# Connecting Food Loss and Waste to Greenhouse Gas Emissions:

## Guidance for Companies

Food Loss + Waste

PROTOCOL

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# Introduction

# 1. The Connection between Food Loss and Waste and Greenhouse Gas Emissions

A significant amount of the food produced globally is never eaten (Flanagan et al. 2019). This food loss and waste (FLW) squanders the energy, resources, and money that went into producing, processing, packaging, and transporting the food. Given that the food system contributes around a quarter of the greenhouse gases (GHGs) emitted globally (Searchinger et al. 2019), reducing the amount of food lost or wasted is an important contributor to reducing GHG emissions and slowing down climate change.[1]

Linking the reduction of FLW to its potential for reducing associated GHG emissions is one powerful way for companies to highlight the value of FLW reduction, in addition to other significant business and societal benefits.[2]

The GHG emissions linked to FLW come from both:

- the production and handling of food that is ultimately lost or wasted (including, for instance, land clearing, fertilizer application, methane from livestock production, and on- and off-farm energy use);[3] and
- how the FLW is managed when discarded (for example, when food decays in landfills).

In light of this, reductions in GHG emissions from reducing FLW can be realized under two circumstances:

- When less food needs to be produced (or purchased) to generate the same amount sold
  - This helps reduce the need to convert land for additional food production as the global population grows—and potentially even frees up some land for reforestation.
  - It also helps reduce the associated emissions from fertilizer application, direct and indirect consumption of fossil fuels to power on- and off-farm operations, and other activities across the food supply chain.
- When less food decomposes, particularly in oxygen-poor conditions like landfills, where methane is generated.[4]

1 About 8 percent of global GHG emissions are associated with FLW, according to estimates by FAO (2013). Cutting FLW rates in half could close the gap between food needed in 2050 and food available in 2010 by more than 20 percent. In terms of the GHG impact, it would lower GHG emissions by 1.5–3 gigatons of carbon dioxide equivalent ($CO_2e$) per year by 2050 (which is more than the amount of energy and industry-related emissions of Japan) (Searchinger et al. 2019).

2 Project Drawdown ranks FLW reduction in its top 3 global climate change mitigation solutions, counting both the reduced farm-level emissions as well as the reduced need to clear forests for agriculture as the population grows (Hawken 2017).

3 Of the emissions generated by food systems, over 80 percent stem directly from agricultural production and its associated land-use change (Poore and Nemecek 2018).

4 As food decomposes, greenhouse gases such as methane, nitrous oxide, and carbon dioxide are produced.

## 2. How to Use This Publication

This publication enables companies across the food supply chain, particularly those calculating GHG inventories and setting science-based targets, to:

- better understand and connect FLW reductions with their efforts to reduce GHG emissions;
- calculate and communicate the climate benefits of FLW reductions; and
- link those benefits to their GHG inventories and science-based GHG reduction targets.

It is designed so that a company can easily navigate to those sections that are most relevant for the company's particular situation. The three parts provide recommendations about:

### How to calculate the GHG emissions associated with FLW (Part I)

This section provides the basic steps and calculations for estimating the GHG emissions associated with FLW and/or its reduction. This includes identifying the FLW-associated emissions from the food supply chain and from FLW destinations. A useful summary framework for accounting and reporting on these various types of GHG emissions is provided on page 16. Also included is an overview of various third-party tools available for estimating the GHG emissions associated with FLW.

### How to determine the contribution of FLW in a GHG inventory (Part II)

Since FLW cuts across multiple categories in a GHG inventory, the climate benefits of FLW reductions are not always easily identifiable or visible in GHG accounting. This section provides calculations and recommendations for determining the contribution of FLW within a corporate GHG inventory. These recommendations will be most relevant for companies that have already developed a GHG inventory and are seeking to identify and isolate emissions from FLW that are embedded within their inventory.

### How to communicate about the GHG benefits of FLW reductions (Part III)

Companies are increasingly stating their interest in fighting climate change by reducing FLW, sometimes to help achieve science-based GHG reduction targets. This section provides recommendations for a company seeking to communicate about the contribution of FLW to GHG reduction efforts.

## 3. How This Publication Links to the GHG Protocol and FLW Protocol

### LINKS TO THE GHG PROTOCOL

The GHG Protocol has developed the world's most widely used GHG accounting standards for businesses, governments, and other entities to measure and report their GHG emissions. This publication draws from various standards developed by the GHG Protocol.

The *Greenhouse Gas Protocol Corporate Accounting and Reporting Standard*[5] (WRI and WBCSD 2004) defined three "scopes" for describing the operational boundaries of a corporate GHG inventory (see Box 1). This publication includes guidance in Part II about how to calculate the contribution of FLW to these different parts of a GHG inventory. For companies that grow agricultural food commodities, this publication also draws from guidance provided in the *GHG Protocol Agricultural Guidance: Interpreting the Corporate Accounting and Reporting Standard for the Agricultural Sector* (WRI and WBCSD 2014).[6]

**Box 1. Definition of Scopes in a Corporate GHG inventory**

Scope 1 emissions are direct emissions from owned or controlled sources.

Scope 2 emissions are indirect emissions from purchased electricity.

Scope 3 emissions are all other indirect emissions that occur—upstream or downstream—in a company's value chain.

Source: WRI and WBSCD (2004).

Among companies that purchase agricultural raw materials (for example, packaged food manufacturers and food retailers), the GHG emissions associated with food production—and therefore with FLW—are typically included in their purchased goods, which are considered "Scope 3" emissions. "Scope 3" emissions are upstream or downstream emissions not under direct control of the company. This publication therefore also draws from the GHG Protocol's *Corporate Value Chain (Scope 3) Accounting and Reporting Standard* (WRI and WBCSD 2011a).[7]

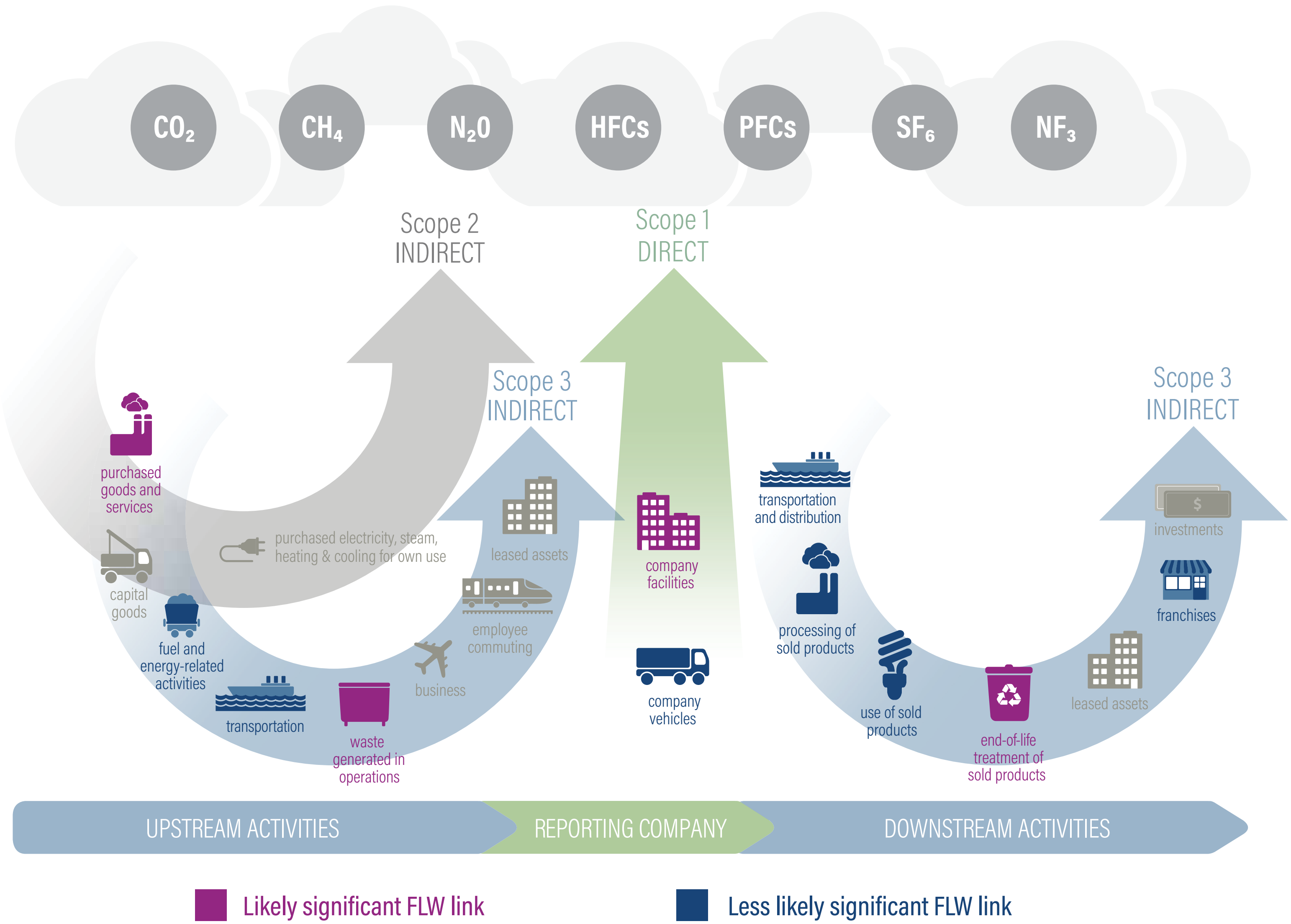
Figure 1 provides a visual example of where links to FLW are likely to be found in a corporate GHG inventory.

Where a company is assessing the GHG emissions of a particular product, it should reference the *Product Life Cycle Accounting and Reporting Standard* (WRI and WBCSD 2011b).[8] For assessing projects that reduce FLW it should draw on guidance in the *GHG Protocol for Project Accounting* (WRI and WBCSD 2005).

The GHG emissions related to FLW are typically found in various parts of a GHG inventory (see Figure 1). This is because FLW includes embodied emissions from food production and the supply chain, as well how the food was managed when removed from the food supply chain (i.e., its destination). This is further discussed in Part II.

5 The *Greenhouse Gas Protocol Corporate Accounting and Reporting Standard* provides requirements and guidance for companies and other organizations, such as NGOs, government agencies, and universities, that are preparing an enterprise-level GHG emissions inventory.
6 The *GHG Protocol Agricultural Guidance: Interpreting the Corporate Accounting and Reporting Standard for the Agricultural Sector* is a supplement to the GHG Protocol Corporate Standard and covers all agricultural subsectors, including livestock, crop production, and land use change.
7 The *Corporate Value Chain (Scope 3) Accounting and Reporting Standard* allows companies to assess their entire value chain emissions impact and identify where to focus reduction activities.
8 The *Product Life Cycle Accounting and Reporting Standard* can be used to understand the full life cycle emissions of a product and focus efforts on the greatest GHG reduction opportunities.

**Figure 1 | Where Links to FLW Are Likely to Be Found in a GHG Inventory**

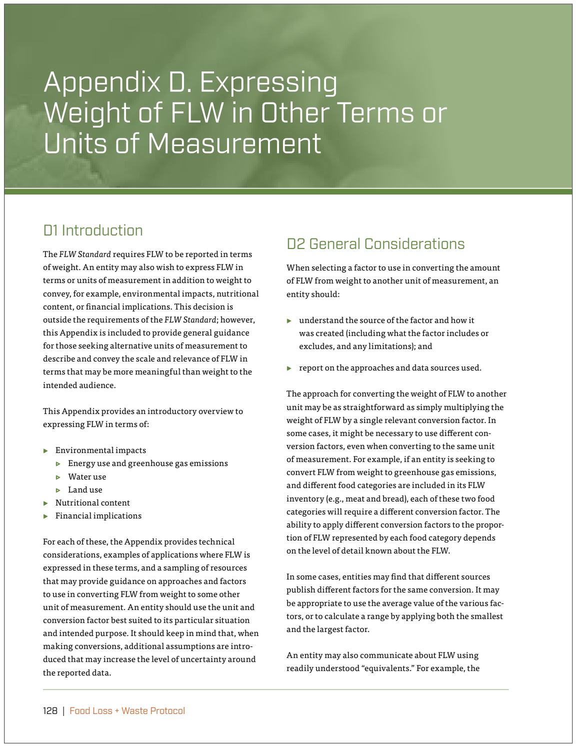



*Source:* Adapted from WRI and WBCSD (2011a), *Corporate Value Chain (Scope 3) Accounting and Reporting Standard.*

## LINKS TO THE FLW PROTOCOL

The *Food Loss and Waste Accounting and Reporting Standard (FLW Standard)* was developed by the FLW Protocol in 2016. The *FLW Standard* provides a common language and requirements for quantifying and reporting on the amount of FLW in a consistent and transparent way. This includes defining 10 possible destinations where food and/or associated inedible parts may go when removed from the food supply chain. These destinations are included in Figure 2 and defined in the *FLW Standard*.

While the *FLW Standard* requires reporting the amount of FLW in weight, it recognizes that it is valuable to also express FLW in alternative units of measurement that describe and convey the scale and relevance of FLW in other meaningful terms. Given that, in its Appendix D, the *FLW Standard* also includes general guidance on expressing the weight of FLW in terms of GHG emissions. This publication expands upon that guidance.



Appendix D. Expressing Weight of FLW in Other Terms or Units of Measurement

D1 Introduction

The *FLW Standard* requires FLW to be reported in terms of weight. An entity may also wish to express FLW in terms or units of measurement in addition to weight to convey, for example, environmental impacts, nutritional content, or financial implications. This decision is outside the requirements of the *FLW Standard*; however, this Appendix is included to provide general guidance for those seeking alternative units of measurement to describe and convey the scale and relevance of FLW in terms that may be more meaningful than weight to the intended audience.

This Appendix provides an introductory overview to expressing FLW in terms of:

- Environmental impacts
  - Energy use and greenhouse gas emissions
  - Water use
  - Land use
- Nutritional content
- Financial implications

For each of these, the Appendix provides technical considerations, examples of applications where FLW is expressed in these terms, and a sampling of resources that may provide guidance on approaches and factors to use in converting FLW from weight to some other unit of measurement. An entity should use the unit and conversion factor best suited to its particular situation and intended purpose. It should keep in mind that, when making conversions, additional assumptions are introduced that may increase the level of uncertainty around the reported data.

D2 General Considerations

When selecting a factor to use in converting the amount of FLW from weight to another unit of measurement, an entity should:

- understand the source of the factor and how it was created (including what the factor includes or excludes, and any limitations); and
- report on the approaches and data sources used.

The approach for converting the weight of FLW to another unit may be as straightforward as simply multiplying the weight of FLW by a single relevant conversion factor. In some cases, it might be necessary to use different conversion factors, even when converting to the same unit of measurement. For example, if an entity is seeking to convert FLW from weight to greenhouse gas emissions, and different food categories are included in its FLW inventory (e.g., meat and bread), each of these two food categories will require a different conversion factor. The ability to apply different conversion factors to the proportion of FLW represented by each food category depends on the level of detail known about the FLW.

In some cases, entities may find that different sources publish different factors for the same conversion. It may be appropriate to use the average value of the various factors, or to calculate a range by applying both the smallest and the largest factor.

An entity may also communicate about FLW using readily understood "equivalents." For example, the

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# Part I

## How to calculate the GHG emissions associated with FLW

This part provides the basic steps and calculations for estimating the GHG emissions associated with FLW and/or its reduction. Also included is an overview of various third-party tools available for estimating the GHG emissions associated with FLW.

# 1. Steps For Calculating the GHG Emissions Associated With FLW

In its simplest form, calculating the GHG emissions associated with FLW involves multiplying the amount of FLW (or activity data) by the relevant GHG emission factors.[9] The relevant GHG emission factors are (a) those associated with producing the food, including from harvest/slaughter and all the related stages up to the moment of loss/waste *plus* (b) those associated with where the FLW goes (i.e., the destination, which may also be referred to as the "material management route").

The steps for undertaking this calculation are as follows.

STEP 1: Gather data on the amount of FLW and aspects that affect the related emission factors.

STEP 2: Select the relevant emission factors.

STEP 3: Calculate the GHG emissions associated with the FLW and/or its reduction.

STEP 4: Summarize the results, including calculation approach, sources of uncertainty, and assumptions.

For Steps 2 and 3, a company may use a third-party calculation tool and/or their own proprietary tool(s). See page 22 for an overview of third-party tools. The subsequent pages provide additional details about each of these steps.

9 An emission factor is a coefficient that quantifies the emissions or removals of a greenhouse gas per unit activity and is often based on a sample of measurement data, derived as a representative rate of emissions for a given activity under a particular set of operating conditions (IPCC 2019). It is typically expressed as kilograms or metric tons (tonnes) of carbon dioxide equivalents (kg or t $CO_2e$). The general equation for estimating GHG emissions is: Activity Data (e.g., volume of product produced or sourced) × Emission Factor (e.g., t $CO_2e$ / volume of product / year).

## STEP 1. Gather data on the amount of FLW and aspects that affect the related emission factors

Gathering the following information enables a company to estimate the GHG emissions associated with FLW and select the emission factors most relevant to its particular situation.

**A. The weight of FLW being analyzed**

- Data on the weight of FLW by the type of food at the level of category or primary ingredient allows for more detailed analysis of the associated GHG emissions.
- If data on the weight of FLW is unavailable, a percentage (for instance, an estimated loss rate) can be used to estimate the weight of FLW based on total food purchases or yield. As noted on page 20, companies should provide a qualitative description and/or quantitative assessment of the uncertainty around the data reported.
- Priority FLW streams for analysis may be based on a mapping of the likely hotspots (for instance, where the amount of FLW, and/or associated GHG emissions, are high).
- It is useful to note that while the *FLW Standard* requires excluding the weight of packaging from the weight of FLW, the carbon footprint of food products may also include emissions related to the product's packaging.
- For more detail on how to quantify FLW, see guidance available at www.flwprotocol.org.

**B. The type of food in the FLW**

- If analyzing FLW that is composed of many different food products, determine what is known about the proportion of FLW at a category level (for example, animal-based products versus plant-based products). Undertaking a waste composition analysis is one way to estimate the product mix.[10]
- If using a third-party tool, keep in mind that the commodities or food categories included may not exactly match those in the FLW being analyzed. If the GHG emissions of the food being analyzed is similar to another product in the tool, a close match may be sufficient, especially if a high degree of accuracy is not required.

**C. Where known, the geographic region in which the agricultural raw materials are produced**

- Most third-party tools use emission factors specific to agricultural production in a certain country or region since subnational and site-specific emission factors are often not publicly available. If a company has its own emission factors, it should use them, provided they are of sufficient data quality (see Appendix, Table A1).
- If the country or region of production is unknown, global proxies can be used for the production-related emission factors.

**D. In which life-cycle stage(s) the FLW has been generated (e.g., agricultural production, manufacturing, retail, consumption)**

- The stage(s) in which the FLW is generated impacts the emission factor used since each stage in the supply chain incurs emissions. The emission factor used should include the relevant upstream stages, as well as any downstream, if relevant. For example, if accounting for FLW by a manufacturer, the factors from agricultural production, logistics, packaging, manufacturing, and waste generated in operations are relevant; the end-of-life treatment of sold products may also be relevant.
- Some third-party tools only allow for the analysis to be undertaken based on impacts associated with agricultural production. However, this may be sufficient to gain a general understanding of the GHG emissions, since agricultural production and the related land use account for the vast majority of global food-related GHG emissions. Other tools include additional assumptions around emissions in other stages of the supply chain (see Table 2).

**E. Where known, the amount of FLW sent to different destinations**

- If the destination of FLW is unknown, to be conservative, emission factors for landfill (or whatever is the most common destination in a particular geography) can be used as the default assumption.

10 For more on waste composition analysis, see *Guidance on FLW Quantification Methods* published by the FLW Protocol.

## STEP 2. Select the relevant emission factors

Emission factors are readily available through public data sets (see page 29 for sources used by third-party calculation tools) and also through proprietary sources. There are several aspects to consider when selecting emission factors.

### A. Primary versus secondary data

Companies can use primary or secondary data, or a mix of both, for the emission factors used in their calculations.

Emission factors that are specific to a company's own operations are referred to as primary data. Companies that have undertaken their own product-specific or site-specific measurement of GHG emissions should use this data when available, as it will improve the level of accuracy.

Secondary data may represent global, regional, national, or other averages, meaning that the emission factors were not specifically derived for a company's own supply chain. Secondary data may include, for instance, emission factors for producing a given commodity in a certain geographic region. An emission factor derived from secondary data allows users to estimate GHG emissions without needing to gather site-specific data on the quantity of emissions released from an activity. The drawback is that secondary data does not reflect the specific production conditions within a company's supply chain, and therefore will also not easily capture changes in emissions resulting from changes to those production conditions. There are many sources of secondary data from which a company could select its emission factors (see page 29).

### B. Emission factors included in third-party calculation tools

The third-party tools highlighted in this publication use secondary data drawn from several publicly available and reputable databases (see page 29).

Many of the third-party tools allow users to override the default emission factors used. This allows a company to apply more customized emission factors that are proprietary to its particular business and reflect its specific circumstances. For example, a company may be able to develop emission factors based on the energy (electricity or natural gas) used in its own operations, such as manufacturing plants.

If adapting a third-party tool, companies should ensure that customized emission factors use data that are of equal or higher quality than the default data according to the data quality indicators in the Appendix, Table A1.

### C. The unit on which emission factors are based

It is important that the emission factors used are expressed in the same measurement unit as the activity data (FLW), which may require conversion of units before completing the calculations. For instance, emission factors for rice may be expressed in paddy equivalent or as white rice equivalent. Understanding whether the emission factor is based on dry matter or not may impact data accuracy particularly for products with significant water weight.

Emission factors based on weight are generally preferable, given that weight is not affected by other variables. Emission factors based on economic value or dollars should be used with care, since prices are subject to market fluctuations.

## STEP 2. Select the relevant emission factors *(continued)*

### D. FLW-related climate impacts outside GHG inventory scopes 1–3

There are other climate impacts associated with FLW that a company may also consider in addition to emissions embodied in the production of food (that becomes FLW) and its end-of-life management. These include carbon opportunity costs of food production (see Box 2), as well as carbon removals, carbon storage, and/or avoided emissions related to food supply chains or the FLW destinations.

These impacts are currently considered outside the GHG inventory "scopes," which means the full GHG benefit of reducing FLW does not show up in a GHG inventory report (see Box 3).[11] This publication recommends that companies nonetheless consider these additional climate impacts to paint a fuller picture of the benefits of reducing FLW and track them separately as required by current GHG inventory accounting and reporting standards (see page 42 for an example).

Third-party tools include default emission factors for some of these additional climate impacts (see Table 2). Factors for carbon opportunity costs can be found in the Cool Food calculator (Waite et al. 2019), drawn from Searchinger et al. (2018). Emission factors for carbon removals, carbon storage, and/or avoided emissions

#### Box 2. The Carbon Opportunity Costs of FLW's Land Footprint

More than one billion hectares of land are used to produce food that is ultimately lost or wasted (FAO 2013). Reducing the amount of food lost and wasted could mitigate the need for further conversion of forests and other natural habitats to farmland as global food demand continues to grow. A reduction in agricultural land demand could thereby allow for more carbon to be stored in plants and soils instead of released into the atmosphere.[a] Currently, however, the loss of carbon from lands converted to agriculture is rarely included when assessing the climate impacts associated with FLW, meaning that the climate benefits from reducing FLW can be underestimated if they do not factor in land use.

The "carbon opportunity cost" is a metric that estimates the climate impacts of ongoing agricultural land use. The carbon opportunity cost of a food is defined as the total historical carbon loss due to land clearing for production of that food (Searchinger et al. 2018).[b] Alternatively, it can be defined as the amount of carbon that could otherwise be drawn down from the atmosphere and stored if land producing that food were allowed to return to its native vegetation (Schmidinger and Stehfest 2012). Estimating FLW-related carbon opportunity costs—alongside FLW-related direct emissions from agricultural production, food supply chains, and FLW destinations—can help paint a fuller picture of the climate impacts of a company's FLW and the climate benefits of reducing that FLW.

a. Avoiding the future conversion of natural habitats for additional farmland is the key reason why Project Drawdown ranks FLW reduction as one of its highest-impact climate change mitigation solutions (Hawken 2017).

b. Because carbon losses occur quickly but food production continues for many years, carbon opportunity costs are annualized using a discount rate (Searchinger et al. 2018).

#### Box 3. GHG Protocol Land Sector and Removals Guidance (Forthcoming)

The *GHG Protocol Land Sector and Removals Guidance*, slated for release in 2022, will update current requirements related to accounting and reporting on some of the climate impacts currently outside scopes 1–3. It is anticipated that in this new guidance, carbon removals and storage, under certain conditions, could be reported in scopes 1–3.

In addition, companies that produce or source land-based products may be required to report "direct land use change emissions" inside scopes 1–3. However, it is important to keep in mind that direct and/or statistical land use change emissions—typically from recent (past 20 years) deforestation linked to commodities like beef, soy, and palm oil—are a subset of carbon opportunity costs, which count total historical carbon loss linked to agricultural production. Therefore, the direct and/or statistical land use change and carbon opportunity costs associated with FLW cannot be added together. Moreover, carbon opportunity costs must be reported separately from a company's GHG inventory.

Any claims of avoided emissions will still need to be reported separately outside the scopes.

11 Carbon opportunity costs, avoided emissions, and carbon removals and storage—while important aspects of the FLW and climate link—cannot currently be included in a company's scope 1–3 GHG inventory, and therefore also cannot be counted toward science-based GHG reduction targets for scopes 1–3. Box 3 notes, however, that the forthcoming *GHG Protocol Land Sector and Removals Guidance* is likely to allow reporting of carbon removals and storage as well as direct and/or statistical land use change emissions (a subset of carbon opportunity costs) inside scopes 1–3 under certain conditions.
The GHG Protocol states that companies shall not include avoided emissions claims in, nor deduct them from, scopes 1–3 because claims of avoided emissions pose several accounting challenges (for instance, determining appropriate product or scenario comparisons, determining analytical boundaries, and double counting). Rather, companies may report avoided emissions separately from the scopes, along with data to support the avoided emissions claims and the methods and assumptions used to calculate them (WRI and WBCSD 2011a).
See more about calculating the contribution of FLW in a GHG inventory in Part II and how to communicate about FLW reductions when reporting on GHG reduction targets in Part III.

## STEP 2. Select the relevant emission factors *(continued)*

are available in the Cool Farm Tool (for soil carbon sequestration) and, for destinations in the United States, in the Environmental Protection Agency's (EPA) WARM tool and other tools that draw on WARM.

When accounting for and communicating about the GHG impacts associated with carbon removal, carbon storage, and/or avoided emissions, the following are important considerations.

- The emission factors used in third-party calculation tools may reflect the net GHG impact from different food production practices and/or destinations, meaning that the carbon removal, carbon storage, and/or avoided emissions benefits are already taken into account. For example, the calculation for the net impact of a destination may come from first identifying the gross emissions associated with the destination (for instance, transporting the FLW to the destination and GHG emissions generated as the FLW decomposes), then subtracting benefits such as the avoided emissions from recovering energy or other resources, the avoided emissions from the FLW replacing another feedstock such as a crop-based animal feed, and/or the carbon stored on the land.
- The emission factors used for these carbon removal, carbon storage, and/or avoided emissions benefits in third-party calculation tools can often be viewed separately (in other words, broken out from the gross emissions) in each tool's technical documentation. An example from EPA's WARM tool is in Box 4, showing the breakdown of all emission factors used to derive a net emission factor that accounts for avoided emissions. The gross emissions are drawn from EPA's Emission Factors Hub.
- When reporting the contribution of FLW to a GHG inventory (scopes 1–3), only gross GHG emissions can currently be included, with any carbon removal, carbon storage, and/or avoided emissions benefits reported separately (Figure 2; Table 6; Table 7). See Box 5 for how this pertains specifically to food donations. If reporting GHG emissions associated with FLW independently from a GHG inventory, aggregating the emissions impact by using the net emission factor may be appropriate. In either case, the emission factor(s) and source used should be clearly described.

### Box 4. Example of Calculation of GHG Emissions from Landfilled Food Waste (Based on WARM Technical Documentation, t $CO_2$e/short ton)

| | |
|---|---|
| Transport to landfill (0.02), landfill methane produced (0.56) | 0.58[a] |
| Avoided $CO_2$ emissions from energy recovery (-0.05), landfill carbon storage (-0.09) | -0.14[b] |
| Net emission factor | = 0.44 |

*Notes:*
a. Gross emissions reported in scopes 1–3.
b. Adjustments reported separately outside the scopes.
*Source:* EPA (2021a), EPA (2019a), WARM Version 15, Exhibit 1–48.

### Box 5. Considerations Related to Food Donations

Donating food to people in need is an important action that can address food insecurity and contribute to resource conservation. If the food would have otherwise been discarded, donation can result in reduced GHG emissions by reducing emissions from landfills, for instance. If the donated food offsets demand for similar food, the donation can also avoid the upstream GHG emissions related to food production and supply chains. Companies can use emission factors to develop a low- and high-end estimate of avoided GHG emissions related to food donations (see the EPA's guidance in *Modeling Food Donation Benefits in EPA's Waste Reduction Model* [2019b]).

While food donations are an important FLW reduction strategy, they do not reduce a company's food purchases and as such do not reduce a company's scope 3 (indirect) GHG emissions from "purchased goods and services." Therefore, when considered in the context of a company's GHG inventory, claims around avoided food production and associated GHG emissions related to a company's food donations must be reported separately from scopes 1–3 as avoided emissions. If a company is counting emissions from waste generated in operations, such as landfilled food, in its scope 3 inventory, then any reductions in those emissions over time from donating food instead of sending it to landfill could be counted in the company's inventory (and could potentially help a company meet a science-based GHG reduction target). See Part II for more on GHG inventories and Part III for more on science-based targets.

## STEP 3. Calculate the GHG emissions associated with the FLW and/or its reduction

**The basic formula for estimating the GHG emissions associated with FLW is as follows:**

GHG emissions associated with FLW = GHG emissions from food supply chains + GHG emissions from FLW destination(s) + Climate impacts outside GHG inventory scopes 1–3 *(reported separately, optional)*

As an example, the basic formula for GHG emissions associated with a kilogram of apples sent to landfill by a grower would be:

(1 kg of apple × $CO_2$eq/kg apple production) + (1 kg of apple × $CO_2$eq/kg apple to landfill)

**Calculations of the GHG emissions associated with FLW are best undertaken using a calculation tool, whether it is third-party or proprietary. This simplifies a company's ability to incorporate various details and run alternative scenarios. To learn more about some of the third-party tools available for performing these calculations, see page 22.**

The following provides basic details about the calculations a company undertakes for the three types of GHG emissions associated with FLW. The result from calculations 1 and 2 can be summed up to arrive at the total GHG emissions associated with FLW. Figure 2 provides a framework for considering what types of GHG emissions associated with FLW to account for and report.

1. **GHG emissions from food supply chains** = (Weight of FLW × Emission factor of agricultural production) + (Weight of FLW × Emission factor(s) of additional relevant life cycle stage(s))
2. **GHG emissions from FLW destination(s)** = Weight of FLW to destination × Emission factor of the destination
3. **Climate impacts outside GHG inventory scopes 1–3** *(reported separately, optional)* = Weight of FLW x Emission factor for relevant climate impact

- Related to **food supply chains**: As noted on page 13, for a fuller picture of the climate impacts, a company may also elect to account for the carbon opportunity cost of producing the food that becomes FLW, as well as any avoided emissions or carbon removals that occur during food production. This involves multiplying the weight of FLW by the relevant emission factor(s).
- Related to the **destinations:** As noted on page 13, a company may also elect to account for any avoided emissions or carbon storage[12] associated with sending FLW to a particular destination. This involves multiplying the weight of FLW by the "avoided emission or carbon storage" factor associated with the destination. An example of how such emission factors are calculated and used is included on Box 4.

12 Box 3 notes that the forthcoming GHG Protocol Land Sector and Removals Guidance is likely to allow reporting of carbon removals and storage inside scopes 1–3 under certain conditions.

## STEP 3. Calculate the GHG emissions associated with the FLW and/or its reduction *(continued)*

### Figure 2. Framework for Accounting and Reporting on the Various Types of GHG Emissions Associated with FLW

**Summing Up GHG Emissions Associated With FLW**

**Where to Report These Emissions in a GHG Inventory (not exhaustive)**

GHG Emissions Associated with **Food Supply Chains**

Agricultural production (food)* + Additional life cycle stages (e.g., handling, transportation. processing, distribution, retail, food service, consumption)

Purchased goods and services (scope 3)
Company facilities/operations (scope 1)
Purchased electricity (scope 2)

GHG Emissions from **FLW Destinations**

Animal feed + Biomaterial/processing + Co/anaerobic digestion + Compost/aerobic + Controlled combustion

Land application + Landfill + Not harvested + Refuse/discards + Sewer + Other

Waste generated in operations (scope 3)
End-of-life treatment of sold products (scope 3)

Climate Impacts Outside GHG Inventory Scopes 1–3 *(reported separately, optional)*

Carbon opportunity costs of food production − Avoided GHG emissions, carbon removals, and/or carbon storage linked to food supply chains (e.g., food donation, soil carbon sequestration) or destinations (e.g., avoided feed/fertilizer, energy recovered, landfill C storage)

Outside of scopes 1–3, *not* counted in GHG inventory, reported separately

*Note:* To assess the net GHG impact of an action to reduce FLW, apply this framework to analyze GHG emissions in a baseline scenario and also in the "FLW reduction" scenario, then calculate the difference between the scenarios as noted on page 17. As noted in the *Food Loss and Waste Accounting and Reporting Standard*, entities may select which destinations are in scope for their FLW inventory. For example, a common definition used by multiple organizations for the purpose of achieving a 50 percent reduction by 2030 (i.e., proposed by Champions 12.3 and used by WRAP along with others) excludes the two destinations of animal feed and biomaterial/processing (Champions 12.3 2017). Other stakeholders, however, may define FLW differently.

*Regarding GHG emissions from agricultural production, companies may elect to include emissions from direct and/or statistical (recent 20-year period) land use change in their estimate. Under the forthcoming *GHG Protocol Land Sector and Removals Guidance*, these direct and/or statistical land use change emissions will likely be reported in scopes 1 (producer company) or 3 (consumer company).

*Source:* WRI Authors.

## STEP 3. Calculate the GHG emissions associated with the FLW and/or its reduction *(continued)*

**Reducing the amount of FLW, or moving it from one destination to another, changes the associated GHG emissions. Calculating this involves comparing a baseline case to an alternative scenario. Several of the third-party calculation tools available enable users to calculate the GHG impacts associated with different scenarios.**

**When assessing the GHG emissions associated with actions that reduce FLW, there are several considerations to take into account.**

### A. Calculating the net impact of an action to reduce FLW

To assess the net impact of an action to reduce FLW, the basic steps are to identify and analyze GHG emissions in a baseline scenario, identify and analyze GHG emissions in the "FLW reduction" scenario, and then calculate the difference between the scenarios.

Actions to reduce the amount of FLW may also lead to some additional emissions relative to the baseline scenario (for example, for additional energy, fuel, and/or packaging material required for the action taken). These emissions should ideally also be taken into account to have a full picture of the impact of an action to reduce FLW. There are several third-party tools that allow users to also take into account these additional emissions. These include Wageningen's Agro-Chain Greenhouse Gas Emissions Calculator, The FOod side flow Recovery LIFe cycle Tool (FORKLIFT), and Provision Coalition's Food Loss + Waste Toolkit (Tables 2 and 3). Additional assessments and/or assumptions may be needed for specific actions, such as certain packaging designs, that do not have data in an existing public database or tool.

If it is impractical to accurately estimate all the related emissions resulting from an action to reduce FLW, a company should decide whether to include or exclude these emissions based on the accounting and reporting principle of "relevance" and the decision-making needs of the intended users.[13]

13 See *FLW Accounting and Reporting Standard*, Chapter 5 (FLW Protocol 2016) and *GHG Protocol Corporate Accounting and Reporting Standard*, Chapter 1 (WRI and WBCSD 2004).

## STEP 3. Calculate the GHG emissions associated with the FLW and/or its reduction *(continued)*

### B. Scale of the GHG benefits from reducing FLW varies

A number of factors impact the scale of GHG emission reductions associated with a reduction in FLW.

- Life cycle assessments provide evidence that, for most food products, the bulk of environmental impacts occur earlier, such as during the production phase, rather than later in the life cycle of a product (Heller 2019). That said, reducing FLW generated during other stages beyond the farm gate—including long-distance transportation, processing, packaging, and refrigeration—can also present important opportunities for GHG emissions reductions. Since GHG emissions from producing food typically are larger than those from end-of-life management, the largest opportunity to reduce GHG emissions often arises by preventing food from leaving the human food supply chain in the first place through source reduction (Bernstad and Canovas 2015; Reutter et al. 2017). Several of the third-party tools reviewed in this publication enable a company to assess the impact of FLW at various points in the food supply chain.
- Sending FLW to different destinations also impacts the associated GHG emissions. While the amount of GHG emissions associated with waste management is often lower than those associated with food production, diverting FLW from one destination to another can reduce emissions and also result in avoided emissions and/or carbon storage benefits. For example, moving FLW from landfill to the production of animal feed not only reduces the amount of methane emitted in landfills but also can avoid the need to produce feed-quality crops. Third-party tools that enable a company to assess alternative management scenarios include EPA's WARM tool and the ReFED Food Waste Impact calculator (see page 26 for additional details about these tools).

### C. It's not just the GHG emissions that matter

While this publication is focused on the connection between FLW and climate impacts, it is important to keep in mind that even in cases where the GHG emissions associated with FLW are not substantial, the impact from reducing FLW may be meaningful in other terms or units of measurement. For example, water and land resources are also "embedded" in food and drink products at all stages of the supply chain. FLW also represents a loss of nutrients, which could have gone to feed people in need, and has significant financial implications in the form of direct costs and forgone benefits. Further guidance on expressing FLW in other terms is available in Appendix D of the FLW Standard (FLW Protocol 2016) and in the Commission for Environmental Cooperation's *Technical Report: Quantifying Food Loss and Waste and Its Impacts* (Commission for Environmental Cooperation 2019).

## STEP 4. Summarize the results, including calculation approach, sources of uncertainty, and assumptions

**When reporting on the GHG emissions associated with FLW, companies should document the calculation approach taken, sources of uncertainty, and any relevant assumptions. Reporting the following should be in line with requirements contained in the FLW Protocol and GHG Protocol standards. Guidance on communicating about these results is covered in Part III.**

The below provides additional detail. An illustrative example of how one can calculate the sum of the following is provided in Table 1 and Figure 3.

**1. Results**

- Report the amount of FLW analyzed in weight (e.g., kilograms or metric tons), and GHG emissions related to FLW and/or its reduction in the amount of carbon dioxide equivalent ($CO_2e$).
  - If reporting as part of a GHG inventory, additional climate impacts related to carbon opportunity costs, avoided emissions, carbon removals, and/or carbon storage must be reported separately (see example in Table 6).[14]
  - Even if not reporting as part of a GHG inventory, best practice is to make clear when these additional climate impacts are included in the results. In some cases—for instance, if using the WARM tool, where gross emissions and avoided emissions and/or carbon storage are combined into net emission factors for destinations—the results may inevitably include a combined net emissions amount. In that case, the fact that it is "net" should be clearly described and communicated.

**2. The scope and calculation approach, including emission factors used**

- Report on scope, including food category, life cycle stage(s) analyzed with assumptions, and geography.
- Describe the methodology used to calculate emissions, including emission factors used and their sources. Sources may be a reference or link to the calculation tool(s) used, with the same information.
- Where a change in emissions is reported (possibly due to FLW prevention actions or a change in destination) describe the context around the action taken.

**3. Provide a qualitative description and/or quantitative assessment of the uncertainty around the data reported.** Sources of uncertainty to consider include the following:

- FLW data used: For example, any assumptions that are reported in the FLW inventory about how the FLW data was calculated should be referenced when reporting on the associated GHG emissions (See *FLW Standard* for reporting requirements of an FLW inventory).
- Emission factors used: Secondary data is often used but introduces uncertainty because the emission factors are not customized to a particular company's situation. For example, they may not fully reflect the growing practices of a particular company's suppliers, nor the exact nature of practices to manage the FLW.

14 Box 3 notes that the forthcoming *GHG Protocol Land Sector and Removals Guidance* is likely to allow reporting of carbon removals and storage inside scopes 1–3 under certain conditions.

## STEP 4. Summarize the results, including calculation approach, sources of uncertainty, and assumptions *(continued)*

### Table 1 | Hypothetical Example: Fresh Tomatoes in Food Service Setting (GHG Results, Boundary, Source of Emission Factors Used, and Sources of Data)

| TOTAL GHG EMISSIONS ASSOCIATED WITH FLW | Total FLW weight: 1,000 kg<br>Total FLW-related emissions: 1,430 kg $CO_2e$<br>Other climate impacts: 710 kg $CO_2e$ (carbon opportunity costs), -150 kg $CO_2e$ (destination-related avoided emissions and carbon storage) | | |
|---|---|---|---|
| **Boundary Categories** | **Characteristics of the FLW** | **Emission Factor Used** | **Source of Emission Factors (note which tool used or dataset)** |
| **Food type** | Tomatoes | Tomatoes | Cool Food Calculator |
| **Geographic region** | Canada | North America | Cool Food Calculator |
| **Life-cycle stage(s)** | Food service | Agricultural production, transport, packaging | Cool Food Calculator |
| **Destination** | Landfill | Landfill | EPA WARM Tool |
| **Uncertainty: qualitative description and/or quantitative assessment** | The sources of uncertainty included here stem from the emission factors used all being based on secondary data and not being an exact match (i.e., North America is used as proxy for Canada; landfill factors represent averages for all food waste in the U.S.; transport and packaging emission factors are based on regional averages in Poore and Nemecek [2018]). In addition, the carbon opportunity cost factor is global, and FLW weights are scaled up from measurements taken at sites representing 75 percent of the company's total volume. | | |

*Source:* WRI authors.

A sample of how the detailed results might be presented visually (based on the framework in Figure 2) is provided on the next page.

**Figure 3. Hypothetical example: fresh tomatoes in food service setting (Using Framework for Accounting and Reporting on the Various Types of GHG Emissions Associated with FLW)**

| Summing Up GHG Emissions Associated With FLW | Where to Report These Emissions in a GHG Inventory (not exhaustive) |
|---|---|
| GHG Emissions Associated with **Food Supply Chains**<br>Agricultural production (food) = 220 kg of $CO_2e$ + Additional life cycle stages = 250 kg of $CO_2e$ (transport); 210 kg of $CO_2e$ (packaging) | **Purchased goods and services** (scope 3) = 680 kg of $CO_2e$ |
| GHG Emissions from **FLW Destinations**<br>Animal feed + Biomaterial/processing + Co/anaerobic digestion + Compost/aerobic + Controlled combustion<br>Land application + Landfill = 750 kg of $CO_2e$ + Not harvested + Refuse/discards + Sewer + Other | **Waste generated in operations** (scope 3) = 750 kg of $CO_2e$ |
| Climate Impacts Outside GHG Inventory Scopes 1–3 *(reported separately, optional)*<br>Carbon opportunity costs of food production = 710 kg of $CO_2e$ – Avoided GHG emissions linked to destinations (energy recovered, landfill C storage) = -150 kg of $CO_2e$ | **Outside of scopes 1–3 *not* counted in GHG inventory, reported spearately**<br>Carbon opportunity costs = 710 kg of $CO_2e$<br>Other emissions linked to destination = -150 kg of $CO_2e$ |

*Note:* Colored boxes represent the types of GHG emissions and climate impacts included in this example.
*Source:* WRI Authors.


# 2. An Overview of Third-Party Calculation Tools

## BACKGROUND

The calculation tools described in this publication represent some of the options that are currently publicly available for assessing the GHG emissions associated with FLW. Because they were designed for different business audiences and needs, there is no one tool that fits every context.

To simplify the selection of which tool is most appropriate for a certain company's needs, the following pages summarize for each the focus and target audience, which GHG impacts the tool covers, and how the tool can be used.

## WHAT IS COMMON ACROSS THE THIRD-PARTY TOOLS ANALYZED

Each of the nine tools reviewed (Tables 2 and 3):

- enables a company to calculate the GHG emissions associated with FLW;
- uses third-party emission factors (i.e., secondary data); and
- documents directly in the tool, or in an accompanying document, the emission factors used and sources. This therefore also enables a company to incorporate the emission factors used in these tools into their own proprietary tool(s) where primary data is not available.

Most are publicly available as a downloadable Excel or online calculator.[15]

Some allow a user to override the default emission factors with customized information.[16]

15 The Cool Farm Tool is free for everyone but requires a free registration. Provision Coalition's Food Loss + Waste Toolkit is free to manufacturers but requires registration.
16 These include the ACE Calculator, Cool Farm Tool (for CFA members), the Cool Food Calculator, the FLW Value Calculator, and the FORKLIFT Tool.

## WHAT ASPECTS DIFFER ACROSS THE THIRD-PARTY TOOLS ANALYZED

The tools differ with respect to the following:

**Target audience and focus**

- Geographic scope: Some were designed for a national or regional audience (e.g., U.S., Canada, Europe), which affects the GHG emission factors used by the tool.
- Sectoral focus: Some were designed for a particular sector (e.g., farmers, food service operators) though most can nonetheless be used and/or adapted for other sectors.
- Food products included: The number of products included and the level of granularity (e.g., single ingredient versus category level) varies.

**Which GHG emissions associated with FLW the tool covers**

This may include GHG emissions related to food supply chains, FLW destinations, and/or climate impacts outside GHG inventory scopes 1–3. Emission factors may cover one or multiple stages in food supply chains, and may cover one or multiple FLW destinations, as detailed further in Table 2.

**How to use the tool**

- The types of comparisons that can be made between alternative scenarios varies in several ways.
  - Some tools enable a user to compare scenarios automatically. In other cases, a tool will only help the user calculate the GHG emissions associated with a given scenario, but not the net impact between scenarios. In that case, the user can calculate the net impact themselves.
  - If a tool does not allow for the analysis of more than one scenario, to analyze the effect of different actions, users can also have open additional copies of the tool in parallel to more easily compare outcomes.
  - Some provide users with the ability to vary multiple factors (for instance, distance and mode of transportation and amount of fuel or electricity used) when assessing the impact of an action to reduce FLW, while others only allow a user to vary one or two factors, such as the weight of FLW and destination.
- Some assess other impacts of FLW besides GHG emissions, including water impact, economic impact, and nutritional value.

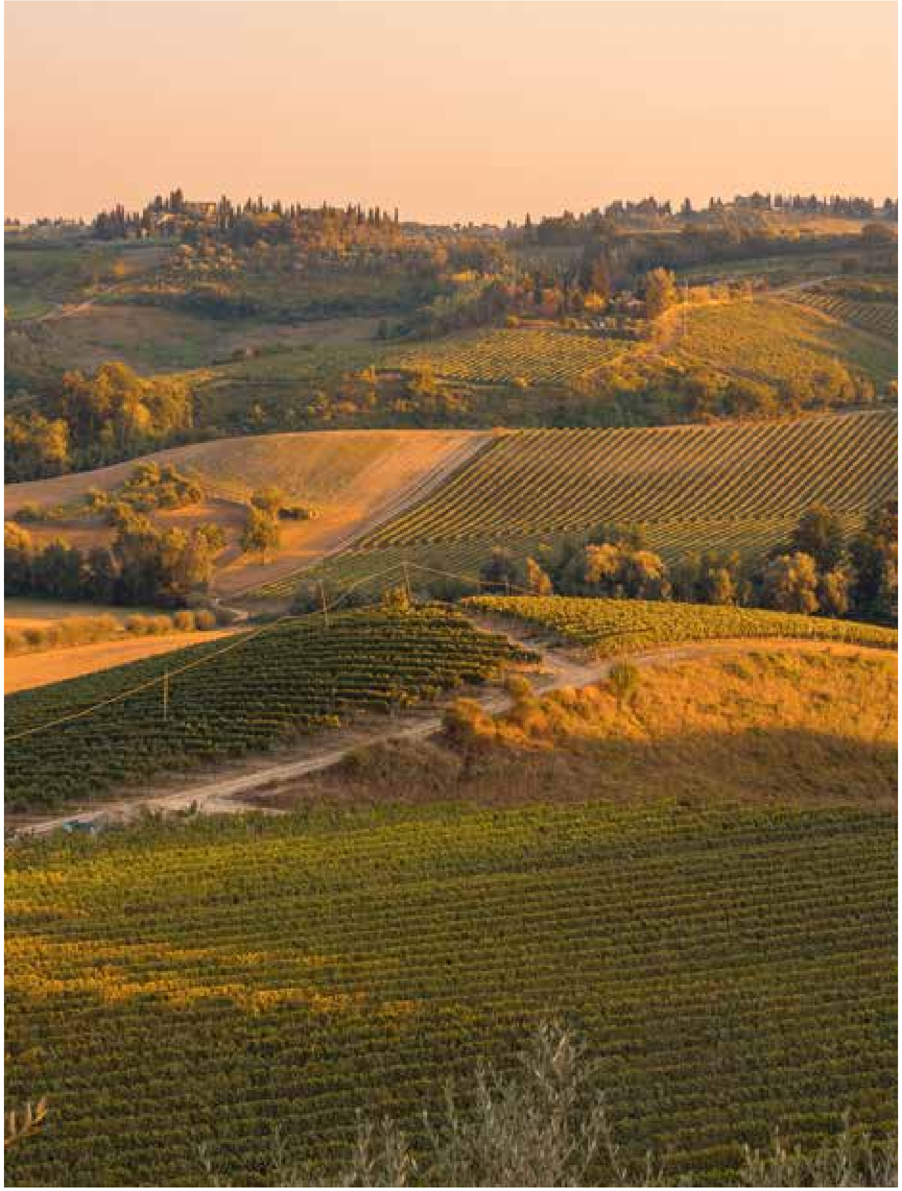
## CONSIDERATIONS IF USING A THIRD-PARTY TOOL

The decision to use one of the existing calculation tools developed by a third-party instead of undertaking a proprietary analysis is partly a function of resources available—most publicly available tools are free—and the desired level of accuracy.

A third-party calculation tool will likely be less accurate because generalized emission factors and assumptions are used. How accurate the associated GHG emissions estimates will be when using a third-party tool is linked to how closely a company's FLW data matches the food product(s) and how representative the tool's emission factors are of the company's context (see Table 2). If the third-party tool represents the company's situation well, the calculations can be as adequate as proprietary analysis.

To elaborate on this point:

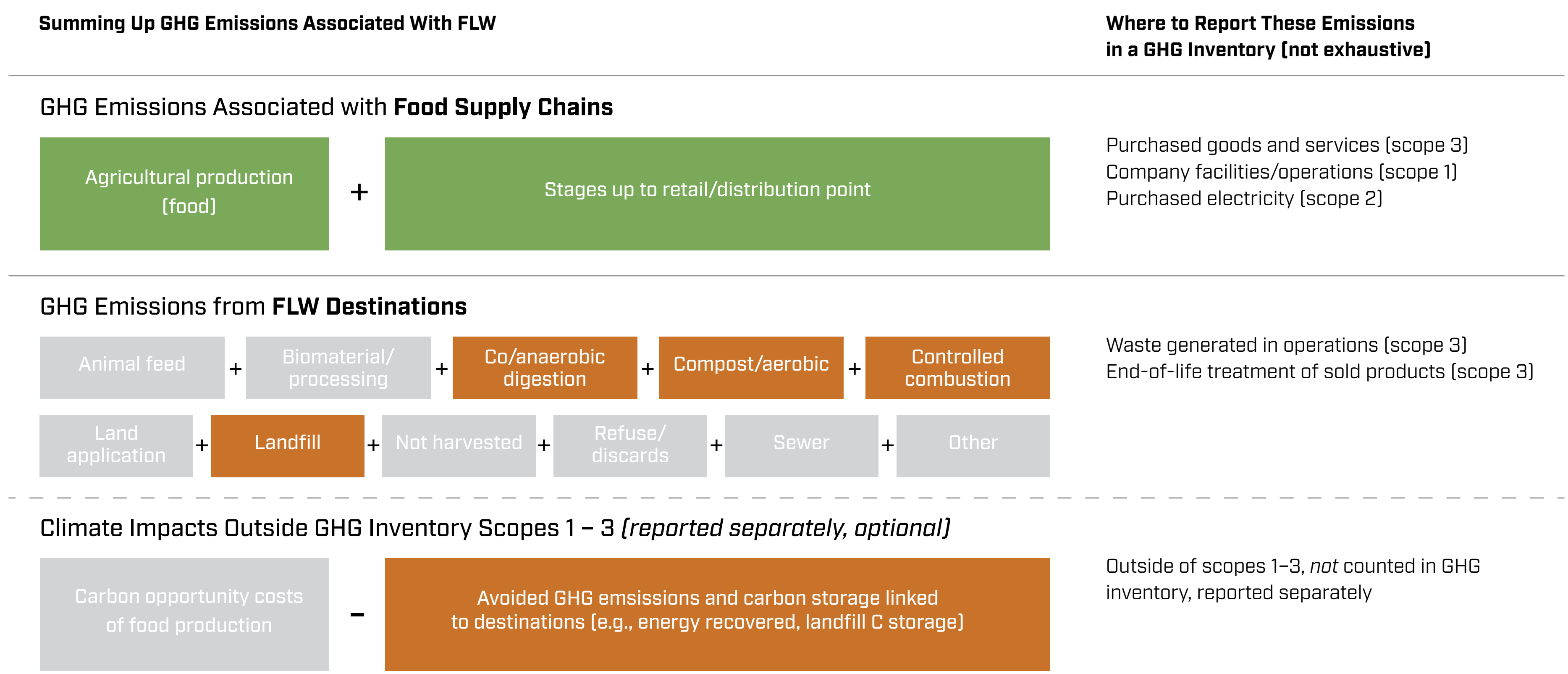
- For a multi-ingredient item, such as a corn-based sweetened cereal, a company could, however, identify the main raw materials (corn, sugar, etc.) and total up the emissions from each ingredient to determine an overall emission factor for that item.
- Some tools are even less granular on food types—for instance, giving one average emission factor for all meat products or all grains, which can obscure significant differences between food types (such as between beef and poultry).
- Emission factors in third-party tools typically come from publicly-available datasets with limited granularity, relying on national-, regional-, or sometimes even global-average data. If a company's data on FLW is more granular—for example, specific types of meat from specific parts of a country or from specific production systems—the company may be able to adapt a third-party tool by overriding the default emission factor data with product-specific emission factors and other assumptions.



## THIRD-PARTY TOOLS INCLUDE DIFFERENT COMBINATIONS OF THE GHG EMISSIONS ASSOCIATED WITH FLW

The tools reviewed in Tables 2 and 3 each analyze different types of GHG emissions associated with food supply chains and FLW destinations. Figure 4 uses the framework in Figure 2 to summarize for one of the tools (U.S. EPA's WARM) which types of GHG emissions a user can analyze.

**Figure 4. Types of GHG Emissions Included in the EPA WARM Tool (Version 15) (Using Framework for Accounting and Reporting on the Various Types of GHG Emissions Associated with FLW)**




*Note:* Colored boxes represent the types of GHG emissions and climate impacts included in this tool.
*Source:* WRI Authors.

## Table 2. Tools for Calculating the GHG Emissions and/or Impact Associated with FLW (not exhaustive)

| TOOL | TARGET AUDIENCE & FOCUS | | | | WHICH GHG EMISSIONS ARE INCLUDED | | | HOW TO USE THE TOOL | |
|---|---|---|---|---|---|---|---|---|---|
| | **Primary Audience** ***& Purpose*** | **Stages Covered** | **Geographic Focus** | **Granularity of Product Data** | **GHG emissions related to food supply chains** | **GHG emissions related to FLW destinations** | **Climate impacts beyond GHG inventory scope 1–3** | **Analyze changes in the GHG emissions from an action** | **Non-GHG impacts assessed** |
| Agro-Chain Greenhouse Gas Emissions (ACE) / **Wageningen & CCAFS** | Broad<br>*Estimates GHG emissions associated with food products across supply chains* | Agricultural production until product purchased by consumer | Global with regional factors | About 20 individual food types, fresh and simple processed product | Agricultural production through to retail | 6: anaerobic digestion, composting, incineration (no energy use), left on field, landfill, neglect (dumped) | Avoided emissions (in composting and anaerobic digestion destinations) | Compare two different interventions to reduce FLW; customize transportation, refrigeration, packaging, and other factors | — |
| Cool Farm Tool: Food Loss and Waste Module **(beta)** | Farmers<br>*Enables farmers to measure their GHG emissions and understand mitigation options* | Agricultural production, first level processing (storage, packaging, grading), and transport | Global | Any crop and livestock | Agricultural production (various steps, including direct land use change), packing, storage, transport | Quantities for all 10 FLW Standard destinations, but not the emissions | Carbon stock changes (due to changes in management practices) | Not available for FLW. Can customize overall GHG impact based on growing/ farm management practices; can compare multiple assessments | Financial value |
| Cool Food Calculator **(plus beta FLW version)** | Food service operators and retailers (could be modified for other sectors)<br>*Estimates food- and FLW-related GHG emissions in order to set baselines and track progress* | Agricultural production, processing, packaging, and transport (up to point of purchase by food service operator or retailer) | Global, with regional factors for North America and Europe (others to be added in 2021) | Includes 50+ food types | Agricultural production, processing, transport, packaging, upstream FLW assumed | 4: Anaerobic digestion, combustion, composting, landfill | Carbon opportunity costs | Compare up to 4 scenarios | Land occupation and calories |

*Note:* Climate impacts beyond GHG inventory scopes 1-3 currently need to be reported separately in a GHG inventory (see Box 3).

## Table 2. Tools for Calculating the GHG Emissions and/or Impact Associated with FLW (not exhaustive) *(continued)*

| TOOL | TARGET AUDIENCE & FOCUS | | | | WHICH GHG EMISSIONS ARE INCLUDED | | | HOW TO USE THE TOOL | |
|---|---|---|---|---|---|---|---|---|---|
| | **Primary Audience & *Purpose*** | **Stages Covered** | **Geographic Focus** | **Granularity of Product Data** | **GHG emissions related to food supply chains** | **GHG emissions related to FLW destinations** | **Climate impacts beyond GHG inventory scope 1–3** | **Analyze changes in the GHG emissions from an action** | **Non-GHG impacts assessed** |
| **EPA Waste Reduction Model (WARM)** | Broad<br>*Assesses alternative materials management scenarios to determine the lowest-impact waste management practice* | Not sector specific (but assumes waste occurs at consumer facing business level) | United States | Meat; non-meat & 6 product categories: beef, poultry, grains, bread, fruits and vegetables, and dairy products | Agricultural production to retail distribution point | 4: composting, landfilling, combustion, anaerobic digestion (includes avoided emissions) + source reduction | Avoided emissions/ carbon storage in certain destinations | Compare 2 scenarios of alternative management destinations | — |
| **FLW Value Calculator (beta)** | Broad<br>*Quantifies FLW in terms of nutritional values or environmental impacts* | All stages of the food supply chain | Global, with regional factors | Based on life-cycle impact of 19 food types | Agricultural production, handling and storage, processing, packaging, distribution, consumption | All 10 from FLW Standard except not harvested | Avoided emissions/ carbon storage in certain destinations | Compare changes in weight or destination of FLW for up to 6 scenarios | Water scarcity footprint, soil quality index, eutrophication, nutritional content |
| **The Food side flow Recovery LIFe cycle Tool (FORKLIFT)** | Broad<br>*Helps stakeholders compare valorization options in common EU food waste streams* | Processing | EU-centric with regional factors | 6 examples: Apple pomace; pigs' blood; brewers' spent grains; tomato pomace; whey permeate; oilseed press cake | Agricultural production, transport, processing | Varies by product analyzed (a pre-set selection of valorization and destination options are included) | Avoided emissions associated with destinations | Compare GHG emissions across different valorization options. Can customize values (e.g., energy sources, transport mode/ distance) | Financial costs |

*Note:* Climate impacts beyond GHG inventory scopes 1-3 currently need to be reported separately in a GHG inventory (see Box 3).

## Table 2. Tools for Calculating the GHG Emissions and/or Impact Associated with FLW (not exhaustive) *(continued)*

| TOOL | TARGET AUDIENCE & FOCUS | | | | WHICH GHG EMISSIONS ARE INCLUDED | | | HOW TO USE THE TOOL | |
|---|---|---|---|---|---|---|---|---|---|
| | **Primary Audience & *Purpose*** | **Stages Covered** | **Geographic Focus** | **Granularity of Product Data** | **GHG emissions related to food supply chains** | **GHG emissions related to FLW destinations** | **Climate impacts beyond GHG inventory scope 1–3** | **Analyze changes in the GHG emissions from an action** | **Non-GHG impacts assessed** |
| **Provision Coalition Food Loss + Waste Prevention Toolkit (based on Enviro-Steward's approach; use restricted)** | Processing companies<br>*At a facility level, quantifies the economic, social and environmental cost of FLW* | Processing | Canada | 9 food types, user can enter very detailed facility and process data | Raw material production, amount of energy embedded in the FLW at the point where it is disposed during production/processing | 6: animal feed, anaerobic digestion, composting, landfill, waste-to-energy, wastewater | Avoided emissions associated with destinations | Compare GHG emissions relative to a baseline scenario | Financial and resource costs of FLW, water and energy, meal equivalent |
| **ReFED US Impact Calculator** | Broad<br>*Estimates the environmental, economic, and social impacts of food waste* | Agricultural production to consumer (residential) | United States | For 5 sectors (farm, manufacturing, retail, food service, residential), GHG factors for a "standard mix" and a by-product category; also factors for 44 individual food types, along with processing factors | Agricultural production, manufacturing, retail, food service, residential | All 10 FLW Standard destinations | Avoided emissions/carbon storage in certain destination | Calculate footprint and compare changes in weight or destination of FLW for 2 scenarios | Water impacts, meals recovered |
| **Walmart waste diversion calculator (Project Gigaton)** | Walmart suppliers<br>*Estimates avoided, sequestered, or reduced emissions reported by Walmart suppliers for Project Gigaton* | Simplified version of the EPA WARM calculator (not sector specific) | Global | Meat and non-meat | Agricultural production to retail distribution point | EPA WARM destinations + donations and animal feed | Avoided emissions through improved date labeling | Intended for suppliers to measure "observed" impacts (not scenarios) | — |

*Note:* Climate impacts beyond GHG inventory scopes 1-3 currently need to be reported separately in a GHG inventory (see Box 3).
*Source*: WRI authors.

## Table 3. Data Sources Used by Third-Party Calculator Tools

| TOOL | DATA SOURCES FOR GHG EMISSIONS | | | TECHNICAL DOCUMENTATION |
|---|---|---|---|---|
| | **GHG emissions related to food supply chains** | **GHG emissions related to FLW destinations** | **Climate impacts outside GHG inventory scopes 1–3 (carbon opportunity costs, avoided emissions, carbon removals and/or carbon storage)** | **Where to find full references to source data** |
| **Agro-Chain Greenhouse Gas Emissions (ACE) / Wageningen & CCAFS** | Various LCA studies, Porter et al. (2016) | EPA WARM | Avoided emissions and carbon storage associated with destinations; see EPA (2019a), section 1.4 for details | Broeze (2019), Table 1 |
| **Cool Farm Tool: Food Loss and Waste Module (beta)** | A broad range of published data sets and IPCC methods | Not included | Studies on soil carbon sequestration from over 100 global datasets | Technical description available upon request |
| **Cool Food Calculator (plus beta FLW version)** | Poore and Nemecek (2018) | Added to beta FLW version: EPA GHG Emission Factors Hub (note: avoided emissions and carbon storage not included) | Carbon opportunity costs; Searchinger et al. (2018) | Waite et al. (2019); EPA (2021a) |
| **EPA Waste Reduction Model (WARM)** | U.S. average figures from various LCA studies | U.S. average figures from various LCA studies | Avoided emissions and carbon storage associated with destinations; see EPA (2019a), section 1.4 for details | EPA (2019a) |
| **FLW Value Calculator** | Quantis World Food Database Powered by Ecoinvent; additional life cycle impacts assumptions were adapted from the European Commission's Product Environmental Footprint (PEF) guidance | Destination impacts were calculated by Quantis using basic assumptions from expert knowledge (see Methodology Tab) | Avoided emissions (calculated by Quantis) included in several destinations; see Methodology Tab for details | FResH/WBCSD and Quantis (2019) |
| **The FOod side flow Recovery LIFe cycle Tool (FORKLIFT)** | Various LCA studies | Various LCA studies | Avoided emissions associated with destinations, see Metcalfe et al. (2019) for details | Davis et al. (2017); Metcalfe et al. (2019) |
| **Provision Coalition's Food Loss + Waste Prevention Toolkit (based on Enviro-Steward's approach; use restricted)** | Raw materials: Tool by Cleanmetrics<br><br>Electricity: NIR Report GHG Sources and Sinks in Canada<br><br>Natural gas: CME SmartGreen | Derived from multiple sources including Bernstad et al. (2016), Salemdeeb et al. (2017), and Eriksson et al. (2015). | Avoided emissions associated with destinations, contact Provision Coalition for details | Contact Provision Coalition |
| **ReFED US Impact Calculator** | U.S. average figures from various LCA studies | EPA WARM with adjustments by Quantis | Avoided emissions and carbon storage associated with destinations; see ReFED (2020), Tables A1-A6 for details | ReFED (2020) |
| **Walmart waste diversion calculator (Project Gigaton)** | EPA WARM | EPA WARM plus donation and animal feed | Avoided emissions through improved date labeling | Walmart (2020), Waste Appendix |

*Source:* WRI authors.

# Part II

## How to Determine the Contribution of FLW to a GHG Inventory

**This part provides recommendations for how a company can determine the contribution of FLW in the various parts of a GHG inventory.**

## 1. Overview

This part includes guidance related to:

- Where FLW appears in a GHG inventory
- Steps for determining the contribution of FLW in a GHG inventory
- For food supply chain emissions in a GHG inventory—guidance on determining the contribution from FLW
- For FLW destination emissions in a GHG inventory—guidance on determining the contribution from FLW
- Summing the FLW-associated emissions within a GHG inventory

The GHG Protocol's *Corporate Value Chain (Scope 3) Standard* groups emissions into 15 distinct categories (see Figure 5) as an organizing framework to understand and report on the diversity of activities within a corporate value chain. For a company that purchases food, the largest FLW-related GHG emissions will most likely be related to producing the food and reported in the "purchased goods and services" category of its scope 3 inventory. For agricultural producers, these would be included in its scope 1 inventory.

The significance of FLW in terms of its GHG emissions varies by company depending on factors such as its product mix, production practices, and decisions about how the FLW is managed. As a company identifies where emissions from FLW are included in the various parts of a GHG inventory, one way to focus its analysis is by considering first those products (or ingredients) which are associated with significant GHG emissions. For the GHG inventory categories that are less significant sources of emissions, it may be less relevant, impractical, or difficult to estimate the contribution of FLW. As decisions are made about including or excluding in the analysis certain types of emissions, a company should take into account the following principles of FLW and GHG inventory accounting and reporting:

- Relevance: Include information necessary for stakeholders to make decisions.
- Completeness: Cover all FLW and GHG emissions within the scope selected. Disclose and justify any exclusions.
- Consistency: Use consistent methods to allow for meaningful comparisons over time and transparently document any changes to the data, inventory boundary, methods, or any other relevant factors in a time series.
- Transparency: Disclose quantification methods used, relevant assumptions made, and data sources.
- Accuracy: Be sufficiently accurate to enable intended users to make decisions with reasonable confidence that the information in the inventory is credible.

The recommendations in Part II will be most relevant for companies that have already developed a GHG inventory and are seeking to identify and isolate emissions from FLW that are embedded within their inventory.

## 2. Where FLW Appears in a GHG Inventory

The GHG emissions related to FLW are typically found in various parts of a GHG inventory (see Figure 5). This is because FLW includes embodied emissions from how the food was produced, as well how it was managed when removed from the food supply chain (i.e., its destination).

The most relevant categories in a GHG inventory with respect to the food's production and the FLW destination are indicated in Figure 5 as a likely significant FLW link.

### 1. Food supply chains

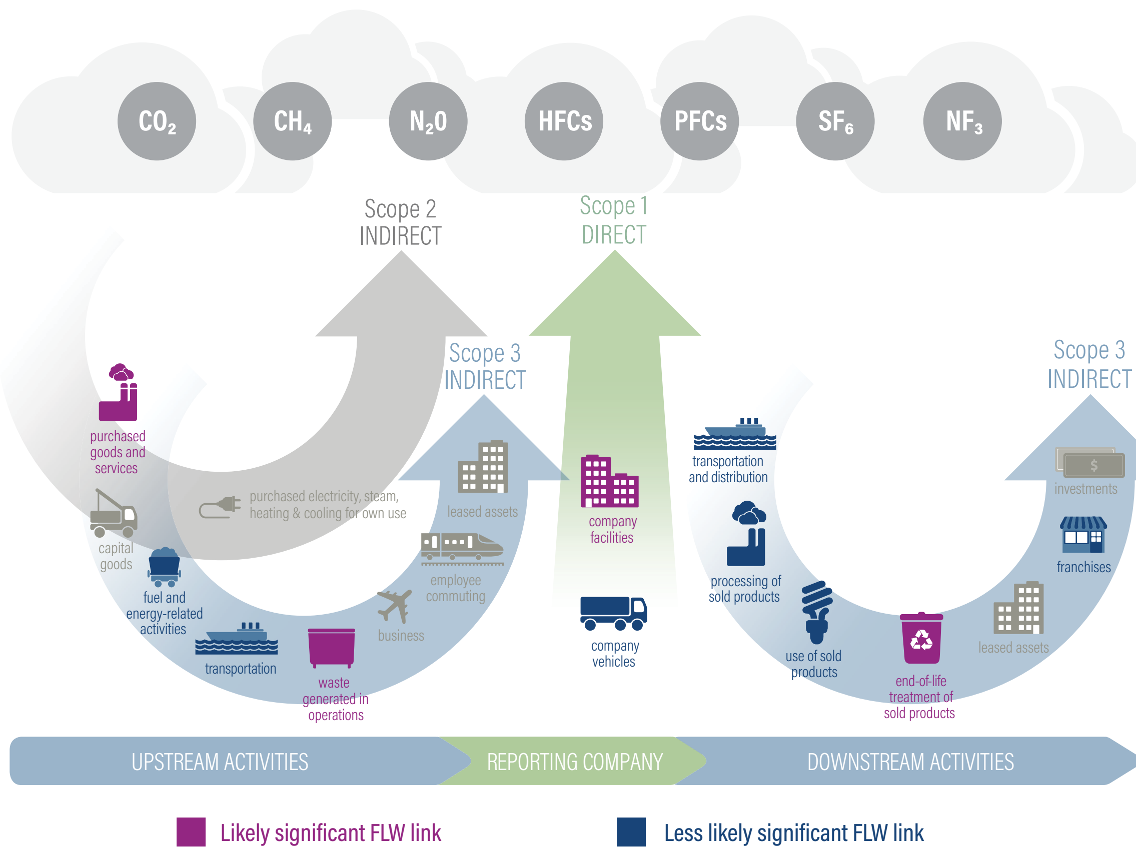
For a company that *purchases* food, the GHG emissions associated with producing the food that becomes FLW is included in the "purchased goods and services" category (part of its scope 3 inventory), as well as in categories relevant to direct and indirect GHG emissions generated by its operations to process, transport, or handle the food (part of its scope 1 or 2 inventories).

For a company that *owns or controls agricultural production* of food products, the GHG emissions associated with growing the food that becomes FLW is included in its operations as a scope 1 or 2 inventory. Emissions associated with inputs purchased to grow the food, such as fertilizer, would be included in the "purchased goods and services" category (part of its scope 3 inventory).

### 2. FLW destinations

The GHG emissions associated with where the food goes if not sold or consumed is included in the scope 3 categories of "waste generated in operations" or "end-of-life treatment of sold products."

**Figure 5 | Where Links to FLW Are Likely in a GHG Inventory**



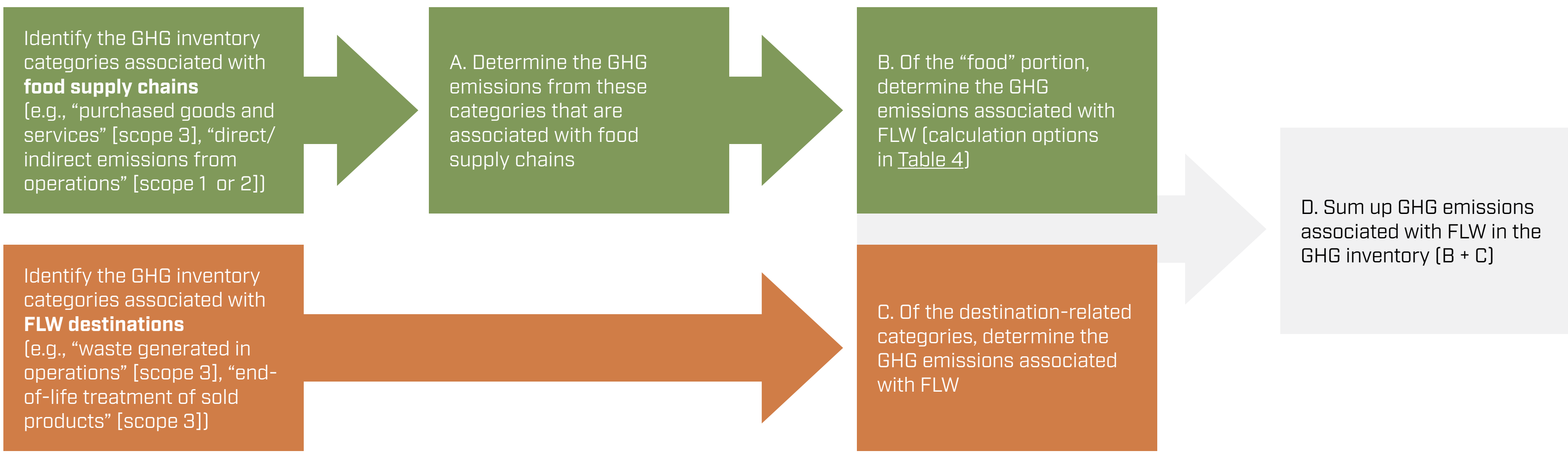

*Source:* Adapted from WRI and WBCSD (2011a), *Corporate Value Chain (Scope 3) Accounting and Reporting Standard*.

## 3. Steps for Determining the Contribution of FLW in a GHG Inventory

There are several steps to identify FLW-associated emissions in a corporate GHG inventory. FLW-associated emissions include both the GHG emissions associated with producing the food that becomes FLW, as well as emissions from managing FLW. The first step is to identify the GHG inventory categories in which emissions related to FLW would be generated. Which categories are relevant will differ depending on a company's role in the food supply chain. For each relevant GHG category, a company should then determine the portion of GHG emissions that are food-associated and, of that, the portion of emissions that are FLW-associated (Figure 6).

If analyzing a product-level GHG inventory, a company can use the resources provided in Part I to calculate the GHG emissions associated with the FLW of that product. For multi-ingredient products, additional guidance is available in the *Tracking Progress toward the Cool Food Pledge* technical note appendix.

**Figure 6 | Steps for Determining the GHG Emissions Associated with FLW in a GHG Inventory**




*Source:* WRI Authors.

# 4. For Food Supply Chain Emissions in a GHG Inventory—Guidance on Determining the Contribution from FLW

## STEPS AND FOUR POSSIBLE CALCULATION APPROACHES

As summarized in Figure 6, the steps to determine the FLW portion of GHG emissions associated with producing food are below.

**A. Determine the GHG emissions from the relevant category that are associated with food supply chains.**

**B. Of that amount, calculate the GHG emissions associated with FLW.**

- For this step of the calculation, there are four possible approaches based on what type of data a company has available on FLW (Table 4). If a company only knows the percentage of FLW, it should use options B1 or B3; if it knows the weight of FLW, it can use options B2 or B4.
- Keep in mind that these options differ in terms of their accuracy and data requirements. Most accurate are the calculations using the weight of food-specific FLW and corresponding emission factors.
- Pages 35–38 provide additional detail about these four options, alongside hypothetical examples.

**Table 4 | For Food Supply Chain GHG Categories, Options for Calculating the Contribution of FLW in the Food Portion of GHG Emissions (not exhaustive)**


| SELECT OPTION BASED ON DATA ABOUT FLW | | EQUATION (PART 1) | EQUATION (PART 2) |
|---|---|---|---|
| **B1. Mixed-FLW** | FLW percentage approach | Use percentage estimate of FLW (the FLW rate) across a mix of foods purchased… | …multiplied by food portion of GHG emissions from food supply chain GHG categories |
| **B2. Mixed-FLW** | Weight-based approach | Use weight of a mixed stream of FLW… | …multiplied by a GHG emission factor that is a weighted average estimate for the mix of foods sourced |
| **B3. Food-specific** | FLW percentage approach | Use percentage estimates of FLW by food type (for instance, percentage of beef lost or wasted)… | …multiplied by the GHG emission factor for each food type (then total up food-specific FLW GHG estimates) |
| **B4. Food-specific** | Weight-based approach | Use weight of FLW by food type… | …multiplied by the GHG emission factor for each food type (then total up food-specific FLW GHG estimates) |

## Option B1: Where a company has a mixed stream of FLW and knows the rate of FLW *(Mixed FLW, percentage approach)*

### EQUATION

Step A. Food-associated GHG emissions = GHG emissions from purchased goods and services × Portion of category emissions that are from food supply chains

Step B. Total FLW-associated GHG emissions = Rate of FLW × Step A (i.e., food-associated GHG emissions)

### HYPOTHETICAL EXAMPLE

**Variables:**

1. GHG emissions from purchased goods and services in 2019 were 1,500,000 tonnes $CO_2e$.
2. Eighty percent of the GHG emissions in purchased goods and services were from purchased food.
3. Average rate of FLW of purchased food (in company operations) in 2019 was 10 percent.

**Results:**

Step A. Food-associated GHG emissions = 1,500,000 tonnes $CO_2e$ × 80% = 1,200,000 tonnes $CO_2e$

Step B. FLW-associated GHG emissions (from purchased goods and services): 10% x 1,200,000 = **120,000 tonnes $CO_2e$**

**Takeaway:**

FLW portion of GHG emissions in total purchased goods and services category was 8 percent (120,000/1,500,000 tonnes $CO_2e$).

GHG emissions from FLW account for 10 percent of GHG emissions associated with total food purchases (120,000/1,200,000 tonnes $CO_2e$).

## Option B2: Where a company has a mixed stream of FLW and knows its weight *(Mixed FLW, weight-based approach)*

### EQUATION

Step A. Food-associated GHG emissions = GHG emissions from purchased goods and services × Portion of category emissions that are from food supply chains (Note: This step is only necessary if you want to compare FLW-associated GHG emissions to all food purchases.)

Step B. Total FLW-associated GHG emissions = Total weight of FLW × Average emission factor of food sourced in mixed FLW[17]

### HYPOTHETICAL EXAMPLE

**Variables:**

1. GHG emissions from purchased goods and services in 2019 were 1,500,000 tonnes $CO_2e$.
2. Eighty percent of the GHG emissions in purchased goods and services were from purchased food.
3. Total weight of FLW (mixed stream) was 38,000 tonnes.
4. Weighted average emission factor of food sourced was 3.07 kg $CO_2e$/kg food sourced.[18]

**Results:**

Step A. Food-associated GHG emissions = 1,500,000 tonnes $CO_2e$ × 80% = 1,200,000 tonnes $CO_2e$

Step B. FLW-associated GHG emissions (from purchased goods and services): 38,000 × 3.07 = **116,660 tonnes $CO_2e$**

**Takeaway:**

FLW portion of GHG emissions in total purchased goods and services category was 7.7 percent (116,660/1,500,000 tonnes $CO_2e$).

GHG emissions from FLW account for 9.7 percent of GHG associated with total food purchases (116,660/1,200,000 tonnes $CO_2e$).

17 A company could develop a mixed-FLW emission factor based on the weight of their purchases, or another context-appropriate weighted average.
18 The weighted average emission factor of 3.07 represents the average dietary pattern of North America in 2015 from FAOSTAT (2020) and agricultural supply chain emission factors from Poore and Nemecek (2018) for North America, as used in the Cool Food calculator (Waite et al. 2019). This includes GHG emissions up to point of purchase by retailer/food service provider, including from farm, feed, processing, transport, packaging, and upstream losses.

## Option B3: Where a company knows the type of FLW and the rate of FLW *(Food-specific, percentage approach)*

### EQUATION

Step A. Identify food products that are FLW and the GHG emissions associated with each product's food supply chain. If these food-associated GHG emissions need to be calculated, multiply food purchases (weight) by the food-specific emission factor. Emission factors from third-party calculators could be used as a source of secondary data.

Step B. Total FLW-associated GHG emissions (for each food) = Rate (percentage) of FLW × Step A (i.e., food-associated GHG emissions). Then sum results across the foods.

### HYPOTHETICAL EXAMPLE

**Variables:**

1. GHG emissions from purchased goods and services in 2019 were 1,500,000 tonnes $CO_2e$.
2. 1,200,000 tonnes $CO_2e$ of the GHG emissions in purchased goods and services were from purchased food, comprised of four items (beef, milk, corn, and vegetables).
3. The calculation for FLW-associated GHG emissions is as shown in Column C at right.

**Results:**

Step A. Food-associated GHG emissions = sum of foods (Column A) = 1,200,000 tonnes $CO_2e$

Step B. Total FLW-associated GHG emissions (from purchased goods and services) = **116,000 tonnes $CO_2e$**

**Takeaway:**

FLW portion of GHG emissions in total purchased goods and services category was 7.7 percent (116,000/1,500,000 tonnes $CO_2e$).

GHG emissions from FLW account for 9.7 percent of GHG associated with total food purchases (116,660/1,200,000 tonnes $CO_2e$).

| FOOD | [A] FOOD SUPPLY CHAIN-RELATED GHG EMISSIONS [T $CO_2E$] | [B] PERCENT OF FOOD PURCHASE THAT IS FLW [RATE OF FLW] | [C] = [A X B] FOOD SUPPLY CHAIN-RELATED GHG EMISSIONS FROM FLW [T $CO_2E$] |
|---|---|---|---|
| **Beef** | 600,000 | 5% | 30,000 |
| **Milk** | 300,000 | 12% | 36,000 |
| **Corn** | 200,000 | 10% | 20,000 |
| **Vegetables** | 100,000 | 30% | 30,000 |
| **Total** | **1,200,000** | | **116,000** |

### Option B4: Where a company knows the type of FLW and its weight *(Food-specific, weight-based approach)*

#### EQUATION

Step A. Identify food products that are FLW and the weight of the FLW. Calculate the GHG emissions associated with each product's food supply chain. Emission factors used in third-party calculators can be used as secondary data sources. (Note: This step is only necessary if you want to compare FLW-associated GHG emissions to all food purchases.)

Step B. FLW-associated GHG emissions (for each food) = Weight of FLW × Emission factor for that food. Then sum results across the foods.

#### HYPOTHETICAL EXAMPLE

**Variables:**

1. GHG emissions from purchased goods and services in 2019 were 1,500,000 tonnes $CO_2e$.
2. 1,200,000 tonnes $CO_2e$ of the GHG emissions in purchased goods and services were from purchased food, comprised of four items (beef, milk, corn, and vegetables).
3. Based on these foods' emission factors (Column A) and weight of FLW (Column B), the calculation for FLW-associated GHG emissions is in Column C.

**Results:**

Step A. Food-associated GHG emissions = 1,200,000 tonnes $CO_2e$

Step B. Total FLW-associated GHG emissions (from purchased goods and services) = **116,000 tonnes $CO_2e$**

**Takeaway:**

FLW portion of GHG emissions in total purchased goods and services category was 7.7 percent (116,000/1,500,000 tonnes $CO_2e$).

GHG emissions from FLW account for 9.7 percent of GHG associated with total food purchases (116,660/1,200,000 tonnes $CO_2e$).

| FOOD | [A] FOOD SUPPLY CHAIN-RELATED GHG EMISSION FACTOR (KG $CO_2E$/KG) | [B] FOOD PURCHASE THAT IS FLW (TONNES) | [C] = (A X B) FOOD SUPPLY CHAIN-RELATED GHG EMISSIONS FROM FLW (T $CO_2E$) |
|---|---|---|---|
| **Beef** | 41.35 | 726 | 30,000 |
| **Milk** | 2.23 | 16,143 | 36,000 |
| **Corn** | 0.97 | 20,619 | 20,000 |
| **Vegetables** | 0.55 | 54,545 | 30,000 |
| **Total** | | **92,033** | **116,000** |

*Note:* Emission factors are from Poore and Nemecek (2018) for North America as used in the Cool Food calculator (Waite et al. 2019). This includes point of purchase by retailer/food service provider, including from farm, feed, processing, transport, packaging, and upstream losses.

# 5. For FLW Destination Emissions in a GHG Inventory—Guidance on Determining the Contribution from FLW

## TWO POSSIBLE CALCULATION APPROACHES

How FLW is managed after being removed from the food supply chain also affects the associated amount of GHG emissions. Companies will therefore have FLW-related GHG emissions in the "waste generated in operations" category of their GHG inventory, and also possibly in the "end-of-life treatment of sold products" category.

There are two options (Table 5) for calculating the FLW portion of GHG emissions associated with the waste and end-of-life categories:[19]

C1. "Top-down" approach: Determine the percentage of the emissions from waste/end-of-life that are associated specifically with FLW.

C2. "Bottom-up" approach: Conduct a more detailed analysis, based on food type and FLW destinations, to determine the FLW portion of the waste and end-of-life categories.

Pages 40–41 provide additional detail about these two options, alongside hypothetical examples.

*Note: Each option may generate different figures because of differences in methods and data.*

### Table 5 | For FLW Destination GHG Categories, Options for Calculating the Contribution of FLW


| OPTION | EQUATION |
|---|---|
| **C1. "Top-down" approach** | Multiply GHG emissions from waste and end-of-life categories × Proportion of FLW in waste stream |
| **C2. "Bottom-up" approach** | Calculate destination-related GHG emissions from FLW (see Part I). Use this amount as the FLW-associated GHG emissions in the waste and end-of-life categories. |

19 For the purposes of this publication, this shorthand refers to "waste generated in operations" (category 5), and potentially "end-of-life treatment of sold products" (category 12).

## Option C1: Where a company knows what percentage of its waste stream is FLW, by weight *(Top-down approach)*

### EQUATION

FLW-associated GHG emissions = GHG emissions from waste and/or end-of-life categories × Proportion of FLW in waste and/or end-of-life stream.

### HYPOTHETICAL EXAMPLE

**Variables:**

1. A company's GHG emissions from waste generated in operations in 2019 were 100,000 tonnes $CO_2e$.
2. Fifty percent of the waste stream is composed of FLW.

**Results:**

FLW-associated GHG emissions = 50,000 tonnes $CO_2e$

**Takeaway:**

FLW contribution to the waste generated category in the GHG inventory is 50,000 tonnes $CO_2e$.

## Option C2: Where a company knows what products make up its FLW *(Bottom-up approach)*

### EQUATION

Calculate destination-related GHG emissions from FLW by food type. Sum up these amounts to obtain the FLW-associated GHG emissions in the "waste generated" and/or "end-of-life" categories.

*Note: Avoided emissions (such as energy recovery from landfill methane) and carbon storage cannot currently be reported in scopes 1–3 of a GHG inventory and as such must be reported separately. See* *Box 3* *and* *page 42* *for more on avoided emissions and carbon storage.*

### HYPOTHETICAL EXAMPLE

**Variables:**

A company sent FLW to the landfill and to compost and used destination-specific emission factors to estimate FLW-associated GHG emissions. Use the amount of $CO_2e$ derived from equations (see table below for an example).

**Results:**

FLW-associated GHG emissions = 51,000 tonnes $CO_2e$ (Column H)

**Takeaway:**

FLW contribution to "waste generated" category in the GHG inventory is 51,000 tonnes $CO_2e$.

| (A) FOOD | (B) AMOUNT TO LANDFILL (SHORT TONS) | (C) LANDFILL EMISSION FACTOR (T $CO_2E$/SHORT TON) | (D) LANDFILL-RELATED EMISSIONS FROM FLW (T $CO_2E$) (D = B X C) | (E) AMOUNT TO COMPOST (SHORT TONS) | (F) COMPOST EMISSION FACTOR (T $CO_2E$/SHORT TON) | (G) COMPOST-RELATED EMISSIONS FROM FLW (T $CO_2E$) (G = E X F) | (H) WASTE-RELATED EMISSIONS FROM FLW (T $CO_2E$) (H = D + G) |
|---|---|---|---|---|---|---|---|
| **Beef** | 17,241 | 0.58 | 10,000 | 6,667 | 0.15 | 1,000 | 11,000 |
| **Milk** | 25,862 | 0.58 | 15,000 | 20,000 | 0.15 | 3,000 | 18,000 |
| **Corn** | 34,483 | 0.58 | 20,000 | 13,333 | 0.15 | 2,000 | 22,000 |
| **Total** | **77,586** | | **45,000** | **40,000** | | **6,000** | **51,000** |

*Note:* Emission factors from EPA. 2021a. Center for Corporate Climate Leadership GHG Emission Factors Hub. Factors include emissions only; they do not include avoided emissions from energy recovery (for landfill) or carbon storage (for composting or landfill).

## 6. Summing the FLW-Associated Emissions within a GHG Inventory

After calculating FLW emissions related to food supply chains and FLW destinations, sum the emissions to determine the full contribution of FLW to a company's GHG inventory.

As noted in Part I (Box 3), additional climate impacts outside GHG inventory scopes 1–3 may also be calculated based on the carbon opportunity costs related to land that was used to produce the FLW, as well as any carbon removal, carbon storage, and/or avoided emissions related to food supply chains or the FLW destinations.[20] However, these additional impacts must be reported separately from—not simply added to—the GHG inventory.

Table 6 is a hypothetical example of how the GHG emissions from a corporate inventory could be reported alongside these additional impacts.

### Table 6 | Hypothetical Example: GHG Emissions from FLW (Corporate GHG Inventory plus Climate Impacts Outside Scopes 1-3)

| TYPE OF GHG EMISSION | GHG INVENTORY CATEGORY | FLW-ASSOCIATED EMISSIONS WITHIN GHG INVENTORY (T $CO_2E$) | *OPTIONAL:* REPORT SEPARATELY FROM GHG INVENTORY (OUTSIDE SCOPES 1–3) | *OPTIONAL:* ADDITIONAL FLW-ASSOCIATED CLIMATE IMPACTS (T $CO_2E$) |
|---|---|---|---|---|
| **Food Supply Chains** | Purchased goods and services (scope 3) | 116,000 | Carbon opportunity costs | 450,000 |
| **FLW Destination** | Waste generated in operations (scope 3) | 51,000 | Avoided emissions and carbon storage | -5,000 |
| **FLW Destination** | End-of-life treatment (scope 3) | 13,000 | Avoided emissions and carbon storage | -1,000 |
| | **Total contribution of FLW to GHG inventory** | **180,000** | | |

20 Box 3 notes that the forthcoming *GHG Protocol Land Sector and Removals Guidance* is likely to allow reporting of carbon removals and storage inside scopes 1–3 under certain conditions.

# Part III

## How to Communicate about the GHG Benefits of FLW Reductions

This part provides companies with recommendations on how to make general statements that link FLW reduction efforts with associated reductions in GHG emissions, as well as how to communicate about the contribution of FLW to a corporate GHG inventory and related GHG reduction targets.

## 1. Overview

Communicating about the GHG emissions associated with FLW provides companies with another way to highlight the value of reducing FLW, in addition to the benefits related to improved food security, financial outcomes, and natural resource conservation. How to most effectively communicate about the GHG benefits of reducing FLW can vary based on several factors, including a company's level of commitment to addressing climate change, the nature of its GHG or FLW reduction targets, and what audiences it is trying to reach.

For some companies, the value of connecting FLW to GHG emissions is to communicate generally with stakeholders. For others, the benefit in calculating the amount of GHG emissions associated with FLW is to make the internal business case that reducing FLW is a lever in its fight against climate change and can support progress against meeting GHG reduction targets. This part therefore provides companies with recommendations on two types of possible communication:

- Making a general statement about the link between FLW reduction efforts and the associated reductions in GHG emissions (page 46)
- Communicating about the contribution of FLW to a corporate GHG inventory and related GHG reduction targets. This could include communicating about FLW-associated emissions within the context of a corporate GHG inventory, as well as identifying how actions that reduce FLW might serve as a pathway to achieving GHG reduction targets (page 47).

In either situation, a company may seek to use readily understood "equivalents" to explain the FLW-related GHG emissions in a way that is meaningful to its target audience (for instance, the number of cars taken off the road for a year). It is important that a company prepares clear and transparent documentation of its equivalency calculations. Conversions of this type are supported by various tools, such as the EPA's Greenhouse Gas Equivalencies Calculator.

## CONSIDERATIONS WHEN COMMUNICATING ABOUT THE CAUSAL EFFECTS OF FLW REDUCTION ON GHG EMISSIONS

Activities that reduce FLW may not always correspond directly to actual decreases in GHG emissions to the atmosphere. While in many cases a direct link can be made between reductions in FLW and the GHG impacts related to the management of FLW—for instance, where less food is sent to a landfill—there is usually uncertainty about the extent to which a reduction in FLW results in avoiding upstream production of the food that was lost or wasted. There is therefore a degree of uncertainty inherent in the related reductions of GHG emissions from agriculture and other upstream production activities. This uncertainty stems from the complexity of food supply chains, with supply and demand affected by multiple factors.

That said, the *Corporate Value Chain (Scope 3) Accounting and Reporting Standard* recognizes that companies' decisions do impact aggregate demand for goods and services (and associated GHG emissions) over time, and thus allows companies to claim that changes in their purchases led to changes in their scope 3 (indirect) GHG emissions. Companies should, however, include appropriate caveats and explanations to describe the sources of uncertainty (see examples on page 20).

For example, a hospitality company's effort to reduce buffet overproduction, and thereby reduce FLW, could reduce its scope 3 emissions related to food purchases. Whether the company's reduction in food purchases truly leads to a reduction in agricultural production and related emissions depends on other factors. This may include whether or not other buyers then purchase the no-longer-needed food, or if it instead gets thrown away. Most crucially, it also depends on the extent to which the reduction in the hospitality company's food demand ultimately contributes to reduced aggregate food demand over the longer term. Nevertheless, the *Scope 3 Standard* allows the company to claim this reduction in indirect GHG emissions associated with a reduction in FLW. Therefore, this action can help a company make progress toward meeting its GHG reduction targets.

## 2. General Statements about FLW Reduction Efforts and the Associated Reductions in GHG Emissions

A company can simply share the amount of GHG emissions estimated to be associated with FLW, and will likely do so in the context of describing an action taken to reduce FLW. This might take the form of a general statement, as seen in the examples in Box 6.

### Box 6. Sample General Statements

**1. Example from "Nestlé's Milk Losses from Farm Gate to Factory in 30 Countries: An FLW Standard Case Study"**

Nestlé worked to reduce milk losses from farm gate to factory in 30 countries. The company found that in 2017 the emissions associated with milk losses were 65,000 tonnes of $CO_2e$. In 2018, based on the reduction in losses, GHG emissions were reduced to 38,000 tonnes of $CO_2e$. The reduction in FLW-associated emissions of 27,000 tonnes of $CO_2e$ is equivalent to 2,470 trips around the world in a small car.[a]

**2. Hypothetical example about surplus food donated**

Company X has established a partnership with local food banks and successfully diverted 100,000 kg of surplus chicken in the past year. This amount of chicken previously went to a landfill. As a result of this action to reduce FLW, the company has reduced the GHG emissions in its scope 3 inventory from the "waste generated" category by 62,010 kg of $CO_2e$. If one assumed that for every kilogram of donated chicken, one less kilogram of chicken would need to be produced, 230,385 kg $CO_2e$ of emissions would be avoided from agricultural production, as well as an additional 196,380 kg $CO_2e$ from other supply chain stages (processing, transport, packaging, and upstream losses).[b]

a GHG emissions associated with transportation by a small car, operated with petrol, class Euro 5, are 0.278 kg $CO_2e$ per km. A trip around the globe equals 40,000 km. *Sources*: ecoinvent v.3.3 database; impact assessment method: IPCC 2013, 100 years. Swiss Centre for Life Cycle Inventories (SCLCI) (2016). ecoinvent Database v. 3.3 Dübendorf, Switzerland. (www.ecoinvent.org).

b Following guidance by the EPA in *Modeling Food Donation Benefits in EPA's Waste Reduction Model*, it was assumed that 3 percent of the donation would nonetheless go to landfill uneaten regardless. The GHG emissions were estimated based on 97,000 pounds using emission factors in the Cool Food Calculator (Waite et al. 2019) and EPA GHG Emission Factors Hub" (EPA 2021a). See *Modeling Food Donation Benefits in EPA's Waste Reduction Model* (EPA 2019b) for a summary of uncertainties inherent in accounting for source reduction. While food donations are an important FLW reduction strategy, they do not reduce a company's food purchases and as such do not reduce a company's scope 3 (indirect) GHG emissions from purchased goods and services. Therefore, claims around avoided food production and associated emissions related to a company's food donations must be reported separately from scopes 1–3 as avoided emissions (Box 5).

# 3. Communicating about the Contribution of FLW to a Corporate GHG Inventory and Related GHG Reduction Targets

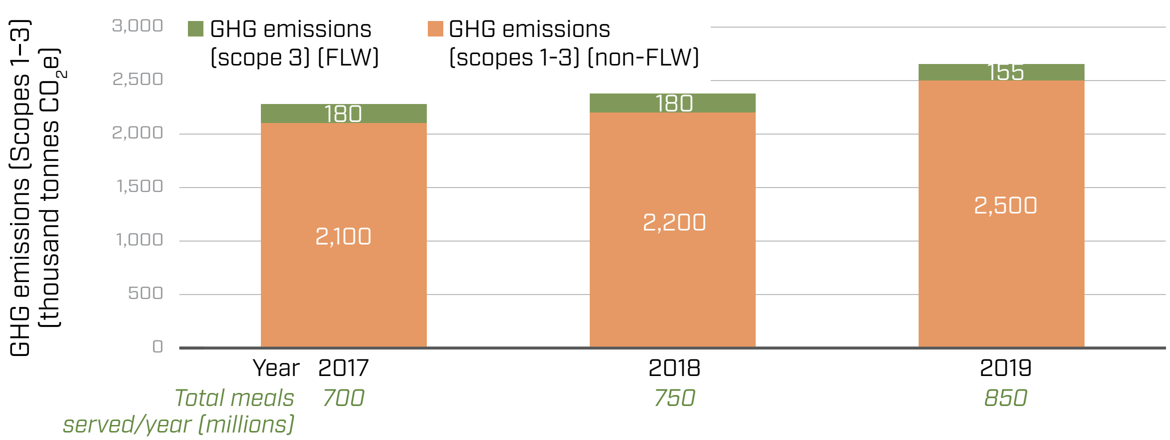
## COMMUNICATING ABOUT FLW-ASSOCIATED EMISSIONS WITHIN THE CONTEXT OF A CORPORATE GHG INVENTORY

Companies can use Part II to calculate the GHG emissions associated with FLW within their corporate GHG inventory.

Figure 7 provides a hypothetical example of changes in a food service company's FLW-related emissions within its total corporate GHG inventory, and possible ways to communicate about these changes (see Table 7 for additional details). In that example, the company's total GHG emissions have grown from 2017 to 2019, even as it successfully reduced FLW and associated emissions (from purchased goods and services, waste generated in operations, as well as the end-of-life treatment of sold products). The implication is that the business grew quickly and outpaced efficiency gains from FLW reductions. Thus, as demonstrated in Figure 7, while total GHG emissions grew, the contribution from FLW decreased between 2018 and 2019.

As these figures are on an absolute basis, a company could also calculate the GHG emissions associated with FLW on an intensity basis. Although absolute emission reductions are what ultimately matter for the climate, using a normalization factor to show changes in GHG intensity can be helpful when communicating changes over time, especially as a business expands and contracts. Using Figure 7 as an example, if its GHG emissions grew between 2017 and 2019 because it served more total meals, total emissions (and FLW-associated emissions) could also be reported per meal or another denominator.

**Figure 7 | Hypothetical Example Showing FLW-Related Emissions within a Corporate GHG Inventory**




**Sample narrative to summarize FLW-associated GHG emissions:**

Food service company X reduced the GHG emissions associated with FLW in 2019 through actions that reduced the amount of FLW. This reduced FLW-associated emissions by **25,000 tonnes $CO_2e$ (or 14%)** versus 2017 even though the company's total emissions rose during that period.

In addition, FLW-associated emissions per meal served fell from **0.26 kg $CO_2e$ to 0.18 kg $CO_2e$** between 2017 and 2019, a decline of **30%**.

*Source:* WRI Authors.

## COMMUNICATING ABOUT FLW-ASSOCIATED EMISSIONS WITHIN THE CONTEXT OF A CORPORATE GHG INVENTORY (CONTINUED)

Building on the hypothetical example in Table 6, and Figure 7, a company could use the format in Table 7 for tracking FLW-associated emissions and other climate impacts over time.

### Table 7 | Hypothetical Example: Comparing over Time the GHG Emissions from FLW (Corporate GHG Inventory plus Climate Impacts Outside Scopes 1–3)

| | | BASE YEAR (2017) | COMPARISON YEAR (2019) | | BASE YEAR (2017) | COMPARISON YEAR (2019) |
|---|---|---|---|---|---|---|
| **TYPE OF GHG EMISSION** | **GHG INVENTORY CATEGORY** | **FLW-ASSOCIATED EMISSIONS WITHIN GHG INVENTORY (T $CO_2$E)** | | ***OPTIONAL:* REPORT SEPARATELY FROM GHG INVENTORY (OUTSIDE SCOPES 1–3)** | ***OPTIONAL:* ADDITIONAL FLW-ASSOCIATED CLIMATE IMPACTS (T $CO_2$E)** | |
| **Food Supply Chains** | Purchased goods and services (scope 3) | 116,000 | 100,000 | Carbon opportunity costs | 450,000 | 385,000 |
| **FLW Destination** | Waste generated in operations (scope 3) | 51,000 | 42,000 | Avoided emissions and carbon storage | -5,000 | -4,000 |
| **FLW Destination** | End-of-life treatment (scope 3) | 13,000 | 13,000 | Avoided emissions and carbon storage | -1,000 | -1,000 |
| | **Total contribution of FLW to GHG inventory** | **180,000** | **155,000** | | | |

*Note:* Box 3 notes that the forthcoming GHG Protocol Land Sector and Removals Guidance is likely to allow reporting of carbon removals and storage inside scopes 1–3 under certain conditions.

## IDENTIFYING THE LINK BETWEEN FLW REDUCTIONS TO ACHIEVING GHG REDUCTION TARGETS

A company may seek to communicate about the contribution of FLW to its corporate GHG inventory and the role of FLW reduction in helping to meet GHG reduction targets. Reductions in FLW that reduce GHG emissions in scopes 1–3 specifically can be used to claim progress in meeting targets based on GHG inventories (for instance, for companies participating in the Science Based Targets Initiative, Box 7). Any additional climate impacts that currently fall outside of scopes 1–3—including carbon opportunity costs, carbon removals, carbon storage, and/or avoided emissions—can also be communicated, and may be important for decision-making, but cannot be counted toward meeting GHG inventory reductions (Box 3).[21]

FLW reduction can contribute alongside other GHG mitigation strategies as a company takes action to achieve its GHG reduction targets, whether science-based or otherwise. A company can use Part II to identify the level of emissions FLW contributes to its base year GHG inventory.[22] It can use Part I to estimate the potential GHG emissions associated with various actions to reduce FLW. Estimating a company's FLW-related GHG emissions, alongside the potential GHG benefits of FLW reduction actions, can help that company identify how FLW reduction complements other mitigation strategies to hit their targets. Figure 8 provides a hypothetical example for how actions to reduce FLW might compare against other steps a company could take to achieve GHG reduction targets.

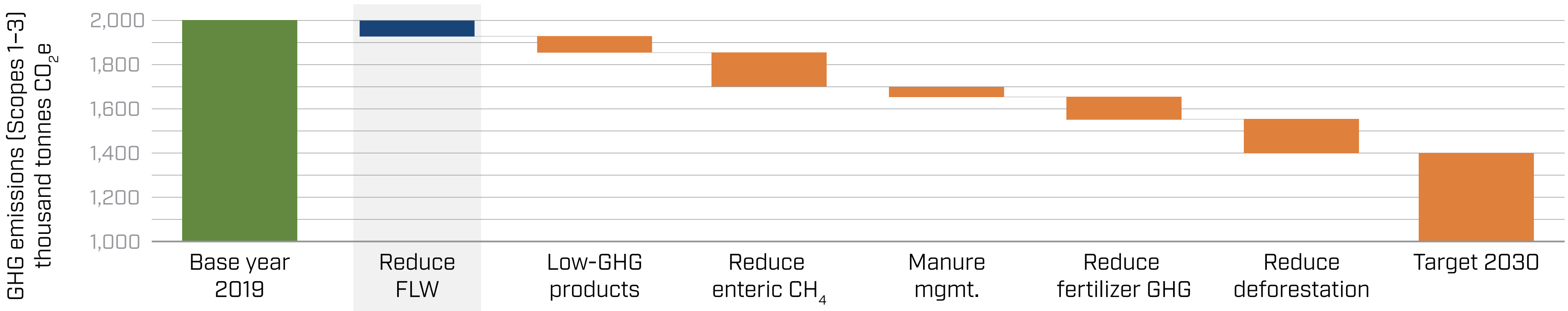
### Box 7. Setting Science-Based Targets in the Food and Agriculture Sector

At the time of this publication, over 1,800 companies have committed to setting GHG reduction targets in line with the goals of the Paris Agreement on climate change, with over 900 companies having approved targets in line with keeping warming below 1.5-2°C (Science-Based Targets 2021).

The Science-Based Targets Initiative's Forest, Land, and Agriculture (SBTi FLAG) project is currently developing guidance for companies in land-intensive sectors to set science-based targets, slated for release in 2022. For the purpose of those targets, only some of the categories in which FLW occurs may be relevant.

In the future, as the Science-Based Targets Network develops targets for other sustainability areas (including land, water, and ocean), companies may be able to use similar approaches to link their FLW reduction actions with these other targets.

**Figure 8 | Hypothetical Example Showing How FLW Reduction Can Complement Other Corporate Strategies to Hit a GHG Reduction Target**




21 Box 3 notes that the forthcoming *GHG Protocol Land Sector and Removals Guidance* is likely to allow reporting of carbon removals and storage inside scopes 1–3 under certain conditions.
22 If over time the method(s) a company uses to estimate the contribution of FLW to its GHG emissions improve, the company should recalculate the base year inventory to take this methodological change into account and communicate about it appropriately. Section 14.5 in the *FLW Standard* and Chapter 5 in the GHG Protocol's *Corporate Standard* provide related guidance.

# Appendix

## Assessing Data Quality

There are several aspects to take into account when selecting the appropriate emission factors (Table A1).

### Table A1 | Indicators to Assess Data Quality (of FLW Estimates and Emission Factors)

| INDICATOR | DESCRIPTION |
|---|---|
| **Temporal representativeness** | This is the degree to which the data set reflects the actual year or age of the activity. |
| **Geographical representativeness** | This is the degree to which the data set reflects the actual geographic location of the activity, such as country or site. |
| **Completeness** | This is the degree to which the data are statistically representative of the relevant activity. This includes the percentage of locations for which data are available and used out of the total number that relate to a specific activity, and seasonal and other normal fluctuations in data. |
| **Reliability** | This is the degree to which the sources, data collection methods, and verification procedures used to obtain the data are dependable. |
| **Technological representativeness** | This is the degree to which the data set reflects the actual technology or technologies used. |

*Sources:* Based on WRI and WBCSD (2011a) and Weidema and Wesnæs (1996), modified by WRI in Waite et al. (2019).

# Methods

The authors used the following approach to develop the guidance in this publication during 2020–21:

1. **Build from documents produced by the Greenhouse Gas Protocol and Food Loss & Waste Protocol.**
   This publication connects to the accounting and reporting standards companies use worldwide to measure and report their GHG emissions and FLW.

2. **Review third-party tools.**
   The authors conducted a review of publicly available English-language tools that estimate FLW-related GHG emissions, drawing on the literature and years of project experience with FLW reduction initiatives. See "References and Additional Resources," below, for a full list of literature cited and tools reviewed.

3. **Interview FLW and GHG accounting experts.**
   The authors conducted interviews with third-party tool developers, FLW accounting experts, and GHG accounting experts to verify conformance of this guidance with existing accounting standards and to verify accuracy of the guidance regarding third-party tool use.

4. **Interview corporate user experts.**
   The authors conducted interviews with FLW, GHG accounting, and other sustainability professionals within companies in the food, beverage, and agriculture sector to determine current capabilities and needs regarding the connection of FLW reductions with corporate climate strategies; calculation and communication of the climate benefits of FLW reductions; and links between FLW reduction, corporate GHG inventories, and science-based GHG reduction targets.

5. **Synthesize previous guidance, tools, and interview responses.**
   The authors developed a comprehensive framework to describe GHG emissions and climate impacts associated with FLW (Figure 2), along with guidance regarding calculation approaches (Part I), links to corporate GHG inventories (Part II), and communication of climate benefits of FLW reductions with potential links to GHG reduction targets (Part III).

6. **Test drafts of this guidance with users and incorporate feedback.**
   Development initially followed an iterative process, which was followed by a structured peer review.

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## Links to Tools Evaluated (see Tables 2 and 3 for more details)

1. Agro-Chain Greenhouse Gas Emissions (ACE) Calculator
2. Cool Farm Tool: Food Loss and Waste Module
3. Cool Food Calculator
4. EPA Waste Reduction Model (WARM)
5. The FOod side flow Recovery LIFe cycle Tool (FORKLIFT)
6. FLW Value Calculator
7. Provision Coalition Food Loss + Waste Prevention Toolkit (based on Enviro-Steward's approach; use restricted)
8. ReFED US Impact Calculator
9. Walmart waste diversion calculator (Project Gigaton)

## Other Relevant Data Sets

In addition to the tools evaluated above, a number of other life cycle assessment data sets are publicly available that provide GHG emission factors related to agricultural production and/or material management, and therefore could be relevant to users who want to calculate FLW-related GHG emissions. These data sets include:

- Database of Food Impacts on the Environment for Linking to Diets: This data set was built by the University of Michigan and Tulane University and is further detailed in Heller et al. (2018).
- EPA's GHG Emission Factors Hub: Of note, EPA's WARM tool, and others that use a life cycle approach to estimating emissions from waste management, account for the GHG consequences of material management (such as landfill methane emissions and landfill carbon storage) that are distributed across many years, rather than annualized.
- US Department of Agriculture (USDA) Life Cycle Assessment Commons is a collection of data sets for use in life cycle assessments.
- There are also a number of commercial databases, such as Ecoinvent, GaBi, FoodCarbonScopeData, World Food LCA Database (Quantis), and Agri-Footprint (Blonk Consultants).

Individual product life cycle assessment studies can also be found through search engines and can complement data from these data sets and calculation tools. A number of tools also exist that support decision-makers in identifying the GHG emissions along food value chains. FAO's EX-Ante Carbon-balance Tool for Value Chains (EX-ACT VC) is one example and encourages users to estimate food loss rates.

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## About the Authors

Kai Robertson is the Lead Advisor for the Food Loss & Waste Protocol at WRI. Contact: robertson.kai@gmail.com.

Richard Waite is a Senior Research Associate in the Food and Climate Programs at WRI. Contact: richard.waite@wri.org.

## About the Food Loss & Waste Protocol

The Food Loss & Waste Protocol (FLW Protocol) is a multi-stakeholder partnership which has developed the global Food Loss and Waste Accounting and Reporting Standard (or FLW Standard) for quantifying food and/or associated inedible parts removed from the food supply chain—commonly referred to as "food loss and waste" (FLW). www.flwprotocol.org

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