VCS Methodology

VM0046

METHODOLOGY FOR REDUCING FOOD LOSS AND WASTE

Version 1.0

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Sectoral Scope 13

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1 SOURCES

This methodology is based on the following protocols:

- *Food Loss and Waste Accounting Standard (FLW Standard)* (FLW Protocol, 2016)
- *The GHG Protocol for Project Accounting* (WBCSD & WRI, 2005)

The following have also informed the development of this methodology:

- *Connecting Food Loss and Waste to Greenhouse Gas Emissions: Guidance for Companies* (FLW Protocol, 2021)
- *Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM): Organic Materials Chapters* (US EPA, 2020)
- *VM0042 Methodology for improved agricultural land management, v1.0*

This methodology uses the following tools:

- *DEFRA's GHG conversion factors*
- *CDM Methodological Tool 04: Emissions from solid waste disposal sites, v8.0*

2 SUMMARY DESCRIPTION OF THE METHODOLOGY

Additionality and Crediting Method	
Additionality	Project Method
Crediting Baseline	Project Method

The methodology applies to project activities which reduce the amount of food discarded, and therefore increases food available for human consumption. Project activities may prevent food loss or waste at different stages of the food chain (e.g., farm level, food processing facility, retailer, foodservice/hospitality, residential).

The methodology provides procedures to quantify the net greenhouse gas (GHG) emission reductions from keeping food (edible and/or inedible parts) in the human food chain. The methodology includes downstream emission reductions from diverting food from a food loss and waste (FLW) destination, including destinations without valorization (e.g., landfill without biogas capture) and with valorization (e.g., soil amendment production, energy recovery) (see Appendix 1).[1,2]

3 DEFINITIONS

Biogenic CO_2

CO_2 emissions deriving from the respiration of organic matter by bacteria (biological processes) or its oxidation through physico-chemical processes (e.g., combustion or pyrolysis). Fast-cycling biogenic CO_2 emissions are considered climate-neutral.[3]

Eventual discards

Food discarded later in the supply chain after implementation of a project designed to prevent its discard

Food

All parts of plants, fungi, and animals —whether processed, semi-processed, or raw— that could be eventually consumed by humans[4]

Food loss and waste (FLW)

Food (and any associated inedible parts) that goes to any FLW destination[5]

Food loss and waste (FLW) destination

Where food goes when removed from the human food supply chain (see Appendix 1: FLW Destinations)

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[1] It is useful to note that in situations where the FLW received by a facility is being valorized (e.g., soil amendment is created, energy is recovered), the expected GHG emission reductions for projects diverting this FLW are likely small.

[2] For other purposes (e.g., general communication about GHG emissions associated with food loss and waste), organizations may use *Connecting Food Loss and Waste to Greenhouse Gas Emissions: Guidance for Companies* (FLW Protocol, 2021).

[3] Biogenic CO_2 emissions originating from long-term carbon (C) stocks like soil C pools or forests add to the CO_2 concentration in the atmosphere and are considered relevant to climate change.

[4] The definition of "food" used in this methodology is broader than that in the *FLW Standard*, which differentiates "food" (i.e., edible parts intended for human consumption in a particular context) from its associated "inedible parts." The definition of "food" includes drinks.

[5] The abbreviation FLW is used in this document as shorthand for "food loss and waste" as defined in this methodology. This definition does not match definitions used in other programs for food loss or food waste, such as for the UN SDG 12.3 target (i.e., which excludes animal feed and bio-based materials/biochemical processing destinations; see Champions 12.3's *Guidance on Interpreting Sustainable Development Goal 12.3*).

Food loss and waste (FLW) flows
The mass of food that without adoption of the project activity would go to an FLW destination. Note that this is equivalent to the mass of food that is eventually recovered by project activities.

Food loss and waste (FLW) source
Where food loss and waste is generated

Inedible parts[6]
Components associated with a food that, in a particular food supply chain, are not intended to be consumed by humans. Examples of inedible parts associated with food may include bones, rinds, and pits/stones.[7]

Recovered food
Food that has been kept in the human food chain because of the project activity; includes activities that focus on "prevention" (preventing food from being discarded in the first place) as well as "rescue" (redistributing to people food at risk of being discarded).

4 APPLICABILITY CONDITIONS

The methodology applies to project activities which reduce the amount of food that would otherwise have left the human food chain by being discarded. Project activities may prevent this loss or waste of food products at different stages in the food chain (e.g., at farm level; during transport; in storage; at a food processing facility, retail outlet, foodservice/hospitality location; in households).

The methodology is applicable under the following conditions:

1) The project activity must reduce the amount of food lost or wasted compared to the baseline scenario.

2) Project activities must introduce or implement one or more changes at any stage of the food's life cycle.[8] The following are examples of project activities that may reduce the amount of food discarded at different stages (not exhaustive):[9]

[6] Ibid.

[7] What is considered inedible varies among users (e.g., chicken feet are consumed in some food value chains but not others), changes over time, and is influenced by a range of variables including culture, socio-economic factors, availability, price, technological advances, international trade, and geography. In some sectors, inedible parts may also be referred to as by-products or co-products.

[8] Including farms and agricultural cooperatives, retailers and warehouses, restaurants, canteens, food vendors and other business-to-consumer and food stakeholders directly selling or serving food to end-users and private households

[9] Taken from ReFED *Solutions Database.* For more info and additional solutions see: https://insights-engine.refed.org/solution-database?dataView=total&indicator=us-dollars-profit

(a) Farm level: gleaning; value-added processing; donation coordination and matching; imperfect and surplus produce channels

(b) Processing and warehouse level: reduced warehouse handling; intelligent routing; intelligent packaging; improved packaging design; standardized date labels; enhanced demand planning; manufacturing line optimization; food donations

(c) Retailer level: dynamic pricing; value-added processing; enhanced demand planning; markdown alert applications; food donations

(d) Residential and foodservice/hospitality level: education campaigns; smart refrigerators; lunch improvements; flexible portions; buffet signage

3) All recovered food must adhere to relevant food health and safety legislation in the jurisdiction containing the project activity.

4) The project activity must divert food away from one of the following FLW destinations:

(a) Anaerobic digestion (wet)

(b) Anaerobic digestion (dry)

(c) Composting

(d) Controlled combustion, incineration

(e) Landfill without flaring

(f) Landfill with flaring

(g) Open burning

(h) Open dump

(i) Sewer / wastewater

This methodology does not apply to:

5) Project activities that shift food from one FLW destination to another (e.g., from landfill to composting[10]) as this does not reduce the amount of food leaving the human food chain.[11]

[10] For a methodology that credits these activities please refer to the Clean Development Mechanism (CDM) methodology AMS-III.F. available at https://cdm.unfccc.int/UserManagement/FileStorage/V5BK1NFHM6ORYGI324CD78L0ZA9UJQ

[11] This focus on "food waste avoidance" aligns with the priority of other FLW reduction targets and programs such as the US EPA's Food Recovery Hierarchy and UN Sustainable Development Goal 12.3.

5 PROJECT BOUNDARY

The project boundary includes the jurisdiction(s) where:

1) The mass of food that would have been wasted (i.e., sent to an FLW destination) in the baseline scenario (i.e., FLW flows) is generated (i.e., FLW source);
2) The baseline scenario FLW destinations are located; and
3) The recovered food is used or consumed due to the project activities.

Baseline emission sources

The main baseline emissions accounted for under this methodology are associated with the treatment of food at the FLW destination. Emissions from transport activities of FLW flows to the FLW destination may be accounted for with available evidence and collected or inferred from available data.

Project emission sources

GHG emissions from recovered food transport, processing, packaging, storage, distribution, and any other project GHG emission source not included in the baseline scenario must be included. Other GHG emissions from eventual discards of recovered food and from co-product displacement in FLW destinations with valorization must be included as leakage emissions (see Section 8.3). An illustrative diagram is presented in Figure 1.

Emissions that do not change between the project and baseline scenarios are excluded from the project boundary. These may include emissions associated with food storage, handling, preparation and consumption, such as refrigeration or freezing, cooking, digestion of food and treatment of human excreta.

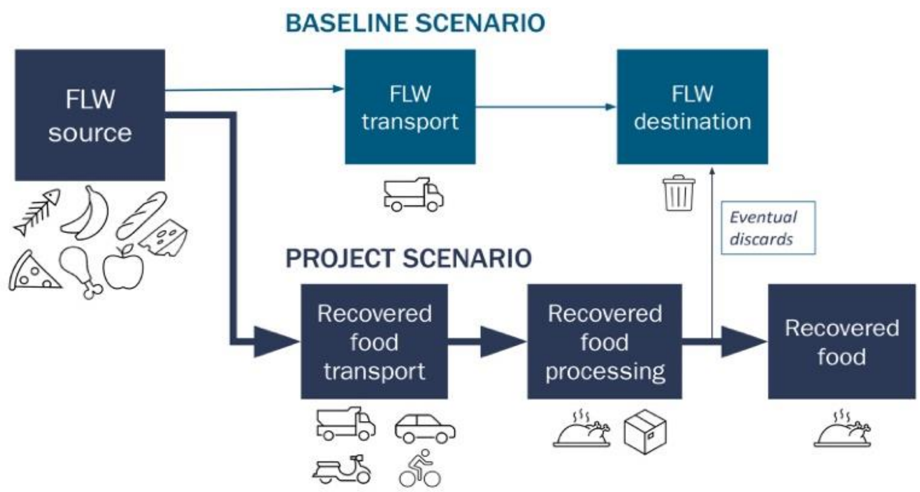

Figure 1: Simplified schematic diagram of the project boundary

The greenhouse gases included in or excluded from the project boundary are shown in Table 1.

Table 1: GHG sources included in or excluded from the project boundary

Source		Gas	Included?	Justification/Explanation
Baseline	Food treatment at FLW destination	CO_2	No	Biogenic CO_2 emissions from food are assumed to be climate-neutral and are therefore excluded.
		CH_4	Yes	Biogenic CH_4 emissions are a major GHG source of emissions in the treatment of FLW
		N_2O	Yes	N_2O emissions may arise from landfill, combustion, and digestate application.
	Transportation of FLW and recovered food	CO_2	Yes	CO_2 emitted from the combustion of fossil fuels consumed to transport FLW and recovered food must be included. Indirect CO_2 emitted from electricity production to charge the batteries of electric vehicles must be included
		CH_4	Optional	*De minimis*, therefore may be excluded
		N_2O	Optional	
Project	Recovered food processing and other activities (electricity and fossil fuel consumption)	CO_2	Yes	CO_2 may be emitted from the generation of electricity and fossil fuels consumed during the processing of recovered food.
		CH_4	Optional	*De minimis*, therefore may be excluded
		N_2O	Optional	
	Recovered food processing (biogenic emissions of recovered food)	CO_2	No	Biogenic CO_2 emissions from food are assumed to be climate-neutral and are therefore excluded
		CH_4	Yes	Must be included if produced during the processing of recovered food
		N_2O	Yes	
	Additional ingredients, packaging, and chemicals	CO_2	Yes	Any other GHG derived from the use of ingredients, food additives, chemicals and packaging materials used for the processing, storage, handling, packaging, and distribution of the recovered food must be included
		CH_4	Yes	
		N_2O	Yes	

6 BASELINE SCENARIO

The baseline scenario is the pre-project situation in which the food is not ultimately consumed by people and is sent to any FLW destination (see Figure 1). Project proponents must identify the FLW destination where pre-project FLW flows ended up. Next, project proponents must specify the characteristics of the treatment technology at the FLW destination to which the recovered food would otherwise have gone.

All FLW flows covered by the project activities must be characterized in terms of mass (i.e., expressed as pounds, kilograms, tons, or metric tons [tonnes]) and water or dry matter (DM) content, which affects the calculation of avoided GHG emissions (see Section 8). FLW flows must also be mapped to the FLW source(s) and FLW destination(s) prior to the project start date. Project proponents must demonstrate that food would have been discarded and exited the human food chain in the absence of the project and quantify GHG emissions in the baseline scenario based on evidence. This will require information on the following:

- Data to calculate, estimate or infer the FLW flows. Including their characteristics (e.g., food type, classified using the Codex General Standard for Food Additives [GSFA] categories) such that the FLW flows are accounted for and reported in line with the requirements of the *FLW Standard*;
- Description of the activity that generates FLW and its location;
- Description of the FLW destination and its location, as well as the characteristics of the treatment technology at the FLW destination to which the recovered food would otherwise have gone; and
- Transport methods and transport distances from the FLW source to FLW destination, either measured or otherwise inferred from available information using conservative assumptions.

The following data considerations must be addressed:

- Credible evidence such as contractual agreements and waste management records (in-house, or ideally externally verified) must be provided to show that the food recovered by the project activity, was previously sent to the FLW destinations used to calculate the baseline scenario.
- For project activities that divert FLW to an animal feed destination, the project proponent must provide credible evidence that the animals consuming this feed stay in the human food chain, e.g., vendor sales records.

The time period considered when calculating the food diverted from an FLW destination and the related GHG emissions is one calendar year (365 days). If dealing with FLW flows that vary over the course of a year, project proponents are required to follow the guidance on sampling and scaling data in the *FLW Standard* and follow the principle of conservativeness. Moreover, where FLW flows vary from year to year (e.g., on agricultural lands where weather has a significant impact on yield) or in the case of an anomalous year (e.g., because of serious disruptions due to a natural disaster or a pandemic such as COVID-19), project proponents must apply a three-year average.

7 ADDITIONALITY

This methodology uses a project method for the demonstration of additionality. The project proponent must apply the following steps.

Step 1: Demonstrate regulatory surplus

Project proponents must demonstrate regulatory surplus in accordance with the rules and requirements regarding regulatory surplus set out in the latest version of the *VCS Standard*.

Step 2: Identify barriers that would prevent implementation of a practice that keeps food from leaving the human supply chain

The project proponent must determine whether there are barriers (e.g., investment, institutional, cultural, social) to the proposed activity's adoption. The identified barriers are sufficient grounds for demonstrating additionality only where they prevent potential project proponents from carrying out the proposed project activity unless it is registered as a VCS project.

The project proponent must document and describe the barriers to implementation of a practice that keeps food in the human supply chain. Such barriers may include the following, among others:

1) Investment barriers, for example:
    a) Similar activities in the region have been implemented only with grants or other non-commercial finance terms;
    b) The cost of discarding food is lower than the cost of keeping it in the human supply chain;
    c) Current economics limit adoption of new supply chains or other innovative projects (e.g., upcycling FLW) because the consumer market is underdeveloped.
2) Institutional barriers, for example:
    a) Lack of skilled and/or properly trained labor familiar with FLW tracking and monitoring;
    b) Disjointed markets, transport, and storage;
    c) Overly strict quality standards for perishable items;
    d) Food item expiry dates that do not accurately reflect edibility;
    e) Established supply chain processes for efficiency/transport purposes are difficult and expensive to break, thus discards are accepted as part of business/supply chain process;
    f) Contractual/legal agreements related to the price and purchase of food.
3) Cultural and social barriers, for example:
    a) Lack of motivating incentives to change practices;
    b) Lack of visibility of the issue;

c) High aesthetic standards for produce and a consumer tendency to not purchase suboptimal foods;
d) Activity is the "first of its kind"[12], or no activity of this type is currently operational in the host country or region (defined as within 200 km of project area).

The project proponent must provide documented evidence from an independent, third-party source that demonstrates the existence of the identified barriers. The types of evidence may include:

- Peer-reviewed and/or published studies;
- Relevant studies or surveys undertaken by universities, research institutions, NGOs, companies, bilateral/multilateral institutions; or
- Relevant statistical data from national or international statistics.

Anecdotal evidence may be included but alone is not sufficient proof of barriers. Guidance for the objective demonstration of barriers to implementation of the project activity can be drawn from Annex 13 of the CDM's Guidelines for Objective Demonstration and Assessment of Barriers[13].

Step 3: Demonstrate that adoption of the proposed project activity (or activities) is not common practice

Unless the project activity was demonstrated to be "first of its kind" in Step 2, this step is required.

The project proponent must determine whether the proposed project activity, or scope of activities,[14] are common practice in each region included within the project spatial boundary (defined as encompassing the jurisdiction(s) where food ends up (the FLW destination) under the baseline scenario, as well as the jurisdiction(s) where the recovered food is used or consumed as a result of the project activities). Common practice is defined as greater than 20 percent adoption rate[15] in the applicable geographic area based on the amount of food being recovered relative to the quantity wasted.

Common practice analysis must be completed based on the implementation of similar project activities over the ten years immediately prior to the project start date (e.g., gleaning of surplus produce) in:

1) the relevant stage in the supply chain (e.g., at the farm level, retail, etc.);

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[12] Drawing from *CDM Methodological Tool 23: Additionality of first-of-its-kind project activities,* a "first of its kind" activity means the project is the first in the applicable geographic area to apply a technology that is different from technologies implemented by any other projects that are able to deliver the same output and have started commercial operation in the applicable geographic area before the project design document is published for stakeholder consultation or before the start date of the proposed project activity.

[13] https://cdm.unfccc.int/EB/050/eb50_repan13.pdf

[14] This refers to all activities implemented across an aggregated project.

[15] Based on the latest version of the CDM *Methodological tool: Common practice.*

2) the same region; and

3) at a similar scale as the project (defined as +/-50% of kg food diverted annually).

Evidence must be independent and provided in the form of publicly available information contained in peer-reviewed scientific literature; independent research data; and/or reports or assessments compiled by industry or trade associations. The highest quality available evidence source appropriate to the project must be used. Evidence at the second order jurisdictional level (i.e., state or province) where the project is being developed is preferred. Where supporting evidence is not available at this level, aggregated data at a country or regional level may be used, with justification.

A project proponent may include project instances where more than one activity to keep food from leaving the human supply chain will be implemented at the same location.[16] If this is the case, the common practice assessment must be completed for each individual project activity (unless the project activity was demonstrated to be “first of its kind” in Step 2).

Where the above steps are satisfied, the proposed project activity is additional.

8 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

8.1 Baseline Emissions

The total baseline GHG emissions are associated with the baseline FLW flows to pre-project FLW destination(s) and the transport of the FLW flows. Total baseline GHG emissions are calculated using Equation (1).

$$BE_y = \sum_j BE_{j,y} + BE_{Trans_{j,y}} \qquad (1)$$

Where:

BE_y	Total baseline emissions in year *y* (tCO_2e)
$BE_{j,y}$	Baseline emissions from the FLW destination *j* in year *y* (tCO_2e)
$BE_{Trans_{j,y}}$	Baseline GHG emissions from collection and transport of FLW flows to destination *j* in year *y* (tCO_2e)

[16] For example, a project may include both enhanced demand planning and dynamic pricing in a retail location.

The steps for a project proponent to calculate the total baseline GHG emissions (BE_y) are illustrated in Figure 2 and explained in detail below.

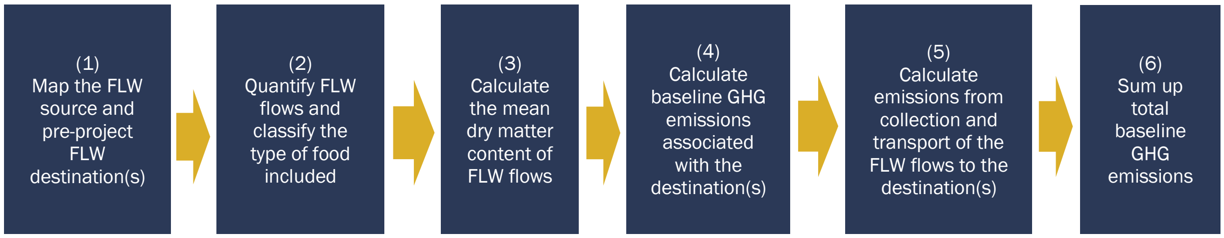

Figure 2: Steps to calculate baseline emissions

1) **Map the FLW source and pre-project FLW destination(s)**, which includes (a) identifying and describing all FLW sources and FLW destinations before the project start date within the project boundary, and (b) determining the distance between all sources and destinations, which will be used in Step 5.

2) **Quantify FLW flows and classify the type of food included.** Project proponents are not required to use a particular quantification method[17] to calculate FLW flows but must minimize the degree of uncertainty (see guidance in Chapter 9 of the *FLW Standard*).[18] To undertake Step 3, food content in the FLW flows must be described using FAO's Codex General Standard for Food Additives (GSFA)[19] system. As a minimum, food ingredients must be classified down to the second non-null digit category of the GSFA Codex system (e.g., 01.1 Fluid milk and milk products).

3) **Calculate the mean dry matter (DM) content[20] of FLW flows using default values from the USDA FoodData Central database.**[21] Project proponents must select the water content (which is the inverse of the DM content) for the food ingredients that best represent the content of the FLW flows according to the classification performed in Step 2. Project proponents may

[17] Data on FLW flows may be from direct measurements, inferred from surveys, or indirectly calculated from existing food records (e.g., food purchased minus food served). Refer to the *FLW Standard* for additional guidance on possible quantification methods and tradeoffs, and to Appendix 2 for guidance on representative sampling. Representative sampling with direct measurements and indirect calculations through food records are typically the preferred option to quantify FLW flows as they are usually more accurate than FLW estimated through other methods.

[18] As an example, project proponents may use material flow analysis tools and/or related software to support quantification, which minimize accounting errors (e.g., keeps mass balance within the project boundary) and facilitates future monitoring of FLW and recovered food flows.

[19] Available at: https://www.fao.org/gsfaonline/foods/index.html

[20] The DM content of discarded food is a critical parameter that determines the amount of GHG (CH_4 in particular) emissions from waste treatment facilities, especially landfills. The DM content (or alternatively, the water content) varies greatly across different types of food (e.g., from 100 percent DM of oils to 5 percent DM of some vegetables). In anaerobic conditions like a landfill, most of the dry matter becomes CH_4 hence the emission factors from landfill for drier food products (with a higher DM content) are greater than those of wetter food products (with a lower DM content).

[21] Online food search available at: https://fdc.nal.usda.gov/fdc-app.html#/. Water content data available for Foundation Foods, SR Legacy Foods and Survey Foods (i.e. not Branded Foods). Make sure to download the latest version of the database if using the csv or json files.

extend or complement water content data of food ingredients or prepared foods that are not listed in the FoodData Central with region- or country-specific food databases available in the FAO/Infoods site[22] (e.g., WAFCT database for West African food ingredients and recipes).

i. Project proponents must calculate the mean DM content of the FLW flows, which will be composed of mixed ingredients from multiple food categories, as follows:

$$DM_{j,y} = \sum\nolimits_{i,j} (1 - WC_{i,j,y}) \times \frac{M_{FLW_{i,j,y}}}{M_{FLW_{j,y}}} \qquad (2)$$

Where:

$DM_{j,y}$	Mean dry matter content of FLW flows going to destination *j* in year *y* (weight fraction)
$WC_{i,j,y}$	Default water content of food ingredient or food category *i* inside the FLW flow going to FLW destination *j* in year *y* (weight fraction)
$M_{FLW_{i,j,y}}$	FLW flow (i.e., mass) pertaining to food ingredient or food category *i* going to FLW destination *j* in year *y* (t)
$M_{FLW_{j,y}}$	Sum of all FLW flows going to FLW destination *j* in year *y* (t)
i	Types of food ingredients or food categories in FLW flows
j	FLW destinations
y	Reporting year

ii. Where project proponents cannot calculate a mean DM content of baseline FLW flows, e.g., because they cannot determine the food composition of FLW flows, then they must assume either:
a) for homogeneous FLW flows, i.e. flows for which all food content falls inside one of the sixteen food groups of the FAO GSFA system: the highest water content of all food ingredients within the food group;
b) for heterogeneous FLW flows, a mean water content of 73% (i.e. a mean DM content of food of 27% as given in the US EPA (2020) report).

iii. Alternatively, project proponents may carry out a sampling to characterize the collected FLW flows in terms of mass ($M_{FLW_{i,j,y}}$) and water ($WC_{i,j,y}$) content. Please see the guidance on representative sampling in Appendix 2 and the associated cited references.

4) **Calculate baseline GHG emissions associated with the pre-project FLW destination(s).** Project proponents must use the decision tree in Figure 3 to determine whether the appropriate approach for calculating baseline GHG emissions is using data from the FLW destination

[22] Available at: https://www.fao.org/infoods/infoods/tables-and-databases/en/ ; check also http://www.langual.org/langual_linkcategory.asp?CategoryID=4&Category=Food%20Composition

facility in which the pre-project FLW flows are treated or using a default GHG emission factor for the relevant FLW destination(s).

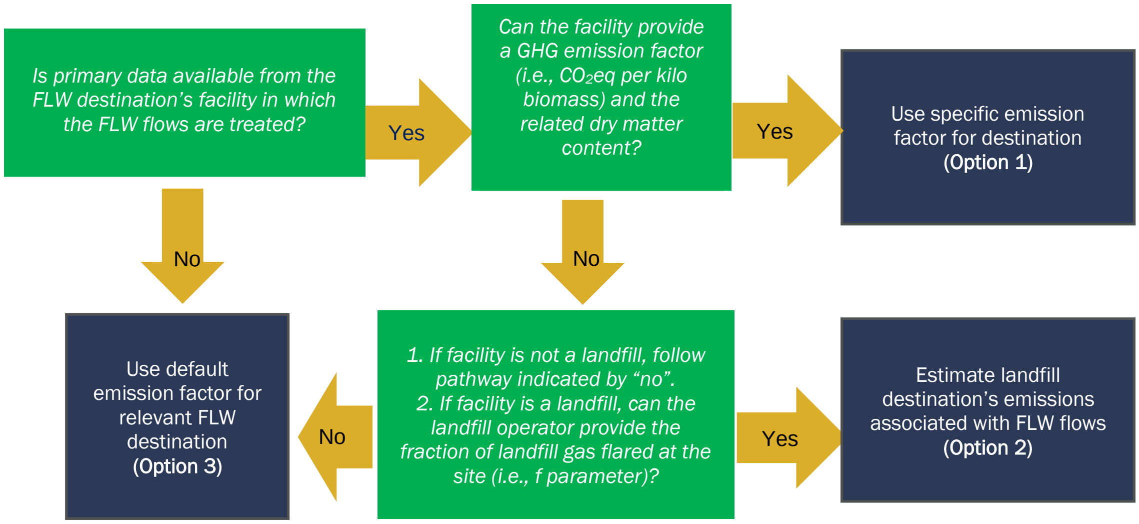

Figure 3: Decision tree to calculate baseline GHG emissions for FLW destinations (step 4)

The following lays out the equations to use when applying Option 1, 2, or 3 from Figure 3.

Option 1: Use specific emission factor from FLW destination facility

If primary data is available from the FLW destination's facility in which the FLW flows are treated, and the facility can provide a GHG emission factor (i.e., CO_2e per t biomass) as well as related dry matter content for the organic waste it treats, a project proponent must use this emission factor as it is more accurate than using a default factor.

To calculate the specific GHG emissions associated with the FLW flows, when the facility provides an emission factor ($EF_{j,y}$) on a wet basis, the project proponent will need information from the facility on the related mean DM (or water) content of all the organic waste treated at the facility ($DM_{facility,j,y}$ below). However, if $EF_{j,y}$ is given on a dry basis, then $DM_{facility,j,y}$ in Equation (3) has a value of 1.

Project proponents must use the following equation to calculate baseline emissions for the project's FLW destination(s):

$$BE_{j,y} = \varphi_{default} \times M_{FLW_{j,y}} \times \frac{DM_{j,y}}{DM_{facility,j,y}} \times EF_{j,y} \quad (3)$$

Where:

$BE_{j,y}$	Baseline emissions from the FLW destination *j* in year *y* (tCO_2e)
$\varphi_{default}$	Default discount factor of 0.9 to account for model uncertainties in Option 1 (fraction)

$EF_{j,y}$	Emission factor of FLW destination *j* in year *y* (tCO_2e/t biomass)
$DM_{facility,j,y}$	Mean dry matter content of the organic waste (i.e., biomass) treated in destination *j* in year *y* (weight fraction)

Project proponents may overrule $\varphi_{default}$ by a calculated discount factor if they are able to quantify the uncertainty behind $M_{FLW_{j,y}}$ and $DM_{j,y}$, i.e., only if they have characterized the FLW flows through representative sampling (see step 3) and if the facility operator can provide the standard deviation of the provided emission factor. The discount factor must be calculated and included as per the latest version of the *VCS Methodology Requirements*, substituting $\varphi_{default}$ with *(1 – discount factor)* in Equation (3).

Option 2: Estimate landfill destination's emissions associated with FLW flows

If the FLW flows are treated in a landfill but the facility cannot provide a GHG emission factor or related dry matter content for the organic waste it treats, and where a project proponent has access to the fraction of methane flared at the solid waste disposal site, Equation (4), must be used.[23]

$$BE_{j,y} = \varphi_{SWDS} \times \left(1 - f_{j,y}\right) \times GWP_{CH_4} \times MCF \times 0.3 \times M_{FLW_{J,y}} \times DM_{j,y} \qquad (4)$$

Where:

$BE_{j,y}$	Baseline emissions from the destination landfill *j* in year *y* (tCO_2e)
φ_{SWDS}	Default discount factor to account for model uncertainties in Option 2, variable according to the climatic conditions (dimensionless, see Section 9)
$f_{j,y}$	Fraction of the CH_4 captured, flared, combusted, or recovered at the destination landfill *j* in year *y*. Monitored parameter (fraction, see Section 9)
GWP_{CH_4}	Global warming potential of CH_4 (tCO_2e/t CH_4). Use value referenced in the latest version of the *VCS Standard*
MCF	Default methane correction factor applied to the destination landfill facility, variable according to the type of solid waste disposal site (dimensionless, see Section 9)
0.3	Default factor that converts the carbon content of dry organic matter to released CH_4 (t CH_4/t DM)

Option 3. Use default emission factor for relevant FLW destination

If Options 1 and 2 are not feasible, project proponents must select from the default emission factors in Table 2 to calculate the baseline emissions associated with the relevant FLW destination. These emission factors are globally representative of the listed FLW destinations,

[23] This equation has been adapted from the CDM Methodological Tool 04 *Emissions from solid waste disposal sites, v8.0.* Available at: https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-04-v8.0.pdf

since the factors are reflective of a specific waste treatment technology rather than geography-dependent.

Table 2: Default GHG emission factors (tCO_2e/t DM) for calculating baseline emissions

FLW destination	Emission factor (EF)	Destination with valorization	Note
Anaerobic digestion (wet) [a]	0.359	Yes	Includes fugitive CH_4 and N_2O emissions from the digester and from digestate application on land. Excludes avoided emissions from co-product offsets and transportation.
Anaerobic digestion (dry) [a]	0.457	Yes	
Composting [a]	0.392	Yes	Includes fugitive CH_4 and N_2O emissions from composting. Excludes avoided emissions from co-product offsets and waste transportation.
Controlled combustion, incineration [a]	0.131	Yes	Includes non-CO_2 emissions from the combustion process. Excludes avoided emissions from co-product offsets and transportation
Landfill without flaring [b]	6.528	No	Excludes emissions from transportation
Landfill with flaring [b]	2.222	Yes	Excludes avoided emissions from co-product offsets and transportation
Open burning [c]	0.141	No	Includes non-CO_2 emissions from the combustion process. Excludes emissions from transportation
Open dump [b]	2.285	No	Excludes transportation emissions
Sewer / wastewater [d]	0.418	No	Includes emissions from electricity consumption for wastewater treatment and subsequent anaerobic digestion process

[a] Adapted (i.e., converted from short wet tons to kg DM) from the emission factors in the US EPA (2020) report;[24] combustion EF from Exhibit 1-44, composting EF from Exhibit 1-43, and wet and dry anaerobic digestion EF from Exhibit 1-52 and Exhibit 1-51, respectively. Discount factors (φ) of 0.8 have been applied.

[b] Adapted from CDM TOOL04 (see Equation 3 in Option 2). Applied MCF value of 1 (landfill with and without flaring) and 0.4 (open dump considered as unmanaged shallow solid waste disposal site). Global warming potential of biogenic methane from latest IPCC AR6 report. Average flaring factor of 0.61 applied (US EPA, 2020). Discount factors (φ) of 0.8 (landfill without flaring) and 0.7 (landfill with flaring and open dump) applied.

[c] Adapted from Ecoinvent 3.8 database.

[d] Represents the average anaerobic digestion EF from US EPA (2020) plus the GHG emissions from an average electricity consumption at wastewater treatment plants for aeration (Ecoinvent 3.8).

The EF in Table 2 include a discount factor to account for model and parametric uncertainties.

[24] Available at: https://www.epa.gov/sites/default/files/2020-12/documents/warm_organic_materials_v15_10-29-2020.pdf

Once the relevant EF have been selected from Table 2, the following equation must be used to calculate baseline emissions from the pre-project FLW destinations:

$$BE_{j,y} = M_{FLW_{j,y}} \times DM_{j,y} \times EF_{default\,j,y} \quad (5)$$

Where:

$EF_{default_{j,y}}$	Default EF of the FLW destination *j* in year *y* (Table 2) (tCO_2e/t DM)

5) Calculate emissions from collection and transport of the FLW flows to the FLW destination(s).

Equation (6) must be used to calculate emissions from FLW collection and transport to the relevant destination(s):

$$BE_{Trans_{j,y}} = D_{j,y} \times M_{FLW_{j,y}} \times EF_{trans.mode_{m,y}} \times .001 \quad (6)$$

Where:

$BE_{Trans_{j,y}}$	Baseline GHG emissions from collection and transport of FLW flows to destination *j* in year *y* (tCO_2e)
$D_{j,y}$	Distance travelled by the waste collection vehicle for collection of FLW flows going to destination *j* during year *y* (km). It must correspond to the distance(s) between the FLW source and the FLW destination(s), measured, inferred, calculated, or estimated in Step 1.
$EF_{trans.mode_{m,y}}$	Emission factor for transportation mode *m* in year *y* (kg CO_2e/t km). The emission factors per transport mode and vehicle type may be taken from DEFRA's latest GHG conversion factors.
.001	Conversion factor to convert kg CO_2e/t km to tCO_2e/t km

6) Sum up total baseline GHG emissions

To calculate the total baseline GHG emissions (BE_y), the baseline emissions associated with the FLW destination(s) (calculated in Step 4) must be added to those related to the collection and transport of the FLW flows (from Step 5) using Equation (1).

8.2 Project Emissions

Project activity emissions are those related to the new project activities taking place to recover food and avoid FLW (i.e., keeping food within the human supply chain) and are calculated using Equation (7).

$$PE_y = PE_{Trans_y} + PE_{Proc_y} \quad (7)$$

Where:

PE_y	Project emissions in year *y* (tCO_2e)
PE_{Trans_y}	Project emissions from transportation to collect and deliver the recovered food in year *y*. This parameter must consider all trips for the different transportation stages (e.g., collection, distribution, delivery) and the means required for the completion of project activities included in the project boundary (see Equation (8); tCO_2e)
PE_{Proc_y}	Project emissions from electricity consumption or other energy and/or material use for additional processing, storage etc. in year *y* where these processes are considered additional for the recovery of food (see Equation (9); tCO_2e)

The emission factors per transport mode and vehicle type, as well as per fuel type (energy usage for additional processing activities) and electricity consumption (country or regional grid-mix average factors), may be taken from DEFRA's latest GHG conversion factors. To correctly calculate transport-related emissions, the transport mode, vehicle type and distances traveled must be known. Transport emissions are calculated using Equation (8).

$$PE_{Trans_y} = \sum_{m,x} D_{m,x,y} \times M_{FLW_{m,x,y}} \times EF_{trans.mode_{m,y}} \times .001 \quad (8)$$

Where:

$D_{m,x,y}$	Distance travelled by transport mode *m* for the collection of recovered food flows going from the FLW source to new destination *x* during year *y* (km)
$M_{FLW_{m,x,y}}$	Sum of recovered food flows going from the FLW source to new destination *x* by transport mode *m* during year *y* (t). The sum of recovered food flows ($M_{FLW_{m,x,y}}$) must be equal to the sum of FLW flows used in the baseline emissions calculation ($M_{FLW_{j,y}}$)
$EF_{trans.mode_{m,y}}$	Emission factor for transportation mode *m* in year *y* (kg CO_2e/t km). The emission factors per transport mode and vehicle type may be taken from DEFRA's latest GHG conversion factors
.001	Conversion factor to convert kg CO_2e/t km to tCO_2e/t km

To estimate transport details, the project proponent must determine the distances between the FLW source and the new destinations ($D_{m,x,y}$) and transport modes (m). This may be determined by surveying a representative sample of project activity beneficiaries. The average distance traveled in the representative sample must be used to extrapolate transportation emissions to the whole population reached by the project activities.

The emission factors per transport mode and vehicle type may be taken from the latest GHG conversion factors of DEFRA[25]. To correctly calculate transport-related emissions, the transport mode, vehicle type, and distances traveled between the source(s) and destination(s) of the recovered food flows must be known.

The processing emissions are calculated using Equation (9).

$$PE_{Proc_y} = PE_{EC_y} + PE_{FC_y} + OE_y \quad (9)$$

Where:

PE_{EC_y}	Project emissions from electricity consumption associated with the processing of recovered food flows ($M_{FLW_{m,x,y}}$) in year *y* (tCO_2e). These emissions must be calculated with the CDM Methodological TOOL05: *Tool to calculate baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation*.[26]
PE_{FC_y}	Project emissions from fossil fuel consumption associated with the processing of recovered food flows ($M_{FLW_{m,x,y}}$) in year *y* (tCO_2e). These emissions must be calculated with the CDM Methodological TOOL03: *Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion*.[27]
OE_y	Other emissions from the consumption of additional materials needed for processing and delivering the new food product (e.g., packaging) in year *y* (tCO_2e). Additional minor ingredients, such as food additives, preservatives, etc., may be excluded from project emission calculations where they comprise less than 1 percent of the recovered and processed food mass (see Equation (10)).

Other emissions from consumption of additional materials (e.g., packaging) are calculated using Equation (10), unless shown to be de minimis. Project proponents should strive to minimize GHG emissions from the use of packaging materials by first minimizing the use of packaging as much as possible and second, when necessary, selecting low-impact packaging (e.g., recycled materials). Emission factors for the most common packaging materials are provided in Table 3.

$$OE_y = \sum_{py} M_{material_{p,y}} \times EF_{material_p} \quad (10)$$

Where:

$M_{material_{p,y}}$	Mass of additional material type *p* used in the project scenario in year *y* (t)
$EF_{material_p}$	Emission factor for material type *p* (Table 3) (tCO_2e/t material type *p*)

[25] Factors for 2022 available at: https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2022

[26] Available at: https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-05-v3.0.pdf

[27] Available at: https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-03-v3.pdf

Table 3: Emission factors for common packaging materials

Category	Emission factor (tCO_2e/t material)	Common examples of use/description
Corrugated container board (Fiberboard or fluter fiberboard)	0.91	Corrugated cardboard made from gluing fluted corrugating medium
Polylactic Acid (PLA)	2.70	Constructed from renewable agricultural products, PLA is considered a "greener alternative" packaging option. Includes rigid packaging. Common uses: folding boxes, disposable cups, cutlery, bottles, films, carpet, apparel, and more.
Polyethylene terephthalate (PET) Plastic Rigid packaging	2.44	PET is also known as polyester. Common uses: Water bottles, other packaging.
High Density Polyethylene (HDPE) Plastic Rigid packaging	1.68	Harder and more rigid than PET. Common uses: Bottles, packaging containers, cooking oil jugs, milk cartons, bottle caps.
Low Density Polyethylene (LDPE) Plastic flexible packaging	1.98	Flexible packaging material. Common uses: film applications like poultry wrapping, trash bags.
Linear LDPE (LLDPE) Plastic flexible packaging	1.74	High strength film applications, resistant to puncture.
Virgin glass	0.66	Virgin glass assumes 5% recycled content.
Recycled materials	0.00	Packaging made from a substantial amount (>50%) of material recovered or diverted from the non-hazardous solid waste stream, that may otherwise be produced using raw or virgin materials.

Source: EPA, Documentation for GHG Emission and Energy Factors Used in the Waste Reduction Model (WARM): Containers, Packaging, and Non-Durable Good Materials Chapters v15. November, 2020[28].

8.3 Leakage

8.3.1 Total Leakage Emissions

The total leakage emissions for a project occurring in year *y* (LE_y) are calculated as the sum of the leakage emissions from eventual discards ($LE_{discards_y}$, section 8.3.2) and the leakage emissions

[28] https://www.epa.gov/sites/default/files/2020-12/documents/warm_containers_packaging_and_non-durable_goods_materials_v15_10-29-2020.pdf

from recovering food that would have otherwise been transformed into co-products in FLW destinations with valorization ($LE_{valorization_y}$, section 8.3.3), as shown in Equation (11).

$$LE_y = LE_{discards_y} + LE_{valorization_y} \tag{11}$$

Where:

LE_y	Total leakage emissions in year *y* (tCO_2e)
$LE_{discards_y}$	Leakage due to eventual discards of recovered food in year *y* (tCO_2e)
$LE_{valorization_y}$	Leakage due to recovering food from FLW destinations with valorization in year *y* (tCO_2e)

8.3.2 Leakage from Eventual Discards

A project that prevents FLW at a certain point in the supply chain may still result in food discarded later in the supply chain; this is referred to as "eventual discard" in this methodology. The risk of leakage from eventual discard will depend on the type of FLW addressed by project activities, where in the food chain the project activities intervene, the activity type, and consumer behavior related to the project. For example, the risk of leakage in a project that addresses food recovery by consumers (e.g., an app where consumers make a conscious choice to recover food) likely has lower risk of leakage than a project that keeps food in the human chain at the farm or retailer level, but still depends on someone to eat, immediately process, or deep freeze (and not discard) the recovered food. A project that recovers food and processes it to produce a new product (e.g., fruit that does not meet retail quality standards is collected and processed as jam) may considerably extend the shelf life of that food, thereby reducing the risk of leakage from eventual discards.

Project proponents must present evidence that the food recovered in the project is not disposed of downstream, e.g., if the project activity adds a treatment process that preserves food prolonging its shelf life by a certain amount of time (as presented in the new label of the recovered food). Such evidence may be from peer-reviewed literature, expert testimony, measurements, surveys, or monitoring of key parameters.

Where evidence does not exist, an adjustment for leakage must be applied to all projects to reflect the probability that the recovered food is discarded. In these cases, leakage emissions from eventual discards must be calculated using a default leakage factor, which represents the percentage of recovered food that would eventually end up, on average, in an FLW destination. Default leakage factors for USA and EU are presented in Table 4 and Table 5, respectively:

- Table 4 provides default leakage factors according to food types and the point in the supply chain at which the project activity is implemented. These are based on average food loss statistics reported by the USDA[29] (values for 2019) and as proxies contain several assumptions.

- Table 5 provides default leakage factors based on a recent study that covers the former 28 countries of the EU (Caldeira et al., 2019; i.e., including the United Kingdom). The leakage factors for the EU have higher granularity than those presented for the US; estimated food waste in Table 5 is reported for every stage of the food supply chain.

Project proponents must use the leakage factors that best represent the recovered food items, making a weighted average of the food-mix where more than one food type is recovered. Leakage factors of broader categories must be used where no specific data on the composition of the recovered food-mix are available. When selecting leakage factors, the most conservative option must be chosen.

To apply leakage factors for other geographies, project proponents must use country-specific data from national statistics or reports on FLW, if available. Where national data are unavailable, project proponents must use FAO's FLW database.[30] Where country-specific data are not available for a certain food group and food supply chain stage in FAO's database, project proponents must use regional statistics from the same source (e.g., if primary production losses for fruits and vegetables are not available for Afghanistan, then use the FLW average of the same food group and supply chain stage for West and Central Asia).

Table 4: Default leakage factors for recovered food per food type and supply chain stage for US projects (USDA, 2019)

Food Group Category	Primary Production (percent)	Retail (percent)[a]	Final Consumer (percent)[b]
Meat, fish, eggs	27	5	22
Meat	-	4	23
Fish and seafood	-	8	31
Eggs	-	7	21
Dairy products	0	11	20
Beverage milks	0	12	23
Cheese	0	6	24
Fruits	18	12	21
Grains	0	12	20
Nuts	0	6	19
Vegetables	31	9	23
Fats	0	21	22

[29] Available at: https://www.ers.usda.gov/data-products/food-availability-per-capita-data-system/food-availability-per-capita-data-system/#Loss-Adjusted%20Food%20Availability

[30] Available at: https://www.fao.org/platform-food-loss-waste/flw-data/en/

Oils	0	21	10
Legumes	0	6	10

[a] Rates noted here include retail, distribution, manufacturing, and processing.
[b] Food services are considered a final consumer together with residential households.

Table 5: Default leakage factors for recovered food per food type and supply chain stage for EU projects (Adapted from Caldeira et al., 2019)

Food Group Category	Primary Production (percent)	Processing & Manufacturing (percent)	Retail & Distribution (percent)	Food Services (percent)	Households (percent)
Meat	0.8	4.7	2.8	11.8	2.8
Fish	0.0	37.8	2.4	6.1	3.7
Dairy	3.3	7.2	2.6	27.6	3.9
Eggs	4.8	1.6	1.6	17.7	4.8
Cereals	1.5	3.2	2.2	10.2	2.8
Fruit	16.3	9.0	1.2	12.7	2.2
Vegetables	19.6	3.8	1.3	17.8	3.2
Potatoes	2.8	4.9	0.7	11.4	1.9
Sugar beets	2.6	0.0	0.3	1.1	0.3
Oil crops	2.5	28.2	0.3	4.0	0.8

Where a leakage factor is used (i.e., a percentage of the baseline scenario given eventual discard), the generic leakage emissions due to eventual discards are calculated as follows:

$$LE_{discards_y} = \sum_{i,j} BE_{i,j,y} \times LF_{i,l} \quad (12)$$

Where:

$BE_{i,j,y}$ Baseline emissions from recovered food ingredient or food category *i* associated with the FLW destination *j* in year *y* (Step 4, Section 8.1) (tCO_2e)

$LF_{i,l}$ Leakage factor of food category *i* in the food supply stage *l* relevant to the project (percent, see default factors in Table 4 and Table 5)

8.3.3 Leakage from Recovering Food from FLW Destinations with Valorization

Where the FLW is valorized by the facility that receives it (e.g., for land application or energy generation), GHG emission reductions can be minimal. All project activities that divert food from an FLW destination facility with valorization must consider additional leakage emissions ($LE_{valorization_y}$). The FLW destinations with valorization are those with a "Yes" in the column "Destinations with valorization" in Table 2.

The following steps must be considered for any FLW that is diverted from a destination with valorization:

Step 1. Demonstrate one of the following:

(i) There is a surplus of FLW or a similar biomass residue in the project region, which the project does not utilize. Project proponents must provide evidence that demonstrates the total quantity of biomass residue (e.g., for energy generation or as feedstock) annually available in the project region is at least 25 percent larger than the quantity of FLW which is utilized annually in the project;

(ii) If the FLW were not diverted, it would not have been collected or utilized (e.g., as fuel, fertilizer, or feedstock) but would have been dumped and left to decay, landfilled with no energy recovery, left in the field to decay after harvest, or burnt without energy generation. Project proponents must provide evidence to support this scenario.

Step 2. In the absence of evidence to demonstrate one of the scenarios outlined in Step 1, projects must use Equation (13) to quantify leakage emissions ($LE_{valorization_y}$). This equation has been adapted from Equation 9 in the CDM Methodological Tool 16 *Project and leakage emissions from biomass, v4.0.*[31]

$$LE_{valorization_y} = \sum_j EF_{CO2,LE} \times M_{FLW,j,y} \times NCV_y \quad (13)$$

Where:

$EF_{CO2,LE}$	CO_2 emission factor of the most carbon intensive fossil fuel used in the country (tCO_2/GJ, see Section 9)
$M_{FLW,j,y}$	Mass of FLW diverted from FLW destination *j* with valorization in year *y* (t)
NCV_y	Net calorific value of FLW in year *y* (GJ/t, see Section 9)

8.4 Net GHG Emission Reductions

The net GHG emission reductions are calculated as follows:

$$ER_y = BE_y - PE_y - LE_y \quad (14)$$

Where:

ER_y	Net GHG emissions reductions from project activities in year *y* (tCO_2e)

[31] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-16-v4.pdf

9 MONITORING

9.1 Data and Parameters Available at Validation

Where there is discretion in the selection of a parameter value, the principle of conservativeness must be applied as described in the latest version of the *VCS Standard*.

Data/Parameter	$EF_{j,y}$
Data unit	tCO_2e/t biomass
Description	Emission factor of FLW destination *j* in year *y*
Equations	Equation (3)
Source of data	Use primary data from the FLW destination facility. If given on a wet basis, the project proponent will also need information on the related DM content of organic waste treated at the facility.
Value applied	Variable
Justification of choice of data or description of measurement methods and procedures applied	This emission factor is relevant for Option 1 to calculate baseline emissions. It is only relevant if the FLW destination facility has primary data available.
Purpose of data	Calculation of baseline emissions
Comments	Project proponents may overrule the calculated discount factor in Equation (3) if they are able to obtain the standard deviation of the provided emission factor from the facility operator.

Data/Parameter	φ_{SWDS}
Data unit	-
Description	Default discount factor to account for model uncertainties.
Equations	Equation (4)
Source of data	Parameter Table 1 in CDM *Methodological Tool 04, v8.0,* section 6.3.1 and 6.4.

Value applied	For humid/wet conditions: 0.85 For dry conditions: 0.8
Justification of choice of data or description of measurement methods and procedures applied	Model correction factor to account for the uncertainties resulting from variability of climatic conditions.
Purpose of data	Calculation of baseline emissions
Comments	-

Data/Parameter	GWP_{CH_4}
Data unit	$tCO_2e/t\ CH_4$
Description	Global warming potential of methane
Equations	Equation (4)
Source of data	IPCC defaults to be taken from the most recent version of the *VCS Standard*
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	Unless otherwise directed by the VCS Program, the *VCS Standard* requires that CH_4 is converted using the 100-year global warming potential derived from the latest IPCC Assessment Report.
Purpose of data	Calculation of baseline and project emissions
Comments	-

Data/Parameter	*MCF*
Data unit	Dimensionless
Description	Methane correction factor
Equations	Equation (4)

Source of data	*IPCC 2006 Guidelines for National GHG inventories*
Value applied	Where the water table at the solid waste disposal site (SWDS) is lower than the bottom of the SWDS, select the applicable value from the following: 1) 1.0 for an anaerobic managed SWDS that has controlled placement of waste (i.e., waste directed to specific deposition areas, a degree of control of scavenging, and a degree of control of fires) and includes at least one of the following: (i) cover material; (ii) mechanical compacting; and (iii) levelling of waste; 2) 0.5 for a semi-aerobic managed SWDS that has controlled placement of waste and includes all of the following structures for introducing air to the waste layers: (i) permeable cover material; (ii) leachate drainage system; (iii) regulating pondage; and (iv) gas ventilation system; 3) 0.8 for an unmanaged deep SWDS, which comprises all SWDS not meeting criteria a) or b) and with depths greater than or equal to 5 meters; 4) 0.4 for an unmanaged shallow SWDS, which comprises all SWDS not meeting criteria a) or b) and with depths of less than 5 meters. This includes stockpiles of solid waste that are considered SWDS (according to the definition given for an SWDS in the CDM *Methodological Tool 04, v8.0*). Where the water table at the SWDS is above the bottom of the SWDS, project proponents must estimate the MCF with Equation 12 in the CDM *Methodological Tool 04, v8.0,* following the requirements thereof.
Justification of choice of data or description of measurement methods and procedures applied	Taken from Table 5 in CDM *Methodological Tool 04, v8.0*. Where Option 2 is used to calculate baseline emissions and the water table at the SWDS is lower than the bottom of the SWDS, MCF is established at the start of the project. If the water table at the SWDS is above the bottom of the SWDS, MCF must be monitored throughout the project.
Purpose of data	Calculation of baseline emissions
Comments	If the water table at the SWDS is higher than the bottom of the SWDS, project proponents will have to know the depth of the SWDS and monitor annually the average height of the water table in the SWDS. Only relevant for Option 2 within Step 4

Data/Parameter	$EF_{default_{j,y}}$
Data unit	tCO_2e/t DM
Description	Default emission factor of FLW destination *j* in year *y*
Equations	Equation (5)
Source of data	Table 2 provides default emission factors for calculating baseline emissions from FLW destinations. The values for anaerobic digestion, composting, and controlled combustion are adapted from the emission factors in the US EPA (2020) report; combustion EF from Exhibit 1-44, composting EF from Exhibit 1-43, and wet and dry anaerobic digestion EF from Exhibit 1-52 and Exhibit 1-51, respectively. The values for landfill and open dump are adapted from the CDM *Methodological Tool* 04: Tool to determine methane emissions avoided from disposal of waste at a solid waste disposal site. The values for open burning are adapted from the Ecoinvent 3.8 database. The values for sewer/wastewater represent the average anaerobic digestion EF from US EPA (2020) plus the GHG emissions from an average electricity consumption at wastewater treatment plants for aeration (Ecoinvent 3.8).
Value applied	Variable based on FLW destination
Justification of choice of data or description of measurement methods and procedures applied	The default emission factors are globally representative of the listed FLW destinations since the factors are reflective of a technology rather than geography dependent.
Purpose of data	Calculation of baseline emissions
Comments	-

Data/Parameter	$D_{j,y}$
Data unit	km
Description	Distance travelled by waste collection vehicle for the collection of food flows going to FLW destination *j* during year y
Equations	Equation (6)

Source of data	Logistic logbook, trip records, or indirectly calculated from location data
Value applied	Estimated distance based on location of FLW source(s) and FLW destination(s)
Justification of choice of data or description of measurement methods and procedures applied	Estimated once at the start of the project
Purpose of data	Calculation of baseline emissions
Comments	It must correspond to the distance(s) between the FLW source and the FLW destination(s), measured, inferred, calculated, or estimated in Step 1

Data/Parameter	$EF_{trans.mode_{m,y}}$
Data unit	kg CO_2e/t km
Description	Emission factor of transportation mode *m* used in year *y*
Equations	Equation (6), Equation (8)
Source of data	DEFRA's *GHG conversion factors 2022*
Value applied	If unknown, a default value of 0.00022924 may be used (based on the emission factor of a diesel truck)
Justification of choice of data or description of measurement methods and procedures applied	The DEFRA emission factors are globally representative and reflect a technology whose performance is not geography dependent.
Purpose of data	Calculation of baseline and project emissions
Comments	Please note that DEFRA provides emission factors in kg CO_2e/t km. Equations 6 and 8 provide a conversion factor to convert kg CO_2e/t km to tCO_2e/t km.

Data/Parameter	$EF_{CO2,LE}$
Data unit	tCO_2/GJ
Description	CO_2 emission factor of the most carbon intensive fossil fuel used in the country

Equations	Equation (13)
Source of data	Identify the most carbon intensive fuel type pulling from literature or other sources (e.g., IEA, https://www.iea.org/). If available, use national default values for the CO_2 emission factor. Otherwise, IPCC default values may be used.
Value applied	Variable by country
Justification of choice of data or description of measurement methods and procedures applied	Selected at the start of the crediting period
Purpose of data	Calculation of leakage emissions
Comments	-

Data/Parameter	NCV_y
Data unit	GJ/t
Description	Net calorific value of FLW in year y
Equations	Equation (13)
Source of data	Table 1.2 in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories
Value applied	11.6
Justification of choice of data or description of measurement methods and procedures applied	This value represents the default net calorific value for the biomass fraction of municipal wastes, which is most representative of FLW. The IPCC Guidelines for National Greenhouse Gas Inventories is internationally recognized, and the data provided in the guidelines is peer reviewed.
Purpose of data	Calculation of leakage emissions
Comments	-

9.2 Data and Parameters Monitored

Data/Parameter	$DM_{j,y}$

Data unit	Unitless (% of total weight of the mass measured)
Description	Mean dry matter content of FLW flows going to destination facility *j* in year *y*
Equations	Equation (2), Equation (3), Equation (4), Equation (5), Equation (7)
Source of data	USDA Food Data Central database. Region, or country-specific food databases also available at FAO/Infoods site
Description of measurement methods and procedures to be applied	Use water content parameters of food ingredients or categories from USDA Food Data Central Database (or other regional databases if necessary), to determine the water content of each food category. The dry matter content is the inverse of the calculated food water content.
Frequency of monitoring/recording	Annually
QA/QC procedures to be applied	-
Purpose of data	Calculation of baseline emissions
Calculation method	-
Comments	Since the DM content of the recovered food is a critical parameter for the calculation of avoided GHG emissions, project proponents should strive for full characterization of the recovered food-mix in terms of water content. Where it is not possible to infer the DM content of the recovered food from existing records, the default DM value of 0.27 must be applied (step 3) or it may be derived through sampling. Once the composition of the recovered food-mix is known, standard water content as found in Food Central database may be applied. The mass of recovered food must be quantified prior to any processing or modification associated with the project activity

Data/Parameter	$M_{FLW,j,y}$
Data unit	t
Description	Mass of food (FLW flows) going to FLW destination *j* in year *y*
Equations	Equation (2), Equation (3), Equation (4), Equation (5)
Source of data	Direct measurements, inferred from surveys, or indirectly calculated from existing food records
Description of measurement methods	A specific quantification method is not required. Project proponents must choose the method most practical for their project and that best minimizes the degree of uncertainty. The quantification method must

and procedures to be applied	address the natural variability of FLW, in terms of i) spatial variations; ii) temporal variations; and iii) uncertainty or fundamental variation due to FLW heterogeneity. Further guidance for different methods can be found in Chapter 9 of the FLW Standard.
Frequency of monitoring/recording	Annual records must be used as a minimum.
QA/QC procedures to be applied	Where the food has a heterogeneous composition (i.e., with diverse food ingredients from different origins and/or seasonality), food-mix compositions inferred from records must be cross-checked with source sampling.
Purpose of data	Calculation of baseline emissions
Comments	-

Data/Parameter	$f_{j,y}$
Data unit	Fraction
Description	Fraction of CH_4 captured, flared, combusted, or recovered at the landfill destination *j* in year *y*
Equations	Equation (3)
Source of data	Select the maximum value from the following: (a) contractual or regulatory requirements specifying the amount of methane that must be destroyed/used (where available) and (b) historic data on the amount of methane captured.
Description of measurement methods and procedures to be applied	Historic data on the amount of methane captured by the landfill must be monitored
Frequency of monitoring/recording	Once for the crediting period
QA/QC procedures to be applied	-
Purpose of data	Calculation of baseline emissions
Calculation method	-
Comments	Only relevant for Option 2 within Step 4 for calculating baseline emissions

Data/Parameter	*MCF*
Data unit	Dimensionless
Description	Methane correction factor
Equations	Equation (3)
Source of data	*IPCC 2006 Guidelines for National GHG inventories*
Description of measurement methods and procedures to be applied	Where the water table at the solid waste disposal site (SWDS) is lower than the bottom of the SWDS, select the applicable value from the following: 1) 1.0 for an anaerobic managed SWDS that has controlled placement of waste (i.e., waste directed to specific deposition areas, a degree of control of scavenging, and a degree of control of fires) and includes at least one of the following: (i) cover material; (ii) mechanical compacting; and (iii) levelling of waste; 2) 0.5 for a semi-aerobic managed SWDS that has controlled placement of waste and includes all of the following structures for introducing air to the waste layers: (i) permeable cover material; (ii) leachate drainage system; (iii) regulating pondage; and (iv) gas ventilation system; 3) 0.8 for an unmanaged deep SWDS, which comprises all SWDS not meeting criteria a) or b) and with depths greater than or equal to 5 meters; 4) 0.4 for an unmanaged shallow SWDS, which comprises all SWDS not meeting criteria a) or b) and with depths of less than 5 meters. This includes stockpiles of solid waste that are considered SWDS (according to the definition given for an SWDS in the CDM *Methodological Tool 04, v8.0*). Where the water table at the SWDS is above the bottom of the SWDS, project proponents must estimate the MCF with Equation 12 in the CDM *Methodological Tool 04, v8.0,* following the requirements thereof.
Frequency of monitoring/recording	Where Option 2 is used to calculate baseline emissions and the water table at the solid waste disposal site (SWDS) is lower than the bottom of the SWDS, MCF is established at the start of the project. If the water table is above the bottom of the SWDS, MCF is monitored annually.
QA/QC procedures to be applied	-
Purpose of data	Calculation of baseline emissions
Calculation method	-

Comments	In case the water table at the SWDS is higher than the bottom of the SWDS, project proponents will have to know the depth of the SWDS and monitor annually the average height of the water table in the SWDS. Only relevant for Option 2 within Step 4.

Data/Parameter	$M_{FLWm,x,y}$
Data unit	t
Description	Sum of the mass of recovered food (FLW flows) going from the FLW source to new destination *x* by transport mode *m* during year *y*
Equations	Equation (7)
Source of data	Direct measurements, inferred from surveys, or indirectly calculated from existing food records
Description of measurement methods and procedures to be applied	A specific quantification method is not required. Project proponents must choose the method most practical for their project and that best minimizes the degree of uncertainty. The quantification method must address the natural variability of FLW, in terms of i) spatial variations; ii) temporal variations; and iii) uncertainty or fundamental variation due to FLW heterogeneity. Further guidance for different methods can be found in Chapter 9 of the FLW Standard.
Frequency of monitoring/recording	Annual records must be used as a minimum.
QA/QC procedures to be applied	For project activities where the recovered food has a heterogeneous composition (i.e., with diverse food ingredients from different origins and/or seasonality), food-mix compositions inferred from records must be cross-checked with source sampling.
Purpose of data	Calculation of project emissions
Comments	-

Data/Parameter	$EF_{trans.mode_{m,y}}$
Data unit	kg CO_2e/t km
Description	Emission factor of transportation mode *m* used by project activities to recover food in year *y*
Equations	Equation (7)
Source of data	DEFRA's *GHG conversion factors 2022*
Value applied	Project proponents must select the relevant emission factors to the utilized transportation modes from the referred source

Description of measurement methods and procedures applied	The emission factors from DEFRA are globally representative and reflect a technology whose performance is not geography dependent.
Frequency of monitoring/recording	Annually
QA/QC procedures to be applied	-
Purpose of data	Calculation of project emissions
Comments	Please note that DEFRA provides emission factors in kg CO_2e/t km. Equation 8 provides a conversion factor to convert kg CO_2e/t km to tCO_2e/t km.

Data/Parameter	$D_{m,x,y}$
Data unit	km
Description	Distance travelled by transport mode *m* for the collection of recovered food flows from FLW source *x* to new destination during year *y*
Equations	Equation (7)
Source of data	Logistic logbook, trip records, or indirectly calculated from location data
Description of measurement methods and procedures to be applied	Project proponents must estimate the distances between recovered food points (i.e., FLW source) and project warehouse or processing facility addresses (i.e., destination of recovered food).
Frequency of monitoring/recording	Annually
QA/QC procedures to be applied	-
Purpose of data	Calculation of project emissions
Calculation method	-
Comments	-

Data/Parameter	$M_{material_{p,y}}$
Data unit	t
Description	The mass of additional materials type *p* used in the project scenario in year *y*
Equations	Equation (10)
Source of data	Direct measurements, inferred from surveys
Description of measurement methods and procedures to be applied	Project proponents should directly measure the mass of additional materials used in the project scenario. If it is not possible to directly measure, projects may infer from surveys of a representative sample of packaging materials. Justification must be provided to support any estimates made.
Frequency of monitoring/recording	Annual
QA/QC procedures to be applied	-
Purpose of data	Calculation of project emissions
Calculation method	-
Comments	Projects should minimize the amount of additional materials used in the project scenario. If possible, projects should use materials with low impact (e.g., recycled materials).

Data/Parameter	$EF_{material_{p}}$
Data unit	tCO_2e/t material type *p*
Description	Emission factor of additional material type *p* used by project activities to recover food
Equations	Equation (10)
Source of data	US EPA, Documentation for GHG Emission and Energy Factors Used in the Waste Reduction Model (WARM): Containers, Packaging, and Non-Durable Good Materials Chapters. November 2020.
Description of measurement methods and procedures to be applied	Project proponents must select the relevant emission factors based on the type(s) of additional packaging used in the project scenario
Frequency of monitoring/recording	Annual

QA/QC procedures to be applied	-
Purpose of data	Calculation of project emissions
Calculation method	-
Comments	-

Data/Parameter	$LF_{i,l}$
Data unit	Percent
Description	Leakage factor of food category *i* in the food supply stage *l* relevant to the project
Equations	Equation (12)
Source of data	Default factors are provided in Table 4 and Table 5. Table 4 provides default leakage factors according to food types and the point in the supply chain at which the project activity is implemented. These are based on average food loss statistics reported by the USDA (values for 2019) and as proxies contain several assumptions. Table 5 provides default leakage factors based on a recent study that covers the former 28 countries of the EU (Caldeira et al., 2019; i.e., including the United Kingdom). The leakage factors for the EU have higher granularity than those presented for the US; estimated food waste in Table 4 is reported for every stage of the food supply chain.
Description of measurement methods and procedures to be applied	Project proponents must select the relevant default leakage factor based on the food category and stage in the food supply chain. Projects must select the most conservative default leakage factor.
Frequency of monitoring/recording	Annual
QA/QC procedures to be applied	-
Purpose of data	Calculation of leakage emissions
Calculation method	-
Comments	-

9.3 Description of the Monitoring Plan

Monitored parameters are collected and recorded at the sample unit scale, and emission reductions are estimated independently for every sample unit. The main objective of monitoring is to quantify recovered food flows, distribution distances, and transport modes during the project crediting period, prior to each verification, and energy and material consumption related to food processing where applicable.

Project proponents must detail the procedures for collecting and reporting all data and parameters listed in Section 9. The monitoring plan must contain at least the following information:

1) A description of each monitoring task to be undertaken, and the technical requirements therein;
2) Definition of the accounting boundary, spatially delineating any differences in the accounting boundaries and/or quantification approaches;
3) Parameters to be measured;
4) Data to be collected and data collection techniques and sample designs for directly sampled parameters;
5) Modeling plan, if applicable;
6) Anticipated frequency of monitoring, including anticipated definition of “year” (i.e., fixing a starting date);
7) Ten-year baseline re-evaluation plan, detailing source of regional (sub-national) data and procedures to revise the baseline schedule of management activities where necessary;
8) Quality assurance and quality control (QA/QC) procedures to ensure accurate data collection and screen for, and where necessary correct, anomalous values, ensure completeness, perform independent checks on analysis results, and other safeguards as appropriate;
9) Data archiving procedures, including procedures for any anticipated updates to electronic file formats. All data collected as a part of monitoring processes, including QA/QC data, must be archived electronically, and kept for at least two years after the end of the last project crediting period; and
10) Roles, responsibilities and capacity of monitoring team and management.

10 REFERENCES

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APPENDIX 1: FLW DESTINATIONS

The following destination definitions are adapted from the *FLW Standard* (FLW Protocol, 2016).

Codigestion/anaerobic digestion
Breaking down material via bacteria in the absence of oxygen. This process generates biogas and nutrient-rich matter. Codigestion refers to the simultaneous anaerobic digestion of food loss and waste and other organic material in one digester. This destination includes fermentation (converting carbohydrates—such as glucose, fructose, and sucrose—via microbes into alcohols in the absence of oxygen to create new products).

Composting/aerobic processes
Breaking down material via bacteria in oxygen-rich environments. Composting refers to the production of organic material (via aerobic processes) to be used as a soil amendment.

Controlled combustion
Sending material to a facility that is specifically designed for combustion in a controlled manner, which may include some form of energy recovery. This may also be referred to as incineration.

Land application
Spreading, spraying, injecting, or incorporating organic material onto or below the surface of the land to enhance soil quality

Landfill
Sending material to an area of land or an excavated site that is specifically designed and built to receive wastes

Not harvested/plowed-in
Leaving crops that were ready for harvest in the field or tilling them into the soil

Refuse/discards/litter
Abandoning material on land or disposing of it in the sea. This includes open dumps (i.e., uncovered, unlined), open burning (i.e., not in a controlled facility), the portion of harvested crops eaten by pests, and fish discards (the portion of total catch that is thrown away or slipped).

Sewer/wastewater treatment
Sending material down the sewer (with or without prior treatment), including that which may go to a facility designed to treat wastewater

APPENDIX 2: GUIDANCE ON REPRESENTATIVE FLW SAMPLING

FLW sampling is required in cases where no food or FLW records exist. Representative FLW sampling is necessary to determine the amounts (wet mass) and water fraction (or conversely, dry matter content) of the FLW flows and food streams recovered by project activities. This allows calculation of avoided GHG emissions from keeping food in the human supply chain using this methodology. Representative FLW sampling must be made to address the natural variability of FLW, in terms of: i) spatial variations; ii) temporal variations; and iii) uncertainty or fundamental variation due to FLW heterogeneity. Addressing variability and heterogeneity in a consistent and systematic manner may require sampling large amounts of FLW, thereby increasing cost and effort. Hence, in practice, representative FLW characterization is a compromise between limited resource availability and the need for generating robust and usable results.

Appendix A of the *FLW Standard* (2016) provides general guidance on sampling, including considerations relevant to selecting a sampling approach, obtaining a sample that represents FLW production over time, and determining an appropriate sample size. It also provides guidance on approaches for scaling up data, which is required when the sample data do not cover the whole population and/or timeframe of the FLW inventory.

Important aspects to consider when planning FLW sampling include:

1) **Sample size:** The amount of FLW that is retrieved from the primary lot depends on the heterogeneity of the material and the size of the waste particles (e.g., homogeneous FLW may require a sample size <100 kg, whereas FLW composed of multiple heterogeneous products may require a larger sample size)[32].

2) **Number of subsamples:** The number of subsamples included in the sample, where subsamples originate for example from source points, depends on the size of the area surveyed and the level of significant representativeness to be reached. For example, Nordtest (1995)[33] recommends a sample of 100–200 households when investigating waste composition in a defined community.

3) **Number of repetitions:** FLW may be linked to seasonality, hence repeated sampling may be required to address temporal variation. Edjabou et al. (2018, 2019)[34] recommend collection and analysis of at least one sample per season where it is known that FLW may vary seasonally.

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[32] European Committee for Standardization (CEN) (2005). DS/EN 14899 Characterization of waste – Sampling of waste materials – Framework for the preparation and application of a sampling plan. European Standard EN 14899.

[33] Nordtest (1995). *Municipal Solid Waste: Sampling and Characterisation. NT ENVIR 001*. Nordtest Method. Espoo, Finland. Available at: http://nordtest.info/images/documents/nt-methods/environment/NT%20envir%20001_Solid%20waste,%20municipal_Sampling%20and%20characterisation_Nordtest%20Method.pdf

[34] Edjabou, M.E., Boldrin, A., & Astrup, T.F. (2018). Compositional analysis of seasonal variation in Danish residual household waste. *Resources, Conservation and Recycling*, *130*, 70–79. https://doi.org/10.1016/j.resconrec.2017.11.013

DOCUMENT HISTORY

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