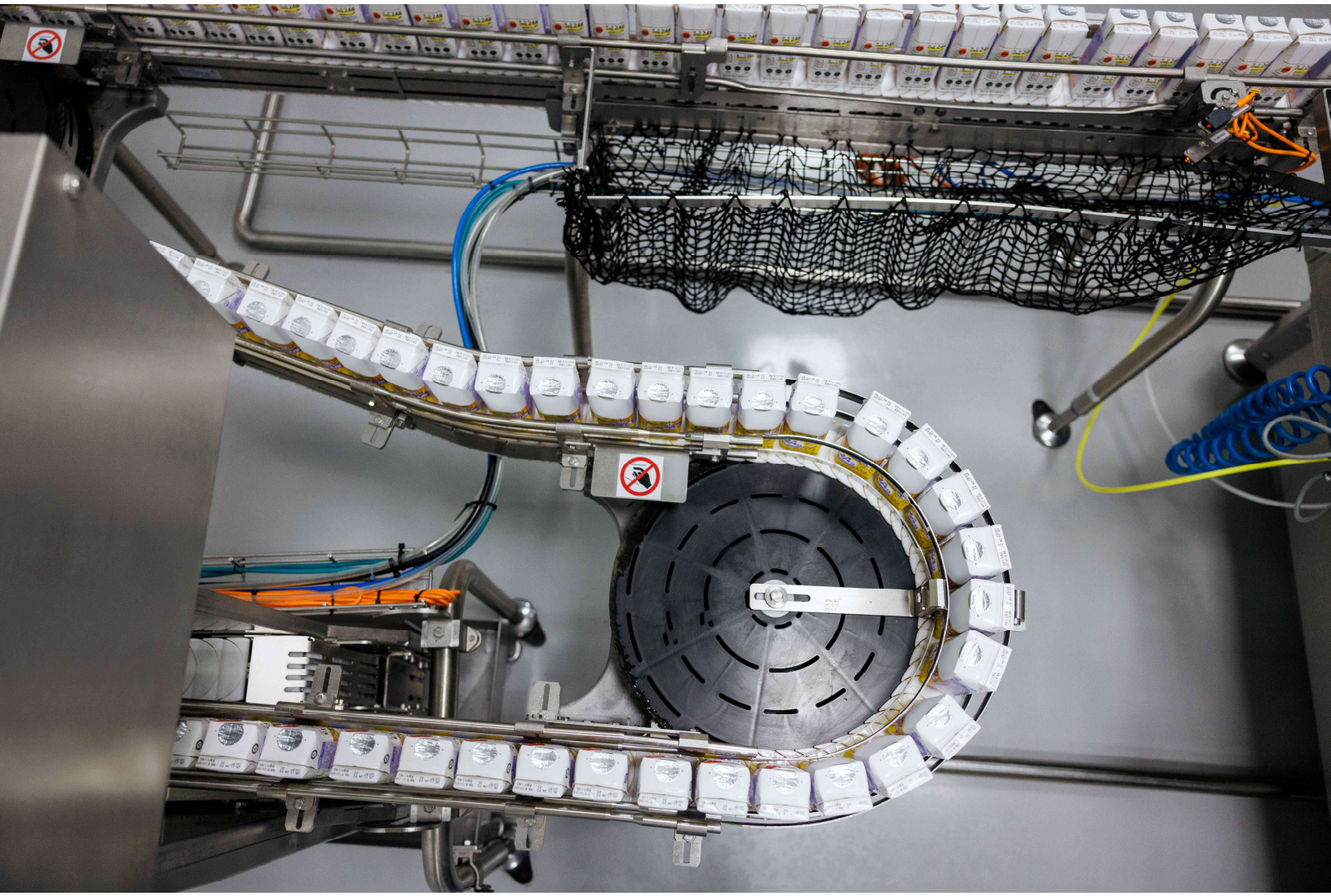
This assessment, albeit useful for the time, is now outdated and more recent estimates have indicated higher levels of food waste within the processing stage. For example, according to Eurostat data, 19% of food waste within the EU is generated at the processing stage (Eurostat 2025). In recent years, this understanding has shifted in two significant ways, reflecting the farm and the consumer levels most specifically.

In 2021, WWF and Tesco partnered to publish Driven to Waste: The Global Impact of Food Loss and Waste on Farms, a study of on-farm and post-harvest losses. This study found that 8.3 percent of food is lost or wasted at the harvest stage of the food value chain, and an additional 7 percent of food is lost or wasted during farm-stage post-harvest activities, representing 1.2 billion tons of food. This amount of loss and waste represents approximately $370 billion worth of food, 2.2 gigatons of carbon dioxide equivalent greenhouse gas emissions, and 4.4 million square kilometers of land, or an area larger than the size of India (WWF-UK 2021). This finding emphasized the importance of finding solutions that will address on-farm losses.

Also in 2021, UNEP published the first edition of the Food Waste Index and updated the Index in 2024 (UNEP 2024). Among other findings, the Food Waste Index revealed that waste at the household-level is relatively consistent across income levels, but even more strikingly highlighted the lack of data availability for generating estimates across sectors.

The 2024 edition of the Food Waste Index also introduced the option for countries to report "food loss generated at manufacturing level" and provided measurement guidance for companies and countries for engaging the manufacturing level. This guidance is reflected in the "Measuring FLW at the Processing Stage" of this paper, but UNEP is not yet reporting losses at the processing stage.

In short, although food loss and waste is now globally recognized as a significant issue by both countries and companies, action has lagged behind this understanding. Many significant data gaps still exist, most globally-available data is based on older estimates, and much of the available data does not reflect waste levels at the processing stage.





Processing's Role in Reducing Food Loss and Waste

Processors sit at the hinge of the food value chain, which gives them the power to cut losses on the farm, in their own operations, and all the way to the consumer's plate.

The processing and manufacturing stage of the food value chain has been less prominent in most studies of food loss and waste in relation to other stages of the food value chain. Perhaps because a smaller proportion of FLW occurs at the processing stage, it has received less attention than other stages within the food value chain in FLW literature. These companies have the unique ability to influence the entire food value chain, positioned at the fulcrum between the production and consumption ends. Within this paper, we are examining the unique role of the processing sector in addressing systematic FLW.

Why focus on the processing sector?

Food companies, many of which sit within the processing sector, have so far been outpacing governments and regional bodies in taking action on food loss and waste. While few countries are taking consistent and systematic action to address food loss and waste, companies have been demonstrating major reductions and motivating further action throughout the value chain (Lipinski 2024). These reductions in turn demonstrate to governments, companies, and other actors within the food value chain that addressing food loss and waste is a priority and motivates further action in turn.

Due to their location within the food value chain, companies involved in processing are uniquely able to affect what occurs both upstream and downstream from their own operations. They serve as a "hinge" point within the value chain that most food passes through as it moves from production to consumption. They are therefore well-placed to not just reduce their own losses, but to reduce losses throughout the food value chain.

Affecting upstream losses

Agricultural producers and farmers frequently are motivated to produce as much food as possible in order to meet the expectations of their buyers and maximize incomes, and in the case of smallholder farmers, provide food for their own households (Kiaya 2014). However, in cases where an agricultural producer is not able to sell the entirety of its yield due to lack of market access or yields that are larger than anticipated, processors play a vital role. Access to processing can reduce upstream losses by providing opportunities for agricultural producers to extend the shelf life of products and avoid losses due to overproduction or higher than anticipated yields (Rolle 2006). In addition to extending shelf life, processing adds value to agricultural goods and provides further revenue streams for producers.





Case Example: Upcycling Agri-Waste

Agri-waste refers to all byproducts and residues that are generated during crop or animal production that are not used as primary products. On the plant-based side, this refers to items such as stems, stalks, leaves, roots, and other components of agriculture that remain after a crop is harvested or processed. These residues are rich in bioactive compounds, including proteins, sugars and minerals that go to waste if the residues are not properly recycled.
These residues can be used as an alternate source for the production of products like biogas and biofuel, as well as in the production of foodstuffs such as mushrooms and tempeh. Companies such as Gaia Tech have begun to remake these compounds into upcycled products for use in food and cosmetic products, thus turning previously wasted products into a new revenue stream and more efficiently using the entire crop.
Animal-based agri-waste, which includes bones, skins and tissues that go un-eaten, is also rich in nutrition and resources. Although more difficult to upcycle into the food stream than plant-based residues, better utilization of animals helps to reduce carbon emissions and other associated environmental inputs while also getting more value out of often-expensive livestock. Companies such as SuperGround have pioneered approaches that use the entire mass of animals such as chicken and fish to prevent bones and organs from going to waste without diminishing the consumer experience.
Source: Sadh et al. 2018.

Affecting downstream losses

As the "hinge" point within the food value chain, processors also can influence downstream actors, including retailers, food service providers and households. The actions taken by processors influence such factors as the date labels that appear on packaging, packaging choices that can affect the shelf life of food or a consumer's perception of food, or even the amount of food contained within a package. These decisions can each lead to higher or lower levels of FLW which would be measured as occurring in a different stage of the food value chain, but would be directly impacted by the decisions during processing.

For example, food donation is frequently highlighted as an intervention to prevent food from going to waste. However, date labels on packaging can affect whether a food product can legally be donated, and many such date labels do not actually indicate food safety. In countries such as Argentina, Singapore and the United States, it is expressly illegal to donate past-date food, even when that date is merely intended as a signal of peak quality rather than relating to food safety (Beckmann et al. 2021). In this way, the date determined by the processor can cause FLW to occur downstream, or conversely, can lead to prevention of FLW.

Losses Within the Processing Sector

By its nature, the processing sector contains a wide range of companies and actors. They vary in geographic location, company size and type(s) of food handled. There is no single type of FLW that is most prevalent among all processors and manufacturers, and there is no single intervention that will apply to all companies within the processing sector. Additionally, FLW causes at the processing sector have historically been less addressed in favor of studies relating to FLW at other stages in the food value chain (Sheahan and Barrett 2017).

The challenge of addressing loss within the processing sector is exemplified by a 2019 study of the Belgian processing industry, which identified 18 different potential sources of FLW among processors (Dora et al. 2019), each of which would be affected by a different solution set. Table 1 summarizes these potential sources of FLW.

Table 1. Potential Causes of FLW Within the Processing Sector

Before production	Wrong order
	Suboptimal storage
	Suboptimal inventory management
Processing	Poor transportation
	Interrupted production
	Product changes
	Machine maintenance issues
	Human errors
	Product defects
Packaging	Labeling errors
	Non-sealed packaging
	Damaged packaging
	Incorrect filing
	Incorrect stacking
After production	Suboptimal inventory management
	Poor transportation
	Buyer contracts



Measuring Food Loss & Waste in Processing

Processors sit at the hinge of the food value chain, which gives them the power to cut losses on the farm, in their own operations, and all the way to the consumer's plate.

Estimates of FLW in the processing stage vary significantly by food type and geographic focus, however, even when these aspects are consistent, significant variation still exists, and the data is often of poor quality due to high levels of uncertainty (Spang et al. 2019). Measurement for post-harvest losses are negatively impacted by varying definitions, scopes, and lack of a systematic approach to data collection (Kitinoja et al. 2018).

FLW measurement methods are largely context-specific, depending on factors such as data availability, geographic focus, value chain stage, and associated cost (Amicarelli & Bux 2021**).** Additionally, within the existing major FLW measurement frameworks, there are often tradeoffs between the analytical capability of the approach versus how complex the method is (Fabi et al. 2021). The most frequently-applied measurements within the processing sector are summarized below, along with their benefits and drawbacks.

Direct measurement

Direct measurement includes a variety of methods in which FLW is directly counted, weighed, or otherwise measured as it occurs (CEC 2021). Direct measurement often produces the most accurate FLW figures but can also require high levels of expertise, time and cost and may not be feasible within a large facility or a company with numerous facilities.

When engaging in direct measurement within a processing facility, a company will need to directly count or weigh solid amounts of FLW, or assess the volume of liquid FLW. Wastewater assessment methods that measure biochemical oxygen demand (BOD) and chemical oxygen demand (COD) would also be included within direct measurement. For direct measurement to be undertaken, the FLW will need to be diverted to a separate container or set of containers where it can be weighed and compared to overall production within the facility.

Food waste is collected for a period of time (e.g., one eight-hour shift) and then scaled up to provide an approximate estimate of the amount of FLW within a week, month, or year. More accurate estimates require repeated sampling to account for fluctuations over time. For a company with multiple facilities, the data can be extrapolated to other facilities as long as the measurements can be reasonably assumed to be representative of other facilities (FLW Protocol 2016).

Direct measurement provides highly accurate and detailed data but presents drawbacks as well. Companies will need to be able to isolate the FLW, which may be challenging for a facility with numerous product lines. In a facility where numerous types of food are being handled, direct measurement will not necessarily provide information about what types of food are being discarded and why it is occurring. Additionally, the act of diverting the FLW and conducting the measurement can be expensive and time-consuming.

Waste composition analysis

A waste composition analysis is a process of physically separating, weighing and categorizing waste. It can be used both to determine total amounts of FLW and to categorize the different types of foods that have been discarded (e.g., fruits, vegetables, meat) or distinguish between food and inedible parts.

In a waste composition analysis, waste is collected and physically separated in a manner similar to direct measurement. However, measurers then take another step of sorting the food waste into separate categories and weighing each of those categories individually. As with direct measurement, the data can be extrapolated to other facilities as long as the measurements can be reasonably assumed to be representative of other facilities (FLW Protocol 2016). A waste composition analysis provides detailed insight into relative amounts of FLW, but is time-consuming and expensive.

Mass balance

Mass balance measurement infers food loss and waste levels by comparing inputs (e.g., ingredients entering a facility) with outputs (e.g., products produced and sold to customers) along with changes in standing stock levels and adjustments based on transformation of ingredients during the processing process (CEC 2021). At its most basic, a mass balance equation for estimating FLW is: **FLW = Inputs – Outputs ± Changes in Stock ± Adjustments.**

The mass balance approach can be effective when a company has strong existing data, but any inaccuracies among the four variables will lead to inaccuracies in the final FLW calculation. In addition, a mass balance approach does not gather information on causes of FLW.

Interviews and Surveys
Interviews and surveys are all qualitative methods for gathering information relating to FLW. They are not sufficient for measuring qualitative FLW levels on their own, but they will provide additional insight into the causes of FLW as well as possible solutions. Surveys can also help to collect information relating to attitudes and perspectives that can assist in empowering employees and identifying potential roadblocks to action (CEC 2021).

When using interviews and surveys within the processing sector, employees are generally asked to estimate amounts of waste, as well as causes of waste, where the waste occurs (for example, at a specific stage of the manufacturing process), and what types of food are being wasted most. Combined with numerical data, this information can provide a more holistic view of the way FLW is impacting a company's operations. However, respondents to interviews and surveys do tend to underestimate amounts of FLW due to cognitive biases. Also, if employees do not feel empowered to respond honestly and openly they may intentionally omit information about causes and amounts of FLW. These five methods have been summarized in Table 2.



Table 2. Common measurement methods in the processing sector

Measurement Method	Definition	Benefits	Drawbacks
Direct measurement	• Various methods which measure FLW directly by counting, weighing or measuring BOD/COD in waste water.	• Can produce highly accurate data	• FLW needs to be isolated • Can be resource-intensive (costs, time, expertise needed). • May not be appropriate for facilities with numerous product types or waste streams.
Waste composition analysis	• Involves physically separating, weighing, and categorizing FLW.	• Can provide fairly accurate data on the total amount of FLW. • Can provide details on the type of FLW (e.g., by commodity type • Detailed information can be used to estimate cost, impacts and nutritional content of FLW.	• Time consuming and requires specific knowledge • Detailed studies likely to be expensive. • Does not collect much information on causes of FLW.
Mass balance	• Input versus output analysis.	• Cost-effective if there is existing input/output data. • Can help identify FLW hotspots depending on how the data are collected.	• Relies on existing data and assumptions for conversion rates that may be inaccurate.
Records	• Existing collections of data. Even if not collected for FLW originally, these datasets can often be repurposed.	• Fairly cost-effective. • Appropriate for initial assessments into FLW and to supplement other methods.	• Accuracy and breadth of existing records varies. • Data collected may not be well-suited to FLW reduction activities. • Not useful for identifying causes of FLW.
Interviews/ Surveys	• An interview or questionnaire of workers within a business as to amounts and causes of FLW.	• Cost-effective. • Can provide insight into causes of FLW.	• Data quality can be low due to self-reporting biases. • Employees may not feel empowered to speak openly about occurrence of FLW.

Measurement across value chains

There are two main approaches to estimating FLW across value chains: macro and micro (Delgado et al. 2021). Mixed methods are also commonly used depending on the level of analysis (Delgado et al. 2021; Amicarelli & Bux 2021).

Macro approaches
Macro approaches employ aggregated data from national or subnational authorities as well as from large companies. Measurement methods are largely mass balances (raw material inputs compared to what is produced as an output). The benefits of the macro approach are that it is often low cost and can provide estimates of losses for the entire value chain. However, the drawbacks are the lack of high-quality data and data gaps, especially within the processing sector (Delgado et al. 2021).

One example of a macro approach related to a mass balance study of FLW by product group across the European Union (Caldeira et al. 2019). Using a variety of data sources sourced from the FAO, member states within the EU, and scientific literature, the authors applied a mass balance approach to ten commodity types within the EU. These findings highlighted meat, fish, fruit, and oil crops as especially relevant areas of focus for the processing and manufacturing sector. Although these high-level findings provide a helpful guide for policymakers and decisionmakers, they are less useful for a company seeking to identify specific actions to take within their operations.

Micro approaches
Micro approaches source data from specific actors in value chain stages and includes measurement methods such as questionnaires, interviews, diaries, and direct measurements. Which measurement methods are employed is very dependent on region and context, but these micro approaches can be helpful in determining where the hotspots for FLW are within the value chain. Usually, a mixture of micro approaches is needed to gain a complete picture of FLW hotspots. While the information gathered from these methods is more granular and accurate than that gathered from macro methods, these methods can be more resource intensive (time, cost, etc.) and can have limited comparability given the approaches are narrowly tailored to each context. These methods are most likely to provide useful data for companies within the processing sector, however.

One example of several micro approaches being applied to the FLW measurement within the processing sector relates to a study of the dairy value chain in Uganda (Wesana et al. 2019). In this study, the authors assessed losses within the dairy value chain of Western Uganda using a mixture of direct measurements during site visits, existing records kept by producers and processors, and interviews with workers to understand causes and extent of FLW. Because of the application of numerous micro approaches, the authors were able to identify very specific causes of FLW within the value chain and gather highly specific data. However, this approach is resource- and time-intensive compared to more general approaches.



Opportunities for improvement of measurement of FLW within the processing stage

Inevitably, FLW measurement comes down to what resources are available and which method is most suitable under the circumstances at hand. However, some data gaps on FLW in the processing stage can be attributed to insufficient coordination between initiatives, so alignment on frameworks for measurement could improve synergies among stakeholders (Fabi et al. 2021).

International standards can fulfill a key role in this regard. In September 2025, the International Organization for Standardization (ISO) released the draft version of ISO/DIS 20001, titled "Food loss and waste management system — Requirements for the minimization of food loss and waste across the food value chain." This standard is meant to apply to all organizations (e.g. food producers, food processors and manufacturers, wholesalers, retailers, restaurants, food-related charities) within the food value chain. It describes the requirements for what is described as a "Food Loss and Waste Management System (FLWMS)", which lays out how an organization intends to address food loss and waste within its operations.

At its most essential, ISO/DIS 20001 enables an organization "to plan, implement, operate, maintain, review, improve and update a FLWMS to minimize [food loss and waste] within its operations and/or its value chain." It provides guidance and requirements related to measurement, reporting, reduction activities, evaluation and assurance, and communication of food loss and waste reduction efforts. It does not provide specific guidance for processors, but it does provide examples of how companies can analyze and report their FLW.

ISO/DIS 20001 also establishes a hierarchy for prioritization of FLW solutions, that places food waste prevention as the top goal for organizations as they tackle food loss and waste.

Box 3. Measurement via equipment-level metrics

Overall Equipment Effectiveness (OEE) is a standard for measuring production productivity. Essentially, higher levels of OEE correspond with higher productivity. OEE is assessed using a wide range of factors that can be broadly grouped into two categories:

Resource efficiency factors directly relate to food loss and waste and include factors such as product defects, production and technological losses, raw material quality, energy consumption and other similar factors. These factors directly show the level of efficiency (or inefficiency) of equipment in the processing and manufacturing of food products.

Operational productivity factors relate to overall facility efficiency and include factors such as average and maximum capacity, working hours, energy consumption, switchover time, the purchase cost of the machine, time to start the process, time needed to execute the production order, and other similar factors. These operational productivity factors have a more indirect effect on food loss and waste.

Studies such as Soltanali et al. (2021), Mansour & Al-Hamdani (2024) and Zhang et al. (2024) demonstrate that machine downtime, performance efficiency, and repair dynamics can be quantified and directly linked to production losses. Since companies are often already tracking the performance of their equipment and machines within a processing facility, this data can correspond closely with food loss levels, thereby offering an evidence-based complement to existing FLW methods.



Addressing Food Loss and Waste Within Processing Facilities

Practical steps processors can take, from empowering staff and upgrading equipment to upcycling, donation, and smarter packaging, to cut waste in their own operations and beyond.

Although the causes and relevant interventions for loss within the processing sector will vary depending on numerous factors, there are some interventions with broader applicability across numerous stages of the processing sector. Not all of these interventions are directly tied to action by processors and manufacturers, and in fact many require action throughout the value chain. This demonstrates the interconnectedness of the various stages of the food value chain and the role that processors play in reducing FLW not within just their own operations, but in influencing FLW reduction both up- and downstream. (The role of policy in FLW reduction is addressed later in this paper, and therefore is not included here.)

Case example: Whole soya processing

In typical soybean processing for products such as soy milk and tofu, an insoluble portion of the pureed soybeans known as *okara* is discarded. While it is sometimes repurposed for livestock feed or use as fertilizer, it is only rarely used for food consumed by humans. However, a new processing method that uses the whole soybean results in a soy product composed of 1.2% fiber rather than the standard 0.26% in traditionally-produced soy product. It also produces up to 70% more beverage from the same volume of beans, thus resulting in more food being produced from the same field of soybean. This process therefore prevents land conversion, prevents waste, and produces a more nutritious product via a change in processing.

Source: Tetra Pak 2022.



Reducing Food Loss and Waste within Processing Facilities

- **Improve training of staff to reduce technical malfunctions and errors during processing and empower them to report wasteful activities.** Staff are on the front lines in a processing facility and are therefore well-equipped to see sources of waste as they occur. However, they may not feel empowered to address waste directly or may fear blame for wasteful practices. Because of this, inefficient "business-as-usual" practices may continue even when an employee has identified a source of waste. Training and empowering staff in addressing common errors and finding new sources of waste can lead to big shifts.

- **Upgrade equipment and practice preventive maintenance.** Multiple peer-reviewed studies show that improving machine performance (e.g., higher OEE, reduced downtime, improved reliability) directly lowers processing-stage losses (Soltanali et al. 2021; Zhang et al. 2025). Evidence from modernization case studies and Industry 4.0 research further demonstrates that upgraded processing lines and automation reduce defects, variability and waste (Arshad et al. 2025; Hassoun et al. 2023). UNIDO reports also explicitly identify inadequate processing infrastructure as a core loss driver and recommend investment in upgraded equipment and technology transfer to reduce processing losses.

- **Reengineer production processes and product design to reduce waste and preserve high-value components.** Waste effluent often contains high amounts of valuable byproducts that are lost to the waste stream. This compounds the costs of food loss and waste, as companies are paying for both waste treatment costs as well as the opportunity costs of losing these byproducts**.** Technologies such as ultrafiltration and nanofiltration can allow the preservation of these byproducts without leading to higher levels of waste (Cassano et al. 2018).

- **Introduce software and related information and communications technologies to optimize operations.** Technological solutions can help to identify waste, track temperature and ensure freshness, assess ripeness, better balance demand and supply forecasts, and accelerate delivery of food. Combined with proper training of staff, the deployment of these technologies can lead to significant reductions of waste (Jagtap and Rahimifard 2019).

Case example: Digitization to reduce operational food waste

Digitization has the potential to reduce operational food waste by improving data gathering and identifying where waste occurs through the use of software for real-time waste tracking. In one case example of an anonymous facility producing prepared meals, shifting from a paper-based tracking system to the use of digital touch screens resulted in a 60% reduction in food waste over just nine months. The touch screens asked employees to identify the type of waste and the reason for its disposal, while the application automatically recorded the date, time and financial value of the wasted food alongside that input.

This process took up less than five minutes of an employee's time on an average work week, but provided actionable insights around the causes and necessary interventions for food waste that were not previously being captured. This change reduced monthly waste by more than 4,000 kg at the facility, saving the company money via reduced tipping fees and a more effective use of resources.

Source: Jagtap and Rahimifard, 2019.

- **Develop new food products or secondary uses from what may have previously gone to waste.** Known as upcycling, this practice involves repurposing food that would otherwise be wasted to higher uses, thus preventing waste while generating benefits for companies and consumers (Spratt et al.). Upcycling most commonly involves edible food being repurposed into other uses, such as unsold produce being made into soups or jams or brewers processing spent beer grains into bread or flour. However, it can also be applied to parts of food that have previously been seen as inedible, such as fish skin being repurposed as a crispy chip (Aschemann-Witzel et al. 2023). These upcycled products help to prevent waste while generating additional income for companies and reducing waste disposal costs.

- **Seek donation of excess food that is still safe to consume and would otherwise go to waste**. When FLW is not preventable, donation is an option that helps keep food from going to waste and benefits those households experiencing food insecurity. Food donation is increasing globally – for example, in 2023, food banks globally increased distribution by an average of 25%, delivering about 654 million kilograms of food and grocery products, or the equivalent of 1.7 billion meals. And in some locations, such as France, some food businesses are required to donate unsold food (Zero Waste Europe). However, food recovery and redistribution activities should be balanced with FLW prevention activities.

Case example: Upcycling food

Upcycling initiatives offer alternative FLW reduction pathways by converting surplus or cosmetically imperfect produce into value-added products. For example, the “Just Peachy” project established by The Campbell’s Company redirected peaches that would otherwise be discarded into salsa, leveraging new processing and retail partnerships to generate over $250,000 for hunger relief and reducing farm-level dumping fees. Similarly, Matriark’s model rescues vegetable remnants for broth concentrate production, diverting 1,500 lbs of produce per pallet and capitalizing on otherwise overlooked farm-level losses. These approaches demonstrate the feasibility and scalability of FLW reduction through value chain innovation, particularly where direct measurement at the farm or processing level is challenging.



Reducing Loss and Waste in Other Parts of the Value Chain

- **Use product sizes and packaging that reduce waste by consumers (e.g., accommodate desire for smaller or customizable portions).** When consumers are required to purchase larger packages of food, they may end up wasting more food. Some studies have found that households with fewer members have higher levels of waste (Paritosh et al. 2017) due to households of just one or two people being unable to finish a complete package of food before it spoils. And in other studies, authors have found that almost half of household food waste can be attributed to large packaging sizes and that large packaging was especially linked to higher levels of waste for perishable foods such as dairy products and meat and fish (Williams et al. 2020).

- **Adopt technologies such as aseptic processing that extend shelf life for highly perishable foods.** Aseptic processing, in which thermally sterilized liquids are packaged into sterile containers, can extend shelf life of highly perishable foods such as milk that normally require strict cold storage. For example, milk processed using an aseptic ultra-high temperature (UHT) system can be stored for 6-9 months at room temperature, as compared to pasteurized milk which has a shelf life of 7-14 days under ideal cold conditions (Mahmood 2025). This reduces food waste at multiple stages in the value chain—from distribution centers to consumer households—especially during storage delays or transportation disruptions.

- **Standardize date labels (e.g., eliminate "sell by" and use only "use by" for perishable items and "best before" for others) to reduce consumer confusion and facilitate donation of unsold goods.** Current date labeling practices on food packaging are inconsistent across manufacturers and can cause confusion between 'sell-by', 'best-by', 'use-by', and 'best before' dates. This can lead consumers to discard food that is still safe and edible out of an abundance of caution. This confusion is estimated to account for about 7% of consumer waste (ReFED 2025). Manufacturers can alleviate this confusion by aligning around a common set of date labeling language, which makes clear which labels actually pertain to food safety.

Case example: The Food Pact Network

Food Waste Pacts (which bring together national trade associations, businesses, government, local grass roots civil society organizations and other stakeholders to collectively tackle FLW up and down the value chain) have proven that it is possible to mobilize companies in a short period of time. The global Food Pact Network, led by the organization WRAP, is active in 9 countries: Brazil, Indonesia, Mexico and South Africa, as well as Australia, the Netherlands, New Zealand, UK, and the United States. This network encourages peer-to-peer learning by enabling in-country pacts and companies to share experience of practical solutions and innovations. It also facilitates learnings to be shared across countries, value chains and sectors. The Pact approach has shown quick and significant results; for example, the US Food Waste Pact has reported a 21% reduction in emissions from participating companies.



Policy Considerations

How governments around the world are using national strategies, date label standards, data reporting, and infrastructure investment to tackle food loss and waste.



Although much of this document has focused on the actions individual processors can directly take to address FLW, governments have even more potential to influence FLW reduction across the processing sector and beyond. These policies should focus on implementing what is known to currently work to achieve rapid reductions in FLW, while also gathering data for the future to inform future policies and plans. The first policy approach listed below takes on a full value chain approach, while the others are more specifically tailored in their effects on the processing sector.

Intersectoral Plans of Action

Ideally, governmental policies on FLW will be holistic and implement activities across the entire value chain. These approaches look at FLW as an interconnected issue rather than addressing individual issues, thereby promoting circularity and enabling greater reductions while gathering information for future plans, programs and policies.

Recent examples include:

- In 2025, Spain passed Law 1/2025 addressing food loss and waste across the entire food value chain. The law introduces standardized definitions for food loss and waste and establishes a food loss and waste hierarchy prioritizing human consumption of all food products. Additionally, the law requires all food businesses above a determined size to develop and implement a food waste prevention plan within one year of the implementation of the law. The law also introduces financial penalties for businesses that fail to comply.

- In 2025, the South African government released a national strategy for reducing food loss and waste focused on four main areas: creating the enabling environment for the implementation of FLW interventions, the circular economy, capacity building and awareness raising, and food waste diversion/GHG emission reductions. The strategy establishes a set of indicators and targets while identifying which agencies have ownership over which activities.

- In 2024, China released the Action Plan on Food Conservation and Anti-Food Waste, which focuses on reducing FLW occurring within grain production, raising awareness of FLW nationally, and supporting food waste reduction in restaurants and cafeterias. The plan also calls for the establishment of mechanisms for data collection and the release of a set of indicators relating to FLW by 2027.

- The *EU's Waste Framework Directive* requires member countries to reduce FLW in each stage of food value chains and set a goal for member states to reduce food waste in processing and manufacturing by 10%. In addition, the European Commission has other strategies related to FLW prevention and reduction, like the *Framework for Sustainable Food Systems* and the *Circular Economy Action Plan*.

Standardized Date Labels

Confusing date labels on food packaging (e.g., "sell by," "best before," "use by") can cause premature disposal and prevent donation of edible products. Refinement of date labels may lead to lower food waste at the consumer level and facilitate further donation of food that may otherwise go to waste. Most studies highlight the need for a dual date-label system, using a "best before" date for products that are not perishable but may decline in quality, or a "use by" date for perishable products that present food safety concerns (Beckmann et al. 2021). Although the FLW caused by date labels may occur elsewhere in the food value chain, processors often determine what is listed on date labels and therefore are strongly affected by any such policies.

Recent examples include:

- The European Union, which requires processors to label only "highly perishable" products with a "use-by" date and requiring a "best before" date for all other foods.

- France has introduced a national label awarded to food service entities such as supermarkets, suppliers, restaurants and catering companies that contribute to national objectives to reduce food waste and meet France's 50% FLW reduction goal. The initiative establishes three tiers of commitment and are issued by France's Ministry of Ecological Transition and Territorial Cohesion (Ministry of Ecological Transition and Territorial Cohesion 2026).

- The United Kingdom, which follows similar guidance to the EU and also publishes a list of which specific products require which labels (DEFRA 2023).

- California, the most populous state in the US, which passed a law in September requiring simplified date labels. The law came into effect in 2026 (CDFA 2024).

Improved Data Reporting

Reliable data is imperative to identifying food loss and waste hotspots, tracking progress, and enforcing reduction targets. Data collection to date regarding FLW has been inconsistent across all stakeholders, hindering the development and effective implementation of policy due to a lack of reliable information. According to the UNEP Food Waste Index Report (2021), incomplete data collection has led to significant underestimation of food waste levels globally. Through mandatory data collection at the national and sector level, along with standardized definitions and measurement protocols, countries can set more accurate baselines, track progress, and better hold stakeholders accountable, enabling more effective policy.

Recent examples include:

- Outlined in the revised 2023 EU Waste Framework Directive, Article 9 states member states must report food waste data annually using standardized methodology. This data must be reported by weight and sector while methodology sets specified guidelines for measurements (European Commission 2023).

- Japan has reduced national food waste by 53%, making it the only country in the world to achieve SDG 12.3 to date. A representative of the Japanese Ministry of Agriculture, Forestry, and Fisheries identified legally-mandated FLW reporting for companies as a key to success, and the country has now issued an updated target of a 60% reduction in FLW for companies (UNEP 2025).

- The ISO directive ISO/DIS 20001, titled "Food loss and waste management system — Requirements for the minimization of food loss and waste across the food value chain." (See Section 4 of this report for more information.) Although not from a governmental body specifically, this standard will represent the most significant step to date in encouraging consistent FLW reporting across businesses.

Development of Infrastructure and Technology

Updated infrastructure and technological development are integral to continue driving FLW reduction, particularly for perishable products. Through the investment and value chain integration of emerging strategies like cold storage and improved packaging, food loss and waste resulting from spoilage can see a dramatic decrease.

Recent examples include:

- In January 2025, the African Union adopted the Kampala Declaration, which lays out a 10-year strategy and action plan for how its 55 member states intend to enhance food security and nutrition across Africa. Specific activities within the Kampala Declaration related to post-harvest loss reduction include enhancing the integration of smallholder, women, and youth farmers into value chains to improve market access; removing trade barriers and improving infrastructure for efficient movement of goods; and investing in regional value chains and post-harvest infrastructure (African Union 2025).
- Brazil's "Intersectoral Strategy for the reduction of Losses and Food Waste" aims to address post-harvest losses through investment in storage, transportation, and processing infrastructure (Ministry of Social Development 2017).
- Thailand has developed a Food Management Plan Action Plan, which contains a specific Action Plan for Food Loss Reduction in the Production Chain. The stages of the plan include awareness-raising around food loss, deployment of technologies to reduce food losses, and research of new technologies and approaches (Thailand Food and Drug Administration 2024).





Conclusion and Recommendations

Food loss and waste is an opportunity hiding in plain sight. These recommendations show how the processing sector can turn it into social, economic, and environmental gains.

To conclude this assessment of food loss and waste and the processing sector, we offer a series of recommendations that would have the potential to reduce FLW in both the processing sector and beyond. These are grouped by recommendations for processors and manufacturers specifically, followed by cross-cutting recommendations.

Companies

Companies should examine their internal processes to identify opportunities for preventing and reducing food loss and waste within their operations.

Many companies adopt a "business-as-usual" approach to waste, assuming a certain amount is inevitable, unavoidable or simply a necessary part of doing business. However, a regular assessment of operations within a facility can help identify possible points for improvement, such as deficient equipment and inefficient processes. Many of these interventions will not require expensive investments or significant changes, just tweaks to existing approaches and methods of working. Additionally, many of the most successful companies in addressing and reducing FLW are those that empower employees to point out possible sources of waste and suggest possible improvements to implement, since they are closest to the waste as it occurs.

Companies should structure agreements with their supply chain partners with a view on preventing waste.

Processors and manufacturers can structure contracts and agreements with partners both upstream and downstream to help prevent waste from occurring. For example, whole crop purchase contracts are agreements where the buyer purchases the entire crop from a farmer, regardless of quantity or cosmetic quality. These agreements help reduce overproduction by farmers, thus reducing farm-level losses. Conversely, processors can work with retailers on matters such as what dates are used on date labels, which can help prevent waste at retail by allowing more food to be sold and donated when necessary.

Companies should adopt technologies that have the potential to reduce food loss and waste across the value chain.

There are numerous promising technologies that can reduce food loss and waste within processing while improving outcomes across the entire food value chain. The earlier case example of whole-crop processing reduces waste in the processing process, provides farmers with greater sales, and produces a higher-quality product for consumers. Another example comes from fermentation biotechnology, which reduces waste by preserving food in a method that supports resource recycling and reduces greenhouse gases (Gabriele et al. 2026). Companies should explore which technologies are most appropriate for their own sector and begin to adopt systems that will allow for waste reduction while generating new revenues and reducing environmental impacts.

Cross-cutting

Governments should incentivize public reporting on food loss and waste. Although numerous companies have begun to report food loss and waste within their operations, this trend is slowing and in some cases, reversing. A 2025 study found a 52% reduction in companies releasing voluntary ESG reports, reflecting a shift away from public reporting (The Conference Board, 2025). Governments can incentivize and even require public reporting, with countries such as Japan that require companies of a certain size to report their waste experiencing the greatest reductions in overall FLW. Boosting public reporting holds companies accountable while incentivizing action and elevating the issue of FLW for companies that have not yet begun to address it within their operations.

Governments should also incorporate FLW into national targets, policies and plans. National governments experience the greatest success in FLW reduction when it is incorporated into all relevant national strategies. Japan's success in reducing FLW is largely attributable to this multi-agency approach, in which relevant agencies targeted FLW reduction efforts at businesses as well as households (Japan Consumer Affairs Agency 2025). Governments also have the ability to set binding targets for actors across the food value chain, which can motivate businesses to take action, and this approach will be further tested as the European Union rolls out binding targets. Governments should also incorporate FLW reduction into plans such as Nationally Determined Contributions and National Adaptation Plans and ensure those commitments are translated into meaningful policy measures (Global Action Drive 2025).

Finance mechanisms should extend funding to innovative waste-saving technologies within the processing sector. Many methods have shown promising results for reducing FLW, whether it be new processing methods (such as whole crop processing), innovative circular waste treatment methods that turn waste into useful products, or use of emerging technologies such as big data and artificial intelligence to address the issue of FLW (Arshad et al. 2025). However, for smaller technology providers, finance is often not available to scale up these approaches. Finance providers both public and private need to design funding mechanisms in a way that addresses barriers to access and enables promising startups to scale up their approaches.

Conclusion

More companies, governments, and international organizations are seeing food loss and waste as an opportunity to increase circularity and generate social, economic and environmental benefits. However, the rate of progress is too slow and practitioners within this space have failed to see the potential of the processing sector to achieve food loss and waste reduction, focusing instead on the ends of the food value chain. The processing sector has much to offer the global stage as it relates to food loss and waste, including the adoption of new and re-engineered technologies that reduce waste, the potential for avoided greenhouse gas emissions, and the ability to reduce food loss and waste across the entire value chain. The unlocking of this critical middle will allow for greater action across all sectors and provide a crucial boost in efforts toward a more circular food system.



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