Addendum to Companies in the United Arab Emirates on how to use the:

"Connecting Food Loss and Waste to Greenhouse Gas Emissions: Guidance for Companies"

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Foreword

As one of the main causes of deforestation, biodiversity loss and water scarcity, we can all see that the food system is feeding climate change. We know by now that food loss and waste (FLW) is a global issue and when we waste food, we throw away the precious resources that went into producing it. The greenhouse gas (GHG) emissions from processing, storage, packaging and transportation of food that becomes waste are huge.

We've seen through our work that many businesses have a 'lightbulb' moment when they actually measure their food waste and its environmental impact. The adage says, 'what gets measured gets managed', and measurement of emissions and waste are so crucial in forcing us to confront the reality and empowering us to do something about it.

We also know that businesses and organisations value clear guidance on making the connection between FLW and GHG emissions in a robust, transparent manner. Through our experience with international partners, we know that guidance and support must be adapted to the specific context and geography in which we're working. This is why WRAP and Thriving Solutions have joined forces to review global best practice guidance on measuring the GHG impact of FLW. Together, we have assessed its suitability for use in the United Arab Emirates; a country that is acutely aware of the climate impacts of FLW. Indeed, at COP28 the United Arab Emirates (UAE) put food systems transformation high on its agenda via the Declaration on Sustainable Agriculture, Resilient Food Systems and Climate Action, and the national FLW initiative ne'ma will play a crucial role in this.

We believe that measuring the greenhouse gas footprint of food waste in the UAE is not merely a statistical exercise; it will empower both individuals and organisations to make informed decisions, re-evaluate supply chains, and champion sustainable practices that resonate with the UAE's vision for a greener, more sustainable future.

This document lays the foundation for guidance to businesses in the UAE who are seeking to measure and tackle the GHG emissions associated with their FLW. It also highlights the gaps that need to be addressed by the UAE if it wants to ensure that GHG estimations connected to food loss and waste are more accurate and representative.

We look forward to working with governments and businesses in the UAE and the Arab region as together we accelerate progress on reducing the GHGs and footprint of our food and drink system and ensuring that no good food goes in the bin.

If you haven't already, now is the time to commit and play your part in tackling climate change!

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EXECUTIVE SUMMARY

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The Food Loss and Waste (FLW) Standard requires companies to quantify and report their FLW in weight, while recognizing the value of also quantifying and reporting FLW in alternative units of measure that are relevant to the company. In 2021, the FLW Protocol launched "Connecting Food Loss and Waste to Greenhouse Gas Emissions: Guidance for Companies", to support companies in the food system quantify their FLW in greenhouse gas (GHG) emissions. The Guidance for Companies provides step-by-step instructions on how to understand, calculate, describe and communicate the scale and relevance of their GHG emissions associated with their FLW.

According to the Worldwide Fund for Nature (WWF), around 40% of all produced food is lost or wasted, and unconsumed food is responsible for 10% of global GHG emissions. When food waste decomposes in landfills, it releases methane, a GHG that has 27 times the heat trapping capacity of carbon dioxide. Hence, capturing how FLW is handled and discarded is essential. By reducing FLW, we minimize the need to convert more land for agricultural production to meet the food needs of a growing global population. This will limit the growth in fertilizer usage and minimize the direct and indirect usage of fossil fuels to meet the energy requirements along the food value chain. Moreover, by reducing FLW, less food is sent to landfills to decompose and release GHGs and contaminate air, water and land.

This document identifies which of the nine third-party tools listed in the Guidance to Companies for calculating FLW-associated GHG is suitable for use in the United Arab Emirates (UAE). It also highlights the limitations of the tools and the need for further research to develop region-specific conversion factors for the UAE.

The review which informed these findings and recommendations, focused on identifying the assumptions and applicability of each of the tools and associated data sources for conversion factors. It identifies which tools include conversion factors for the UAE, which are adaptable, and which cannot be used for the UAE. It also presents the various secondary data sources for conversion factors to be used, highlights the importance of selecting comparative data based on the reliability, activity scope, and geographic scope of the data.

The Agro-Chain Greenhouse Gas Emissions (ACE) Calculator is the only tool that includes emission factors specific to the UAE and requires minimal adaptation for use. Four tools do not include the UAE in their geographic scope but allow users to adapt them. Among these tools, the Cool Food Calculator is the most applicable and easiest to adapt to UAE conditions.

Food-related emission factors, be it for locally produced food or for imported food for local consumption, are not readily available for the UAE, except for a limited number of food commodities in the FAO-AFOLU Database. The report concludes that a more comprehensive list of UAE emission factors for locally produced and consumed food should be developed to facilitate more accurate GHG emissions calculations.

BACKGROUND

Background

1.0 Connecting Food Loss and Waste to Greenhouse Gas Emissions: Guidance for Companies

Given the significant connection between food loss and waste (FLW) and greenhouse gas (GHG) emissions, in 2021 the Food Loss and Waste Protocol launched the "Connecting Food Loss and Waste to Greenhouse Gas Emissions: Guidance for Companies" guidebook as one of the tools and resources under the Food Loss and Waste Accounting and Reporting Standard (FLW Standard).

To produce, process, package and transport food, we use energy plus natural and financial resources. When that food is not eaten but thrown away, all these resources are lost. This includes all greenhouse gases emitted during land clearing, fertilizer application, methane from livestock and/or rice production, and all associated emissions with the energy used for the wasted food. By reducing food loss and waste we will have more food available for human consumption which will minimize the need to convert more land for agricultural production to meet the needs of a growing population and changing food diets. Thus, limiting the growth in fertilizer usage and minimizing the direct and indirect usage of fossil fuels to meet the energy requirements along the food value chain.

Furthermore, when food waste decomposes in landfills, it releases methane, a GHG that has 27 times the heat trapping capacity of carbon dioxide over a 100-year period, and 56 times over a 20-year period (UNFCCC, n.a.). By reducing FLW less food is sent to landfills to decompose. Hence, the importance of capturing how FLW is handled and discarded.

According to the latest report by Worldwide Fund for Nature (WWF, 2021), around 40% of all produced food is lost or wasted and unconsumed food is responsible for 10% of global GHG emissions (WWF-UK,2021). The UAE is heavily dependent of food imports which constitute 90% of its food requirements (MOCCAE, 2023). However, the country's latest strategy highlights the country's aspirations to expand sustainable local production. No high confidence data currently exists for food loss and waste in the UAE. However, it is estimated that 'food loss in West Asia stands at 44%, and food waste at 34%' (UNEP, 2021). To address food loss and waste, the in May 2020 the UAE launched the National Food Loss and Waste Initiative (ne'ma) to tackle food loss and waste from production to consumption and support the country to achieve an overall objective of halving food loss and waste by 2030.

The FLW Standard requires companies to quantify and report their FLW in weight while recognizing the value of also quantifying and reporting FLW in alternative units of measure that are relevant to the company. Today, we see an increasing drive by the private sector to join the climate action movement and reduce their greenhouse gases. This is observed by the increased number of companies undertaking GHG inventories.

The issued 'Guidance to Companies' is a valuable tool to support companies in the food system undertaking a GHG inventory as it provides step-by-step instructions that helps companies understand, connect, calculate, describe and communicate the scale and relevance of their FLW in GHG emissions. Companies measuring their FLW as per the FLW Standard and pursuing initiatives to manage it will also benefit by being able to estimate the GHG emissions associated with their FLW. It also enables companies to track reductions in GHG emissions associated with reductions in FLW.

The 'Guidance to Companies' is broken down into three parts:

Part 1

How to calculate the GHG emissions associated with FLW

Includes steps and calculations for estimating the GHG emissions associated with FLW and/or its reduction. This includes emissions from the food supply chain, and destination.

Part 2

How to determine the contribution of FLW in a GHG inventory

Includes calculation steps and recommendations guiding companies how to determine the contribution of FLW within a corporate GHG inventory.

Part 3

How to communicate about the GHG benefits of FLW reductions

Includes recommendations for companies seeking to communicate about the contribution of FLW to GHG reduction efforts.

2. Third Party Tools

Using a calculation tool is the most practical mechanism for most companies to calculate FLW-associated GHG emissions. It streamlines the process, ensures consistency and enables running alternative scenarios. The Guidance for Companies advises that a company can either develop its own proprietary calculation tool or use a third-party developed tool. Moreover, it presents nine third-party tools that companies can use to estimate GHG emissions associated with FLW. For their emission factors, these tools use secondary data coming from publicly available datasets that rely on national, regional, or even global averages.

Third-party tools differ in their:

a. Target audience and focus: including geographic scope; sectoral focus, and targeted food products.

b. Which GHG emissions associated with FLW they cover: including emissions related to food supply chains, FLW destinations, and/or climate impacts outside GHG inventory scopes 1–3.

Table 1: Adapted from the Guidance for Companies (Table 2) lists the target audience and focus of each tool.

#	Tool	Primary Audience & Purpose	Stages Covered	Geographic Focus	Granularity of Product Data
1	Agro-Chain Greenhouse Gas Emissions (ACE) Calculator	Broad	Agricultural production until product purchased by consumer	Global, with regional factors	About 20 individual food types, fresh and simple processed product
2	Cool Farm Tool: Food Loss and Waste Module	Farmers	Agricultural production, first level processing (storage, packaging, grading), and transport	Global	Any crop and livestock
3	Cool Food Calculator	Food service operators and retailers (could be modified for other sectors)	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	Includes 50+ food types
4	EPA Waste Reduction Model (WARM)	Broad	Not sector specific	United States	Meat; non-meat & 6 product categories: beef, poultry, grains, bread, fruits and vegetables, and dairy products
5	FLW Value Calculator	Broad	All stages of the food supply chain	Global, with regional factors	9 food types (life-cycle impact of these food types)
6	The Food side flow Recovery LIFe cycle Tool (FORKLIFT)	Broad	Processing	EU-centric with regional factors	6 examples: Apple pomace; pigs' blood; brewers' spent grains; tomato pomace; whey permeate; oilseed press cake
7	Provision Coalition Food Loss + Waste Prevention Toolkit	Processing companies	Processing	Canada	9 food types (user can enter very detailed facility and process data)
8	ReFED US Impact Calculator	Broad	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; factors for 44 individual food types along with processing factors
9	Walmart Waste Diversion Calculator	Walmart suppliers	Simplified version of the EPA WARM calculator (not sector specific)	Global	Meat and non-meat

3. Emission Factors

A key step in estimating GHG emissions associated with FLW and/or its reduction is identifying the specific emissions associated to FLW. The Guidance for Companies identifies three types of FLW-associated emissions:

1. GHG emissions related to food supply chains*.
2. GHG emissions related to FLW destinations.
3. Climate impacts outside GHG inventory scopes 1–3 related to food supply chains and destinations. This may include carbon opportunity costs, avoided emissions, carbon removals and/or carbon storage.

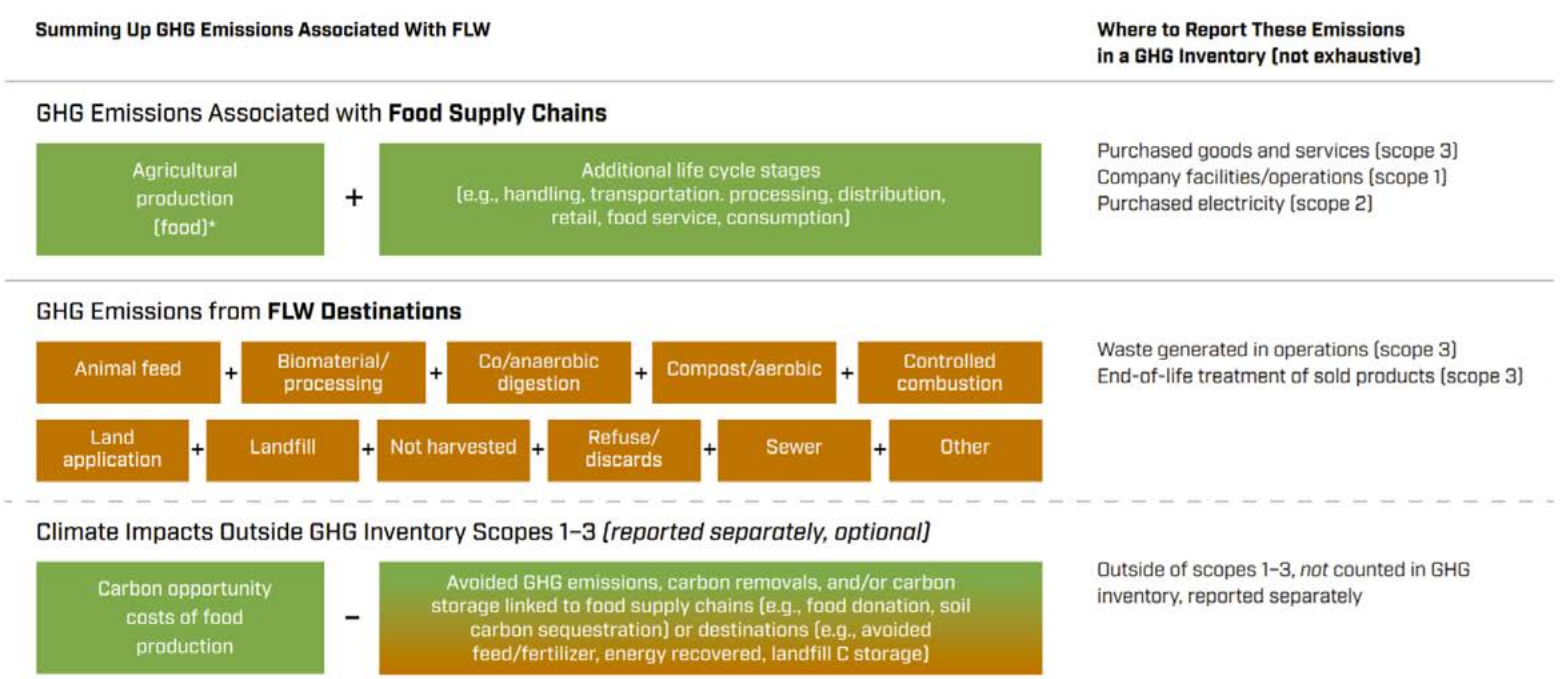
The opposite Figure taken from the Guidance for Companies (Figure 2, page 16) exhibits the 'Framework for Accounting and Reporting on the Various Types of GHG Emissions Associated with FLW'

Emission factors relate the amounts of greenhouse gases emitted by a business to a set amount of activity performed by that business.

To support businesses who do not wish to develop custom values, default values have been developed. These default emission factors are averages based on the most extensive data sets available.

Source: Greenhouse Gas Protocol

Figure 2: Framework for accounting and Reporting omn the various types of GHG Emissions Associated with FLW



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.

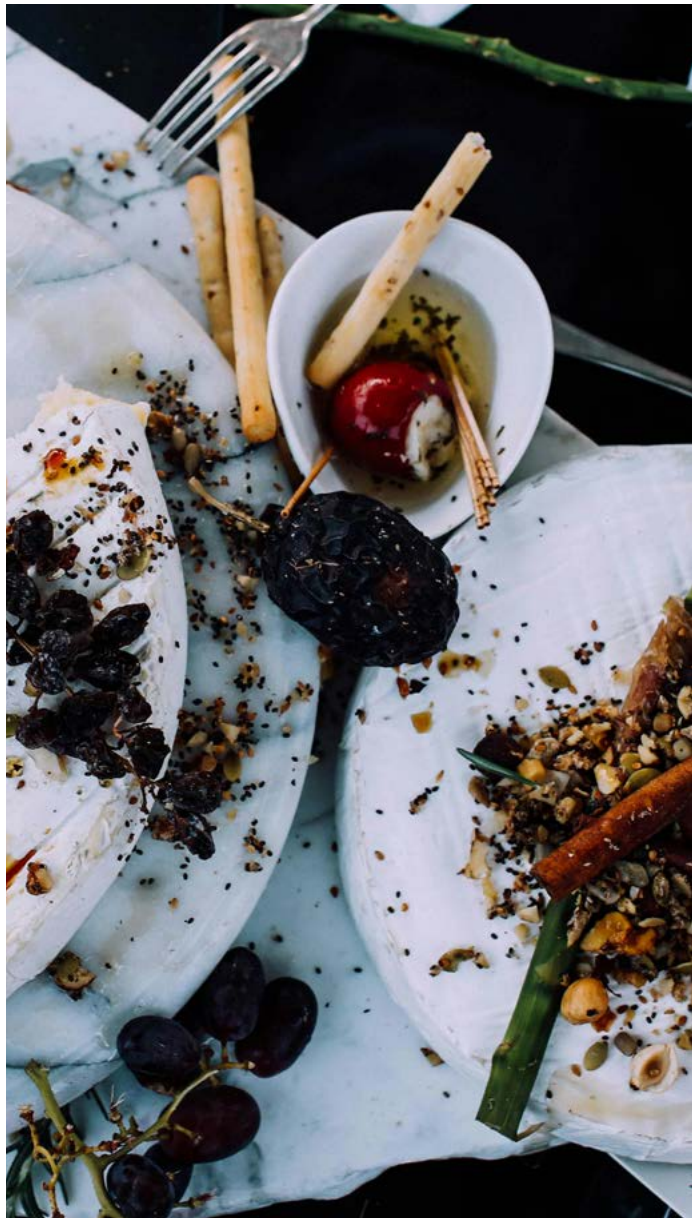
*Given the high percentage of food imports in the UAE, it is critical to distinguish the GHG emissions related to local production versus imported food. Local production dependent on desalinated water may have a higher GHG production footprint than produce produced elsewhere, however, imported food may have higher GHG transportation footprint than locally produced food. When companies carry their assessments, it is imperative to make these distinctions, and do the calculations accordingly.

3. Emission Factors (Cont.)

Calculating any of these three types of emissions requires multiplying the weight of FLW by the relevant emission factor(s). Accordingly, identifying the appropriate values to use for emission factors is one of the most critical components as the soundness of the results depends on it. The 'Guidance to Companies' advises that companies can use:

1. Primary data. Custom values developed for the company and that are specific to its operations. Primary emission factors are the most accurate and companies are recommended to use them whenever such data is available. This is particularly important in gathering accurate data for primary production from specific regions, farms and supply chains, as impacts can vary 60-fold among producers of the same product.
2. Secondary data. Default values that represent global, regional, national or other averages that are applicable to the geographic region and the operations of the company. Using emission factors derived from secondary data allows users a cost-efficient way to estimate GHG emissions when primary data does not exist, and the budget to gather site-specific data on the quantity of emissions released from an activity is not available.

   There are a number of secondary data sources companies can access to select emission factors to use. Third party tools in the Guidance for Companies use a number of secondary data sources. Table 2 below adapted from Tables 2 and 3 in the Guidance for Companies, exhibits both the greenhouse gas emissions covered in each tool and the data sources for these emissions.
3. A combination of both primary and secondary data.



3. Emission Factors (cont) – Table 2: Greenhouse gas emissions and secondary data sources used for each of the third-party tools.

Tool	GHG emissions related to food supply chains		GHG emissions related to FLW destinations		Climate impacts beyond scope 1-3 GHG inventory	
	Which GHG are covered	Data Sources	Which GHG are covered	Data Sources	Which GHG are covered	Data Sources
1. Agro-Chain Greenhouse Gas Emissions (ACE) Calculator	Agricultural production through to retail	Various LCA studies, Porter et al. (2016)	6: anaerobic digestion, composting, incineration (no energy use), left on field, landfill, neglect (dumped)	EPA WARM	Avoided emissions (in composting and anaerobic digestion destinations)	Avoided emissions & carbon storage associated with destinations; see EPA (2019a), section 1.4 for details
2. Cool Farm Tool: Food Loss and Waste Module	Agricultural production (various steps, including direct land use change), packing, storage, transport	A broad range of published data sets and IPCC methods	Quantities of FLW for all 10 FLW Standard destinations, but emissions factors for these destinations are not provided.	Not included	Carbon stock changes (due to changes in management practices)	Studies on soil carbon sequestration from over 100 global datasets
3. Cool Food Calculator	Agricultural production, processing, transport, packaging, upstream FLW assumed	Poore and Nemecek (2018)	4: Anaerobic digestion, combustion, composting, landfill	Added to beta FLW version: EPA GHG Emission Factors Hub (note: avoided emissions and carbon storage not included)	Carbon opportunity costs	Carbon opportunity costs; Searchinger et al. (2018)
4. EPA Waste Reduction Model (WARM)	Agricultural production to retail distribution point	U.S. average figures from various LCA studies	4: composting, landfilling, combustion, anaerobic digestion (includes avoided emissions) + source reduction	U.S. average figures from various LCA studies	Avoided emissions/ carbon storage in certain destinations	Avoided emissions and carbon storage associated with destinations; see EPA (2019a), section 1.4 for details
5. FLW Value Calculator	Agricultural production, handling and storage, processing, packaging, distribution, consumption	Quantis World Food Database Powered by Ecoinvent; additional life cycle impacts assumptions were adapted from the European Commission's Product Environmental Footprint (PEF) guidance	All 10 from FLW Standard except not harvested	Destination impacts were calculated by Quantis using basic assumptions from Expert knowledge	Avoided emissions/ carbon storage in certain destinations	Avoided emissions (calculated by Quantis) included in Several destinations;

3. Emission Factors (cont) – Table 2 (cont): Greenhouse gas emissions and secondary data sources used for each of the third-party tools.

Tool	GHG emissions related to food supply chains		GHG emissions related to FLW destinations		GHG inventory scope 1–3 Climate impacts beyond	
	Which GHG are covered	Data Sources	Which GHG are covered	Data Sources	Which GHG are covered	Data Sources
6. The Food side flow Recovery LIFe cycle Tool (FORKLIFT)	Agricultural production, transport, processing	Various LCA studies	Varies by product analyzed (a pre-set selection of valorization and destination options are included)	Various LCA studies	Avoided emissions associated with destinations	Avoided emissions associated with destinations, see Metcalfe et al. (2019) for details
7. Provision Coalition Food Loss + Waste Prevention Toolkit	Raw material production, amount of energy embedded in the FLW at the point where it is disposed during production/ processing	Raw materials: Tool by Cleanmetrics Electricity: NIR Report GHG Sources and Sinks in Canada Natural gas: CME SmartGreen	6: animal feed, anaerobic digestion, composting, landfill, waste-to-energy, wastewater	Derived from multiple sources including Bernstad et al. (2016), Salemdeeb et al. (2017), and Eriksson et al. (2015).	Avoided emissions associated with destinations	Avoided missions associated with destinations, contact Provision Coalition for details
8. ReFED US Impact Calculator	Agricultural production, manufacturing, retail, food service, residential	U.S. average figures from various LCA studies	All 10 FLW Standard destinations	EPA WARM with adjustments by Quantis	Avoided emissions/ carbon storage in certain destination	Avoided emissions and carbon storage associated with destinations; see ReFED (2020), Tables A1-A6 for details
9. Walmart waste diversion calculator	Agricultural production to retail distribution point	EPA WARM	EPA WARM destinations + donations and animal feed	EPA WARM plus donation and animal feed	Avoided emissions through improved date labelling	Avoided emissions through improved date labeling

3. Emission Factors (cont)

Because food products are typically mixed together when disposed of, it is less important for the waste destination factors to be disaggregated by product than it is for the supply chain emission factors. The key factor is determining the amount of food waste going to each waste destination. This is demonstrated in Option C2 (seen in the following figure) of the 'Guidance for Companies': beef, milk and corn are assigned the same 'landfill emission factor' and 'compost emission factor' as one another, though these products would have substantially different supply chain emission factors. Therefore, companies may seek out appropriate 'mixed food waste' disposal emission factors rather than product-specific ones.

The below Figure taken from the Guidance for Companies (page 41) exhibits the 'Option C2: Where a company knows the product makeup 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 seperately. 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

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

(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	17,421	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

4. Factors to consider when selecting a third-party tool or emission conversion values:

To ensure the quality of generated data pertaining to FLW-associated GHG emissions, the 'Guidance for Companies' outlines the following five critical indicators that companies must consider when choosing the emission factors to adopt and or data sources to use.

Temporal representativeness	The degree to which the data set reflects the actual year or age of the activity.
Geographical representativeness	The degree to which the data set reflects the actual geographic location of the activity, such as country or site.
Completeness	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	The degree to which the sources, data collection methods, and verification procedures used to obtain the data are dependable.
Technological representativeness	The degree to which the data set reflects the actual technology or technologies use.

For companies wishing to use third-party tools to calculate their FLW-associated emissions, the first screening step will be checking if the geographic focus of the tool covers the country where the company operates, and if not the specific country, the region. This is an important first step as the values for calculating emission factors may differ from country to country and region to region. This is particularly important if the tool doesn't allow adapting the emission factors. If the tool does not include the required country or region, but allows for inserting their own conversion factors, then the next step will be identifying the applicable conversion factors. It is important to identify a reliable data source when considering secondary datasets, sources that have been approved by the national government, academic schools and international government communities should be given priority over other sources.

After identifying that a certain third-party tool caters for your geographical location, be it through built-in applicable emission factors, or by allowing users to adapt the tool, the next important factor to look into is the sectoral focus area of the tool and if it is reflective of the business of the company. The next step is to evaluate the technological representativeness and how it corresponds with the business operations. Although some tools can be adapted for other sectors, this basic screening allows for identification of the appropriateness of the tool as is, without the need for adaptation.

THIRD PARTY TOOLS SUITABLE FOR USE IN THE UNITED ARAB EMIRATES

The purpose of this document is to identify the third party GHG tools in the 'Guidance for Companies' manual that can be used by companies in the United Arab Emirates (UAE) either in their current form or adapted, and identify the main secondary data sources for conversion factors that can be used by companies in the UAE.

1. Methodology

To identify the third-party tools UAE companies can use, we reviewed the Guidance document, each of the nine third-party tools, as well as the associated data sources with each of the tools. The objectives from the review was to:

1. Identify the assumptions in each tool and which aspects of the food waste affecting the related emission factors are allowed in the tool and if these are applicable to the UAE.
2. Identify which of the nine third party tools include conversion factors that apply to the UAE, highlighting how a company in the UAE must use each tool to ensure it selects the applicable conversion factors for the UAE.
3. For the tools that do not include conversion factors that apply to the UAE, identify if they are applicable and/or adaptable to the UAE.
4. Identify the tools that cannot be adapted for the UAE due to not including conversion factors applicable to the UAE, and not having the option allowing users to override the default emission factors with customized information and conversion factors.
5. Do a search of the main secondary data sources including those listed in Table 3, with the objective to identify which have conversion factors for the UAE and can be used as reference for the UAE.

2. Third Party Tools

To identify which tools can be used by companies in the UAE, each tool was assessed based on various parameters including the outlined assumptions considered when developing the tool, the tool's applicability to the UAE, and the tool's methodology including the production to destination database. Also assessed was the conversion factors used by each tool, the sources of the conversion factors, their geographical applicability and relevance in the UAE.

Review Findings

Table 3 exhibits which of the nine tools include conversion factors for the UAE and which tools allow users to adapt them by including custom conversion factors.

Table 3: Third-party tool that cover UAE in their geographical scope, and tools adaptable

Table 3: Third-party tool that cover UAE in their geographical scope, and tools adaptable

Tool	UAE emission factors	Tool is adaptable
1. Agro-Chain Greenhouse Gas Emissions (ACE) Calculator	Yes	Yes
2. Cool Farm Tool: Food Loss and Waste Module	No	Yes
3. Cool Food Calculator	No	Yes
4. EPA Waste Reduction Model (WARM)	No	No
5. FLW Value Calculator	No	Yes
6. The Food side flow Recovery LIFe cycle Tool (FORKLIFT)	No	Yes
7. Provision Coalition Food Loss + Waste Prevention Toolkit	No	No
8. ReFED US Impact Calculator	No	No
9. Walmart waste diversion calculator	No	No

Only one tool - the Agro-Chain Greenhouse Gas Emissions (ACE) Calculator developed by the Consultative Group on International Agricultural Research program on Climate Change, Agriculture and Food Security - has geographic scope applicable to the UAE and can be used by companies in the region with minimal adaptation required. It includes the North African and West Central Asia region. Thus, it incorporates region specific emission factors, including the UAE.

The ACE Calculator uses the United Nations Food and Agriculture Organization (FAO) specifically the FAO-AFOLU Database as the source of its emission factors. Moreover, if a specific emission factor is not available for a given case, the tool allows users to either input their own values or choose an emission factor provided for other countries within the region.

The limitation in terms of accuracy of the calculations on FLW-associated GHGs is that the grid emission factor used for North Africa and West Central Asia is an average for the region and not specific to the UAE. Furthermore, as of March 2023, the FAO database includes for the UAE, emission conversion factors for a limited list of food commodities as presented in Table 4.

Table 4: Food Commodities which have emission conversion factors in the FAO Database:

Cereals excluding rice	Hen eggs in shell, fresh
Meat of cattle with the bone, fresh or chilled	Rice
Meat of goat, fresh or chilled	Raw milk of cattle
Meat of sheep, fresh or chilled	Raw milk of goats
Meat of buffalo, fresh or chilled	Raw milk of sheep
Meat of pig with the bone, fresh or chilled	Raw milk of camel
Meat of chickens, fresh or chilled	

Noticeably, this list is very limited and doesn't include many commodities such as vegetables, tubers or fruits although that is a major food category including imported fresh, frozen and dried vegetables and fruits as well as locally produced vegetables and some fruits. Similarly, it doesn't include seeds, nuts and oilseed. The list includes raw camel milk, but no conversion factor for Camel meat although breeding and raising Camel for their meat and milk is a traditional UAE food category that is growing as different local products are being manufactured including Camel yoghurt and chocolates. This is probably because the UAE doesn't produce these food commodities, but imports them. Given the UAE's high import dependence for food supplies, establishing emission factors for locally consumed food, will be very advantageous as it will provide a more accurate representation of GHG emissions associated with FLW. It will also facilitate calculating GHG emissions of a broader category of food commodities.

Annex 1 gives a comprehensive overview of the Agro-Chain Greenhouse Gas Emissions (ACE) Calculator.

Four tools do not include the UAE in their geographic scope and thus do not include conversion factors applicable to the UAE, but allow users to adapt them. These tools are: (1) Cool Farm Tool: Food Loss and Waste Module; (2) Cool Food Calculator; (3) FLW Value Calculator; (4) Food side flow Recovery LIFe cycle Tool (FORKLIFT).

Nonetheless, not all are usable for the UAE. It is our determination that the most applicable and the easiest to adapt to UAE conditions from these four tools is the Cool Food Calculator.

The Cool Food Calculator is an online tool developed by the World Resources Institute (WRI). Although UAE specific emission factors are not included, it is usable for the UAE. The tool built-in emission factors include factors for Asia that UAE users can opt to choose. Moreover, the tool allows users to enter custom values applicable for the UAE from primary or secondary sources.

Developed as a support tool for members of the Cool Food Pledge, the Calculator is designed as a cost-effective versatile tool based on commonly available data, that enables organizations in the business of serving food to calculate the carbon footprint of their meals and identify opportunities to reduce emissions. Utilizing the Scope 3 standard to calculate annual upstream emissions associated with purchased goods and services from their origin to the point of purchase, the tool calculates 5 sets of metrics:

Food purchases by food type in kilograms or pounds.

Food-related GHG emissions from agricultural supply chains in tons of CO2eq.

Food-related land use in hectares.

Food-related carbon opportunity costs in tons of CO2eq.

Normalized metrics

This helps organizations establish a baseline and monitor progress to reduce emissions. It allows the user to customize serving sizes and track the impact this will have on GHG emission and associated land use. The tool provides a breakdown of emission factors utilized, including those related to transportation, and can be customized to include imported items.

Given the large and active food service industry in the UAE, the Cool Food Calculator provides a valuable tool that individuals and food service organizations can utilize to assess the carbon footprint of their meals and identify effective measure to reduce it. Investments by the UAE to work with the developers of the tool to further adapt it with built-in UAE-specific emission factors (for locally consumed food including locally produced and imported, as well as FLW destination GHG emissions) rather than the Asia ones, will improve the accuracy of the calculations for the UAE and make it even more applicable for UAE-based food service providers.

The Cool Farm Tool: Food Loss and Waste Module targets food producers enabling them to calculate the GHG emissions related to the agricultural production of a specific product be it plant or livestock depending on the impact of the location on fuel and energy, and the annual average temperature on emissions from fertilizers and soil carbon management. The tool is built-up in a way that each farm constitutes a single user with a separate account. While the tool does not provide emissions for FLW standard destinations, it offers flexibility in user input as long as users have these values.

The tool includes scope 3 emissions that occur on the farm during grading, packing, storage and other post-harvest operations. It also includes loading and transport methods that are within the farms control and not the full supply chain. Other emissions such as machinery and building infrastructure are not covered to simplify the use of the tool. This could be a limiting factor for use of the tool by large controlled-environment production facilities that require large facilities and are heavily reliant on machinery, and controlling the internal temperature.

The tool requires users to enter specific data to be able to complete the carbon footprint calculations. Data ranges from general information about the grown crop, year, harvested yield and yield to market, to more specific information such as the crop area, soil texture, soil organic matter, soil moisture, soil drainage and PH, number of pesticide applications, crop residue management, land use change, tillage change, cover crop. It also requires users to input data related to energy, processing, and transportation (to and from the farm). For large and sophisticated producers, this kind of information will be available, but that may prove to be a limiting factor for the tool's usage by the smaller farmers and hobby farmers in the UAE. If this tool is to be utilized by them, they may require technical support to enable them to quantify these different data calculations required by the tool.

Currently, the Cool Farm Tool: Food Loss and Waste Module does not provide region-specific emission factors. While it allows users to adapt it and enter custom emission factors as long as users have these values it is critical that the values

entered are well-defined as different locations will impact fuel and energy consumption differently. The scarce existing UAE-related emission factors in secondary data depositories such as FAO and IPCC is a limiting factor for users in the UAE especially. Given the UAE government's direction to increase local production, it will be beneficial to undertake an exercise to identify the food commodities UAE production is expanding in but are currently not in the FAO Database, and establish conversion factors for them.

The FLW Value Calculator is designed to help companies understand the value of preventing food waste by assisting them to quantify their FLW in other values additional to volume, specifically carbon footprint, water scarcity footprint, soil quality index, eutrophication, and nutritional content. The FLW environmental impacts is the sum of agricultural production impacts plus all intermediary life cycle impacts between production and disposal (e.g. transport, storage, processing, cooking), plus destination impacts.

The tool does not include conversion factors related to the UAE, and though it lists North Africa, Central and West Asia as an option, the current beta version does not have sufficient database to calculate the emissions for the region. Some of the sources for conversion factors that the tool uses such as FAO, IPCC, EPA, Quantis World Food Database Powered by Ecoinvent have some applicable conversion factors for the UAE. However, the scope of these applicable conversion factors is limited, and users will have to identify global proxies to use which decreases the accuracy of the projections.

Currently, Life Cycle Assessment studies are mostly carried out in the European Union are the basis for the FLW Value Calculator's emission factors. Similar Life Cycle Assessment studies for the UAE would be advantageous. Work carried by Abu Dhabi Quality and Conformity Council that looked at emission factors, including for waste disposal, can be a starting point for the development of waste destination conversion factors for the UAE.

Quantis, co-creators of the Tool, are open to assisting users to customize the tool to their specific needs. This could be a viable option for UAE companies and academic institutions. UAE government may also opt to consider sponsoring the adaptation of the tool to local needs by Quantis and a UAE research and academic institution. This will make the tool more versatile and applicable for use by UAE companies.

The Food side flow Recovery LIFe cycle Tool (FORKLIFT) is designed for waste management professionals, local authorities, and interested stakeholders involved in making decisions pertaining to food waste management. Although this spreadsheet tool is user-friendly and allows users to enter custom conversion factors, it is not currently applicable for the UAE. Moreover, the tool does not allow the agricultural impact value of the food items to be overridden.

Furthermore, the Tool is designed to calculate the life cycle greenhouse gas emissions and costs associated with utilizing various food side flows for six products only; apple pomace, pigs blood, brewers spent grains, tomato pomace,

whey permeates, oilseed press cake. Currently, as a non-agricultural country, the applicability of the industries covered by the tool to the needs of UAE companies is limited.

Similar to the previous tool, Quantis are open to assisting users in customizing the tool which can be an option for adapting the tool for specific products that are more relevant to the UAE especially given the country's direction to expand on local production of some food commodities.

The remaining four tools neither include conversion factors for the UAE nor allow users to enter custom conversion factors and thus are deemed not usable for the UAE. These tools are:

a. EPA Waste Reduction Model (WARM).
b. Provision Coalition Food Loss + Waste Prevention Toolkit
c. ReFED US Impact Calculator.
d. Walmart waste diversion calculator

3. Emission Factors Secondary Data Sources

Several data sources were identified when reviewing the tools applicable for the UAE. The databases and reports within the identified tools are listed in Table 5.

Table 5: Secondary Data Sources in third-party tool applicable for the UAE

Secondary Data Sources	Open Source	Used by 3rd Party Tool	Comments
FAO- AFOLU Database	Yes	• Agro-Chain GHG Emission Calculator (ACE) • FLW Value Calculator	The FAO database is the only source that has emission factors specific for the UAE and should be visited before other data sources.
IPCC- IPCC is linked through the EFDB page, the Emission Factor Database	Yes	• Agro-Chain GHG Emission Calculator (ACE) • Cool Farm Tool: FLW Module • FLW Value Calculator	The IPCC database is continuously updated. As of 28 March 2023, it does not have food commodity related emission factors for the UAE but has carbon sequestration data, and other regional emission factors.
Poore and Nemecek (2018)	Yes	• Cool Food Calculator	The report is based on a LCA study conducted by the authors. The data available in the database is the basis of the report. It does not include any LCA data for the UAE.
Searchinger et al. (2018)	No	• Cool Food Calculator	The report is based on a LCA study conducted by the author. The database consists of LCA dependent on temporal zones and does not have factors specific to the UAE.
EPA- Environmental Protection Agency	Yes	• FLW Value Calculator	This source does not have conversion factors for the UAE but is continuously updated.
Quantis World Food Database Powered by Ecoinvent	No	• FLW Value Calculator	This source does not have conversion factors for the UAE but is continuously updated.

In addition to the sources listed above, there are some additional sources that should be referred to when conducting a GHG assessment for an organization in the UAE.

- JRC- European Commission Joint Research Center: This source does not have information related to the UAE or the region as of 28 March 2023, but it is continuously updated.
- UNFCCC - United Nations Framework Convention on Climate Change: This source does not have information related to the UAE or region as of 28 March 2023, but it is continuously updated.

When using secondary data sources, a thorough search needs to be conducted depending on the specific commodity emission factors. It is worthy to note that each list does not have a complete database of all commodities. It is up to the user to define which database is applicable as comparative data, based on the reliability of the data, the activity scope and geographic scope. The user needs to choose comparative data based on similarities in activities related to the commodity. These factors should all be taken into consideration when reviewing the sources for comparative data.

4. Choosing the Emission Factor to Use for the United Arab Emirates

Food related emission factors are not readily available for the UAE with the exception of the FAO-AFOLU Database that has a limited number of commodities. Table 4 lists these food commodities which have emission conversion factors in the FAO Database, and the table is accessible at https://www.fao.org/faostat/en/#data. This FAO Database is also referred to in the IPCC EFDB page, accessible through https://www.ipcc-nggip.iges.or.jp/EFDB/main.php, it is found under "other databases". The only emission related data in the IPCC source for the UAE is mangrove carbon sequestration factors. Other than information for the United Arab Emirates, the database is extensive, with data from other countries and for other commodities and activities. It must be noted that the database is continuously updated.

To access the FAO database directly, users are required to follow the link to https://www.fao.org/faostat/en/#data , choose "Climate Change", then "Climate Indicators" then "Emission Intensities". A page opens that lets the user choose the required country, elements, items and years. For this report and for the UAE the user is required to choose the following:

- Country – "United Arab Emirates"
- Elements- "Emissions (CO2eq)(AR5)"
- Items- "Select All"
- Years- Choose the most recent year in this case "2020"
- Output data- Table
- File Type- XLS
- Click Download Data and save locally on computer.

The UAE Ministry of Climate Change and Environment (MOCCAE) has developed the UAE National Inventory Report that reports the GHG emissions per sector, this inventory is based on the IPCC 2006 Guidelines for National Greenhouse Gas Inventories. This inventory includes emissions from the industry, energy, agriculture, waste, aviation, and maritime transport sectors. The last two sectors are not listed in the IPCC guidelines. Even though this inventory includes the agricultural sector, it is an overall sector number and does not include individual food commodity emission factors. The report can be accessed at https://www.moccae.gov.ae/en/home.aspx

RECOMMENDATIONS

To enable more accurate calculation of GHG emissions associated with FLW by companies in the UAE using third-party tools or developing custom tools, it is important for the UAE to invest in developing a more comprehensive list of UAE emission factors associated with food value chains for both locally produced and imported food products that can be added to global depositories. UAE emission factors for current FLW destination also need to be developed. Although companies developing their own conversion factors from primary data will be more applicable to their individual situation, it is safe to assume that most companies will tend to use secondary data sources for the emission factors.

Factors applicable to the UAE will be more accurate than regional conversion factors or global proxies. They will also be more accurate than using conversion factors of a similar country. In addition to ensuring that future calculation of GHG emissions associated with agrifood production, manufacturing, value chain and FLW destinations is more accurate, it can also facilitate identifying and adopting more effective intervention measures.

We recommend developing value chain conversion emission factors for a broader range of agrifood products consumed in the country. This should include both locally produced produce as well as imported ones be it for fresh produce, chilled, dried or frozen. In addition to enabling companies and even municipalities to estimate the FLW-associated GHGs, it will enable comparing the carbon footprint of different locally produced and important produce. Research effort by academic institutions in the UAE and/or international partners will need to be supported through relevant funding mechanisms.

Another important area is investing in life cycle assessments and conversion emission factors of different waste management practices and destinations such as source reduction, recycling, combustion, composting, anaerobic digestion, and landfilling. This can be carried for different food commodities and/or for mixed food waste. This will enable companies and even municipalities to compare the impact and effectiveness of different waste management measures. Research efforts can be carried by research and academic institutions in the UAE independently or in partnership with similar international institutions.

Investing in developing UAE-specific tools will be another option especially given the UAE governments aspiration to reduce food waste by 50% by 2030. This will enable companies, municipalities, practitioners in the country to carry broader-based analysis that also allow comparing the impacts of different practices and measures, including:

- Tools that allow comparing different waste management alternatives similar to the analysis of the EPA Waste Reduction Model, Walmart Waste Diversion Calculator and ReFED US Impact Calculator.

EPA Waste Reduction Model and the Walmart Waste Diversion Calculator enables companies to calculate GHG emissions of waste diversion and management practices including, source reduction, recycling, combustion, composting, anaerobic digestion, and landfilling. While the ReFED US Impact Calculator allows for an analysis of a wider selection of destinations including waste prevention, donations, animal feed, industrial uses, composting, anaerobic digestion, not harvested, land application, sewer, incineration, landfill, and dumping.

- Ability to calculate the value of FLW, the economic costs, social costs, environmental costs, energy savings, and Return-On-Investment of food waste projects and initiatives.

The Provision Coalition Food Loss + Waste Prevention Toolkit which is recognized by the UN enables companies to calculate the value of FLW, the economic, social and environmental cost of the avoidable food waste, and the Return-On-Investment including the payback time frame for food waste projects and initiatives. This allows companies to not only quantify their food waste in GHG emissions terms as well as value, but also to identify the root causes of the waste, the evaluation of different solutions to aid in the selection and implementation of desired solution. It also supports monitoring efforts.

The EPA Waste Reduction Model enables companies to calculate the energy savings, economic impacts, the nutritional values, and the environmental impacts of different waste management practices. It helps organizations and individuals evaluate the GHG emissions, energy and economic impacts of various decisions related to materials management.

Unfortunately, the built-in emission factors in both tools are not applicable for the UAE, and the tools don't allow for overriding these emission factors with custom ones. Furthermore, even if a tool allows for overriding the emission factors, it is important to have comparable emission factors applicable to the UAE conditions.

ANNEX 1

1. Agro-Chain Greenhouse Gas Emissions (ACE) Calculator

Developed by	Consultative Group on International Agricultural Research (CGIAR)
Geographic Focus:	Global, with regional factors The tool's focus is global covering various regions including North Africa and West Asia region. Users have the option to select country, which includes UAE in its list.
Primary Audience:	Broad. The tool is designed to cater to all industries along the agri-food value chain from food production until produce is purchased by the consumer. Moreover, it includes production of plant and animal produce as well as aquaculture.
Purpose	The tool aims to quantify GHG emissions associated to a food product particularly chains for fresh and simple processed products such as canned, frozen, packaged and other minimal processed forms. Currently, it does not cater to fractional processes.
GHG emissions covered	The tool covers GHG emissions related to the full supply chain from production to retail including on-farm, transportation at different stages, processing, packaging and repacking, distribution and Market/retail outlet. Moreover the tool covers GHG emissions factors related to six FLW destinations including anaerobic digestion, composting, incineration (no energy use), left on field, landfill, neglect (dumped). In terms of climate impacts beyond GHG inventory scope 1–3, the tool covers avoided emissions in composting and anaerobic digestion destinations. Some of the emission factors provided in the tool are regional and cannot be edited such as the grid emission factors which are averages for a region.
Stages Covered:	Agricultural production until product purchased by consumer.
Granularity of Product Data:	About 20 individual food types, fresh and simple processed product.
Is the tool Adaptable	The calculator encompasses multiple stages, providing users with the flexibility to make modifications that facilitate the customization of the tool for both domestic and imported agricultural products. It allows users to input their own values for emission factors on farming practices, land use among others. It also allows users to choose an emission factor provided for other countries within the region.
Quality Assurance	To ensure accuracy, the developer has carried comparisons analysis against other calculations. Nonetheless, given that conversion factors built into the tool are from secondary data sources based on averages, calculated GHG emissions are estimates and not exact calculations.

ANNEX 2 – The results for the UAE from the FAO- AFOLU Database for 2020 (accessed on March 2023) are:

Domain	Element Code	Item Code (CPC)	Item	Year	Value (kg CO2eq/kg product)	Flag Description
Emission intensities	71761	F1718	Cereals excluding rice	2020	3.04	Estimated value
Emission intensities	71761	21111.01	Meat of cattle with the bone, fresh or chilled	2020	4.35	Estimated value
Emission intensities	71761	02211	Raw milk of cattle	2020	1.92	Estimated value
Emission intensities	71761	21116	Meat of goat, fresh or chilled	2020	5.84	Estimated value
Emission intensities	71761	02292	Raw milk of goats	2020	4.77	Estimated value
Emission intensities	71761	21115	Meat of sheep, fresh or chilled	2020	75.14	Estimated value
Emission intensities	71761	02291	Raw milk of sheep	2020	5.85	Estimated value
Emission intensities	71761	02293	Raw milk of camel	2020	8.52	Estimated value
Emission intensities	71761	21121	Meat of chickens, fresh or chilled	2020	1.55	Estimated value
Emission intensities	71761	0231	Hen eggs in shell, fresh	2020	0.50	Estimated value

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About Thriving Solutions LLC

Thriving Solutions is a social enterprise established by two Arab women dedicated to decarbonizing our economy, safeguarding biodiversity, advancing food-nutrition-water security, as well as supporting SDG 2030 and ESG priorities, with a focus on Arab region. Our services help companies and municipalities implement nature-based solutions and adopt innovations that eliminate waste and pollution, regenerate ecosystems, transition to circular food systems, and sequester carbon.

Vision: circular, regenerative food systems.

Mission: To reimagine local, regional and global agri-food systems, to sustain our future.

You can learn more about us on www.thrivingsolutions.earth

About WRAP

Our vision is a thriving world in which climate change is no longer a problem. WRAP is a climate action NGO working around the globe to tackle the causes of the climate crisis and give the planet a sustainable future. We were established in the UK in 2000; we now work in 40+ countries.

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