Commission for Environmental Cooperation

Why and How to Measure Food Loss and Waste

A PRACTICAL GUIDE - VERSION 2.0

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Executive Summary

This practical guide provides a step-by-step plan for how companies and governments can begin the process of measuring food loss and waste. It addresses key topics, such as:

- Why measure food loss and waste (FLW)
- Establishing a business case for food loss and waste measurement
- Addressing common barriers and obstacles
- Tracking causes of food loss and waste
- Converting measurements to other financial, environmental and social impacts
- Selecting a measurement method

This guide was developed in partnership with government representatives, business experts and others in Canada, Mexico and the United States as part of work under the CEC to address food waste across North America's supply chain. WRI and WRAP, two international organizations with specialized expertise in FLW reduction, co-authored the CEC guide.

VERSION 2.0

Version 2.0 of the guide, which was developed in 2020, provides a number of improvements upon the initial release, based on feedback and input from pilot testers, expert contributors, and other individuals and organizations consulted by the authors. These improvements were designed to make the guide more user-friendly and allow readers to more easily find the material most useful to them. In addition, a number of new tools and case studies are available at **http://www.cec.org/flwm/** to assist users in their FLW measurement journey. These tools are intended to provide information and activities designed to help businesses, institutions and others prevent, recover and recycle FLW. Appendix A, which provides descriptions of several FLW measurements methods, is also available for download at this link.

Introduction

Across North America,[1] businesses, institutions and others increasingly realize the enormous impacts of food loss and waste. Uneaten food represents social, environmental and economic costs, but also a large opportunity. Taking action to prevent and reduce food loss and waste offers a rare "triple win" for a business, institution or other organization, as it can lower economic costs by addressing operational inefficiencies, support efforts to combat food insecurity in communities, and reduce environmental impacts, including its carbon footprint.[2]

To be successful in preventing and reducing food loss and waste, an organization or facility must first measure how much food is being lost or wasted within its boundaries. Measurement identifies the scale of the problem and the hotspots that most need to be addressed and allows for tracking progress over time. In short, what gets measured gets managed.

This practical guide walks readers through the steps for measuring food loss and waste (FLW).[3] Treat it as a quick reference for assistance and look for internal links that allow you to quickly reach the material of most interest.

The checklist below shows seven steps to measuring FLW and the corresponding modules that address them in this guide. Use it to track progress and easily access the most appropriate module. Steps 1–6 are the same for all user types, while Step 7 offers sector-specific information applicable to measuring FLW at different stages of the food supply chain.

✓	**Step 1: Determine *why* you want to prevent and reduce food loss and waste.** (Module: Why Measure FLW?)
✓	**Step 2: Establish your business case for preventing and reducing food loss and waste.** (Module: The Business Case for FLW Measurement, Prevention and Reduction)
✓	**Step 3: Prepare for the *change* of measuring, preventing and reducing food loss and waste.** (Module: Making the Change)
✓	**Step 4: Determine your *definition* of food loss and waste.** (Module: Setting Your Scope)
✓	**Step 5: Determine your *causes* of food loss and waste and identify solutions.** (Module: Determining Root Causes)
✓	**Step 6: Identify what will be measured to monitor *progress over time*.** (Module: Selecting Key Performance Indicators and Identifying Impacts)
✓	**Step 7: Select and implement a food loss and waste measurement *method* based on your sector.** (Module: Sector-Specific Guidance)

1) In this guide, *North America* refers to the countries of Canada, Mexico and the United States.

2) According to the Food and Agriculture Organizations of the United Nations "Reducing food loss and waste is widely seen as an important way to reduce production costs and increase the efficiency of the food system, improve food security and nutrition, and contribute towards environmental sustainability." FAO. 2019. The State of Food and Agriculture 2019. Moving forward on food loss and waste reduction. Rome. http://www.fao.org/3/ca6030en/ca6030en.pdf

3) Although many definitions of food loss and waste exist in this guide, food loss and waste denote all possible material and disposal routes that could be considered food loss and waste. For more information on defining food loss and waste in specific contexts, see the "Setting Your Scope" section.

Why Measure FLW?

A significant amount of food grown for human consumption is never eaten. In fact, by weight, about *one-third of all food produced in the world in 2009 was lost or wasted* (FAO 2011). In North America, approximately 168 million tonnes of FLW are generated annually: 13 million in Canada, 28 million in Mexico and 126 million in the United States. This equates to 396 kilograms per capita in Canada, 249 in Mexico and 415 in the United States (CEC 2017).

This level of inefficiency suggests three strong incentives to reduce food loss and waste: economic, environmental and social.

ECONOMIC: The huge amounts of food lost or wasted are currently considered part of the cost of doing business as usual. Rather than trying to maximize the value of food produced, companies and other organizations tend to focus on the disposal costs for the products that are lost or wasted. Companies could make significant economic gains by putting food headed for the waste stream to profitable uses.

ENVIRONMENTAL: When food is lost or wasted, all of the environmental inputs used on that food are wasted as well (FAO 2011). That means all the land, water, fertilizer, fuel and other resources that produced, processed, or transported a food item are wasted when food meant to be consumed by people is thrown away. Food waste sent to landfills creates methane—a powerful greenhouse gas. Thus, reducing FLW can reduce a company's environmental footprint.

SOCIAL: Surplus edible food can be redistributed to food banks, food rescue agencies and other charities, which can direct it to food insecure populations, making good use of the food rather than disposing of it. For many companies, food donation or redistribution is an important part of their corporate social responsibility activities. Food directed to human consumption is not considered to be lost or wasted.

The old adage that "what gets measured gets managed" holds true with FLW. Measuring food waste helps an organization understand the root causes of food waste and thus work to prevent it.

THE RISK OF NOT CHANGING

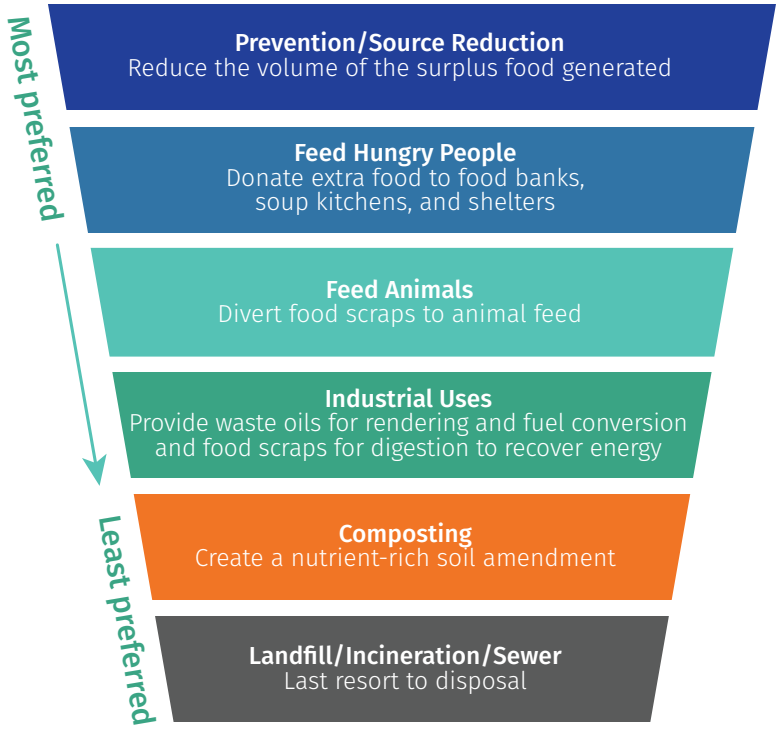
The business-as-usual path has risks. If a company continues to operate with built-in assumptions about acceptable levels of waste, it risks being surpassed by its more innovative competitors who can turn waste into profit. The business case of reducing FLW is strong and those who ignore this opportunity will continue to waste money and resources. Additionally, an increasing number of local, subnational and national governments are imposing disposal bans on food waste or requiring excess food to be donated (Sustainable America 2017; Christian Science Monitor 2018). If this trend continues, companies may face increased expenses from further regulations in the future.

THE FOOD RECOVERY HIERARCHY

When trying to reduce FLW, the first emphasis should be on *prevention*, or source reduction. Although some end-of-life destinations for FLW have fewer negative impacts than others (e.g., FLW going to animal feed is preferable to FLW going to a landfill), prevention should be the foremost goal. This principle is reflected in the Food Recovery Hierarchy (**Figure 1**) developed by the United States Environmental Protection Agency (US EPA).

Source reduction (i.e., preventing food waste in the first place) is the most desirable way to address FLW because it prevents the negative social, environmental and economic impacts of producing food that is wasted. Moving down the recovery hierarchy stages, less value is recovered from the FLW at each stage, until the bottom stage—landfill, incineration, or sewer disposal—where negative environmental impacts are highest. From a climate perspective, tonne for tonne, preventing wasted food is six to seven times as beneficial as composting or anaerobic digestion of the waste (US EPA 2016).

Figure 1: Food Recovery Hierarchy



Source: Adapted from US EPA n.d.

The Business Case for FLW Measurement, Prevention and Reduction

Regional and global institutions are increasingly recognizing the importance of addressing FLW. The CEC Strategic Plan 2021-2025 identifies the circular economy as a key pillar of achieving greater sustainability, pointing out that "food loss and waste entails enormous social, environmental and economic costs" (CEC 2020).

Additionally, in 2015 the United Nations General Assembly adopted a set of 17 Sustainable Development Goals to end poverty and protect the planet. Among these goals is a target (known as Target 12.3) to halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains by 2030.

Businesses, organizations and others are also realizing the importance and benefits of addressing food loss and waste, but many have to start by making their own internal business case for action. Across the food industry, FLW is often buried in operational budgets, where it is accepted as the cost of doing business. However, business leaders around the world are recognizing that reducing FLW is an opportunity to improve their bottom lines while contributing to food security and environmental goals. Although measuring FLW may involve some upfront costs, ample evidence shows that the benefits of measuring and reducing FLW far outweigh the long-term costs of not addressing it. The upfront costs of quantifying FLW for the first time and implementing an FLW prevention and reduction program can lead to a steady stream of financial benefits for years with only minimal continued investment.

An illustrative list of costs and benefits associated with measuring FLW is shown in **Table 1**.

When starting to measure FLW, businesses often see a quick payback. In many cases, a suite of simple solutions can quickly and dramatically cut FLW and its associated costs. Many organizations can achieve a positive return on investment within just one year.

Table 1: Examples of Costs and Benefits Associated with Food Loss and Waste Measurement and Reduction

Costs	Benefits
• Measuring food loss and waste and identifying hotspots • Expenditures on consultants and staff training • Purchasing new equipment and/or repairing existing equipment • Changing purchasing or inventory management practices • Changing daily business operating procedures	• Increased operational efficiency • Lower operating costs (including purchasing costs, energy costs and even labor costs) • Additional revenue via previously unsold foods • Lower waste collection and management costs

Source: Authors.

In fact, as shown in **Figure 2**, it has been found that businesses tend to experience a median savings of $14 for every $1 invested on FLW measurement, prevention and reduction (Hanson and Mitchell 2017).

Financial savings and increased revenue carry on over time with minimal continued investment; especially as "best practice" behaviors and habits for reducing FLW become engrained in a business's standard operating procedures. The positive effects of more efficient business operations compound over time.

In addition to financial benefits, reducing FLW can contribute to environmental and corporate social responsibility goals, brand recognition and improved stakeholder relationships. These impacts are discussed in greater detail in the **"Selecting Key Performance Indicators and Identifying Impacts"** module of this guide.

MAKING YOUR OWN BUSINESS CASE

Although evidence shows that reducing FLW generally results in economic gains, managers may still need to establish the benefits for their own companies.

To make the case, follow two basic steps:

FIRST, DETERMINE HOW MUCH FOOD LOSS AND WASTE IS COSTING YOUR COMPANY.

Waste management fees (e.g., transport, landfill, composting, etc.) account for a relatively small portion of the true cost of FLW to your organization. Focus on the value of the food as it moves through the supply chain and identify processes, activities and services that contribute to unsold surplus and wasted food to find opportunities for improvement. To maximize potential economic savings, focus on FLW attributed to normal day-to-day business operations (versus atypical occurrences like broken equipment). Many businesses assume a certain amount of waste as being fundamental to their operations, so these assumptions should be checked and challenged as well.

For example, imagine a manufacturer that produces canned tomatoes. This manufacturer sends a tonne of oversupplied tomatoes to the landfill each month at a cost of $100. However, that same amount of tomatoes is valued at $900 at the time it is removed from the food supply chain. So in actuality, the cost of the FLW is the $900 in lost product value in addition to the $100 in disposal fees, resulting in a total loss of $1,000 each month.

For another example, imagine a restaurant that generates FLW as part of its front-of-house (dining area) and back-of-house (preparation area) operations. After measuring the FLW that is generated on the diner side, the owners find that much of the FLW is from bread that is given to customers for free before ordering their meals, costing $200 in surplus bread to be sent to landfill. In the kitchen, the FLW is found to be primarily due to over-ordering of food, costing $800 worth of food to be sent to landfill. This same amount of food costs the restaurant $100 a month to be sent to landfill, meaning all of the FLW combined is costing the restaurant $1100 a month.

Figure 2: Average Return on Investment for FLW Prevention and Reduction

Source: Adapted from Hanson and Mitchell 2017.

One useful tool that can be used to estimate the cost of FLW to a business is the Provision Coalition's **Food Loss and Waste Toolkit**, which provides a step-by-step calculator for determining the value of FLW as it moves through processing and manufacturing.[4] Although the toolkit is intended for use by manufacturers, the principle behind it can be adapted to other sectors.

SECOND, DETERMINE THE POTENTIAL BENEFITS OF TAKING ACTION TO PREVENT FOOD LOSS AND WASTE.

After assessing the cost of FLW, assess the costs associated with taking action to prevent or reduce it. For example, in the manufacturing example above, the tomato processor may discover that 2.5 tonnes per month of tomatoes, which could be used for tomato soup, are being sent to a landfill. The soup is valued at $2,000 per tonne and the cost of the equipment necessary to produce the soup is a one-time investment of $10,000. So in this case, reducing the wasted tomatoes by using them in soup would pay for itself in two months and generate $5,000 per month in profit from that point onward. Even if the company did not want to redirect the tomatoes to a new product, it could change ordering practices to avoid tomato surpluses and achieve savings that way.

In the prior restaurant example, the restaurant can achieve savings by serving bread pre-appetisers only upon request (and/or reducing portion sizes) and improving inventory management of food in the kitchen. Each of these interventions is actually cost-free for the restaurant and will immediately begin to realize $1100 in savings a month if implemented fully.

IMPLEMENTATION AND IMPROVEMENT OVER TIME

Once a business case has been accepted, a business or organization can implement cost-effective solutions to prevent and reduce food loss and waste. To ensure continuous improvement over time, it is important to periodically reexamine additional opportunities for reducing FLW and introduce additional corrective actions where appropriate. As seen in **Figure 3**, quantification and implementation are part of a "continuous improvement loop" that lead to greater improvements over time. Measuring and preventing food waste is not a one-time event, but an ongoing journey.

4) The Provision Coalition is a Canadian food and beverage manufacturer sustainability consultancy firm.

Figure 3: Continuous Improvement Cycle for Reducing FLW

Source: Adapted from Provision Coalition 2017.

Making the Change

Measuring and reducing food loss and waste is a big adjustment for many businesses, institutions and other organizations. Achieving significant reductions means challenging key assumptions about how a system operates. To accomplish significant change, you must prepare for it.

Within an organization, individuals will find many reasons to resist taking action on FLW. These concerns are often legitimate and should not be disregarded. However, they generally fall into broad categories.

"We don't waste any food."

FLW occurs whenever food that could have otherwise been sold and safely eaten is discarded. Opportunities to prevent and reduce FLW exist in all organizations and all stages of the food supply chain (i.e., from food production to consumption). Causes of FLW at different stages of the supply chain are highlighted in the "**Determining Root Causes**" module of this guide.

While some organizations may focus on directing wasted food to beneficial end uses, such as animal feed, bioproducts and composting, they can profit more by taking steps to minimize the amount of FLW generated in the first place.

Simply put, FLW represents an operational inefficiency to an organization—the costs of which compound over time. Minimizing the amount of FLW generated from the outset (i.e., before it needs to be managed as waste) is good for the long-term financial health of an organization. Measurement helps to identify where those money saving opportunities exist, by pinpointing where ongoing FLW is generated within a facility.

"We already have too much going on to measure something else."

Many sustainability managers are already tasked with overseeing various measurements, such as greenhouse gas (GHG) emissions or water use. Measurement of FLW can seem like an added burden. However, FLW represents an operational inefficiency that not only costs a business directly but also relates to many other environmental impacts, including land, water, and greenhouse gases. Profit margins for food businesses are often slim and addressing inefficiencies can cause significant benefits for a company's bottom line. So although FLW may seem like "just another thing to measure," it in fact can lead to significant benefits for the business.

Initial measurements may be aided by existing records to provide a cost-effective start. Inventory records and waste transfer receipts can, with minimal investment, provide an early estimate of FLW levels. These records can help ease whatever time burden FLW measurement may represent for a company or organization. The "**Records**" section in Appendix A provides more information about using such documents to estimate FLW levels.

"It's not worth the cost to measure FLW."

The cost of measuring and implementing changes to prevent and reduce FLW is small relative to the long-term economic upside. Measuring FLW helps identify where operational and process inefficiencies may exist, and also signal where corrective action is needed. Many approaches to measuring FLW can be achieved with minimal investment, while others may require higher levels of investment. The "**Sector-Specific Guidance**" module in this guide offers tables displaying a range of methods for measuring FLW, along with the level of resources required.

The upfront costs associated with FLW measurement, prevention and reduction are frequently repaid within a relatively short time period, often in less than a year. The module "**The Business Case for FLW Prevention and Reduction**" provides more information about payback periods for investments.

"This is the way we've always done things."

Generating FLW is often built into the assumptions of how a business or organization operates. For example, in a restaurant that operates a buffet, a certain amount of leftover food may be expected as "the cost of doing business." However, measuring those leftovers might pinpoint opportunities to prevent and reduce FLW and save money (e.g., using smaller plate sizes, discontinuing unpopular dishes).

Different parts of a business or organization will also have different perspectives on FLW. A chef in a restaurant may think of "food waste" as food that gets thrown away from the refrigerators, but not consider waste from food preparation or plate waste. A server in that same restaurant may not think about food that's getting thrown away from refrigerators, but may be very aware of the food that customers leave on their plates. By ensuring that everyone is using the same definition and considering all potential sources, you may be able to overcome some resistance to FLW measurement and reduction. The "**Setting Your Scope**" module of this guide can help you establish a common definition.

"This isn't working."

If a change is not going smoothly it is important to understand why this is the case. Each of the following elements can greatly improve the likelihood of success:

- Senior management commitment and support
- Sufficient resources (funding, time, expertise)
- Concrete plan that allocates responsibilities
- Employee awareness and training
- Internal "champions" to foster action

In one case, the Provision Coalition worked with Ippolito Fruit & Produce in Canada to reduce FLW in its operations. For the "reinforcement" stage in the change management process, they identified key steps to help keep the change in motion (Mereweather 2018):

- Gathering feedback from employees
- Developing accountability and performance management systems
- Auditing and identifying compliance of change
- Finding root causes of FLW and taking corrective action
- Recognizing, celebrating and rewarding successes

These steps can help keep people on board with the difficult process of making a change toward FLW measurement, prevention and reduction. Like any new change, there will be challenges along the way. But if a business has a strong case and rationale, these challenges can be overcome.[5]

5) For more about making the change, see the guidance published by the FLW Protocol titled "**Overcoming Resistance to the Measurement of Food Loss and Waste**."

Setting Your Scope

Once you've determined that it is worthwhile to measure FLW, define what FLW means in your operations and how you will communicate that information, both internally and externally. Reporting FLW data publicly has multiple benefits: it raises awareness of the issue, allows for information-sharing among businesses, provides information to policymakers and assists FLW tracking efforts over time.

Public reporting should align with the ***Food Loss and Waste Accounting and Reporting Standard***, or *FLW Standard*. The *FLW Standard* is "a global standard that provides requirements and guidance for quantifying and reporting on the weight of food and/or associated inedible parts removed from the food supply chain" (FLW Protocol 2016a). The standard clarifies definitions and shows the possible destinations of FLW when it is removed from the human food supply chain.

TRACKING PROGRESS ON PREVENTING FLW

The *FLW Standard* does not provide specific guidance on tracking progress on preventing FLW. However, prevention can be tracked by establishing a base year as a starting point and assessing prevention efforts against that baseline. If total production is increasing or decreasing, intensive measurements (tonnes per unit of production)

can better quantify how much FLW was prevented. For example, a company may set a base year of 2016 when it had 15,000 tonnes of FLW. The following year, the FLW may be 13,500 tonnes, meaning 1,500 tonnes of FLW had been prevented.

A hypothetical example of how prevention can be tracked alongside FLW amounts is shown in **Table 2**.

REPORTING AMOUNTS OF FLW

Reporting using the *FLW Standard* requires setting the "scope" of your FLW, as shown in **Figure 4**. This scope includes only food that has been removed from the human food supply chain, meaning that food donated, redistributed, or otherwise kept in the food supply chain is not included. Tracking redistribution of food may align with your objectives and can be tracked using a method similar to that outlined in the section "**Tracking Progress on Preventing FLW**."

The scope has four components: timeframe, material type, destination and boundary.

Timeframe

Define the period of time for which the inventory results are reported. Typically, results are reported on an annual basis.

Material Type

Identify the materials included in the inventory: food only, associated inedible parts only, or both. Associated inedible parts are defined as the components of a food product that are not intended for consumption, such as bones, rinds or pits.

Destination

The destination is where the FLW goes when removed from the food supply chain. The 10 categories for destinations described in the *FLW Standard* are listed and defined in **Table 3**. Again, these destinations are only for FLW that has been removed from the human food supply chain and do not include prevention or redistribution of FLW, which can be tracked as described in the section **"Tracking Progress on Preventing FLW."** Food that is distributed to humans outside the marketplace is not considered to be lost or wasted, since it is not sent to a destination.

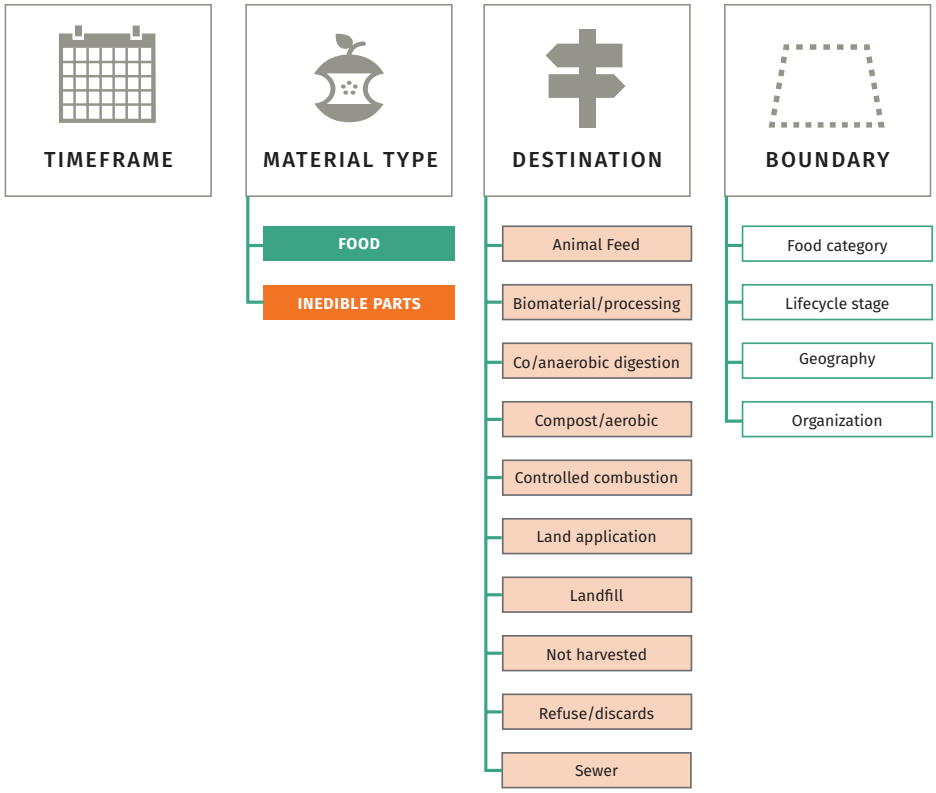
Food that is recovered for donation to feed hungry people and that would otherwise be lost or wasted, is generally not considered to be FLW and therefore not identified as a destination in **Figure 4**. Some organizations may also exclude animal feed and bio-based materials/biochemical processing (where material is converted into industrial products) from their definition of FLW.

Table 2. Tracking Reduction in FLW by Measuring FLW Sent to Various Destinations over Time (tonnes/year)

	2016	2017	2018
Total Production	100,000 tonnes	100,000 tonnes	100,000 tonnes
Anaerobic Digestion	3,000 tonnes	4,000 tonnes	4,000 tonnes
Landfill	8,000 tonnes	6,000 tonnes	5,500 tonnes
Sewer/water treatment	4,000 tonnes	3,500 tonnes	3,500 tonnes
Total FLW	15,000 tonnes	13,500 tonnes	13,000 tonnes
Tonnes FLW per unit of production (percent)	15%	13.5%	13%
Reduction in FLW (percent relative to 2016)	0%	-10%	-13%

Source: Authors.

Figure 4. Scope of an FLW Inventory



Source: FLW Protocol 2016a.

While definitions and scope of FLW can differ, it is nonetheless important to measure all possible end destinations of recovered food and FLW to support efforts to minimize operational inefficiencies.

Boundary

The boundary has four components:

- **THE FOOD CATEGORY**, or the types of food included in the inventory
- **THE LIFECYCLE STAGE**, or the stages of the food supply chain (e.g., processing and manufacturing, retail) included in the inventory
- **GEOGRAPHY**, or the geographic borders within which the inventory occurs
- **ORGANIZATION**, or the type of unit (e.g., household or factory) within which the FLW occurs

WHY SCOPE MATTERS

Disclosing the scope of an inventory is important because numerous definitions of "food loss and waste" exist. Some include only food but not inedible parts, while others consider only a subset of the possible destinations in the *FLW Standard*. By disclosing the scope of an inventory, a business or government clarifies its definition of FLW, thus allowing for more accurate comparisons and tracking of FLW over time.

ADDITIONAL RESOURCES FOR REPORTING

The *FLW Standard* contains a number of reporting resources. **Chapter 6** outlines the process for setting a scope and **Chapter 13** provides additional guidance on reporting. A **sample reporting template** and **customizable scope template** are available for download.

Additionally, multiple online databases allow businesses and organizations to submit their own FLW data and review FLW data from others. These include the UN FAO "**Food Loss and Waste Database**" and the "**Food Waste Atlas**," developed by the World Resources Institute and WRAP.

Table 3. Definition of FLW Destinations used in the *FLW Standard*

Destination	Definition
Animal feed	Diverting material from the food supply chain to animals
Bio-based materials/biochemical processing	Converting material into industrial products
Codigestion/ anaerobic digestion	Breaking down material via bacteria in the absence of oxygen
Composting/aerobic processes	Breaking down material via bacteria in oxygen-rich environments
Controlled combustion	A facility that is specifically designed for combustion in a controlled manner
Land application	Spreading, spraying, injecting or incorporating organic material onto or below the surface of the land to enhance soil quality
Landfill	An area of land or an excavated site specifically designed to receive wastes
Not harvested/plowed-in	Leaving crops that were ready for harvest in the field or tilling them into the soil
Refuse/discards/litter	Abandoning material on land or disposing of it in the sea
Sewer/wastewater treatment	Sending material down the sewer, with or without prior treatment
Other	Sending material to a destination different from the 10 listed above

Source: FLW Protocol 2016a.

Determining Root Causes

It is difficult to reduce FLW without understanding what causes it. For example, after performing a waste composition analysis, a restaurant may discover that it is discarding a large amount of tomatoes each week, but the waste data do not tell it *why* those tomatoes are being discarded. This module describes how to track causes of FLW when the information is not obvious in the quantification method.

DEFINING CAUSES AND DRIVERS

There are two layers to identifying the cause of FLW—the immediate reason why something became FLW and the underlying factor that led to the waste. The *FLW Standard* uses the terms "causes" and "drivers." A cause is defined as the proximate or immediate reason for FLW, while a driver is defined as an underlying factor that played a role in creating that reason (FLW Protocol 2016a). **Tables 4** and **5** list some possible causes and drivers by stage in the food supply chain.

If a restaurant discards a large amount of tomatoes, the immediate cause might be that the tomatoes spoiled after sitting unused in the kitchen. The underlying driver may be that the restaurant is incorrectly forecasting the amount of tomatoes it needs each week. Perhaps a previously popular dish that requires tomatoes is not selling as much as anticipated, but the restaurant is continuing to order tomatoes based on prior rather than current demand.

Table 4. Some Causes of FLW by Stage of the Food Supply Chain

Primary Production	Processing and Manufacturing	Distribution and Wholesale	Retail	Food Service/ Institutions	Household
· Spillage · Cosmetic or physical damage · Damage from pests or animals · Not harvested · Unable to sell due to quantity or size · Unable to reach market	· Spillage · Trimming during processing · Rejected from market	· Cosmetic or physical damage · Spoilage · Past sell-by date · Rejected from market · Unable to reach market	· Product recall · Food prepared improperly · Food cooked but not eaten · Cosmetic damage · Spoilage · Past sell-by date	· Product recall · Food prepared improperly · Food cooked but not eaten · Cosmetic damage · Spoilage	· Product recall · Food prepared improperly · Food cooked but not eaten · Cosmetic damage · Spoilage · Past sell-by or use-by date

Source: FLW Protocol 2016a, CEC 2017.

Table 5. Some Drivers of FLW by Stage of the Food Supply Chain

Primary Production	Processing and Manufacturing	Distribution and Wholesale	Retail	Food Service/ Institutions	Household
· Premature or delayed harvesting · Poor harvesting technique/ inadequate equipment · Lack of access to market or processing facilities · Poor access to farming equipment · Price volatility · Stringent product specifications · Overproduction · Improper storage	· Outdated or inefficient equipment and processes · Stringent product specifications · Human or mechanical error resulting in defects	· Excessive centralization of food distribution processes · Lack of effective cold-chain management · Stringent product specifications · Poor transportation infrastructure · Failure in demand forecasting · Ineffective packaging or storage conditions	· Regular replenishment of stocks to evoke abundance · Package sizes too large · Failure in demand forecasting · Too many products offered · Lack of system for food donation	· Regular replenishment of buffet or cafeteria to evoke abundance · Portion sizes too large · Failure in demand forecasting · Too many products offered · Lack of system for food donation · Improper training of food preparers	· Overpurchase · Inadequate planning before shopping · Lack of cooking knowledge · Confusion over date labels · Inadequate or improper storage of food · Desire for variety, resulting in uneaten leftovers · Overcooking

Source: FLW Protocol 2016a, CEC 2017.

In this example, simply knowing that a large amount of tomatoes was being discarded was not sufficient to determine the correct course of action to reduce waste. However, once the tomato FLW was linked to a cause (e.g., spoilage after not being used) and an underlying driver (e.g., failure of demand forecasting), the restaurant was now able to take action to reduce the FLW (e.g., reduce the weekly order for tomatoes or adjust the menu to remove the dish not being ordered).

In more complicated cases, the causes and drivers may not be clear. Meeting with an outside waste-reduction consultant may be beneficial. Numerous firms make detailed sustainability audits of facilities and organizations to address root causes of inefficiencies and unsustainable practices.

INCORPORATING CAUSES INTO FLW QUANTIFICATION METHODS

The methods described in this guide differ in how well they track the causes and drivers of FLW. **Table 6** provides a list of methods, whether they can track causes and how to best do so.

Table 6. Tracking Causes by Method

Method	Can it track causes?	How to track causes with the method
Direct weighing	Yes	Although direct weighing provides only numerical data, staff can be instructed to log causes while weighing the FLW. This will provide an additional data point about how the FLW occurred.
Waste composition analysis	No	A waste composition analysis will not directly provide information on causes of FLW, since the waste is being analyzed after it has been discarded. For this reason, waste composition analyses are often paired with a survey or process diary to generate qualitative data on causes and drivers assessed in tandem with the waste analysis.
Records	Not usually	Because records are kept for purposes other than FLW quantification, they are less likely to contain information relating to FLW causes and drivers. However, some records will have information that can help identify causes. (For example, a repair record for a piece of faulty equipment may help identify a cause of food waste.) Usually, a diary or survey will need to be implemented to generate qualitative data.
Diaries	Yes	A diary can be used to determine causes and drivers of FLW. The diarist can be asked to provide information on why the FLW occurred while recording it.
Interviews/Surveys	Yes	A survey can be used to determine causes and drivers of FLW. The respondent can be asked to provide information about why FLW occurs within those boundaries.
Proxy data/mass balance	No	Because inference by calculation is a mathematical operation based on material flows and proxy data, it will not provide information about causes and drivers of FLW. It provides only a quantitative estimate of the amount of FLW occurring within a given sector or commodity type. An additional analysis of the relevant sector or commodity will be necessary to understand the causes of FLW.

Source: Authors.

HOW TO TRACK CAUSES AND DRIVERS

Causes and drivers can be tracked simply by capturing information on causes while numerical estimates of FLW are being logged. In most cases, only the immediate cause will be available at first and additional research may be needed to detect the driver. **Table 7** shows an example of how causes and drivers can be tracked alongside numerical estimates of FLW.

Table 7. Tracking Causes and Drivers

Food Type	Amount	Stage of the Supply Chain	Cause	Driver
Wheat	1000 kg	Primary production	Eaten by pests	Improper storage on the farm
Apples	10 kg	Processing	Trimmings	Inefficient equipment trims more than necessary
Strawberries	40 kg	Distribution and wholesale	Spoilage / Damage during transport	Lack of effective cold-chain management / Improper packaging / Excessive centralization of distribution processes
Beef	100 kg	Retail	Spoilage	Improper refrigeration
Fish	34 kg	Food service/ institution	Spoilage	Failure in demand forecasting
Milk	500 g	Household	Past sell-by date (but not spoiled)	Confusion over meaning of date labels

Note: the information in this table is illustrative.
Source: Authors.

Selecting Key Performance Indicators and Identifying Impacts

Measuring FLW should go beyond simply measuring the amount of food that leaves the food supply chain. This measurement fails to capture the impacts and benefits of reducing and preventing FLW. Preventing FLW has far-reaching economic, environmental and social benefits that can also be tracked.

WHICH IMPACTS SHOULD I TRACK?

Key performance indicators can determine an organization's success in achieving an objective or evaluating activities. Using a well-chosen suite of metrics, organizations can find out if they are achieving FLW prevention, redistribution or diversion. These metrics can also evaluate progress and tailor future interventions. Possible impacts fall into three broad categories:

- Financial impacts
- Social impacts
- Environmental impacts

Organizations can monitor progress (and communicate success) more effectively if they use a range of appropriate metrics and consider reporting results in all three categories.

FINANCIAL IMPACTS

Most of the financial impacts of FLW are associated with disposal, however the *total* cost of FLW includes all resource inputs wasted along with the food. Simply focusing on disposal costs overlooks the vast majority of financial opportunities and benefits of preventing FLW. Quantifying the costs of FLW might typically involve assessing the following items:

- The purchasing costs of the incoming food and/or ingredients
- The costs added to the food within the business (e.g., relating to labor and utilities)
- The costs associated with redistribution of surplus food or the disposal and treatment of FLW

Financial impacts that can be tracked alongside FLW data include the following examples:

- The value of the food that was lost or wasted
- The cost of FLW as a percentage of food sales
- The cost and benefits of investment in a food-waste-reduction program

Two direct measurement tools can capture the weight of FLW and translate it into dollar values: smart scales in the food service sector (e.g., **LeanPath** or **Winnow** tools) and the Provision Coalition's **Food Loss and Waste Toolkit** for manufacturers.

SOCIAL IMPACTS

Social impacts refer to the effects of FLW on humans. Examples of trackable social impacts are the value of the donated food, the nutritional content and meals wasted.

Donation Amount

A company may wish to track the amount of food it donates to food banks and other nonprofits. Records of these donations are usually kept and just need to be collated. If a company does not maintain records, food banks may record how much food they have received from each company.

Nutritional Content of FLW

The nutritional content of FLW can be assessed in several ways, including calories, macronutrients (i.e., carbohydrates, fat and protein), fiber and other micronutrients. The most comprehensive database of food types and their associated nutrients is the USDA's **National Nutrient Database for Standard Reference**, which contains information on 8,100 food items and 146 components, including vitamins, minerals, amino acids and more (USDA n.d.). By sorting FLW by food type and multiplying the amount of FLW by the nutrient of interest in the database, you can estimate the nutritional content of the FLW.

Meals Wasted

Expressing FLW in terms of meals wasted can show laypeople the impacts of FLW. Meals are generally expressed as a number of calories, usually 600–700.[6] To determine the number of meals wasted, first determine the total caloric content of the waste using the USDA **National Nutrient Database for Standard Reference,** then divide that number by the calories in a typical meal. This will provide a total number of meals, although it should be specified that these are not necessarily *healthy* or complete meals. Calories are just one measure of nutrition and depending on the type of FLW, meals may not be the best measure.

ENVIRONMENTAL IMPACTS

Food production and all its associated processes (including processing, manufacturing, packaging, distribution, refrigeration and cooking) require resources, such as arable and pasture land, fresh water, fuel and chemical inputs (e.g., fertilizer, herbicides and pesticides) and cause environmental impacts, such as air and water pollution, soil erosion, emissions of greenhouse gases and biodiversity loss.

Depending on its management, FLW can cause additional environmental impacts that would not have occurred had the food been consumed. Some of these are associated with transportation of waste, land uses for landfills and methane emissions from landfills. While less important than impacts associated with production, these impacts can still be significant.

6) There is no correct number of calories to consume per day (since proper intake depends on energy expenditure), but several health organizations suggest 2,000 calories per day for an adult as a reasonable average. Therefore, assuming three meals a day, the average meal would be 600–700 calories.

Examples of environmental impacts that an entity could track alongside FLW data are: greenhouse gas emissions, use of water, land, fertilizers, energy and biodiversity loss.

Greenhouse Gas Emissions

Greenhouse gas (GHG) emissions are the most commonly tracked environmental impact related to FLW. For most food products, the GHGs can be determined by a lifecycle analysis (LCA), which provides a full picture of the GHGs associated with the production of a food item from the point of production to the point at which it is lost or wasted. Each food item has a unique set of GHG factors depending on the land and resources needed to produce it. The GHG impact factors increase the further along the supply chain FLW is generated.

Much LCA data are publicly available. The sources below provide GHG impact factors.

- Individual product LCA studies, found via search engine
- Commercial databases such as Ecoinvent, GaBi, FoodCarbonScopeData, World Food LCA Database (Quantis) y Agri-Footprint (Blonk Consultants)
- **US Department of Agriculture (USDA) Life Cycle Assessment Commons**

The US EPA **Waste Reduction Model** (WARM) can help to assess the GHGs associated with FLW. WARM provides estimates of GHG emissions associated with baseline and alternative waste management practices, including source reduction, recycling, anaerobic digestion, combustion, composting and landfilling.

Water Use

Water is used throughout the food supply chain, including to water crops, in manufacturing processes and to wash food waste down the drain to a sewer. Three types of water can be considered when assessing environmental impacts (Hoekstra et al. 2011):

- Blue water—water withdrawn from ground or surface water sources (e.g., irrigation water)
- Grey water—the water required to dilute polluted water for it to be safely returned into the environment
- Green water—water evaporated from soil moisture (e.g., rainfall)

Most estimates of environmental impacts include only blue water and grey water, although green water is relevant in water-scarce regions.

The largest database of water impacts is from the **Water Footprint Network**, with the Water Footprint Assessment Tool being especially useful (Water Footprint Network 2018). When using the tool, select "Production Assessment" and select the commodity of interest as well as its country of origin to access the data of interest. The Water Footprint Network also provides country-specific blue, grey and green impact factors for crop and animal products.

Although GHGs and water are the most common environmental impacts measured in association with FLW, several others are relevant. Because these impacts are less frequently quantified, they have fewer measurement resources.

Land Use

The impact on land use is more complicated to measure than the impact on GHGs or water. Some complicating factors are multiple cropping (where multiple crops are harvested from the same land within the course of a year) and crops that have multiple-year cycles, such as sugarcane. No simple, easily available tools yet exist to calculate land use associated with FLW, but the Food and Agriculture Organization of the United Nations (FAO) **Food Wastage Footprint** provides global estimates of land used for food that is lost or wasted, as well as the relative impacts of a range of commodity types (FAO 2015).

Fertilizer Use

At the production level, fertilizer use associated with food loss or waste can be roughly estimated by multiplying the percentage of FLW by the total amount of fertilizer used. However, no simple method exists for other stages of the supply chain where the total fertilizer input may not be known. One study has estimated fertilizer loss at the country level using data from the FAO database, **FAOSTAT** (Kummu et al. 2012, FAO n.d.).

Energy Use

Most environmental impact estimates do not break out energy use from GHG estimates, but one US study found

that energy embedded in wasted food represented about 2 percent of the country's annual energy use (Cuellar and Webber 2010). The Provision Coalition's **Food Loss and Waste Toolkit** based on Enviro-Stewards' approach may help companies assess energy use relating to FLW.

Biodiversity Loss

Biodiversity loss associated with FLW is an emerging topic. Food production is the leading driver of biodiversity loss through conversion of natural habitats to farmland, intensification of farming, pollution and, in the case of fish, over-exploitation (Rockstrom et al. 2009). Some of this biodiversity loss occurs to produce food that is wasted. At the time of publication, no simple resources existed to assist in assessing potential biodiversity loss. However, tools may by developed in the future.

Table 8 summarizes the most common key indicators, impacts, and goals for each benefit area.

Table 8. Summary of Most Common Key Performance Indicators and Impacts

	KPI	Metric	Example Goal
Financial	Value of FLW lost or wasted	Monetary value (e.g., dollars, pesos)	Reduce costs associated with FLW by half
	Cost of FLW as a percentage of food sales	Percentage	Cut the cost of FLW relative to the percentage of food sales in half
Social	Donation amount	Weight (e.g., tonnes, kg, pounds)	Double amount of food going to donation/ redistribution
	Nutritional content of FLW	Nutrients (e.g., protein, fiber, carbohydrates)	Reduce FLW associated with a specific nutrient of interest
	Meals wasted	Number of meals (usually 600-700 calories per meal)	Prevent 1,000 meals from being sent to landfill each month
Environmental	Greenhouse gas emissions	CO_{2e} (carbon dioxide equivalent)	Reduce GHGs associated with discarding FLW to landfill by 25% (e.g., via FLW prevention and composting).
	Water use	Volume (e.g., liters, gallons)	Reduce avoidable water losses associated with discarding FLW by 25% (e.g., via FLW prevention).

Source: Authors.

Sector-Specific Guidance

The following pages contain guidance for different sectors of the food supply chain on how to measure food loss and waste. Each section contains a short description of the sector and guidance on how to select the most appropriate measurement method for it, as well as a case study of how a company in that sector measured (or could measure) FLW. You can review the most relevant sector or sectors.

The sectors are:

- **Primary Production**
- **Processing and Manufacturing**
- **Distribution**
- **Retail**
- **Food Service/Institutions**
- **Households**
- **Whole Supply Chain Approaches**

METHODS USED TO MEASURE FLW

Appropriate methods for FLW measurement depend on the context of who is doing the measuring and what information is available. Start by answering the five questions below.

- **DO YOU HAVE DIRECT ACCESS TO THE FLW?** Does the method require the ability to *directly* count, handle, or weigh the FLW?
- **WHAT LEVEL OF ACCURACY DO YOU NEED?** How accurate will the data gathered with this method be?
- **WHAT AMOUNT OF TIME AND RESOURCES CAN YOU ASSIGN TO MEASURING FLW?** The relative amount of resources (time, money, equipment) needed to carry out the method.
- **DO YOU NEED A METHOD THAT CAN TRACK CAUSES OF FLW?** Some methods can track causes associated with FLW, while others cannot.
- **DO YOU WANT TO TRACK PROGRESS OVER TIME?** Some methods can assess increases or decreases in FLW across time to track progress.

Based on the answers to these questions, use **Tables 9-15** to determine which method or methods are most appropriate. If you are addressing multiple types of FLW (for example, both solid and liquid FLW), you may need to select several methods.

For additional guidance, see the **FLW Quantification Method Ranking Tool** published by the Food Loss and Waste Protocol, which asks 11 questions about your circumstances and provides a ranked list of methods based on your answers.

Primary Production

INTRODUCTION

The primary production stage of the supply chain encompasses agricultural activities, aquaculture, fisheries and similar processes resulting in raw food materials. This first stage in the chain includes all activities related to the harvest, handling and storage of food products before they move to either processing or distribution. Any level of processing of raw food products does *not* fall within this stage of the supply chain, but would rather be classified as processing and manufacturing.

Examples of primary production activities are: farming, fishing, livestock rearing and other production methods.

Food losses in primary production can be caused by many factors, including but not limited to: pests or adverse meteorological phenomena, damage incurred during harvest, lack of proper storage infrastructure, cosmetic or size requirements or economic or market variability (i.e., cancellation of orders, rigid contract terms, price variability, or high labor costs).

The following nonexhaustive, illustrative list shows ways to prevent FLW during primary production.

- Work with actors downstream in the food supply chain to increase the share of second-grade products that are accepted and valorized to some point.
- Improve cold-chain management and infrastructure to prevent spoilage or degradation during storage and transport.
- Work with actors downstream in the food supply chain to expand value-added processing to increase the proportion of produced food able to eventually be consumed.

Table 9. Methods Used to Measure FLW in the Primary Production Sector

Method Name	Direct FLW Access Needed?	Level of Accuracy?	Level of Resources Required?	Tracks Causes?	Tracks Progress over Time?
Commonly used methods for gathering new data					
Direct Measurement	Yes	High	High	Yes	Yes
Interviews/Surveys	No	Low-Medium	Medium-High	Yes	Yes
Commonly used methods based on existing data					
Proxy Data	No	Low	Low	No	No
Records	No	Variable*	Low	No	Yes
Less commonly used methods at the production sector					
Diaries	No	Low-Medium	Medium	Yes	Yes
Mass Balance	No	Medium	Low	No	Yes
Waste Composition Analysis	Yes	High	High	No	Yes

*Accuracy depends on the type of record used: for example, waste transfer receipts may be highly accurate for determining FLW levels, whereas other records are less accurate.
Note: The methods named are nonexhaustive.
Source: Authors.

CASE STUDY FOR THE PRIMARY PRODUCTION SECTOR

In the US state of California, the World Wildlife Fund (WWF) collected baseline primary data and supported measurement of post-harvest losses of several crops. The data were both quantitative and qualitative, and the WWF performed subsequent analyses to identify root causes of farm-level losses. They also calculated environmental impacts to illustrate the resource intensity of various crops and the associated impacts of any related FLW. Such a holistic measurement approach and conversion into other metrics helped identify the scale of FLW, identify root causes and find opportunities for interventions.

For example, during the 2017–18 growing season, the average measured losses at harvest on the farms sampled were 40 percent of fresh tomatoes, 39 percent of fresh peaches, 2 percent of processing potatoes and 56 percent of fresh romaine lettuce. Qualitative results highlighted the difficulties farmers face when balancing large yields and fixed contracts, as well as meeting strict product quality standards. WWF recommended further research into whole-farm purchasing contracts for specialty crops, flexible quality/visual standards and further valorization of preserved products to account for overproduction (WWF 2018).

Processing and Manufacturing

INTRODUCTION

The processing and manufacturing stage of the food supply chain encompasses all processes intended to transform raw food materials into products suitable for consumption, cooking, or sale. In this guide, "food processing" and "food manufacturing" are used interchangeably. This stage in the supply chain includes the processes that turn raw agricultural products into saleable goods, which often move to retail, wholesale, distribution or food service institutions. It also includes packaging of processed goods.

Examples of organizations in this sector are: fruit and fruit juice processing plants, cereal manufacturing facilities, pastry factories, canneries, butchers, breweries, bakeries and dairy processing plants.

In processing and manufacturing, FLW can be caused by trimming for consistency, misshapen products, spillage, degradation during processing, production line changes, contamination, overproduction, order cancellation, changes in customer demand or specifications, or improper labeling, among other things.

Food processing represents 15–23 percent of the entire manufacturing industry (including nonfood manufacturing) in North America (USDA ERS 2016, Agriculture and Agri-Food Canada 2014, ProMéxico 2015).

Some approaches to preventing FLW in processing and manufacturing are listed below.

- Work with actors upstream in the food supply chain to increase the share of second-grade products that are accepted and valorized to some point.
- Improve cold-chain management and infrastructure to prevent spoilage or degradation during storage and transport.
- Work with actors across the food supply chain to expand value-added processing to increase the proportion of produced food able to be consumed.
- Standardize date labels to reduce the amount of FLW generated from confusion over food safety.
- Adjust packaging to extend the life of food products and reduce damage during storage or transport.
- Optimize manufacturing lines and production processes to increase yields and reduce inefficiencies.

Table 10. Methods Used to Measure FLW in the Processing and Manufacturing Sector

Method Name	Direct FLW Access Needed?	Level of Accuracy?	Level of Resources Required?	Tracks Causes?	Tracks Progress Over Time?
Methods for gathering new data					
Direct Measurement	Yes	High	High	Yes	Yes
Waste Composition Analysis	Yes	High	High	No	Yes
Methods based on existing data					
Mass Balance	No	Medium	Low	No	Yes
Records	No	Variable*	Low	No	Yes
Less commonly used methods at the food service/institutions sector					
Diaries	No	Low-Medium	Medium	Yes	Yes
Interviews/Surveys	No	Low-Medium	Medium-High	Yes	Yes
Proxy Data	No	Low	Low	No	No

*Accuracy depends on the type of record used: for example, waste transfer receipts may be highly accurate for determining FLW levels, whereas other records are less accurate.
Note: The methods named are nonexhaustive.
Source: Authors.

CASE STUDY FOR THE PROCESSING AND MANUFACTURING SECTOR

Byblos Bakery is the top branded pita maker in western Canada. Byblos worked with Provision Coalition and Enviro-Stewards to measure and prevent FLW generation in its manufacturing operations and saved over C$200,000 from the interventions implemented. Enviro-Stewards conducted a food waste prevention assessment of the facilities and the Provision Coalition's FLW Toolkit helped develop a set of FLW reduction strategies and solutions. By using a facility assessment along with the FLW Toolkit, Byblos could identify root causes for FLW generation and tailor interventions to its business. For example, improvements to retail inventory management helped minimize retail returns and relatively small tweaks to the production process and facility immediately reduce waste generation in the factory. In total, Byblos reduced its food waste by 29% (Provision Coalition 2017).

Distribution and Wholesale

INTRODUCTION

Food distributors and wholesalers ensure that food products make it to market and consumers. Distributors typically maintain exclusive buying agreements with producers, manufacturers and processors or provide products to a certain territory. They rarely sell goods directly to consumers but may work with wholesalers (or larger retailers) that buy in bulk. Wholesalers typically resell goods to retailers, while retailers resell goods directly to consumers.

Because they are subject to supply and demand fluctuations across the food supply chain, they must balance time sensitivity and cost in their operations. Variability within the distribution and wholesale sector can also affect FLW downstream, in the food service, retail and household stages.

In distribution and wholesale, FLW can be caused by damage and spoilage, lack of cold-chain infrastructure, delays during transport (e.g., border inspections), variable customer demands, modification or cancellation of orders, product specifications, variable cost of transport methods, inaccurate forecasting or purchasing, miscommunication with other entities further up and down the food supply chain, and many other factors.

As the specifics of this sector vary by country, so do the root causes behind the associated FLW. Thus generation and prevention of FLW differ from country to country and even from organization to organization, and interventions must be tailored to the context.

Some approaches to preventing FLW in distribution and wholesale are listed below.

- Work with actors upstream in the food supply chain to increase the share of second-grade products that are accepted and valorized to some point.
- Improve cold-chain management and infrastructure to prevent spoilage or degradation during storage and transport.
- Work with actors across the food supply chain to expand value-added processing to increase the proportion of produced food able to be consumed. This could include the creation of processes to valorize food that is damaged or deteriorates during transport and distribution.
- Adjust packaging to extend the life of food products and reduce damage during storage or transport.
- Rethink business models to maintain freshness and reduce shrink.

Table 11. Methods Used to Measure FLW in the Distribution and Wholesale Sector

Method Name	Direct FLW Access Needed?	Level of Accuracy?	Level of Resources Required?	Tracks Causes?	Tracks Progress Over Time?
Methods for gathering new data					
Waste Composition Analysis	Yes	High	High	No	Yes
Methods based on existing data					
Mass Balance	No	Medium	Low	No	Yes
Proxy Data	No	Low	Low	No	No
Records	No	Variable*	Low	No	Yes
Less commonly used methods at the distribution and wholesale sector					
Diaries	No	Low-Medium	Medium	Yes	Yes
Direct Measurement	Yes	High	High	Yes	Yes
Interviews/Surveys	No	Low-Medium	Medium-High	Yes	Yes

*Accuracy depends on the type of record used: for example, waste transfer receipts may be highly accurate for determining FLW levels, whereas other records are less accurate.
Note: The methods named are nonexhaustive.
Source: Authors.

CASE STUDY FOR THE DISTRIBUTION AND WHOLESALE SECTOR

The Mexican Transport Institute (*Instituto Mexicano del Transporte*–IMT) developed a methodology to identify cold-chain coverage and gaps across the country. The IMT uses a database with several metrics, including origin and destination of shipments, classification of loads, ownership of transportation units and cost of transportation. It monitors the status of the distribution and transportation system across Mexico alongside relevant costs, shipment data and records. This allows IMT to identify potential FLW hotspots and regions needing cold-chain management and infrastructure (Morales 2016, CEC 2017).

Retail

INTRODUCTION

Food retailers tend to have a relatively large influence on FLW throughout the supply chain. Because of their dominant buying power, retailers can influence FLW further upstream (i.e., primary production, processing and manufacturing) and even distribution. Because of their typical place right before final consumption in the food supply chain, variability within the retail sector can lead to FLW in the food service and household stages.

FLW in retail can be caused by any number of factors, including but not limited to: damage and spoilage, lack of cold-chain infrastructure, delays during transport (e.g., border inspections), variable customer demands, modification or cancellation of orders, inaccurate customer forecasting and overstocking, reliance on inefficient stocking practices or product sizes, misinterpretation of food safety standards, and misleading or confusing date labeling.

Because the specifics of this sector vary by country, so do the root causes behind the associated FLW. Generation and prevention of FLW differ from country to country and even organization to organization, and interventions must be tailored to the context.

Some approaches to preventing FLW in retail are listed below.

- Working with actors upstream in the food supply chain to increase the share of second-grade products that are accepted and valorized to some point.
- Working with actors across the food supply chain to expand value-added processing in order to increase the proportion of produced food able to eventually be consumed.
- Standardizing date labels to reduce the amount of FLW generated from confusion over food safety.
- Implementing packaging adjustments to extend the life of food products and reduce damage during storage or transport.
- Rethinking purchasing models in order to maintain freshness and reduce shrink.

Table 12. Methods Used to Measure FLW in the Retail Sector

Method Name	Direct FLW Access Needed?	Level of Accuracy?	Level of Resources Required?	Tracks Causes?	Tracks Progress Over Time?
Methods for gathering new data					
Direct Measurement	Yes	High	High	Yes	Yes
Waste Composition Analysis	Yes	High	High	No	Yes
Methods based on existing data					
Mass Balance	No	Medium	Low	No	Yes
Proxy Data	No	Low	Low	No	No
Records	No	Variable*	Low	No	Yes
Less commonly used methods at the retail sector					
Diaries	No	Low-Medium	Medium	Yes	Yes
Interviews/Surveys	No	Low-Medium	Medium-High	Yes	Yes

*Accuracy depends on the type of record used: for example, waste transfer receipts may be highly accurate for determining FLW levels, whereas other records are less accurate.
Note: The methods named are nonexhaustive.
Source: Authors.

CASE STUDY FOR THE RETAIL SECTOR

Delhaize America, a food retailer, implemented a food waste measurement and reduction program in its East Coast stores and distribution centers. Through direct measurement with Scanner information and waste separation, Delhaize America is able to consistently track food waste over time. The company has used this information to identify waste hotspots and to reduce FLW across its operations. For example, daily deliveries of fresh product (via computer-assisted ordering systems) has improved order accuracy and inventory management, greatly reducing the amount of produce that goes to waste. In some locations, staff noticed that more food was going to compost, which signaled a need for better coordination with local food banks to ensure that food safe for human consumption was not needlessly being composted rather than serving those in need. Such observations led to more food going to feed people and less food becoming waste.

Recently, the retailer has started to track progress every quarter based on tonnes of food waste per sales, percentage of food waste diverted from landfills and tonnes of food donated. These metrics allow Delhaize America to monitor its progress toward preventing FLW as well as donating surplus food to charities, while also diminishing the amount of FLW that goes to landfills (FLW Protocol 2017).

Food Service/Institutions

INTRODUCTION

The food service sector includes all institutions that serve prepared food intended for final consumption. In this sector, food products are taken from their raw, processed, or manufactured state and prepared in-house. The final product is usually sold in single portions, though certain business models serve food in larger portions.

Examples of organizations in this sector are: restaurants, caterers, hotels or venues that prepare and/or serve food, street vendors, convenience stores with prepared food, or cafeterias within facilities such as schools, hospitals and prisons.

In this sector, there is an important distinction between pre-consumer and post-consumer waste. Pre-consumer waste is any waste that occurs before the food is on the customer's plate and post-consumer waste is any waste that occurs after that point. Some in the sector refer to this as "back-of-house" and "front-of-house," respectively.

Some approaches to preventing FLW in food service are listed below.

- Working with actors upstream in the food supply chain to increase the share of second-grade products that are accepted and valorized to some point.
- Improving cold-chain management and infrastructure in order to prevent spoilage or degradation during storage and transport.
- Reducing overproduction of under-consumed products or shifting from production models that routinely overproduce food (e.g., buffets).
- Rethinking purchasing models in order to maintain freshness and reduce shrink.

Table 13. Methods Used to Measure FLW in the Food Service Sector

Method Name	Direct FLW Access Needed?	Level of Accuracy?	Level of Resources Required?	Tracks Causes?	Tracks Progress Over Time?
Methods for gathering new data					
Direct Measurement	Yes	High	High	Yes	Yes
Waste Composition Analysis	Yes	High	High	No	Yes
Methods based on existing data					
Mass Balance	No	Medium	Low	No	Yes
Records	No	Variable*	Low	No	Yes
Less commonly used methods at the food service/institutions sector					
Diaries	No	Low-Medium	Medium	Yes	Yes
Interviews/Surveys	No	Low-Medium	Medium-High	Yes	Yes
Proxy Data	No	Low	Low	No	No

*Accuracy depends on the type of record used: for example, waste transfer receipts may be highly accurate for determining FLW levels, whereas other records are less accurate.
Note: The methods named are nonexhaustive.
Source: Authors.

CASE STUDY FOR THE FOOD SERVICE SECTOR

Sodexo has prevented FLW through its "WasteWatch powered by LeanPath" program, which reduces on site food waste by an average of 50 percent. This program uses smart scales, which categorize food waste and generate a food waste inventory that helps identify *how much* and *where* food goes to waste. These inventories and continuous direct measurement allow staff to identify hotspots, take action and monitor progress over time. Sodexo found that tailored messaging to employees improved staff engagement in the FLW prevention program and that this staff engagement was particularly impactful in the food service sector. Additionally, Sodexo identified products going to waste that could not be sold but were still safe for human consumption. In the United States, Sodexo has collaborated with Food Recovery Network, Feeding America and Campus Kitchens to connect surplus food to those in need (Clowes et al. 2018).

Households

INTRODUCTION

Within the food supply chain, the household sector encompasses all food preparation and consumption in the home. While it is uncommon for individual households to independently track their food waste, governmental or nongovernmental organizations may want to monitor household FLW. In this guide, the household sector includes only food consumed in the home. Food consumed away from home falls under the food service stage in the food supply chain.

FLW in the household can be caused by preparation mistakes, lack of proper storage infrastructure or practices, trimming for consistency, misshapen products, spillage during handling, poor portion control, contamination, overproduction, food safety concerns, or many other factors.

Table 14. Methods Used to Measure FLW in the Household Sector

Method Name	Direct FLW Access Needed?	Level of Accuracy?	Level of Resources Required?	Tracks Causes?	Tracks Progress Over Time?
Methods for gathering new data					
Diaries	No	Low-Medium	Medium	Yes	Yes
Direct Measurement	Yes	High	High	Yes	Yes
Interviews/Surveys	No	Low-Medium	Medium-High	Yes	Yes
Waste Composition Analysis	Yes	High	High	No	Yes
Methods based on existing data					
Proxy Data	No	Low	Low	No	No
Records	No	Variable*	Low	No	Yes
Less commonly used methods at the household sector					
Mass Balance	No	Medium	Low	No	Yes

*Accuracy depends on the type of record used: for example, waste transfer receipts may be highly accurate for determining FLW levels, whereas other records are less accurate.
Note: The methods named are nonexhaustive.
Source: Authors.

CASE STUDY FOR THE HOUSEHOLD LEVEL

A household survey in Mexico City and Jiutepec, Mexico, collected demographic and behavioral information alongside a week-long FLW diary. Using these data together gives a more complete image of household FLW and allows analysis of the effects of various socioeconomic factors to identify root causes of household FLW. The results could inform local government agencies, NGOs and others about the potential effectiveness of intervention strategies. Such a community-centered approach lends itself to more tailored (and hopefully more effective) approaches to prevent FLW than broader surveys and diaries (Jean-Baptiste 2013).

Whole Supply Chain Approaches

INTRODUCTION

A whole supply chain approach encompasses all stages in the food supply chain. This includes all activities and destinations from production to final consumption or disposal. Users of this approach would be national and local governments. A useful application of this approach would be to analyze flows of specific food products or food categories across the entire food supply chain. Such an approach can provide insights into material flows, food availability, environmental impacts, food waste hotspots and opportunities for waste prevention, disposal methods, production and consumption trends and so on. Different users could vary the working definition of FLW by adjusting the scope of their analysis to focus on specific aspects of the food supply chain.

FLW can be generated for a variety of reasons throughout the supply chain and the user is recommended to review the relevant modules in this guide for details at each stage. Interventions are often tailored to a stage in the food supply chain with a sector-specific perspective because both existing data and direct measurements tend to occur at the sectoral level.

In addition to the methods listed in **Table 15**, national governments may find the **Food Loss Index** and **Food Waste Index** to be useful tools. These indices, developed by the United Nations, estimate FLW within a country based on existing data relating to key commodities within a country.

Table 15. Methods Used to Measure FLW across the Whole Supply Chain

Method Name	Direct FLW Access Needed?	Level of Accuracy?	Level of Resources Required?	Tracks Causes?	Tracks Progress Over Time?
Methods for gathering new data					
Interviews/Surveys	No	Low-Medium	Medium-High	Yes	Yes
Methods based on existing data					
Mass Balance	No	Medium	Low	No	Yes
Proxy Data	No	Low	Low	No	No
Records	No	Variable*	Low	No	Yes
Less commonly used methods across the whole supply chain					
Diaries	No	Low-Medium	Medium	Yes	Yes
Direct Measurement	Yes	High	High	Yes	Yes
Waste Composition Analysis	Yes	High	High	No	Yes

*Accuracy depends on the type of record used: for example, waste transfer receipts may be highly accurate for determining FLW levels, whereas other records are less accurate.
Note: The methods named are nonexhaustive.
Source: Authors.

CASE STUDY FOR MEASURING ACROSS THE WHOLE FOOD CHAIN

The US Department of Agriculture (USDA) Economic Research Service (ERS) estimates all post-harvest losses, through the entire food supply chain for over 200 agriculture product types, through its Loss-Adjusted Food Availability Data Series. This data series helps the USDA ERS produce estimates of loss-adjusted food availability as a proxy for food consumption. To create this data series, the USDA ERS developed loss coefficients, updated primary conversion factors and compared shipping and point-of-sales data. By estimating food losses in the United States with such a high level of accuracy, the USDA ERS helps US state and local governments, food industries, nongovernmental organizations and others identify opportunities to prevent FLW. These estimates allow others to identify hotspots in which to conduct more detailed research with the aim of preventing FLW (Buzby et al. 2014).

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