Food waste quantification manual to monitor food waste amounts and progression

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Summary

The FUSIONS project promotes efficient food use and food waste prevention strategies. In order to reduce food waste, an understanding of the quantities of food waste is necessary. This document is a Manual that provides practical guidelines for Member States on the quantification of food waste at different stages of the supply chain.

These guidelines cover three main activities:

- Quantifying food waste in each sector (i.e. stage) of the food chain;
- Combining sectorial quantifications using a common framework at national level; and,
- Reporting the results of the national food waste quantification study at country level in a consistent and comparable manner.

The Manual is aimed principally at the Member State authorities. Its goal is to support them in developing coherent methods for acquiring national food waste data covering all sectors of the food chain. It can also be used as a reference by researchers collecting data on behalf of national authorities as well as national statistical offices.

The guidelines presented in this Manual builds on previous FUSIONS reports: "FUSIONS Definitional Framework for Food Waste" (FUSIONS, 2014), "Standard approach on quantitative techniques to be used to estimate food waste levels" (FUSIONS, 2014) and the partners own experience and knowledge. The partners WRAP, DLO, IVL, and OSTFOLD RESEARCH have participated in the work, which has been led by BIO by Deloitte and supervised by SP. In addition, this Manual has been developed in close collaboration with the team of experts contributing to the World Resource Institute's *Food Loss & Waste (FLW) Standard* (FLW Protocol, 2015). Although, the Manual is not in itself an operating procedure for on-site quantification of food waste (in e.g. farms, factories or restaurants), it does highlight for each sector certain quantification methodologies found to be suitable. These quantification methodologies (see appendix 3 of this Manual) are in harmony with the *FLW Standard* approach.

The Manual begins with a presentation of key terms (chapter 2) and subsequently provides a definition of food waste (chapter 3, with further details in appendix 1) and a national approach to quantification (chapter 4). Finally, it details the approach for each sector of the food supply chain (chapters 5 to 9).

Preventing food waste at a national scale enables Member States to secure economic and environmental benefits, through for instance financial savings to households or avoided GHG emissions, as well as easing pressure on water supplies and land use, by not producing and purchasing more food than is needed.

The 2010 European Commission Preparatory Study on Food Waste identified a poor understanding of existing levels of food waste generation across the EU. This finding was replicated more recently by the FUSIONS project (FUSIONS, 2016), with many Members States lacking robust data on the amounts of food waste generated. This Manual responds to a need for coherent quantification, that in turn enables the development of effective food waste prevention strategies.

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1 Presentation of the Manual

1.1 Purpose of the Manual

FUSIONS Description of Work presents the Manual as follows:

"The Food Waste Quantification Manual will provide practical guidelines for a standard approach for EU Members States on how to quantify food waste in different stages of the food supply chain."

These guidelines cover three main activities:

- Quantifying food waste in each sector (i.e. stage) of the food chain;
- Combining sectorial quantifications using a common framework at national level; and,
- Reporting the results of the national food waste quantification study at country level in a consistent and comparable manner.

This Manual provides guidance in relation to these three activities. MSs are not obliged to use the Manual, but if a MS claims having used the Manual's approach for quantifying and reporting food waste at national level, then this MS needs to follow certain *core requirements* (see section 4.1.1 and chapter 2 on Terminology).

The Manual is aimed principally at the MS authorities[1]. It can also be used as a reference by the food sector representatives or by researchers collecting data on behalf of national authorities as well as national statistical offices. Note that it is important for MS authorities to carry out a national food waste quantification in cooperation with the stakeholders in the food supply chain. The possible contribution of key stakeholders is discussed in the approach to be followed in sectorial quantifications (see Chapters 5 to 9).

The goal of the Manual is to support the MS authorities in developing coherent methods for acquiring national food waste data covering all sectors of the food chain. It should be emphasized that the Manual is *not* in itself an operating procedure for on-site quantification of food waste (in e.g. farms, factories or restaurants). However, it does highlight, for each sector, certain operational quantifications methodologies that are deemed suitable.

1.2 Rationale behind food waste quantification

Although food waste prevention efforts can be initiated without having detailed information of the amounts of food waste, food waste quantification would be necessary in order to get a better understanding of the magnitude and location of food waste arisings within the food chain which may inform waste prevention measures. This will, in turn, allow better defining, prioritizing and targeting of prevention efforts, as well as tracking progress in food waste reduction over time.

[1] In practice, these may include Ministries, Agencies or Authorities within the MS covering issues relating to the environment, agriculture, waste (or resource) management, or other food-related issues (e.g. price, food security).

Design, implementation and monitoring of food waste prevention strategies and measures will be facilitated by appropriate food waste quantification. Ultimately, through food waste prevention, quantification will support improvements in economic efficiency and environmental sustainability. Quantifying food waste in terms of weight could also be a first step to further evaluate its corresponding economic value and environmental impact (e.g. in terms of GHG emissions generated, land used).

1.3 How to use this Manual

The Manual begins with a presentation of key terms (chapter 2) and subsequently provides a clear definition of food waste (chapter 3, with further details in appendix 1) as well as a national approach to quantification (chapter 4). Finally, it details the approach for each sector of the food supply chain (chapters 5 to 9).

Chapters 2 to 4 are "generic" (i.e. not sector-specific) chapters. These chapters can be read by any user of the Manual. Chapters 5 to 9 are, on the other hand, *sector-specific chapters*. These chapters can be read separately from each other. However, sector-specific chapters are not standalone. Their contents are complementary to the generic chapters. In particular, as regards the requirements and recommendations provided in this Manual (see section 4.1), each sector-specific chapter should be used in combination with chapter 4.

1.4 Link with the FLW Protocol

This Manual has been developed in close collaboration with the team of experts contributing to the World Resources Institute's *Food Loss & Waste Protocol Accounting and Reporting Standard (FLW Standard)* (FLW Protocol, 2015)[2]. The quantification methodologies (see appendix 3) of this Manual are in harmony with the Protocol approach.

While the Protocol is a broad, multi-user tool, this Manual has a more focused objective: to support EU Member States to quantify their food waste (see Figure 1). This focus enables MSs to track progress towards a potential food waste reduction target, using agreed definitions of food waste and supply chain sectors, and to report results in a manner that is coherent with the global Protocol and consistent between MSs.

[2] FLW Protocol, 2015. FLW Protocol Accounting and Reporting Standard (FLW Standard) – DRAFT as of March 20, 2015 http://www.wri.org/our-work/project/global-food-loss-and-waste-measurement-protocol/documents-and-updates#project-tabs

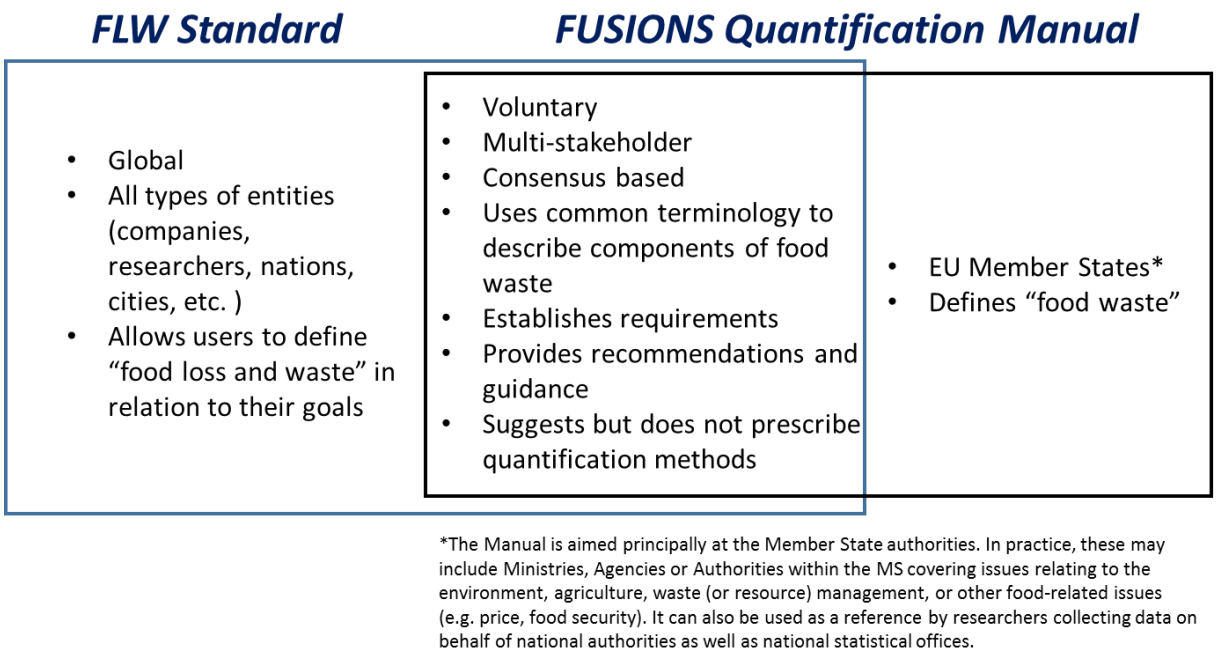

Figure 1 – FLW Standard vs. FUSIONS quantification Manual

2 Terminology

This chapter presents the definitions of several important terms that are used throughout this Manual. These definitions either use the FUSIONS Definitional Framework for Food Waste[3] or were taken/adapted from the World Resources Institute's FLW Standard (FLW Protocol, 2015).

Term	Definition for this Manual	Source
Food	Food means any substance or product, whether processed, partially processed or unprocessed, intended to be, or reasonably expected to be consumed by humans. Food includes drink, chewing gum and any substance, including water, intentionally incorporated into food during its manufacture, preparation or treatment. Inedible materials associated with food are excluded from this definition but are included in the "food waste" definition (see definition below).	FUSIONS Definitional Framework for Food Waste (FUSIONS, 2014)
Food waste	"Food and inedible parts of food removed from the food supply chain" to be recovered or disposed (including - composted, crops ploughed in/not harvested, anaerobic digestion, bioenergy production, co-generation, incineration, disposal to sewer, landfill or discarded to sea)[4]. In addition, packaging is not included in the food waste definition and shall not be taken into account in the food waste quantification.	FUSIONS Definitional Framework for Food Waste (FUSIONS, 2014)
Food supply chain	The food supply chain is the connected series of activities used to produce, process, distribute and consume food. The food supply chain starts when the raw materials for food are ready to enter the economic and technical system for food production or home-grown consumption (A2, Figure 2). This is a key distinction in that any products ready for harvest or slaughter being removed are within scope, not just those that are harvested and subsequently not used. It ends when the food is consumed (A5) or "removed" (Section B) from the food supply chain.	FUSIONS Definitional Framework for Food Waste (FUSIONS, 2014)

[3] FUSIONS, 2014. FUSIONS Definitional Framework for Food Waste – Full Report – 3 July 2014 http://www.eu-fusions.org/index.php/publications?download=5:fusions-definitional-framework-for-food-waste

[4] All these destinations are presented in Table 1.

Term	Definition for this Manual	Source
Material type	The notion of "material type" refers to the material which was removed from the food supply chain and is measured in a National Food Waste Quantification Study (see next definition). The possible material types are: a. Both food and associated inedible parts, b. Only food, or c. Only associated inedible parts.	Adapted from definition in FLW Standard (FLW Protocol, 2015)
National Food Waste Quantification Study (NFWQS)	The process undertaken to quantify food waste at national level as presented in this Manual. The quantified amounts of food waste produced by a NFWQS are referred to in this Manual as the "NFWQS results." The "NFWQS results" are a list of figures expressing the amount (weight in kg, t, kt or Mt, etc.) of food waste within the MS for each sector (i.e. primary production; Processing and manufacturing; Wholesale, Retail and markets; Food service; Households).	Adapted from "inventory" definition in FLW Standard (FLW Protocol, 2015)
National Food Waste Report (NFWR)	A report that describes, in a transparent way, methods used and results of a NFWQS as well as other items required to be reported in conformance with the Manual (see section 4.6).	Adapted from "inventory report" definition in FLW Standard (FLW Protocol, 2015)
Shall	The use of "shall" indicates a *core requirement* to be in conformance with the primary objective of this Manual (i.e. perform a NFWQS to determine food waste quantities generated over one year in a MS).	Adapted from FLW Standard (FLW Protocol, 2015)
Should	The use of "should" indicates an *optional recommendation* of this Manual (i.e. not a core requirement).	Adapted from FLW Standard (FLW Protocol, 2015)
Food Loss & Waste Protocol (FLW Protocol)	A multi-stakeholder effort launched in 2013 by the World Resources Institute (WRI) to develop an internationally accepted accounting and reporting standard for quantifying food and associated inedible parts removed from the food supply chain.	Adapted from FLW Standard (FLW Protocol, 2015)
Food Loss & Waste Protocol Accounting and Reporting Standard (FLW Standard)	Requirements and guidance to account for and report on the amount of Food Loss and Waste (FLW). Also referred to as the *FLW Standard*. The standard provides a set of accounting and reporting requirements, universally applicable definitions, and recommendations and guidance on quantification approaches and data sources.	Adapted from FLW Standard (FLW Protocol, 2015)

3 Definition of food waste in this document

The technical framework on which the Manual is based on is presented below (Figure 2). For details, see appendix 1 of the present manual and the FUSIONS FAQ[5] as well as the sector-specific chapters where the applicability of the general framework is demonstrated.

The technical framework is based on the following **definitions**:

- ***Food[6] –*** "Food means any substance or product, whether processed, partially processed or unprocessed, intended to be, or reasonably expected to be consumed by humans. Food includes drink, chewing gum and any substance, including water, intentionally incorporated into food during its manufacture, preparation or treatment"[7]. As inedible parts of food are excluded from this definition, they have been separately brought out, and included in the framework.
- ***Food supply chain –*** The food supply chain is the connected series of activities used to produce, process, distribute and consume food. The food supply chain starts when the raw materials for food are ready to enter the economic and technical system for food production or home-grown consumption (A2, Figure 2). This is a key distinction in that any products *ready for harvest or slaughter* being removed are within scope, not just those that are harvested and subsequently not used. The food supply chain ends when the food is consumed (A5) or "removed" (Section B) from the chain.
- ***Food waste*** – Food waste is any food, and inedible parts of food, removed from the food supply chain to be recovered or disposed, including the following destinations: composting, crops ploughed in/not harvested, anaerobic digestion, bio-energy production, co-generation, incineration, disposal to sewer, landfill or discarded to sea but not including food or inedible parts of food removed from the food supply chain to be sent to animal feed or bio-based material/chemistry processing.

  In addition, packaging is not included in the food waste definition and shall not be taken into account in the food waste quantification (see section 4.4.5.6).

[5] http://www.eu-fusions.org/index.php/publications/faq
This page provides details on the reasons of certain methodological choices made in the FUSIONS definitional framework.
[6] FUSIONS and FLW Standard definitions of food are equivalent.
[7] EU Regulation No 178-2002: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2002:031:0001:0024:EN:PDF

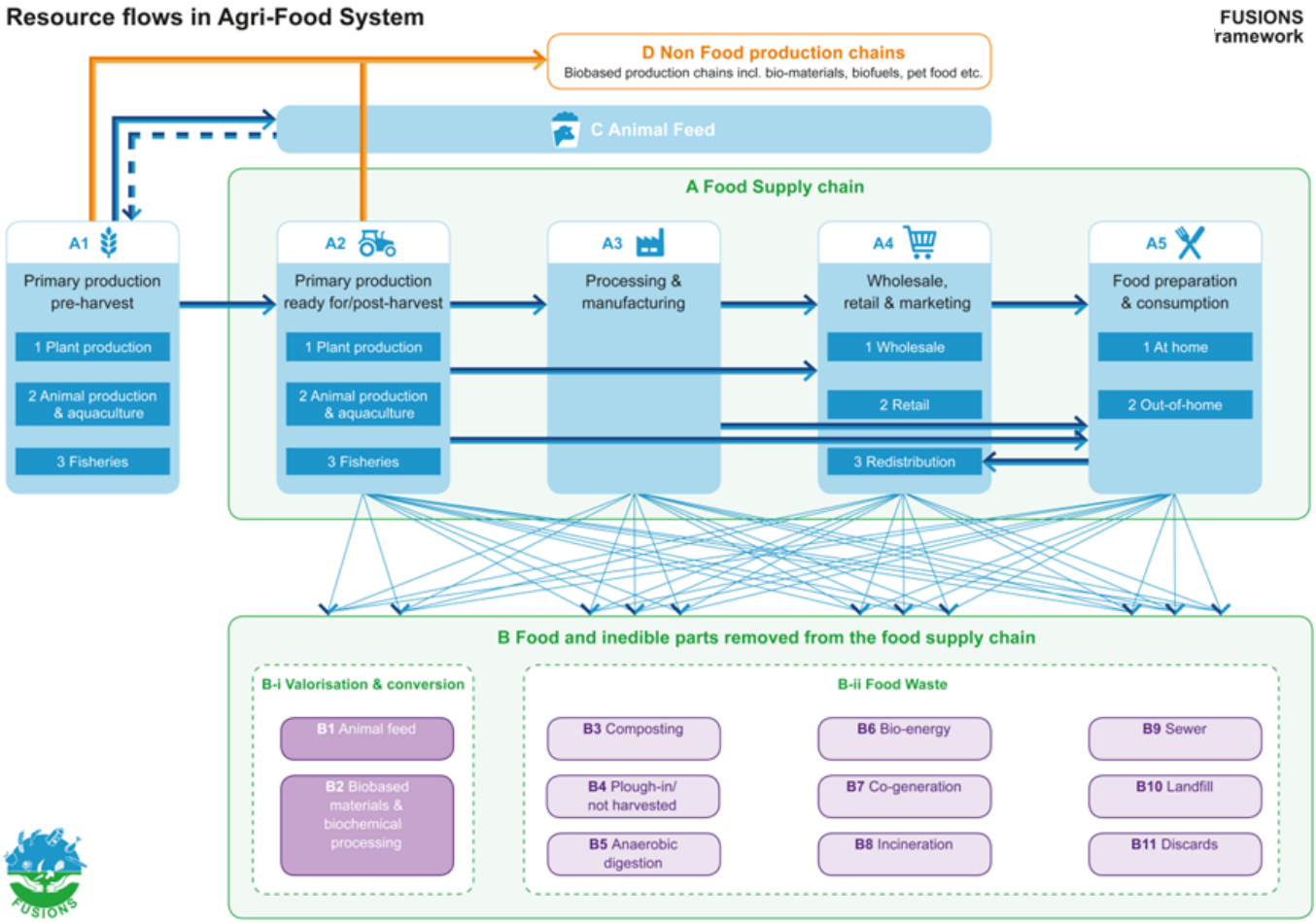

Figure 2 – The technical framework defining the Food supply chain and Food waste, on which the Manual builds[8].

Section A, in Figure 2, presents the major steps in the agri-food system[9] from production to consumption[10].

The destinations (Section B) reflect different routes for re-use, recycling, recovery and disposal of all material that is not eaten by humans. Details on each destination are provided in Table 1. In addition, a conversion table with the FWL standard destinations is provided in appendix 2 in section 2.1.

Section C (not food waste), also a part of the agri-food system, covers the production of animal feed[11], which includes the production of crops for animal feed and in turn produces animals for processing.

[8] Destination B1 includes feed for livestock and pet-food.
[9] In the present Manual, the term "agri-food system" includes the fishery sector.
[10] Note that in A3 there can be some intra-industrial flows – i.e. flows of material that are not going to their originally planned destinations but stay in the food supply chain, because the material is used as a resource for other food products in another food company or food industry sector.
[11] Animal feed in Section C (feed based on crops grown for feed production) has its own production, processing and retail / marketing activities; hence it is shown as spanning these complementary activities in the agri-food system. Furthermore, animal feed in Section C (feed based on crops grown for feed production) is different from animal feed in B1 (feed and pet food based on resource flows removed from the food supply chain) but in both cases the animal feed that fit for livestock and aquaculture consumption is used in A1 for meat and fish production.

Section D (not food waste) refers to non-food uses of primary production resources, such as crops grown for bio-fuel production.

The arrows represent resources flowing from one major processing step to another.

Section B-ii (food waste) covers materials flows included within the definition of "food waste" as applied in the Manual. It is defined by the final destination of all food, and inedible parts of food, removed from the food supply chain. Any food and inedible parts of food, removed from the food supply chain sent to destinations B3-B11 are termed "food waste".

In contrast, food and inedible parts of food going to destinations B-i (i.e. B1 and B2), C and D are not defined as food waste.

Section B-i (not food waste) shows that any food or inedible parts of food, sent to animal feed[12] and biobased materials/ biochemical processing[13] (B1-B2) are termed "valorisation and conversion" and are distinct from "food waste". Note that the destination B2 does not cover bioenergy nor biofuel production of any kind (e.g. biogas, biodiesel, bioethanol).

Redistribution, the act of donating food surplus to charity, is often considered alongside other destinations in Section B. However, for the definitional framework, redistribution is defined as a stage of the food supply chain similar in nature to retail and wholesale[14]. The rationale for this is that redistribution (as with retail and wholesale) is providing food to people with the intention of it being consumed (even though the logistics and distribution activities differ from retail and wholesale). As with retail and wholesale, some of the food that has been redistributed may go on to be wasted, and where this occurs it should be quantified, hence it feeds into Section B in the same way as all other resource flows.

The numbering in the technical framework provides a unique codification of the resource flows in the food supply chain according to their production and use. If this system is used consistently, it will lead to a clear understanding of where food waste arises in the supply chain and how it is being managed. Over time, such estimates will indicate trends by which the effectiveness of waste prevention strategies can be measured.

The boundaries and the practical application of the technical framework are developed in the subsequent chapters of the Manual developed for each sector.

The practical application of the above technical framework to specific sectors within the food supply chain is described in the subsequent chapters of the Manual.

It should be further noted that the definition of "food waste" is a standalone definition to be applied independently of other legal binding definitions of waste or specific side

[12] Note that food sent to animal feed, although not considered "food waste", is considered to be "removed from the human food chain". Indeed, although the (livestock) animal fed with this food may eventually enter back in the human food chain, the food they were fed with was produced in the first place for human use and thus an animal use is considered as a removal from the human food chain.

[13] For instance, food waste may be converted into fatty acids which can be converted into polyhydroxyalcanoates (PHAs) that can be used to produce biobased plastics to be used in e.g. water bottles.
Another example that can be mentioned is the use of orange peel to produce high-end chemicals such as lemonine and terpineol.

[14] Note that in Figure 1, redistribution is presented under section A4 because it is a stage of the food supply chain similar in nature to retail and wholesale but it can happen in other stages of the food supply chain.

streams (by-products, co-products). The developed technical framework is applicable for *all* resource streams according to Figure 2.

Table 1 – Destinations for food and inedible parts removed from the food supply chain

FUSIONS destination	Details
B1 – Animal feed	Feed and pet food based on resource flows removed from the food supply chain
B2 – Biobased materials and biochemical processing	**"Biobased materials"** include: > innovative bio-based plastics (e.g. polylactic acid - PLA) produced from various biological sources including starch, cellulose, fatty acids, sugars, proteins, etc. that can be found in food waste > "traditional" materials such as leather or feathers(for e.g. pillows) The term **"Biochemical processing"** is to be understood in a narrow sense. It refers to chemical processing of food waste in order to extract molecules that will be used in chemistry applications (e.g. fruit peel used to produce high-end chemicals, rendering fat/oil/grease to make soaps, or cosmetics.). In the present Manual, "biochemical processing" does not refer to anaerobic digestion or production of bioethanol through fermentation, these two destinations are considered as food waste.
B3 – Composting	Breaking down biodegradable matter via bacteria in oxygen-rich environments. Composting refers to the production of organic material (via aerobic processes) that can be used as soil amendment. This destination includes both home and industrial composting.
B4 – Plough in / not harvested	Leaving in the field or tilling crops into the soil that were ready for harvest. NB: this destination also includes land application – i.e. spreading, spraying, injecting, or incorporating biosolids onto or below the surface of the land to take advantage of their soil enhancing qualities.
B5 – Anaerobic digestion	Refers to production of biogas (containing methane) from anaerobic processes
B6 – Bio-energy	Bio-energy refers to production of energy using resources other than biogas/methane, including bioethanol and biodiesel as well as gasification / pyrolysis processes.
B7 – Co-generation	Co-generation refers to combined heat and power generation (ultimate destination) from incineration
B8 – Incineration	Incineration without energy recovery, including open-burning (i.e. burning without a chimney of a stack).
B9 – Sewer	Flushing material down the sewer or to a controlled water course
B10 – Landfill	Sending material to a landfill site – i.e. an area of land or an excavated site that is specifically designed and built to receive wastes.
B11 – Discards	Fish discards, which are the portion of total catch which is thrown away or slipped.

4 Recommended approach for a National Food Waste Quantification Study

This chapter provides overarching guidance to Member States on designing, developing or improving a national approach to collecting food waste data.
This chapter presents general key points a MS should consider when performing a National Food Waste Quantification Study (NFWQS):

1. The primary and secondary (optional) objectives of the NFWQS;
2. The scope of the NFWQS;
3. The general approach to be implemented for the food waste quantification in each sector.

As explained in the following sections, the Manual uses precise language to indicate which provisions are *core requirements* ("shall"), and which are *optional recommendations* ("should").

4.1 Why prepare a National Food Waste Quantification Study?

4.1.1 Primary objective

The **primary objective** of a National Food Waste Quantification Study is to allow MSs to determine, in a similar manner, food waste quantities generated over one calendar year within their national territory. The food waste quantification unit to be used in a NFWQS is weight expressed in kilograms, metric tonnes, thousands of metric tonnes, etc. depending on the order of magnitude.

The **core requirements** made in this Manual thus refer to the minimal conditions to fulfil this objective. These requirements are aimed principally at the MS authorities responsible for the overall coordination of the quantification activities, including the data collection and analysis of results (or the entity commissioned by the MS authorities to perform such work) – i.e. "the user(s) of the Manual".

The core requirements are **marked in red** throughout this Manual to indicate what is necessary for a MS to be able to quantify food waste amounts.

If all Members States follow the core requirements of this Manual, then it would be possible for them to:

- Develop a national food waste quantification study in close cooperation with stakeholders in the food supply chain.
- On a basic level, track food waste generation over time at national level;

- Determine how much food waste is arising in each sector within the MS (which would help target actions to prevent or treat food waste more effectively);
- Enable comparison between MSs in order to benchmark performance and to build knowledge;
- Consolidate MS data at the EU level.

4.1.2 Secondary objectives

The MS authorities may require further information to support more focused action on food waste prevention and management. Indeed, knowledge of food waste levels alone will help develop and implement strategies to better manage food waste. Food waste data collected by coherent methods can help to refine policies towards a more resource-efficient, profitable and sustainable food system.

In practice, secondary (additional) objectives of national food waste quantification could include, for instance:

- Understand how much and where food waste is occurring within the MS (e.g. across sectors, regions, food categories, etc.); this implies generating food waste statistics with higher granularity and thus increased analytical possibilities, such as identification of "hot spots";
- Understand why food waste is being generated (root causes);
- Inform which strategies and measures are most appropriate for reducing food waste;
- Monitor and evaluate the efficacy of food waste reduction strategies and measures;
- Develop models of future trends in food waste generation.

From that perspective, **optional recommendations** made in this Manual refer to advice that can help fulfilling those secondary objectives. Such recommendations could be used as a reference by researchers collecting data on behalf of national authorities, national statistical offices, etc.

These secondary objectives generally require higher granularity in data and thus additional work and resources for data collection, calculation and analysis. On the other hand, there will be more opportunities deriving from the exploitation of these results.

The optional recommendations are **marked in blue** throughout this Manual to indicate what can be done to go beyond the simple quantification of food waste amounts at a national level.

Moreover, in the context of each sectorial food waste quantification, sector-specific objectives can be defined. An example of secondary objectives for food waste quantification in the primary production sector is given in appendix 9.

4.2 Scope of a National Food Waste Quantification Study

This section provides core requirements on what to consider in the National Food Waste Quantification Study. Indeed, it is crucial that the scope is aligned with the primary goal of the quantification. It involves addressing the following aspects: timeframe, material type, destinations, and boundaries of the NFWQS.

Timeframe

CR 1 – Core requirement: In any given NFWQS, users of the Manual shall compile food waste quantities on the base of one calendar year (from January 1 to December 31). Note that using such a period of time will account for any seasonal variations.

Note that this core requirement does not imply carrying out quantification activities over a full year. A sample of specific periods may be used but the representativeness of the sample must be ensured, taking into account seasonality issues for each sector.

In practice, it may be difficult for a MS to initiate specific quantification studies for all the sectors of the food supply chain the same year. In this context, a MS may wish to implement a "rolling programme" in order to spread the workload over several years. For instance, a national food waste estimate for 2016 could be based on 2014 data for processing and manufacturing, on 2015 data for households, on an average over a three-year period for a specific sub-sector (for instance in primary production), etc. This approach is allowed by this Manual as long as the particular year for which the data is compiled (2016 in the previous example) is clearly stated.

Material type

The notion of "Material type" refers to the materials which were removed from the food supply chain. The possible material types are:

a. Both food and associated inedible parts,

b. Only food, or

c. Only associated inedible parts.

As mentioned in chapter 3 and appendix 1, the term "food" includes drink, chewing gum and any substance, including water, intentionally incorporated into food (packaging is not included).

As mentioned in the FUSIONS definitional framework, a material is either:

- edible (i.e. material that has or had the potential to be eaten), or
- associated inedible parts (i.e. material that never had the potential to be eaten).

A classification of what materials can be considered edible or inedible is proposed in appendix 7 of this Manual, typical examples of inedible parts include bones, egg shells, banana peel, etc. It should also be noted that the FLW Standard provides further guidance on how to separate and categorise material types. In particular, the FLW

Standard mentions various possible sources for determining the proportion of an item that is food versus associated inedible parts:

- The European Food Information Resource's (EuroFIR)[15];
- The United States Department of Agriculture's (USDA) National Nutrient Database for Standard Reference (NNDSR)[16].

CR 2 – Core requirement: The user of the Manual shall at least quantify the total amount of food and associated inedible parts. The amount reported includes both (i.e. item "a" as listed above).

OR 1 – Optional recommendation: The user of the Manual should separately quantify the amount of i) food and ii) inedible parts (i.e. items "b" and "c", respectively), and then report the combined total ("a") as well as separate results ("b" and "c").

The advantage of quantifying and analysing separately food and inedible parts is to allow for the development of accurate management strategies for these different material flows, thus optimising the resource efficiency of the agri-food system. However, including both edible and inedible materials in the food waste definition is key to ensuring that the framework can be practically used by all MSs and all stakeholders in the food supply chain. Indeed, considering the current level of waste analysis in the EU, it is not considered realistically feasible to include in the Manual a core requirement on the separate quantification of food and inedible parts.

Core requirement if optional recommendation is enacted:

Following the above recommendation has other implications. If the amount of food and inedible parts are quantified separately, then user of the Manual shall:

- Describe what sources or frameworks were used to categorise a material as food or as associated inedible parts. This includes stating if any assumptions were used to define whether a material was "intended" for human consumption or not, and
- If approximations were made to quantify separately the food or associated inedible parts, describe the approach used and, if applicable, all conversion factors, related sources, methods, and assumptions.

Destination

As presented in the chapter 3 of this Manual, there are various possible destinations for food or inedible parts of food removed from the food supply chain.

According to the FUSIONS definitions (see chapter 3), the following destinations are considered food waste: composting, crops ploughed in/not harvested, anaerobic digestion, bio-energy production (biofuels, gasification, and pyrolysis), co-generation, incineration, disposal to sewer, landfill or discarded to sea. In contrast, any food or inedible parts of food sent to animal feed or bio-based material/chemistry processing[17] are termed "valorisation and conversion" and thus are not considered "food waste".

Food donation/food surplus redistribution to charity is not considered food waste according to the FUSIONS definition. These activities are still part of the food supply chain. Food donated/redistributed may ultimately go to destinations that are considered food waste. It is these final material flows that are of interest for the NFWQS.

[15] http://www.eurofir.org
[16] http://ndb.nal.usda.gov/ndb/foods
[17] See chapter 3 for further definition of these destinations.

CR 3 – Core requirement: The user of the Manual shall follow the FUSIONS definition of food waste and therefore, food or inedible parts of food sent to destinations under B-ii (see in Figure 2, destinations B3 to B11) shall be accounted for in the NFWQS. However, food or inedible parts of food sent to "valorisation and conversion" (see in Figure 2, destination B-i, including B1 "animal feed" and/or B2 "biobased materials and biochemical processing") shall be excluded from the NFWQS.

In practice, complying with the above requirement may require the quantification across sectors of the "food or inedible parts of food removed from the food supply chain" going to "valorisation and conversion", most notably it may be necessary to subtract these amounts from the amounts falling in the food waste definition.

Subsequent core requirement:

The user of the Manual shall:

- Describe what sources or frameworks were used to categorise "food or inedible parts of food removed from the food supply chain" as belonging to destination "valorisation and conversion" (B-i) or to destination "become food waste" (B-ii). This includes stating if any assumptions were used to distinguish B-i and B-ii.
- If estimates were used to distinguish B-i and B-ii, describe the approach used and, if applicable, all factors, related sources, methods, and assumptions.

OR 2 – Optional recommendation: The user of the Manual should quantify food waste separately for each destination listed (destinations B3 to B11 within B-ii). In this context, it may help to also quantify destinations B1 and B2, despite them not being considered food waste, in order to have a full picture of material flows and perform overall coherence checks of amounts.

In practice, shifting directly from a food waste quantification study in which all destinations within B-ii are quantified as a whole to a food waste quantification study in which all destinations are quantified separately may not be feasible. In this case, a MS should go through an intermediary step in which certain destinations could be combined (e.g. a consolidated destination "energy" including: B5 – Anaerobic digestion, B6 – Bio-energy, and B7 – Co-generation).

OR 3 – Optional recommendation:

In addition to final destinations B1 to B11, the user of the Manual should also consider trying to quantify the amount of food going to redistribution as well as the flows between supply chains sectors (e.g. from retail sector back to manufacturing sector). This would help in having a complete view of the material flows within the food chain before food reaches its final destination.

Core requirement if certain destinations cannot be accounted for:

In practice, considering the current level of waste analysis in the EU, it will be extremely difficult to quantify food waste for all destinations listed (destinations B3 to B11 within B-ii). Note that destinations B3 to B11 are "possible" destinations of food waste, certain destinations being more common in certain countries. The user of the Manual shall analyse the specific situation in its MS and focus on the most relevant destinations. In addition, if certain destinations could not be accounted for (e.g. food waste from household sent to sewer), this shall be clearly specified in the NFWQS and mentioned as a limitation but this shall not prevent the MS from conducting the quantification.

Boundaries

The boundaries of a NFWQS (see Table 2) are strictly fixed.

CR 4 – Core requirement: The user of the Manual shall comply with the three boundaries dimensions – i.e. food category, food supply chain stage, and geography – presented in Table 2.

Subsequent core requirement
The user of the Manual shall use the classifications presented in Table 2 in order to specify if any components (i.e. region, food category, etc.) of the boundary dimensions that could not be accounted for.

Table 2 – Boundary dimension definitions and sources for reporting

Boundary dimension	Definition	CR 4 – Core requirement
Food category	The food (including drink) and/or its associated inedible parts leaving the food supply chain that are being quantified.	All type of food and associated inedible parts shall be included in the NFWQS. *Core requirement if certain food categories cannot be accounted for:* If certain food categories are not accounted for, the user of the Manual shall specify which ones using the same classification system as the one used in the most recent version of the FLW Standard[18].
Sector or Food supply chain stage	The stages in the food supply chain within which food waste occurs. This Manual uses a sectorial approach to cover the entire food supply chain: primary production, manufacturing, retail & distribution, food service and households.	All sectors listed in this Manual shall be included in the NFWQS. *Core requirement if certain sectors or sub-sectors cannot be accounted for:* If certain sectors or sub-sectors are not accounted for, the user of the Manual shall specify which ones using the NACE codes[19].
Geography[20]	Geographic borders within which food waste occurs.	The entire country shall be considered in the NFWQS. *Core requirement if certain areas cannot be accounted for:* If certain areas are not accounted for, the user of the Manual shall specify which ones using the EU Nomenclature of Territorial Units for Statistics (NUTS)[21] and if needed, Local Administrative Units (LAU) levels.

[18] At the time of writing this Manual, the section of the FLW Standard related to the "boundary dimension" for "food category" refers to the Codex GSFA's food category system – see FAO/WHO Food Standards – Codex alimentarius – GSFA Online – http://www.codexalimentarius.net/gsfaonline/foods/index.html?lang=en
[19] Eurostat, 2008. NACE Rev. 2. Statistical classification of economic activities in the European Community. http://ec.europa.eu/eurostat/ramon/nomenclatures/index.cfm?TargetUrl=LST_NOM_DTL&StrNom=NACE_REV2
[20] Note that the FLW Standard has similar boundary dimensions as well as and additional "organization" dimensions – i.e., organizational unit for which the amount of food waste is being reported. However, for a Member State, the organizational unit is the country, which is the same as it's "geography."
[21] Eurostat, 2013. NUTS (Nomenclature of Territorial Units for Statistics), by regional level, version 2013 (NUTS 2013) http://ec.europa.eu/eurostat/web/nuts/overview

4.3 Analysis of sectorial contributions to food waste

Respective contribution to food waste of each sector at EU level

The *Food waste data set for EU-28* (FUSION, 2016) gives a split of EU- food waste in by sector (see Figure 3). It appears that the sectors contributing the most to food waste are households (47 million tonnes ± 4 million tonnes) and the processing sector (17 million tonnes ± 13 million tonnes). These two sectors account for 72% of EU food waste, although there is considerable uncertainty around the estimate for the processing sector. Of the remaining 28 percent of food waste, 11 million tonnes (12%) comes from food service, 9 million tonnes (10%) comes from production and 5 million tonnes (5%) comes from wholesale and retail.

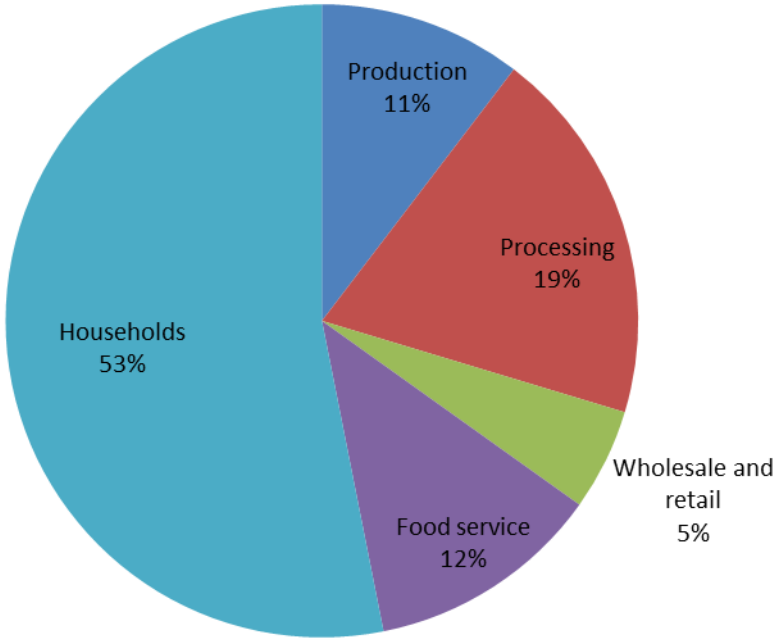

Figure 3 – Split of EU-28 food waste in 2012 by sector; includes food and inedible parts associated with food.

Prioritizing sectorial quantifications in the context of a rolling programme

OR 4 – Optional recommendation:

Figure 3 shows, on one hand, that there is value in obtaining food waste estimates for any stage in the food supply chain and, on the other hand, that it may be worth prioritising sectorial quantifications based on the relative waste arisings between sectors in the MS, focusing first on the stages of the food supply chain that generate the greatest levels of food waste. In the context of a rolling programme, the MS should decide which sector should be quantified in priority. In addition, the MS should decide what would be the suitable updating frequency of the quantification for priority sectors versus non-priority sectors. For example if 80% of a MS food waste arises in "households" and "processing & manufacturing" stages, it would be relevant to update more frequently these sectorial quantifications, as opposed to other stages of the chain.

4.4 General approach for sectorial quantifications

This Manual adopts a sector-wise approach to quantify food waste at national level (see chapters 5 to 9). This section of the Manual presents the general approach and related guidance that is applicable to all sectors. Chapters 5 to 9 present sector-specific aspects. Guidance on how to collate the data from the various sectors in view of getting a complete national quantification is provided in section 4.5.

CR 5 – Core requirement: All sectorial quantifications shall follow similar major steps (see Figure 4):

1. Review the scope and structure of the sector;
2. Set up a work plan;
3. Identify and review existing estimates and / or raw data relating to the sector;
4. Select approach for quantification – i.e. decide on which components of the sectorial food waste can be quantified with existing data and which require additional measurement;
5. Undertake quantification using existing data and/or with new measurements.

The first step is to review the scope and coverage of the sector, identify the sub-sectors present in the MS, determine their relevance and analyse their market structure (i.e. mapping of sub-sectors). After setting up a work plan, in all cases the user of the Manual shall then conduct or commission a national study on what data are available and identify and review existing data (e.g. what company records can be retrieved). In a last step, if a study involving new measurements is undertaken, the user of the Manual shall check what methodology suits each sub-sector best from the MS point of view. Insight in the market structure optimizes the result with respect to effort (cost and time) and supports the determination of the experimental design.

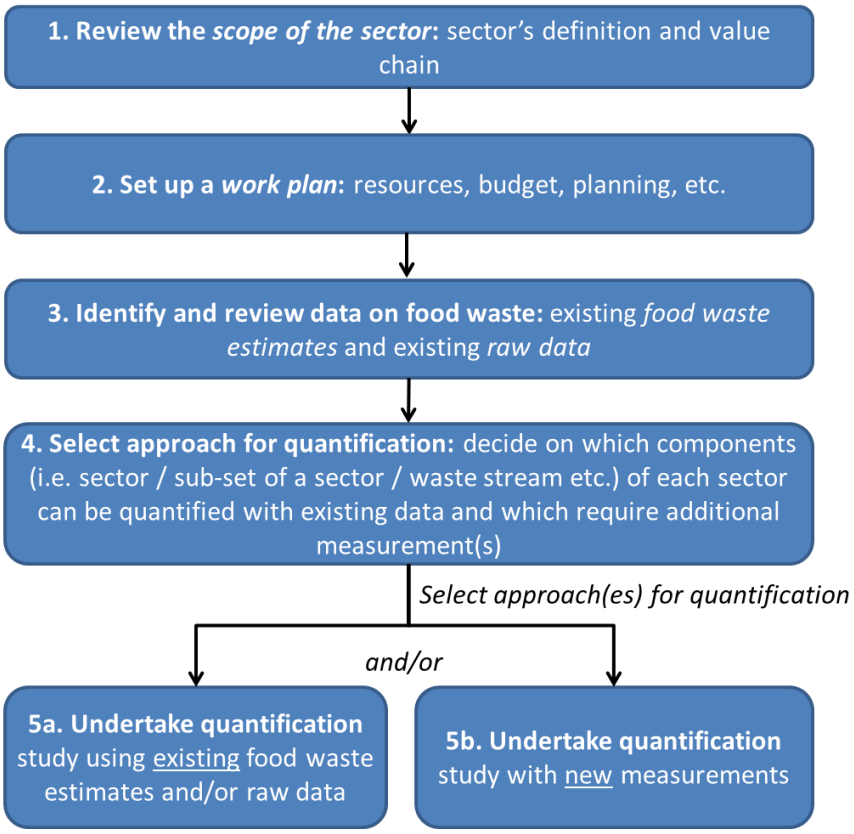

Figure 4 – Steps of the general approach for sectorial quantification

4.4.1 Review the scope and structure of the sector

The key outcome of this step is for the user of the Manual to have a clear understanding of the definition of the sector (i.e. what is included in the sector and what is excluded) as well as what constitutes food waste in this sector (in coherence with the FUSIONS definition).

Definition of the sector

CR 6 – Core requirement: The user of the Manual shall comply with the definition of sectors provided in this Manual as far as possible and to justify and explain any deviations. Definitions are given in each sector-specific chapter.

Core requirement if certain components of the sector cannot be accounted for:

If for any reason (e.g. no information, no relevant proxy/estimate, etc.), a sectorial quantification could not include a certain component of the sector (such as a given product category – e.g. sea food, a given sector segment – e.g. restaurants, a given waste stream – e.g. food thrown away via the sewer, etc.), this shall be clearly specified in the NFWQS and mentioned as a limitation but this shall not prevent the MS from conducting the sectorial quantification[22].

Mapping of the sector

CR 7 – Core requirement: The user of the Manual shall carry out an initial study in order to have a general understanding of the sector's value chain.
This will help greatly with subsequent activities for instance:

- Identifying existing estimates and raw data (see section 4.4.3);
- Ensuring, where sampling takes place, that the sample is representative of the situation within the MS (considering seasonal variation, variation between types/sizes of businesses etc.).

This mapping shall focus on the overall structure of the sectors and involved stakeholders. Key aspects to consider in this initial study can include for instance:

- What are the main organisations / companies involved?
- Who owns / manages these companies?
- What are the main industry/business representative bodies?
- What is the level of consolidation in the sector (number of companies, with distribution by size categories according to e.g. turnover or number of employees)?
- What are the main flows: products, information, money, etc.?
- What are the relationships between the main stakeholders / companies?

Ultimately, the objective shall be to have a typology of key players in the sector (based on their sizes or type of production, or other key characteristics of their operations) with information on their respective market shares, as well as elements (at least qualitative) on their food waste levels.

[22] See Table 2 in section 4.2 that specifies the classifications to be used if a component (e.g. region, food category, etc.) could not be accounted for.

These aspects are illustrated in a more operational manner in each sector-specific chapter.

4.4.2 Set up a work plan.

CR 8 – Core requirement: The user of the Manual shall set up a work plan in order to plan and organise all future activities and resources for quantifying food waste.

Conducting a NFWQS, will generally mean working in a "project mode". This involves using basic project management tools and procedures such as a work plan determining who will be in charge of the overall coordination of the NFWQS and of the sectorial quantifications. In addition, a first estimate of required resources (amount of work, competency and expenses required, etc.) shall be done. These aspects depend on a number of factors such as budget, capacity, competency, network, trust, political considerations, etc.

4.4.3 Identify and review existing data and existing estimates of food waste

A crucial task when preparing a NFWQS is to identify potential information sources for food waste quantification data. Indeed, it is always preferable, considering time and resource constraints, to first assess the appropriateness of existing food waste information that can potentially be used (or scaled/adjusted to national level), before engaging in new food waste measurement activities.

This section takes the user of the Manual through a process for determining whether existing information is good enough to use within a NFWQS.

Identify existing data

CR 9 – Core requirement: The user of the Manual shall a) identify all relevant information sources and b) determine whether any of them are suitable to be used in the NFWQS.

Existing information could take the form of:

- **Existing food waste estimates** from previous studies or previously collated data;
- **Raw data**[23], meaning data that were not developed for the purpose of (national) food waste quantification but from which (national) food waste estimates could be derived. Using such raw data that could be collated typically requires fewer resources than collecting new data.

In practice, the distinction between existing estimates and raw data is not clear cut – information falls on a spectrum with raw data at one end and data processed into final national estimates at the other. In between, information can be used which represents data that have undergone preliminary processing, but requires further processing or analysis to obtain a useable estimate. Nevertheless, this distinction is useful – the user of the Manual should assess which advice is relevant to the information they hold.

[23] Referred to as "records" in the FLW Standard

For instance, "existing food waste estimates" may be available for a certain product category (e.g. tomatoes) in the primary production sector or for a certain segment within a sector (e.g. restaurants in the food service sector). "Raw data" may include a wide variety of sources including waste collection statistics, share of bio-waste in treatments plants, warehouses storage logs, transportation loss data, etc.

CR 10 – Core requirement:
For all sectorial quantifications, the user of the Manual should search the academic and grey literature for relevant data or studies. The user of the Manual should also approach ministries and agencies that work on food and waste statistics to see if there is anything that can be used for NFWQSs. If this does not yield the relevant information, waste management companies may also be a source of information. Additional explanations on where to look for existing estimates/raw data are provided in each sector-specific chapter.

Review identified data

Where promising information is obtained, it needs to be checked in order to ensure it is suitable for use in the NFWQS.

CR 11 – Core requirement: Prior to using existing estimates / raw data, the user of the Manual shall review the data and the study parameters carefully and shall fully understand how these data were obtained.

Subsequent core requirements:
Factors to consider when determining whether to use existing raw data relate to:

- **Scope –** The user of the Manual shall consider whether the time frame, material types, destinations, and boundary of the raw data can fit in the scope of the NFWQS. It includes the following aspects:
    - *Time frame (year)* – Check whether data were collected for the correct year (i.e. the year for which a NFWQS is being conducted). If the data is from a different year, determine whether the data may still be used. This could be the case because the timescale between the two years is limited and it is likely that the data is still relatively similar or because the data can be adjusted with specific factors to the year for which a NFWQS is being conducted.
    - *Time frame* (seasonality) – Check whether measurements were taken throughout the year and, if not, has anything been done to measure or correct for seasonality; the degree of seasonality depends on the source of waste being analysed.
    - *Material types* – Check whether all food waste is included or only edible material: for consistency with the FUSIONS definition, all food waste should be included (see section 4.2 – Paragraph on material types)
    - *Destination* – Check which destinations are covered; if there are missing destinations of food waste (see section 4.2 – Paragraph on destinations), these will need to be quantified using other data or measurement.
    - *Boundaries (food category)* – Check whether drink is included alongside food; for consistency with the FUSIONS definition, drink should be included (see section 1.2.1 in appendix 1).
    - *Boundaries (sector)* – Check the scope in terms of sector(s) covered; if the sector(s) covered align well with those in this Manual (see section 4.2 – Paragraph on boundaries), the data can be used more straightforwardly. If there are considerable differences, then this may require further

quantification of missing parts of the sector, or adjustment of the estimate if parts of other sectors are included.

- *Boundaries* – Check whether packaging of the food is included; the Manual asks that the estimate of food waste excludes the weight of packaging (see section 4.4.5.6).
- *Boundaries* – Check whether other type of organic material (e.g. garden waste) is included; the Manual asks that the estimate of food waste excludes any other type of organic material[24].

- **Reliability –** The uncertainty associated with existing estimates / raw data generally depends mostly on the choice of quantification methods and on sampling procedures.

  Before using existing data, the user of the Manual shall consider whether the data are reliable enough to be used. It includes:

  - *Quantification methods* – Review how the quantification of the food waste was undertaken (e.g. sorted by hand and then weighed) and how the results of the quantification were collected (e.g. in a diary, from a recall survey, electronically recorded); some quantification methods introduce a substantial bias into any estimate.
  - *Sampling procedures* – Where samples have been used, review how sampling was undertaken. There is the potential for considerable bias to be introduced through inappropriate sampling. In particular, studies where probability sampling (also known as random sampling) has been undertaken are usually more reliable.

  In addition to the points above, which are relevant to both raw data and existing estimates, the following points shall also be considered specifically for existing estimates:

  - *Scaling factor* – In case the data have been scaled to obtain an estimate, check the factor used to scale the data. A scaling factor may be per person/employee, per tonne or production, etc. It is essential to use a scaling factor that has a strong correlation with food waste.
  - *Stratification / weighting* – In case the data have been scaled to obtain an estimate, review any stratification or weighting procedures used. This is important where there are distinct sub-sectors producing different amounts of food waste for a given unit of the scaling factor (e.g. per person, per tonne of production). If the sample has an under- or over-representation of any of these sub-sectors, they can be weighted during the scaling process to ensure the results are more representative of the overall sector's structure. (Stratification of the sample before scaling has the same effect.)
  - *Overall uncertainty around estimates* – In case estimates have been produced, the user of the Manual shall understand the degree of uncertainty around those estimates.

    This includes sampling error, which is related to a) the variability of the food waste between measurements, as measured by (for example) the standard deviation, and b) the sample size. It also includes biases (systematic error) that could relate to how sampling was performed or how measurement of the food waste was undertaken (see previous points).

    Preference should be given to studies with lower levels of sampling error and less opportunity for biases to be introduced. The user of the Manual

[24] In particular, this is the reason why the EUROSTAT Food waste plug-in approach – in which the data reported include both food waste and other materials – does not give the full picture of food waste arisings in EU. See appendix 2.3.

should consult someone with statistical expertise if they do not have this expertise to make these judgements themselves.

The list of points presented above is not exhaustive. It is the user of the Manual's responsibility to check if the existing data are aligned (or can be aligned following some adjustment) with the core requirements of this Manual.

OR 5 – Optional recommendation: In case there is insufficient information on existing data (e.g. in accompanying documentation), the collectors of the data or study authors / commissioners should be contacted to try to obtain all necessary details to conduct the review. This will help inform whether existing information can be used, or whether new measurements are required to quantify food waste.
If needed, the existing data may be adapted in agreement with the data's authors/owner in order to match the Manual's requirements.

4.4.4 Select approach for quantification

This section guides the user of the Manual through the process of deciding what information to use for quantifying food waste. The key outcome of this section is to obtain a clear plan of where information will be coming from for the NFWQS.
There are three main types of source:

- Existing estimates
- A new estimate based on existing raw data
- A new estimate based on new measurement

The hierarchy of which information to use is given in the decision tree in Figure 5. In order to reduce burdens on MSs relating to cost and resources, existing estimates (if of high enough quality) are preferable, followed by using existing raw data (again, if of high enough quality) and finally commissioning a new study including measurement.

It must be underlined that a MS may use a combination of these three sources of information across and within sectors to estimate food waste in various "components" (i.e. any given sector / segment of a sector / waste stream / destination / etc.) of the NFWQS (for instance using existing estimates for cereals in the primary production sector, performing a new study for tomatoes, using existing raw data from a sample of supermarkets in the retail sector, etc.).

Note that whatever the source being used for the quantification, sharing of information between private companies and the public sector may be necessary. This may require authorities to set up voluntary agreements or amend national legislations.

OR 6 – Optional recommendation:
In addition, preserving business confidentiality should be an important concern for MS authorities in any data gathering exercises. Individual company data must not be made public without express permission, for example in a case study that has been approved for publication by the company. Aggregated and anonymised data may be published (e.g. for all retailers in a MS) with permission from data providers. For organisations (e.g. a ministry or an environment agency or a consultancy commissioned by public authorities) receiving the individual company data, processes should be in place to ensure these data are protected from unintentional or intentional misuse.

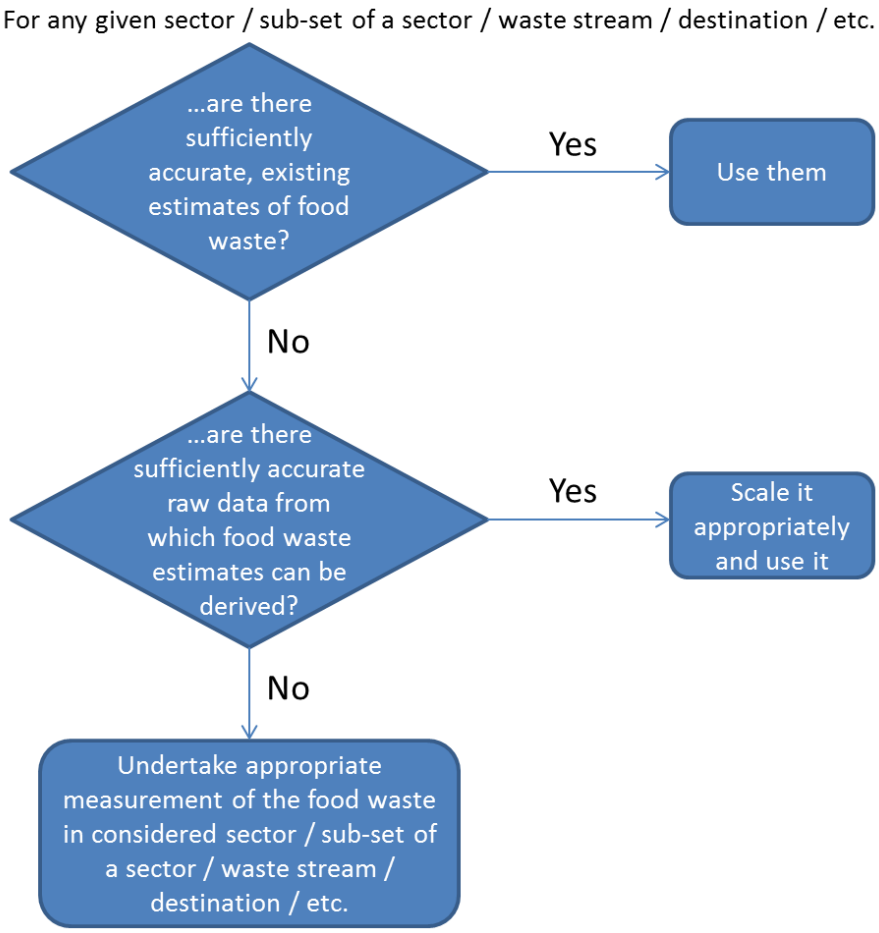

Figure 5 – Decision tree for types of approach for quantification to be used in NFWQS

The decision of which of these sources to use is rarely straightforward as the assessment of quality (whether existing estimates or raw data are good enough to use) depends on a large number of factors. These include the scope of the existing information (e.g. what definition of food waste was used, the waste destinations included) and how it was measured (as previously outlined in section 4.4.3).

If neither existing estimates nor raw data are suitable, then a new study will be required involving measurement of food waste. Advice on how to undertake or commission a new study is given in section 4.4.5.3.

4.4.5 Undertake quantification

4.4.5.1 Using existing food waste estimates

This section assumes that existing estimates have been deemed suitable for use in the NFWQS either in their original form or with some adjustments to ensure the core requirements of the Manual are fulfilled.

Core requirement if existing food waste estimates are used:

CR 12 – Core requirement: When using existing estimates, the user of the Manual shall indicate in the National Food Waste Report (see section 4.6) how these estimates for food waste have been exploited. This shall include:

1. A reference to the original study that contains the existing estimate used.
2. A description of how the existing estimate aligns with the core requirements of the Manual, in terms of scope and reliability. Any adjustments made to the estimate to ensure that the core requirements of the Manual are fulfilled shall be clearly documented. This documentation shall be in sufficient detail so that a third party could understand the principles and make a judgement on the validity of the adjustment procedure. Any supplementary information used for this procedure shall also be clearly referenced.
3. A description of the food waste "component" (i.e. any given sector / segment of a sector / waste stream / destination / etc.) for which the existing estimate is used.

4.4.5.2 Using existing raw data

This section assumes that existing raw data have been deemed suitable for use in the NFWQS either in their original form or with some adjustments to ensure that the core requirements of the Manual are fulfilled.

Core requirement if existing raw data are used:

CR 13 – Core requirement: When using existing raw data, the user of the Manual shall indicate in the National Food Waste Report (see section 4.6) the source of the data. This could be either a reference to the original study that was used to obtain the data (if such a source exists) and/or explanations on the process for obtaining the raw data (if the data are not coming from a study or if it does but further adjustments were made). Then, the user of the Manual shall also detail the procedure to derive food waste estimates from the raw data. In particular, the user of the Manual shall detail (if relevant) the scaling procedure used (see section 4.4.5.5). Finally, the user shall describe the food waste "component" (i.e. any given sector / segment of a sector / waste stream / destination / etc.) on which the existing raw data are applied.

4.4.5.3 Undertaking a study involving new measurements

Overview of quantification methodologies

This section provides an overview of methods commonly used to quantify food waste, as a reference for the users of the Manual. These methods are described in further details in appendix 3. A MS may use a combination of multiple methods across and within sectors to estimate food waste in various "components" (i.e. any given sector / segment of a sector / waste stream / destination / etc.) of the NFWQS.

The quantification method(s) a MS chooses is driven by a range of factors such as its particular secondary objectives for its NFWQS, budget, resources and other constraints. An important consideration is also the level of access to physical amounts of food waste. Indeed, certain methods can only be implemented in organisations with direct (physical) access to food waste (see next paragraph). In the end, the decision about which way to quantify food waste will involve a series of trade-offs (see section 4.4.4), this is the reason why the Manual does not provide any core requirement on a specific method to be used.

Methods based on measurement and approximation

These are methods that an organisation with direct (physical) access to food waste can use to measure or approximate it. It includes:

- **Direct weighing** – which involves using a measuring device to determine the weight of samples of food waste or fractions of total waste.

- **Scanning / Counting** – which involves assessing the number of items that make up food waste, and using the result to determine the weight.
- **Volumetric assessment**– which involves assessing the space food waste takes up, and using the result to determine the weight.
- **Waste composition analysis** – which involves physically separating food waste from other fractions in order to determine the weight of the fractions sorted out.

A MS that does not have direct access to food waste may still be able to quantify it based on measurement or approximation but typically relies on other organisations with direct access to the relevant food waste (or food waste data) providing information. These methods are based on social-science research practices and include:

- **Diaries** –which involves an individual or group of individuals keeping a record or log of food waste information on a regular basis.
- **Surveys** – which involves gathering information from a large number of individuals or entities on attitudes, beliefs, and self-reported behaviours through a set of structured questions.

The accuracy of data collected through these methods will vary widely depending on the nature of the data and the way in which it is collected and analysed. For example, an industry association may decide to collect data from its members through a survey, but the accuracy of the results will be much higher if the members provide weight-based records of food waste than if they provide rough approximations (as they may have little understanding of the amounts of food waste generated in their business). Similarly, data will be more accurate where fewer assumptions have to be applied, for example in making conversions to weight and in scaling up.

4.4.5.4 Methods based on inference by calculation

For reasons of cost effectiveness, some MSs may choose to infer (via calculation) some elements of food waste. These methods involve taking existing data and manipulating it computationally to produce estimates of food waste. The quantification methods are (as described in the FLW Standard and in the FUSIONS' report Standard approach on quantitative techniques to be used to estimate food waste levels (FUSIONS, 2014)):

- **Mass balance** – An organisation (e.g. a company) measures inputs (e.g. ingredients at a factory site) and outputs (e.g. products made) and uses a mass-balance method to infer food waste. Account is taken of changes in levels of stock and changes to the weight of food during processing (e.g. evaporation of water during cooking). This method could also be used by a MS at national level interested in comparing household purchases with household consumption to infer food waste.

- **Models** (mathematical, statistical or computed) – A MS could develop a model to predict food waste. The model may draw on factors such as climatic, agricultural and fishery statistics, or other data from which a scientific analysis has demonstrated that food waste values can be calculated. One example is African Postharvest Losses Information System (APHLIS,) which uses a transparent algorithm to express postharvest losses in grains in Africa, based on scientific literature, local data and local external environmental factors such as rains at harvest or storage and marketing practice.

- **Use of proxy data** – This involves using food waste data that are outside the scope of a MS (e.g. in another MS, in a specific part of Europe – North-West, South-East, etc.) as a proxy to infer quantities.

OR 7 – Optional recommendation:
Using calculations based on data from outside the scope of the quantification study (e.g. from another country) should be kept to a minimum. This is because the results of the NFWQS could be used to assess a target (see section 4.7.1) and basing the quantification on information from outside the scope risks invalidating the target monitoring. In general, calculations should be confined to occurrences where they have minimal impact on the results (e.g. for minor waste streams) or where there is not significant change.

4.4.5.5 About sampling and scaling

When quantifying food waste at national level, it is obviously not feasible to quantify food waste generated in all individual sites (e.g. all households, all restaurants, all supermarkets, etc.) across the food supply chain. Therefore, the user of the Manual may instead collect data on the amount of food waste from samples representatives of specific sectors or segments of sectors and then scale up the data from the samples to generate an estimate of the total food waste.

The FLW Standard provides general guidance on how to build samples of individual sites producing food waste[25]. In addition, the FLW Standard provides explanations on how to deal with physical samples of food waste from these sites.

The FLW Standard also provides general guidance on how to scale up data – i.e. adapt the sample data to cover the entire scope of the sector or of a segment of sector of which it is deemed representative.

OR 8 – Optional recommendation: The user of the Manual should follow the advice provided in the above-mentioned sections of the FLW Standard when using a sample-based approach for food waste quantification (be it for existing estimates, new estimates based on existing raw data, or new estimates based on new measurement).

In addition, the following scaling factors (see table hereafter) are provided for indicative purpose since they have been previously used in the *Food waste data set for EU-28* (FUSION, 2016)[26]:

Table 3 – Factors used to fill in data gaps for the different sectors studied.

FUSIONS denominations	Scaling factors used to fill in data gaps for the different sectors studied	NACE codes
Primary production	Produced food amounts in this sector	NACE 01-03
Processing	Produced food amounts in this sector	NACE 10-11
Wholesale and logistics and retail and markets	Population (but turnover would be preferred)*	NACE 46-47
Food service	Turnover number	NACE 55-56
Household	Population	N/A**

* Population was used instead of turnover since data on turnover were available for all types of products and not specifically for food product. As there should be a correlation between the food waste amounts (weights) produced from the sector and the population, it was decided to use population as a scaling factor, which also is publically available and updated on a regular basis by Eurostat.
** There is no NACE code for households.

[25] Called FLW-producing units in the FLW Standard.
[26] These factors are called "normalization factors" in this deliverable. FUSIONS, 2016. Food waste data set for EU-28 – WP & Task number: WP 1 task 1.6 – Deliverable Number: D1.8

4.4.5.6 About packaging

CR 14 – Core requirement:
The FUSIONS definitional framework for food waste does not include packaging (e.g. boxes, wrapping, or plastic containers)[27]. This includes any primary packaging discarded with food: for instance in the case of a boxed ready-meal being discarded, it is the net weight (the food) that should be recorded not the weight including the packaging material (the box). Therefore, the user of the Manual shall exclude packaging from the food-waste estimates obtained within a NFWQS.

In practice, in many cases food-waste items removed from the food supply chain will still be in its packaging (e.g. yoghurt in its container) or data relating to food waste will include the weight of the packaging. The FLW Standard provides several approaches on how to exclude the weight of packaging from the amount of food waste. These approaches are as follows (from most to least accurate):

- Remove packaging before quantification;
- Subtract estimated packaging weight from each item;
- Subtract estimated packaging weight from waste stream or existing data.

Subsequent core requirement:
If certain packaging could not be excluded from the food waste quantification: the user of the Manual shall specify which ones – i.e. which food categories, which sectors, and which type of packaging.

4.5 Coordinating and combining sectorial food waste quantifications to perform NFWQS

This section provides guidance to the user of the Manual on how to consolidate the results from the sectorial quantifications into a National Food Waste Quantification Study. The MS authorities responsible for the overall coordination of the quantification activities, (or the entity commissioned by the MS authorities to perform such work) will also be in charge of the consolidation of sectorial quantifications. In this chapter, this organisation is referred to as the "coordinating organisation".

Role of the coordinating organisation

The coordinating organisation can be a service of a ministry or an environment agency or a consultancy commissioned by relevant public authorities. The role of the coordinating organisation is to aggregate food waste quantification data from all sectors in order to:

- Obtain a NFWQS;
- Gain a general understanding of food waste for the country.

Considering that the sectorial quantifications may be done by distinct organisations and that various "components" (i.e. sub-sectors / waste stream / product categories) may be quantified separately, the role of the coordinating organisation is crucial to ensure the proper consolidation of multiple inputs possibly coming from various entities.

[27] Edible packaging would be considered food in the context of the present Manual since it is intended for human consumption.

CR 15 – Core requirement: The coordinating organisation shall pay particular attention to any potential differences in terms of methodology between sectorial quantifications. Such differences will affect the ability to add or compare results and draw accurate conclusions. In particular, the scope and definitions upon which the sectorial quantifications are based shall be thoroughly consistent.

In principle, if the core requirements of this Manual (generic requirements and sector-specific requirements) are followed, then consistency across sectorial quantifications is maximised.

Providing specifications to other organisations involved in the sectorial quantifications

It is likely that the coordinating organisation will not perform the entire NFWQS by itself. Certain tasks such as specific sectorial quantifications may be commissioned to other organisations (e.g. consultants or research organisations, other ministries/agencies, local administrations, etc.).

CR 16 – Core requirement: The coordinating organisation shall communicate with enough detail any relevant aspects of this Manual that other involved organisations may need in order to carry out their tasks.

In particular, if sectorial quantifications have been assigned to distinct organisations, the coordinating organisation shall communicate to each of these organisations i) the general core requirements and ii) the core requirements corresponding to their sector included in the present Manual.

4.6 Reporting

For a MS, food waste reporting means publicly disclosing the national food waste quantities, possibly in the context of developing a coherent national approach to food waste issues. This is a **voluntary national reporting** aiming to build knowledge and to create best practice. In the future, food waste reporting could also be used to communicate the waste quantities (expressed in weight) to the European Union.

The following sections provide optional recommendations on how to publicly disclose the results of a NFWQS, through a National Food Waste Report (NFWR).

This Manual has no core requirement as regards the frequency (every year, every two years, etc.) of the national reporting, this reporting is done on a voluntary basis. However, an optional recommendation is made on this aspect when the reporting is used to track performance over time (see section 4.7.1).

4.6.1 Reporting principles

CR 17 – Core requirement: To the extent possible, the National Food Waste Report (NFWR) prepared by the MS shall be in accordance with the following principles (adapted from the FLW Protocol):

Relevance

Ensure that the quantification approach for developing the National Food Waste Quantification Study and National Food Waste Report serve the decision-making needs of

the intended users (i.e. among other possible MS authorities and EU Commission / Eurostat services). Present information in the report in a way that is readily understandable by the intended users.

Completeness

Ensure that the National Food Waste Report covers all food waste within the specified scope. Disclose and justify any significant exclusions (e.g. food waste that could not be quantified for any reasons – see core requirement in section 4.4.1 – Definition of the sector).

Consistency

Use consistent methodologies to allow for meaningful tracking of food waste over time. Transparently document any changes to the data, NFWQS scope, approaches to quantification, or any other relevant factors in the time series.

Transparency

Address and document all relevant issues in a factual and coherent manner based on clear documentation. Disclose any relevant assumptions and make appropriate references to the quantification approaches and data sources used in the NFWR. Clearly explain any estimates and avoid bias so that the report faithfully represents what it purports to represent.

CR 18 – Core requirement: It may happen that the user of the Manual may not be capable of complying with all the principles above (in particular for the first reporting).

One example related to scope in terms of food categories, is liquid waste from households and businesses which is particularly difficult to quantify. It is still preferable to provide a report in this case and limitations shall be properly identified and explained rather than not reporting at all[28].

In addition, if a core requirement has not been followed, the deviation shall be clearly mentioned and justified in order to be transparent in the NFWR.

4.6.2 Potential audiences

The possible audiences for a national reporting are varied. Examples are presented in the table below.

Table 4 – Potential audiences of a National Food Waste Report (that would be publicly disclosed by the MS on a voluntary basis)

Type of audience	Nature of interest in National Food Waste Report (illustrative)
Intergovernmental agencies (e.g. United Nations)	May have food waste targets or goals that a country seeks to report against. This includes, for example, the United Nations' Sustainable Development Goals, which define aspirational global targets.[29]

[28] See Table 2 in section 4.2 that specifies the classifications to be used if a component (e.g. region, food category, etc.) could not be accounted for.

[29]The Sustainable Development Goals (SDG) define aspirational global targets with each government setting its own national targets, guided by the global level of ambition but taking into account national circumstances. Goal 12 of the SDGs

Type of audience	Nature of interest in National Food Waste Report (illustrative)
Policy makers and government programme administrators	May use the NFWQS results to plan future programmes and policies, such as programmes on food waste reduction
Food waste practitioner (e.g. researchers, academics)	May wish to use the NFWQS results as data inputs for research purposes.
Sustainability / environmental practitioner	May seek to understand more about food waste in a country, sector, or food category.
Companies (agri-food companies, retailing companies, catering and food service)	May seek to understand more about food waste in a country, sector, or food category.
Private sector representatives (e.g. professional federations, workers' trade unions such as farmers unions)	May seek to understand more about food waste in a country, sector, or food category.
NGOs (e.g. food banks)	May use the NFWQS results to plan future activities.
General public	May have an interest in food waste but no understanding or prior experience with NFWQS.

4.6.3 Recommendations on the information to be presented in the National Food Waste Report

OR 9 – Optional recommendation: A NFWR prepared by the user of the Manual should contain the basic information presented in Box 1.

Box 1 – Basic information that should be included in a NFWR

BASIC INFORMATION
Presentation of the NFWR • Name of MS; • Coordinating organisation (the organisation in charge of the overall coordination of the NFWQS and of the submission of the NFWR): Name of the organisation and contact details; • Date of the NFWR (and version if it is an update of a previous report); • For subsequent reports, a link to previous reports and description of any methodological changes. ***Scope (see section 4.2)*** • Timeframe – Reporting year (calendar year for which the quantification is compiled); • Material type – Indicate if the NFWR includes:

is to: "Ensure sustainable consumption and production patterns." An accompanying target (Target 12.3) is: "by 2030 halve per capita global food waste at the retail and consumer level, and reduce food losses along production and supply chains including post-harvest losses." Sourced January 27, 2015 from: https://sustainabledevelopment.un.org/focussdgs.html

- Only a quantification of the overall amount of food waste considering food and associated inedible parts as a whole. The amount reported is thus a combination of both; or
- Also separated quantifications for food and inedible parts of food (optional recommendation).

  If wasted amounts of food and inedible parts are reported separately, indicate in the NFWR the sources or frameworks used to categorise a material as food or as associated inedible parts. In addition, if estimates were made to quantify separately the food or associated inedible parts, explain the approach used and, if applicable, all conversion factors, related sources, methods, and assumptions.

- Destinations
  - Clearly specify if certain destinations considered as food waste in the FUSIONS definition could not be accounted for (e.g. home composting);
  - If separate reporting is provided for the "Valorisation and conversion" category (optional recommendation), then specify, for each sector, the main types of materials that were considered to fall in this category (i.e. not considered as food waste).
- Boundaries – Clearly specify if certain food categories / (sub) sectors / geographical area could not be accounted for.

Results of the NFWQS

- Amounts of food waste expressed in metric tonnes / thousands of tonnes / Megatons (depending on the order of magnitude) – Provide the amounts for the "food and inedible parts of food" whose final destination is any destination except "valorisation and conversion";
- See Table 5 for a proposed template to report food waste amounts.

Tracking food waste over time[30]

- Indicate if any changes to the scope or methodology for quantification has occurred from one reporting period to the next;
- Recalculate the baseline NFWQ when significant changes in the quantification method or assumptions have occurred;
- Provide appropriate context identifying and describing significant changes that triggered base NFWQ recalculations (reasons and effects).

ADDITIONNAL DETAILS

Methodological details

- Additional background information on NFWQS results and how they are calculated;
- Additional qualitative data gathered through the food waste quantification study, for example, about causes of food waste (see 4.7.2);
- Additional disaggregation of results. For instance by region, or by destinations;

Assessment of uncertainty (quantitative – e.g. confidence intervals around the figures – and qualitative – a list of sources of uncertainty which are difficult to quantify –).

Selected approach(es) for quantification

- For any component of the quantification (any given sector / segment of a sector / waste stream / destination / etc.), specify whether existing food waste estimates or if new estimates (based on existing records or on new measurements) were used;
- If existing food waste estimates were used, specify:
  - Source and reference year(s);

[30] This is applicable only when a food waste reduction target is defined

- As much as is known about the specific scope for this sector, assumptions, and methods used to perform the sectorial food waste quantification (e.g. scaling factors);
- Areas of uncertainty and their likely impact on the results of the quantification.

- If records were used, from which food waste data are derived, specify:
  - Source and reference year(s) of the records;
  - As much as is known about the specific scope for this sector, methods and assumptions used to create the records (e.g. scaling factors);
  - Assumptions and calculations made to perform the sectorial food waste quantification;
  - Sources of uncertainty and their likely impact on the results.

- If a new study is undertaken to produce the sectorial food waste quantification data, specify:
  - Scope, methods and assumptions used, including as much as is known about any data collected from others (e.g. scope, methods and assumptions);
  - Assumptions and calculations made to perform the sectorial food waste quantification;
  - Sources of uncertainty and their likely impact on the results;
  - Approach used to build a representative sample and the scale-up factors used (where relevant).

Where relevant, specify the approach used for isolating quantities of food waste from packaging.

Table 5 – Template for providing food waste quantification results in the NFWR

	PART A			**PART B**			**PART C**
	Edible			**Inedible**			**Edible + Inedible**
	Dest.1	**Dest. 2**	**Dest. X**	**Dest.1**	**Dest. 2**	**Dest. X**	**TOTAL**
Sector 1	**OR**	**OR**	**OR**	**OR**	**OR**	**OR**	**CR**
Sector 2	**OR**	**OR**	**OR**	**OR**	**OR**	**OR**	**CR**
Sector X	**OR**	**OR**	**OR**	**OR**	**OR**	**OR**	**CR**
OR: Optional recommendation CR: Core requirement							

Each cell of this template should include a numeric value as well as comments on the value. It can be for instance details on the scope of the value, in case certain sectors or sub-sectors or product categories or areas could not be accounted for.

This template can be used either to report on:

- Amounts for edible and inedible parts presented separately (i.e. part A and part B of Table 5);
- Amounts for "Edible + Inedible" without distinction between the two (i.e. part C of Table 5);

4.6.4 Additional advice for communicating results publicly on a voluntary basis

Advice for public NFWR

OR 10 – Optional recommendation: Regardless of the audience, the report disclosed publicly on a voluntary basis should be designed to clearly describe the goals of the NFWQS, context and rationale behind various accounting decisions, summarise the overall conclusions that can be drawn from the evaluation of food waste quantities, as well as the limitations of the quantification exercise. Particular attention should be paid to the food waste definition, proper explanations on what is considered food waste or not should be provided in any communication in order to avoiding misunderstanding and misuse of the food waste data provided in the report. Typically it should always be clearly mentioned whether the considered food waste amount is only for edible materials or includes bother edible and inedible materials.

In addition to understanding the amount of food waste at national level, the audience of a NFWR may also be interested in what the MS is doing, or plans to do, to prevent or reduce food waste as a result of the quantification. Therefore, in preparing a report, a MS may also choose to inform the public of the activities it plans to implement and, where appropriate, the opportunity for particular stakeholders (e.g. consumers, industry) to take actions that prevent or reduce food waste.

If this is a subsequent report, an organisation should provide an overview of any changes (e.g. reductions or increases) observed since the previous NFWR and highlight efforts to address food waste as well as results. Examples could include a plan to focus reductions around a few key food waste hotspots, or summary of reductions or increases relative to the previous quantification study, highlighting the most effective initiatives or the reasons why food waste has increased if this is the case.

It can be noted that giving contextual information such as changes in population, in number of households, in retail sales, in food production, etc. should be communicated in the public NFWR to provide background to any changes, as would reference to other factors that may have an influence on the levels of food waste over the period in question (such as changes in food prices/earnings which can have a significant affect).

Describing limitations of NFWQS results

CR 19 – Core requirement: In order to raise awareness with audiences that the quantification study's scope and other factors affect the results and to therefore be aware of any limitations, a MS shall include a relevant disclaimer. A disclaimer is a text paragraph, which lays out considerations that should be taken into account when evaluating and using results provided in the NFWR. This helps communicate to audiences the limitations that may affect the comparability and accuracy of the results.

4.7 Other activities

4.7.1 Track performance over time

Introduction

NFWQS and NFWR allow a MS to track and report food waste quantities over time.

CR 20 – Core requirement: The user of the Manual shall follow the principles presented in this section when tracking food waste quantifications over time.

Base year and characterisation of a target

The timeframe (e.g. year) against which an organisation's NFWQ is tracked over time, is often referred to as a base or reference year. In addition to a base year, a target can be defined, whether a target has been achieved is determined by comparison between the base year NFWQ (i.e. amount of food waste generated that year) and amount of food waste at the end of the target period.

CR 21 – Core requirement: When tracking performance over time, a base year shall be defined by the user of the Manual.

CR 22 – Core requirement: Several factors shall be considered by the user of the Manual when characterising a target: Target type (absolute[31] or relative[32]), completion date, and level (more or less ambitious).

Monitoring performance

Ensuring consistency of scope and quantification method: Recalculating base year

In order for an organisation to successfully monitor progress, it is necessary to ensure the scope of the NFWQ being compared over time remains the same. In addition, changes to the quantification method can also have a significant effect on the estimate of food waste.

CR 23 – Core requirement: In order to consistently track food waste, the user of the Manual shall recalculate the base year NFWQ when significant changes in quantification method occur. In such cases, this recalculation is necessary to maintain consistency and enable meaningful comparisons of the food waste quantification over time.

Significant changes may include:

- Changes to the scope of the quantification study;
- Changes in calculation methodologies, improvements in data accuracy, or discovery of significant errors.

OR 11 – Optional recommendation:
Frequency of quantification should be defined based on the scale of change, absolute level of food waste, methodology, resources, budgets, etc. For a mid-term target (e.g. 20 years), the NFWQS should be (even partially) updated every two to three years (i.e. "low-cost" estimates based on synthesis of existing data) while more in-depth updating activities could be carried out every 4 to 6 years.

Considering the current level of waste analysis in the EU, it is most likely that the confidence intervals for the results a national food waste quantification study will be above 5%, whereas changes over a short period of time, at a national level, are likely to be less than that. Therefore, it would not bring any added value to a MS to carry out food waste quantification studies too frequently.

[31] An absolute target is a specific amount: a MS may intends to reduce food waste from 2015 levels by 5 million tonnes by 2025.
[32] A relative target is a reduction in the relative amount of food waste for example per capita or per unit of production: a MS may set a target of reducing food waste per capita from 2015 levels by 10% by 2025.

4.7.2 Recording causes of food waste

Recording causes is not the primary objective of the NFWQS and therefore the Manual does not provide guidance on this aspect. However, recording causes of food waste (i.e. why food waste is occurring) may be conducted by a MS at the same time as the NFWQS. Indeed, waste quantification is often motivated by an aim of waste reduction. Therefore, it is likely that waste reduction will be a common secondary objective of the users of the Manual. In such cases studying the root causes of the food waste, in order to more efficiently tackle its reduction, will be essential.

Note that the FLW Standard provides general guidance on how to identify classify and report root causes of food waste.

OR 12 – Optional recommendation: MS wishing to record causes of food waste should follow the FLW Standard guidance which distinguishes three broad types of causes that may lead to food waste: micro-level, meso-level, and macro-level causes[33].

A short presentation of these three types of causes is presented hereafter:

- Micro-level – Most immediate causes of food waste, for example: improper harvesting techniques, leading to damaged crops; improper storage of food, leading to rotting or consumption by pests; etc.
- Meso-level – More structural causes of food waste, for example: lack of cold storage technology in a region, leading to improper storage of food; confusion over food-date labelling, leading to food not being eaten in time by households; etc.
- Macro-level – Causes that are due to regulation or systemic in nature. For example, regulations on food donations can influence the amount of food waste produced by an entity. As regards systemic causes, examples (in low-income countries) include: lack of government investment in training and extension, contributing to insufficient farmer skills; unaffordable or unavailable electricity in a region, leading to the lack of cold storage technology; etc.

Additional remark:

In relation to the above-mentioned causes of food waste, it can be recalled that food waste prevention policies have a certain scope in which they can operate but there will always be a certain irreducible amount of food waste since food waste prevention cannot be at the detriment of human/animal health. Food safety/animal health regulations can impact on quantities of food/by-products going to incineration/landfill. Such regulations can change over time as public health scenarios evolve[34]. Food waste quantification can help to monitor the impact of such developments over time.

4.7.3 Review

Verification activities on a NFWR (e.g. peer review, quality assurance, audit, etc.) may be conducted either by the coordinating organisation or an external third party. Performing

[33] This typology of causes, as well as options for addressing, are presented in details the report HLPE, 2014. Food losses and waste in the context of sustainable food systems – A report by The High Level Panel of Experts on Food Security and Nutrition June 2014

[34] See for instance the developments in the Transmissible Spongiform Encephalopathies (TSE) Roadmap leading to relaxation of certain measures taken to control TSE-related risks.

such verification is not a core requirement of this Manual and therefore it is not the purpose of this document to provide guidance on the related activities.

Note that the FLW Standard provides general guidance on what is called "assurance" and which relates to verification activities in relation to food waste quantification.

OR 13 – Optional recommendation: If the user of the Manual wishes to implement a verification procedure, then it should follow the FLW Standard guidance.

5 Recommended approach for Primary Production (agriculture, aquaculture, and fisheries)

The primary objective of this chapter is to guide the reader through the process of determining food waste quantities (expressed in weight) in the primary production sector. The major steps of this process are found in Figure 4.

Conducting a food waste quantification at national level in the primary production sector

Primary production of food in the EU is very diverse. Food is produced in the sea or on land, captured wild or grown, using a number of different technologies and taking place in different climate zones and with different basic conditions such as soil types. It is also organized differently, e.g. regarding farm size and ownership. Natural variability in primary production can be very high because at the core are biological processes that are variable by nature. Finally, the availability of data varies a lot from place to place and between different production systems. Given these facts, it is not possible to give a detailed operating procedure on how to make a food waste quantification in the sector. Instead, this section on primary production gives guidance on different important aspects, for example on methods that can be used and advice on how to use the methods.

In spite of the mentioned difficulties, it is possible to apply the general steps of sectorial quantifications of food waste as presented in Figure 4.

- Review the scope of the sector, in particular carry out a mapping of primary production sector (see section 5.1.2)
    - Based on the main categories of produce in the sector and on the national production figures (e.g. from Eurostat), find out what are the main categories of produce in the MS (e.g. cereals).
    - Within each main category of produce, identify the main products (e.g. wheat in cereals) considering both production level and food waste level: identify those key crops/production methods which are most likely to result in significant food waste for further investigation and assessment or quantification.
    - Map the main sub-sectors e.g. greenhouses, fisheries, open field production, aquaculture.
- For each sub-sector identify and review existing data relating to food waste (see section 5.2)
    - Identify studies that quantify waste amounts for any product. Determine what other products these can represent.
    - Identify raw data that can be useful in the waste quantification, e.g. national statistical data.

- Select an approach for quantification
    - Choose a methodology for filling the data gaps through a new waste quantification study (see section 5.3). Where needed and feasible, plan a new waste quantification study. Choose methods and make preparatory work to facilitate the quantification – e.g. close collaboration with farmers' associations and similar organisations can be very useful to give valuable information and to motivate farmers to participate.
    - For each subsequent step, whether it consists of using existing food waste estimates/raw data or undertaking new measurements, define minimal acceptable quality levels and note where quality is inferior or uncertain (see sections 5.4 and 5.5).
    - Based on gathered information do the national quantification. Prepare a reporting document that clearly describes procedures followed, data sources and all other information that is needed to verify the results and to repeat the study in coming years (see section 4.6).

5.1 Scope and structure of the sector

This section helps the user of the Manual to have a better understanding of what is covered by the term "Primary production" and what is characteristic of this sector.

Applicable general core requirements: CR1, 2, 3, 4, 5.

5.1.1 Definition of primary production

Applicable general core requirement: CR6

Presentation

Important characteristics of the primary production sector (from a food waste perspective) are presented below.

Primary production operations are generally viewed as the activities that occur at farm/fish farm/fishing boat level. It is important to note that the primary production sector is different from the other sectors in several respects:

- **Large number of primary producers –** The number of production units in the EU is very large.
- **High variability in output** – Food production depend on biological processes that may vary significantly depending on factors such as diseases, temperature, precipitation and a number of other aspects beyond human control. Large variations in yields and product quality are often observed across different years, fields, regions, etc.
- **Considerable differences between MSs**, for a number of key aspects such as weather conditions, soils, crops, farm size, farm technology, etc.
- **Smaller number of products than other sectors –** Food products at primary production level are "raw" or "unprocessed". In subsequent steps of the food chain these raw materials are processed into a large number of products for sale.
- **Part of the waste occurs before the product enter the economic system** – i.e. before the product is sold for the first time. Thus data on the yield and waste

streams are less likely to be recorded, and in many cases no measurements are made.

CR 24 – Core requirement: The user of the Manual shall regard the following NACE codes as the parts of the food supply chain corresponding to primary production:

- 1 – Crop and animal production, hunting and related service activities
- 3 – Fishing and aquaculture

Sub-codes below NACE codes 1 and 3 referring to non-food productions (e.g. tobacco, fibre crop, etc.) shall not be included in the NFWQ for primary production. Examples include:

- 01.15 Growing of tobacco;
- 01.16 Growing of fibre crops;
- 01.30 Plant propagation;
- 01.64 Seed processing for propagation;
- etc.

In principle, the scope shall include all "primary" food categories[35], all life cycle stages within primary production and all organisations (producers, growers, etc.) involved across the entirety of the MS.

OR 14 – Optional recommendation:
For NWQS with secondary objectives, the scope should be further adapted to these specific objectives – e.g. if the goal is to increase profitability for milk farmers, only milk is considered and the relevant stakeholders are farmers and transportation companies. The study may even target only the parts of the milk farmer population where profitability is a problem, e.g. farms in a certain area or small farms[36].

Boundaries – Food supply chain steps to be considered for primary production

CR 25 – Core requirement: The primary production is the first step in the food chain and is followed by the processing stage; the user of the Manual shall consider the stages as presented in the figures hereafter:

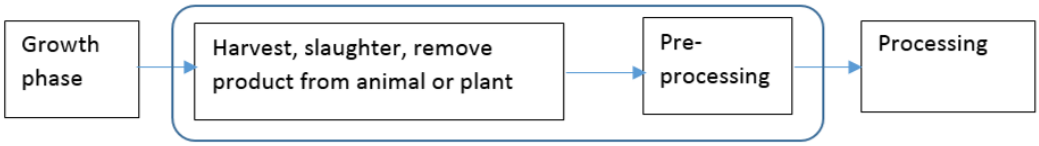

Figure 6 – General system boundaries (blue box)

In the FUSIONS definitional framework, the **starting point** is the point at which an organism (plant, animal, animal product) has **reached maturity** and is ready to enter the food value chain. Thus, the pre-harvest is outside of the system (see also section 1.2.2).

[35] i.e. "raw" or "unprocessed" food products e.g. Milk; Fruits and vegetables, including herbs; Nuts and seeds; Cereals; Meat; Fish and other types of seafood; Eggs; Honey.
[36] Note that there are two approaches to fulfil secondary objectives. The user of the Manual can either 1) first carry out a full study on all sectors and thus fulfilling the primary objectives defined in this Manual and then put an additional focus on certain parts of the food chain to fulfil specific secondary objectives or 2) Use the Manual to only fulfil (secondary) objectives of its own while not aiming at meeting the primary objectives.

The general system boundary is given in Figure 6, whereas Figure 7 gives examples of system boundaries for different products.

The **end point** of primary production is when the product enters the processing phase. "Processing" in this context is the conversion of food raw materials to food products.

Determining whether a given operation is "processing" or another type of activity – e.g. "pre-processing" is not always straightforward. Certain operations on products are carried out in the field, right after harvesting – e.g. separating vegetables from outer leafs, roots and other non-edible materials.

Some stages that could be called processing stages are included in the primary production sector if they are conducted on the farm / on the primary production site, specifically activities that further separate non-edible from edible material or other processes that change the product but maintains the structural integrity of the product. These processes could be called pre-processing.

In addition, activities such as washing, drying, sorting, intermediate storing, etc. may be performed on the farm or by the primary processor depending on countries and product categories. Therefore, related food waste may be reported in the "primary production" sector or in the "processing and manufacturing" sector depending on situations, the key point being to avoid double counting.

Food waste during transportation between the location of primary production and processing site is accounted for in the primary production sector. If products are refused at the gate of the processing site thus generating food waste, the ownership of the material will define the stage in which the food waste shall be accounted for. For instance, if the processor gets refunded or does not pay for these refused materials, then the waste shall be accounted for in the primary production stage. On the other hand, if the refused material is paid for by the processor, then the waste shall be accounted for in the processing stage.

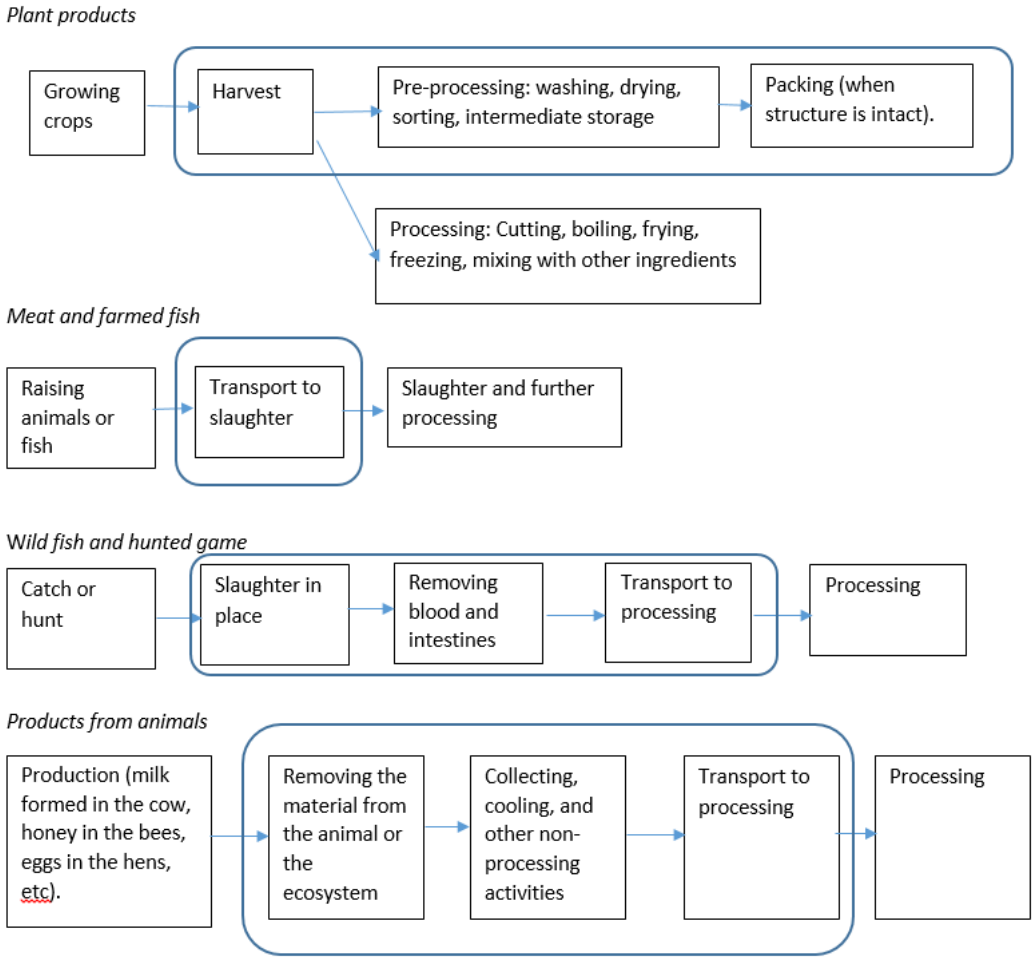

Figure 7 – Primary production system boundaries for different products (blue boxes)

5.1.2 Mapping of primary production sector

Applicable general core requirement: CR7

A good understanding of the overall structure of the sector is essential for sampling and scaling (see section 4.4.5.5).

As a first step, it is necessary to identify the main agricultural productions of the MS and the corresponding production systems. The type of information to be considered for the mapping can include for instance:

- Respective shares in terms of quantity (tonne) and value (euro) of the primary food product categories (e.g. fruits, vegetables, cereals)
- For each major categories,
    - Identify the key products that represent the category, based on production quantity, perishability, and other relevant criteria (e.g. for fruits in France four fruits – apple, peach, apricots, pear – represent 85% of the production in quantity in 2013[37]).

[37] FranceAgriMer, 2014. Les cahiers de FranceAgriMer. Les filières des fruits et légumes – Données 2013

- Identify the most representative production systems for those key products, in terms of technology, climate, soil type, geography, farm size, etc.

In a second step, one needs to determine who the key operators in the sector are. Relevant stakeholders are likely to include farmers, transportation companies, storage companies, primary processing and packing companies, etc. In some cases, contractors might carry out unit operations, such as harvesting or storage. In other cases, companies within the processing, wholesale, industry or retail sector might manage or own companies within the primary production sectors.
Understanding the characteristics of the stakeholders involved in the primary production sectors as well as their characteristics is a key aspect of this mapping exercise. Therefore, for each key product, the types of information to be considered in the mapping include:

- Which unit operations are done on the same site? – e.g. is the product in general stored on-farm?
- Who performs these operations? – e.g. does the farmer in general transport the product (animals, cereals, etc.) to processing?
- How big are the production units? – e.g. the farm, storage facility, pack house.
- Who owns the involved companies? Is the sector dominated by vertically integrated players or do different companies/people own the different stages like farming, storage, transport, pre-processing, etc.? Vertical integration can e.g. be when one company catch the fish and performs all operations until delivery to wholesale or retail

OR 15 – Optional recommendation:
When mapping the different product categories from agriculture, aquaculture, fisheries, hunting and gathering, a classification system (such as the Codex GSFA's food category system[38]) should be used.

About size of farms

The question of the size of the agricultural holdings is important. Larger units mean fewer entities have to be sampled in order to reach a certain level of representativeness. According to Eurostat: "*There were 12.2 million farms across the EU-28 in 2010, working 174.1 million hectares of land (the utilised agricultural area) or two fifths (40.0 %) of the total land area of the EU-28. The average size of each agricultural holding (farm) in the EU-28 was 14.2 hectares. However, there were big contrasts in the structure of agriculture across the EU: on the one hand, there were a large number (6.0 million or half of all holdings) of very small farms (less than 2 hectares in size) that farmed a small proportion (2.5 %) of the total land area that was used for farming in 2010 and, on the other, a small number (2.7 % of all holdings) of very large farms (over 100 hectares) that farmed almost half (50.2 %) of the farmland in the EU-28.*"[39]

It should be kept in mind that the size distribution of farms can also differ significantly from country to country. For example, Romania and Bulgaria are dominated by small-scale farmers whereas in Belgium and France the farms are larger (see for instance Table 16 and Table 17 in appendix 4). It may be easier to get a high coverage of the sampled

[38] FAO/WHO Food Standards – Codex alimentarius – GSFA Online
http://www.codexalimentarius.net/gsfaonline/foods/index.html?lang=en
[39] Eurostat Agricultural census 2010 - main results.
http://ec.europa.eu/eurostat/statistics-explained/index.php/Agricultural_census_2010_-_main_results

population if only larger farms are sampled but by doing so, the results will be biased towards such larger operations. Thus, representative data for each size category that contribute significantly to the overall production must be collected.

About production systems

Production systems must also be considered. Distinctions between combined and specialised production, and possibly between organic and conventional farming, may be relevant. One important example is specialised beef production vs combined milk and beef production.

Representative data must be collected for each of the different production systems if data suggest that they form a significant part of the entire production and if it is likely to have a significant influence on different wastage rates. It is not possible to set an absolute threshold of what can be considered significant as a production system that only makes up a small part of the entire production might be worth sampling separately if the studies suggest that the typical waste rate is much higher or lower than in other production systems for the same product.

About ownership of companies and organisation of supply chains

These are important aspects to review. Large differences may be observed across product types. In the meat sector, it is common that different people or companies own or operate farms, transport companies and slaughterhouses. In the vegetable or fruit sectors, the farmer may not only grow the crops, but may also do one or several of the following unit operations: harvesting, transportations, storage, initial processing and packing.

As an example, Table 18 in appendix 4 gives information about the labour force, which is an important clue to ownership structure.

Understanding ownership structure is important for a number of reasons. For example, it determines where the necessary information can be found and who shall be asked permissions for doing field measurements or to approach for information.

5.1.3 Definition of food waste in the sector

A clear understanding of how food waste in the primary production sector is defined is needed before a quantification study is undertaken. The definition of food waste is closely linked to the destination of the produced food, inedible/edible parts, and the intention behind the production.

Destinations

Requirements on destinations to be considered when evaluating if a material stream is food waste are presented in the section 4.2. Since it is not possible to give a complete list of possible destinations for food removed from the food chain at primary production stage, only some typical destinations are recalled below.

- Leaving the food in the field (e.g. unharvested mature crop) is a destination that is specific to this sector: mature crops may remain unharvested or ploughed back into the field for e.g. economic reasons. This is considered food waste in the FUSIONS definition (destination B4) if the material has passed the starting point

of the food supply chain (i.e. mature and ready to harvest) according to the FUSIONS theoretical framework (see section 1.2.2 in appendix1).

- Crops can be harvested but not regarded as edible because they are e.g. rotten/contaminated/subject to diseases. Various destinations may be possible for such crops and thus may or may not be consider food waste in the FUSIONS definitional framework (i.e. not considered food waste if crops are going to destinations B1 and B2 as defined in Table 1). In addition, the following criteria must be fulfilled to consider these crops as food waste
    - The crops on the field are intended for food;
    - The crops have or had the potential to be eaten;
    - The crops are ready for harvest and thus a part of the food supply chain.
- Animal by-products of category 1, 2 and 3[40] (e.g. blood and bones[41]) getting out of the food chain at some point are not allowed to re-enter the food chain. Depending on the category, various destinations may be possible for the animal by-products and thus may or may not be consider food waste in the FUSIONS definitional framework: animal by-products may be landfilled or used for energy purposes such as biogas production or incineration, or other purposes such as fertilization of fields, pet food or feed for animals. In addition, the following criteria must be fulfilled to consider these animal by-products as food waste[42]:
    - The animal is intended for food;
    - The animal has or had the potential to be eaten;
    - The animal is ready for slaughter and thus a part of the food supply chain.
- Milk may be mixed with manure or sent to sewer. The manure/milk mixture may be used (e.g. after compost, anaerobic digestion or spreading on fields) for energy and soil improvement, or not utilised at all. In such cases, the milk part of the mixture is considered food waste.
- Food used for energy purposes is considered food waste. Some examples of energy produced with agricultural materials:
    - **Anaerobic digestion** – production of methane from fermentation processes (destination B5);
    - **Bio-energy** – production of energy using resources other than methane, including bioethanol, for fuel (destination B6);
    - **Co-generation** – combined heat and power generation from incineration (destination B7).
- The definition of fish discard used in this Manual is adapted from the FAO's definition[43]. Fish[44] discard (destination B11) is the portion of total catch which is thrown away or slipped. It comprises the following components:
    - a. Species which are intended to be caught but got spoilt and unfit for consumption by the act of catching; these discards are food waste

[40] Animal by-products categories as defined in the EU regulation EC 1069/2009 of 21 October 2009

[41] See https://www.gov.uk/guidance/animal-by-product-categories-site-approval-hygiene-and-disposal

[42] For instance:

> Food waste: grown up animals ready for slaughter (part of the food supply chain): e.g. mortality when animals are brought together to be slaughtered or during transport to slaughter house

> Not food waste: mortality of very young animals (not considered to be a part of the food supply chain because not ready for slaughter)

[43] FAO Definitional Framework of Food Loss, 27 February 2014.

[44] Fish includes fish, shellfish and cephalopods.

- b. Species which are intended to be caught but do not meet the legal or quality standards, such as size; these discards are food waste.
- c. Species which are not intended to be caught, but which are fit for entering the food supply chain; these discards are food waste.

Some destinations typical for the primary production sector are not considered waste by the FUSIONS definition:

- **Gleaning** is the act of collecting leftover crops from farmers' fields after they have been commercially harvested or on fields where it is not economically profitable to harvest. Similarly to Food donation/food surplus redistribution (see chapter 3), this activity is still part of the food supply chain and thus is not considered food waste according to the FUSIONS definition. Gleaned food may ultimately go to destinations that are considered food waste. It is these material flows that, ideally, should be of interest for the NFWQS.

  CR 26 – Core requirement:

  It shall be ensured that the material gleaned is excluded from food waste quantifications if the scale of gleaning activity is sufficiently high to have an impact – i.e. in cases where, if not deducted, gleaning would lead to overestimation of food waste since gleaning reduces the amount of harvest waste.

- **Animal feed** is a common destination for food intended for human consumption but for some reason (quality, overproduction, low price etc.) not used as such.

  OR 16 – Optional recommendation:

  It may be worth quantifying gleaning and animal feed usage separately.

Finally, manure is not considered food waste since it neither food nor an associated inedible part.

Additional remark about fish discarding and the landing obligation in EU

In the EU, the new Common Fisheries Policy introduced in the beginning of 2015 a landing obligation: all catches have to be kept on board, landed and counted against the quotas. Undersized fish cannot be marketed for human consumption purposes. This change in regime serves as a driver for more selectivity, and provides more reliable catch data.

To allow fishermen to adapt to the change, the landing obligation will be introduced gradually, between 2015 and 2019 for all commercial fisheries (species under TACs[45], or under minimum sizes) in European waters. The first affected fisheries (from 1 January 2015) are the pelagic and industrial fisheries, and in the Baltic the salmon fisheries and fisheries for cod fall under the landing obligation.

Inedible and edible parts

Most food in the primary production sector contains both edible and inedible parts. The core requirement states that food waste is the sum of inedible and edible parts leaving the food chain, and not being valorised.

The optional recommendation is to quantify edible and inedible parts separately. This can in many cases be done using fixed factors. Such factors have been developed for many products, e.g. several vegetables, fruits, meat, fish. Rather than making a new

[45] Total allowable catches

quantification of edible material being wasted, the total number of inedible and edible material together can then be multiplied with a fixed factor to give the amount edible if the waste stream in question only includes one product. For example, carrots contain 89 % edible material, thus for each ton of carrots wasted, 890 kg can be considered edible.

One other problem concerns the definition of associated inedible parts. The harvesting technology and agricultural practices may vary from place to place. For wheat it is common to use combined harvesters that separate the straw from the ears during the harvesting process. In a few cases the straw is separated later. In the latter case it might be seen as correct to include the straw in the waste quantification for the waste occurring between harvest and straw removal. This might lead to inconsistencies in reporting. The solution to the problem in the case of cereals is that straw shall never be regarded as part of food waste regardless of technology.

CR 27 – Core requirement:
The same principle (as presented above for straw) shall be applied to all plants that are commonly harvested without associated inedible parts or whose inedible parts are removed during the harvesting process itself. This applies in particular to fruit trees, maize plants, outer leaves of certain vegetables such as sugar beet, etc. These parts of plants are not considered food since they are not intended to be consumed. In addition, although they can be seen as inedible part, they do not enter the food chain and therefore cannot be considered as food waste.

The general rule is as follows: if the inedible parts are typically removed during harvesting (e.g. sugar beet leaves) or not harvested (e.g. wheat straw, fruit tree, etc.) then these parts are not considered food waste since they do not enter the food chain. If the inedible parts are harvested and enter the food chain (e.g. olive pits), then it can be considered food waste (depending on final destination).

Intention behind the production

The definition states that the key to establishing whether a product is food waste is the intention behind the production. Was the material produced in the first place for energy, feed, human consumption, or another purpose? In certain cases, the farmer does not know what the harvested products will be used for. Common example of dual-purpose are crops for human consumption vs. animal feed or crops for human consumption vs. biofuels (e.g. rapeseed oil).

CR 28 – Core requirement:
When a product is widely used for multiple purposes (for instance food and energy purposes for crops such as corn and rape seed), the user of the Manual shall use national statistics on the respective shares between food and non-food applications. Food waste amounts for such products at primary production phase shall be adjusted using the average national share of the product going to food applications.

5.2 Identify and review existing data relating to food waste from primary production

This section takes the user of the Manual through a process for determining whether existing information related to primary production is robust enough to use within the sectorial quantification.

The key outcomes of this section are a) to identify all relevant data sources and b) to determine whether any of them are of sufficient quality to be used by the MS.

Applicable general core requirements: CR9, 10, 11

5.2.1 Identify existing data

Data gathering, e.g. by direct measurements or surveys is very time consuming, especially in the primary production sector where there are considerable number of operators. Using existing data relating to primary production food waste can thus save a lot of time and resources, although timely and relevant data may not exist for many products. It is therefore crucial to do a thorough search of existing data in order to take advantage of available food waste estimates and records. In many cases data can be found in other studies such as economic studies, studies of energy systems or studies aimed at identifying waste streams. It is important to notice that the nomenclature used to define food waste may be different in such sources, e.g. it can be called "production loss", "by-products", "co-products".

Identifying existing food waste estimates

The user of the Manual must keep in mind that, in general, availability of food waste quantification studies or food waste estimates is relatively low in the primary production sector as compared to other sectors. Indeed, most of the studies on food waste do not focus on primary production. In addition, certain waste-generating activities are performed before the materials enter the economic system which, means that the incentive to accurately measure them is low[46]. This means that food waste amount are often not measured or estimated. In cases where the amounts are actually measured or estimated, the results are often not reported.

OR 17 – Optional recommendation: Identifying existing food waste estimates should be done by reviewing public data sources and studies as well as getting in touch with e.g. farmers' unions, cooperatives, producer organisations, agricultural technical institutes, universities, agricultural advisors, research institutes, relevant agricultural departments of MS public authorities, etc. to check whether any public or private food waste quantification initiatives/projects have already been launched.

The user of the Manual should also keep in mind that it is important to search for data not only where the waste is produced, but also where it is treated, e.g. biogas plants. Transportation companies may also have important information.

Identifying records

Raw data on the primary production sector may have been collected for other purposes than studying waste. For example, economic studies of primary production may contain some information, but the format / nomenclature for data reporting can be very different from what is sought for in the NFWQS. Hence, it is important to have an open and broad approach when searching for data.

OR 18 – Optional recommendations:
As a first step, identifying records should be done by reviewing existing data sources.

[46] An example is grain falling from an agricultural trailer during transportation between the field and the silo.

For instance for meat products, losses of animals can occur by trauma when loaded on trucks, driven to the slaughter facility and unloaded (preslaughter mortality). The number of animals that are "dead on arrival" (DOA) is registered by MSs in a national database. For bovine animals specifically, but also for other farm animals, the requirements on cattle identification, registration and tracing are governed by several pieces of EU legislation and are very strict. The legislation allows having a thorough record of dead animals on the farm, during transport or at the slaughterhouse. Such animals are treated according to the EU regulation on animal by-products. The treatment varies according to the cause of death, but the animals are only sent to destinations regarded as food waste.

As a second step, it is suggested to get in touch with key stakeholders of the sector to assess whether they would be willing to provide records. The fact that data are recorded does not necessarily mean that the data are publicly available or available to those carrying out the study. If the data are not publicly available, it is recommended to contact the data owners and find out whether data can be made available for the study and under what conditions. Building trust is of high importance in this phase. It is important to stress that data collection is anonymous and will not be used for purposes other than food waste quantification. The life cycle stages or unit operations in primary production is the basis for planning contact with stakeholders and finding records.

- For animals:
    - The farmer generally has records of number of animals sent to slaughter and number of dead animals occurring in transport and on arrival;
    - As mentioned above, another source is the national database with numbers of animals that are “dead on arrival”.
- For vegetables, fruits and cereals:
    - Yield amounts are often not recorded before delivery to the next stage and sometimes not until the product is packaged or sent to processing. Food waste occurring on farm is often not recorded, especially harvest waste.

      Availability of records depends on the destination of the materials and whether the materials enter the economic system. It also depends on the way the system is organised. If the farmers do little or no sorting at harvest or before delivery, the bulk of the material is “delivered” to the next stage. The stakeholder in the next stage is more likely to measure and record overall delivered quantities, the quantity utilised and amounts of materials sent to the different destinations.
    - Data on harvest waste can be estimated based on information from agricultural advisors who often have knowledge on typical yields and sales yields, and on harvesting machinery and procedures and post-harvest handling. Suppliers of harvesting machinery also have knowledge that can be used to calculate harvest waste. In addition, nitrogen balance calculations can, in certain cases, be a useful input to estimate harvest waste. Nitrogen balances are based on fertiliser application guidelines and on information nitrogen compounds converted through chemical reactions as well as on information about nitrogen content in harvested products, in shredded parts, in run-off water, etc.

5.2.2 Review identified data and estimates

As a complement to core requirements presented in section 4.4.3, it is of crucial importance for this sector that the user of the Manual check the quality of data. In particular, the

representativeness of the data is very important because of high number of entities and (often) high variability in waste and yields.

One important objective is to check whether the identified data (food waste estimates or raw data) rely on e.g. a sufficient number of agricultural holdings for each main production systems for each product representative of the main primary food categories produced in the MS. It is also important to assess the uncertainties and biases inherent in the data. In particular, it is important to determine whether the food waste has actually been measured (e.g. weighed) or whether it has been estimated or inferred by an indirect method.

CR 29 – Core requirement: The assessment of the data quality (e.g. representativeness) shall be based on the information gathered during the mapping of the sector.

OR 19 – Optional recommendation: When ongoing initiatives/projects have been identified but provide data or results with limited representativeness or of inferior quality for other reasons, the user of the Manual should get in touch with the responsible of the project/initiative to discuss if the outcomes could be aligned to the Manual's requirements.

About products / production systems representativeness

OR 20 – Optional recommendation: The user of the Manual should consider if the identified records cover the main product groups (e.g. meat, vegetables, cereals, etc.). For each groups, the approach to select certain products (based on production quantity, perishability, etc.) should be reviewed. For each product, the approach for selecting a sample of farms should be reviewed: important parameters are technology, climate, soil type, geography, farm size and other parameters relevant for the product type.

5.3 Select approach for sectorial food waste quantification

As presented in section 4.4.4, there are three main types of source:

- Existing estimates: For MS where there is at least one significant ongoing project/initiative for measuring primary production FW;
- A new estimate based on existing raw data : For MS where there is records which can be exploited to derive food waste quantities;
- A new estimate based on new measurement: For MS where there are neither significant ongoing project/initiative nor proper records;

The hierarchy of which information to use is given in the decision tree in Figure 5.

5.4 Using existing estimates or raw data

Applicable general core requirements: CR12 and 13

Advice on how to use existing estimates is given in section 4.4.5.1. In the primary production sector, there may be results from previous quantifications that can be used, e.g. on the percentage of the amount of a certain product or group of products that becomes waste. To use this information to estimate the total food waste for that product for a member state, the percentage wasted needs to be multiplied by the total production figures, which are reported for MSs as national statistics on websites such as FAOSTAT and Eurostat.

Data on the percentage of production that is wasted is unlikely to be available for all products. Where this is the case, it may be possible to use data for one product as a proxy for other similar products (or the whole class of products that includes the product in question, e.g. wheat for cereals or carrots for root vegetables). This can be done in cases where the other products in the category are produced in a relatively similar manner and where experience has shown that the wastage is in the same range.

When applying this method, the user should be aware that some waste data may quantify edible waste, whilst other data may also include associated inedible parts. Similarly, the production data may include the total weight of product (including inedible parts) or may refer only to the edible material. Therefore, the calculations performed should be appropriate for the type of data obtained.

OR 21 – Optional recommendation: The user of the Manual should use the amount produced in the sector at national level and multiply it with the percentage of production that is wasted, using specific percentages for each product. Where data are lacking, proxy percentages from similar products can be used. The user of the Manual should keep in mind that differences in the percentage wasted might be large between different types of products like fish, meat, different vegetables, etc.

5.5 Undertaking a study involving new measurements

When neither food waste estimates/quantifications nor raw data for food waste quantification exists or are not sufficient, it is necessary to collect data or make measurements to do a food waste quantification.

OR 22 – Optional recommendation: Performing food waste measurements for all operators of the primary production sector is not practically and economically feasible. It is therefore necessary to study a selected sample. It is highly recommended to define and implement a sampling strategy based on the findings of the mapping of the sector. Consideration should be given to what constitutes a sampling unit (e.g. a farm, a field, a specified area within a field) and how to ensure that waste within the units sampled is measured.

Core requirement if optional recommendation is enacted:
When certain products/productions systems have not been considered, justifications and explanations for such choice shall be provided.

For instance, for the category "vegetables" in Belgium the following products represent less than 10% of the total vegetable production: asparagus, pumpkins, squash and gourds, cucumbers and gherkins, eggplants, chillis and peppers (green), mushrooms and truffles. Food waste may be estimated using food waste percentages from other products as proxies, considering the limited contribution of these products to the overall production. However, if the waste amounts are known to be very high for any of the low quantity products, the product groups should nevertheless be quantified from data that are more specific.

Recommended quantification methods

OR 23 – Optional recommendation: Methods presented in this section are recommended by the authors of this Manual and should be used by MS when undertaking a new study involving new measurements.

5.5.1 Calculation methods based on statistical data and new measurements

"Statistical data" refers to data collected in a standardised way, (often) analysed and published. Government bodies often collate statistical data, but sometimes, other stakeholders may also collect such data. Statistical data can be a good source of data for specific types of food waste e.g. mortality during transport of live animals. In other situations, statistical data can be combined with new measurements to obtain an estimate of food waste in primary production. Statistical data can also be used indirectly as in consistency checks to verify other calculations. An example of such verification activities is to use national numbers on mass flows going to one destination, e.g. anaerobic digestion, to compare with calculated waste amounts (from e.g. questionnaires to farmers) going to this destination.

Section 5.4 outlines the method if there is existing information on the percentage of production that gets wasted. However, this information is not always available (or, if it is, may too old to be used for the purposes of the manual user – e.g. tracking a target). In such cases, a programme of measuring waste percentages would need to be implemented.

To obtain data on the percentage of production that gets wasted for a given product, there are the following considerations:

- Consideration of where the measurements are going to take place. Ideally, a representative sample of production would be made. Some of the factors to consider include the production systems used, the geography, the climate, soil types, breeds / strains grown or reared.
- Consideration of when to measure – in many cases food waste is only generated for during a specific time frame (e.g. immediately post-harvest) and measurement should reflect this.
- How food waste will be collected or collated – for some processes, food waste will be produced in one location, but in others it will be more disparate (e.g. in multiple locations within a single farm). Consideration should be given to whether the food waste needs to be brought together for measurement to occur.
- How to measure – there are a number of methods for measuring food waste that could be applied to primary production. If the food waste has been collected together and is separate from other material, it could be directly weighed (the most accurate measurement method – see below for more details). Other methods are available, including counting the number of items and applying an average weight to determine the total waste.
- Who performs the measurements – possibilities include researchers performing the study and the primary producers (e.g. farmers) with suitable instructions.
- How the food-waste information is collated – depending on how the information is generated and by whom, there are a number of methods for collecting the information together for the study. These include use of questionnaires, surveys and forms (paper or electronic) within which those performing the measurement enter the data (see below for more details).

- Comparing waste and production data – to determine the percentage that is wasted, production data is also required.

To obtain this information for a range of products will take a co-ordinated effort with co-operation from a range of stakeholders. Below are two ideas for how existing organisations and initiatives could be used to help in such projects:

- The Farm Accountancy Data Network (FADN)[47] could be used as a possible tool to gather "food waste" data on an EU-level from farmers although the information found in FADN is mainly economic data and very general. An extension to cover waste specific aspects would be necessary.
- Country specific farmers' unions' statistics, public farm statistics, and farm networks could be used. For instance, in some countries the statistical agencies have a number of model farms or model fishing boats that they have an agreement with for the delivery of information for different kinds of statistical data at regular intervals.

5.5.2 Questionnaires and interviews

Questionnaires and interviews are methods for collecting data that are measured or estimated but not recorded. The data may also be recorded, but not publicly available. Interviews are much more labour-intensive than questionnaires, but gives more insight because of the possibility of follow-up questions and for helping respondents understand questions. Questionnaires allow the study of large populations, especially if the questionnaires can be distributed by email and response made online.

5.5.3 Direct measurements

Direct measurement refers to weighing or volumetric assessment of a material. It may be the only method to use if no measurements have been made and mass balance (see next paragraph) is difficult to use. It is a very resource-intensive data collection method but give very precise data. Because of high cost, it is difficult to measure a representative sample. This may in many cases be the only method available for quantification of harvest waste.

5.5.4 Mass balance

Mass balance is an indirect method to calculate food waste using data on e.g. sold harvest, total harvest, waste treatment, etc. (Gustavsson et al., 2011 & 2013) but it requires available statistics and/or expertise (Almeida, 2011; Beretta, 2012). Collecting data on waste is not needed when using this method. The amount of waste is calculated from other mass flows. For example, the amount of wheat waste may be calculated by using data on harvested yields and imports (the inflows) and subtracting outflows (e.g. amount sold to consumer, amounts used for sowing, amounts intended for animal feed and exports). Such calculations can be performed for a whole country, but could also be applied to individual businesses (e.g. farms).

When using a mass balance it is important to know all material streams entering and leaving a system. In some cases food that goes to some destinations, e.g. used for

[47] The Farm Accountancy Data Network (FADN) is an instrument for evaluating the income of agricultural holdings and the impacts of the Common Agricultural Policy
http://ec.europa.eu/agriculture/rica/

animal feed on-farm, is not recorded. Where this is the case, failing to take this flow into account in the mass balance will overestimate the quantity of food waste.

The data used in mass balances must be clearly defined and shown to actually be usable to define food waste. Estimates on wasted food retrieved from mass-balances, for example from food balance sheets of governmental statistical agencies, may not be a reliable indicator. In food balance sheets, losses are one amongst other parameters when putting supply and demand in the following equation:

Total domestic supply = total domestic demand, of which:
Total domestic demand = production + imports – exports + stock variation
Total domestic demand = Seeds + Losses + Feed + Industrial usage + Processing + human consumption (without industrial processing)

According to the methodological documentation provided with food balance sheets, losses are one parameter that are used, at least partially, for outbalancing other parameters (production, industrial processing etc.) which are based on primary data. Therefore, it should be underlined that "losses" in food balance sheets do not truly reflect food waste but instead should be seen as a statistical adjustment variable.

Mass balance is a recommended tool in cases when food waste data are lacking and when the data used in the mass balance approach are clearly defined and found to be usable to calculate food waste and data on material going to all relevant destinations is included.

Additional remark: about food waste diaries
Food waste diary involves data collection by individual farmers or other relevant stakeholders by making notes of their observations (and measurements) while being involved in the unit operations in the sector. It is much more time consuming for a farmer to make a diary than answering a questionnaire or being interviewed. Such data collection might be useful in cases where data are otherwise lost, data that might provide useful insights for the quantification. The use of a diary can for example give important information on how weather conditions in the harvesting stage, choice of harvesting equipment, soil type or cultivar type affects not only harvesting wastage but also wastage in later stages, e.g. storage.

Food waste diaries are a very resource intensive method. It seems unrealistic to persuade a large enough sample of farmers needed to make a statistically valid quantification. Diaries also depends on the participants being consistent in making their observations. Thus it is better to use diary for observing something that occurs in a limited space of time, e.g. harvest, rather than something that occurs over a longer time period. In the example given above, the information from diaries is not used directly in quantification but rather to give insight that can be useful, e.g. when making questionnaires and questions for interviews.

Further details on quantification methodologies are provided in appendix 3.

5.6 Other activities: recording causes of waste

Food waste in primary production occurs for distinct reasons. The apparent reason might be that an animal dies during transport to slaughter, the milking cow is ill, fish is damaged in a trawl haul, vegetables are of wrong size and shape, the protein content of wheat is too low, fruit has small spots and blemishes or a number of other reasons. This

is caused by another set of factors, e.g. bad weather during harvest, improper storage conditions, improper handling, not taking enough care to prevent illness, insufficient pesticide application. While investigating these causes, it might be that a number of underlying structural causes are uncovered. The farmers may have little incentive to prevent food waste because such efforts give little financial reward. It might not be profitable to gather harvest waste and sell it, due to low prices. Another such underlying cause is inadequate training. Overproduction to make sure that a contract is fulfilled is a further example.

OR 24 – Optional recommendation:
When recording data on causes for waste, the user of the Manual should not mix up the different layers of causes – e.g. when recording reasons for carrot waste, the amount that is caused by each apparent reason may be recorded first, then for each of these reasons the factors behind are uncovered and finally the underlying reasons. If all these layers of causes are investigated simultaneously, the result will be confusing.

6 Recommended approach for Processing and Manufacturing

The primary objective of this chapter is to guide the reader through the process of determining food waste quantities (expressed in weight) in the processing and manufacturing sector in an EU Member State. The major steps of this process are found in Figure 4.

6.1 Scope and structure of the sector

This section helps the user of the Manual to have a better understanding of what is covered by the terms "processing and manufacturing".

Applicable general core requirements: CR1, 2, 3, 4, 5.

6.1.1 Definition of processing and manufacturing

Applicable general core requirement: CR6

Details on the organisation of the sector are provided below.

Presentation

Food manufacturers process raw materials to make food products such as biscuits, ready meals, snack foods, drinks, etc. During manufacturing, foodstuffs undergo one or more of a whole range of procedures such as washing, trimming, cutting, mixing, pasteurization, baking, frying, blending, packaging, etc.

A "process", in this context, refers to a series of activities which could include all, or part of the activities occurring in a food processing industry, from incoming raw materials to finished product. Different processing industries (bakery industry, dairy industry, etc.) perform different types of activities when transforming raw materials into various food products. Processes can be relatively simple (e.g. cleaning and bagging of fruits) or more elaborated (e.g. manufactured of prepared meals).

As previously mentioned in chapter 5, activities such as washing, drying, sorting, intermediate storing, etc. may be performed on the farm or by the primary processor depending on countries and product categories. Therefore, related food waste may be accounted in the "primary production" sector or in the "processing and manufacturing" sector depending on situations, the key point being to avoid double counting.

CR 30 – Core requirement: The user of the Manual shall regard the following NACE codes as the parts of the food supply chain corresponding to processing and manufacturing:

- 10 –Manufacture of food products (Except code C10.9 - Manufacture of prepared animal feeds)

- 11 –Manufacture of beverages

Boundaries – Food supply chain steps to be considered

CR 31 – Core requirement: The user of the Manual shall consider all activities occurring in a food processing industry and carried out in order to obtain a finished product from incoming raw materials.

The **starting point** shall be at the gate of the *primary* processing and manufacturing factory, when raw materials enter industrial food processing industries (food manufacture). The **end point** shall be at the gate of the factory where the *final* processing and manufacturing takes place, when the finished products leave the food processing industries. Food waste occurring during possible transportation steps between two processing stages shall be included in the sectorial quantification.

A generic process for food manufacturers may include activities such as:

- Reception of raw materials in the factory[48]
- Sorting of raw materials (quality control)
- Storage of raw materials
- Pre-processing treatments
- Processing treatments
- Sorting products (quality control)
- Packaging
- Storage

6.1.2 Mapping of processing and manufacturing sector

Applicable general core requirement: CR7

A good understanding of the overall structure of the sector is essential for sampling and scaling (see section 4.4.5.5).

As a first step, it is necessary to identify the main sub-sectors[49] within the food processing sector of the MS and the corresponding key processes. The type of information to be considered for the mapping can include for instance (see appendix 5 for illustrations):

- Analysing the respective size of the various food and drink industry sub-sectors (e.g. meat products, bakery, drinks, etc.) in terms of number of companies and production units, production volume, turnover, value added, number of employees, etc.

[48] Certain "pre-processing" activities may be performed on the farm or by the primary processor depending on countries and product categories. Therefore, related food waste may be accounted in the "primary production" sector or in the "processing and manufacturing", the key point being to avoid double counting. See paragraph on "boundaries" in section 5.1.1.

[49] i.e. Oils and fats; Processed fruit and vegetables; Bakery and farinaceous products; Dairy products; Drinks; Meat products; Grain mill and starch products; Fish products; etc.

- For each major sub-sectors,
    - Identify the key products that represent the category, based on production (e.g. about 55% of milk in France is transformed in cheese or butter[50]).
    - Identify the most representative processes for those key products, in terms of technology, sequence of activities, etc.
    - Identify the main organic wastes associated with these representative processes.

In a second step, one needs to determine, based on the number of companies, production volume, turnover, etc., who the key operators in the sector are.

The question of the size of the factories is important. Larger units (i.e. in terms of production volumes) mean a fewer entities have to be sampled in order to reach a certain coverage of the whole industry. In particular, it may be relevant to evaluate the share of the production being done by Small and medium-sized enterprises (SMEs) which are likely to generate different level of food waste as compared to larger companies.

Illustration with a mapping carried out in the UK

For instance, a study carried out in the UK (Anthesis, 2014) has shown that six main organic waste categories were associated with manufacturing sites:

- food sludges;
- animal tissue wastes;
- materials unsuitable for consumption or processing;
- effluent sludges from on-site treatment;
- animal wastes; and
- edible oils / fats.

A set of food and drink manufacturing "clusters" (i.e. sub-sectors) were identified in this study, and were differentiated by key attributes relating to product type, waste arisings, waste treatment and disposal practices:

- Milling of grain, ingredients such as starch and malt
- Edible oils and fats
- Fruit and vegetables (fresh & frozen)
- Meat, fish and poultry
- Dairy: milk and cream
- Dairy: cheese and ice cream
- Bakery and cakes (fresh)
- Soft drinks, including juices
- Alcoholic drinks
- Confectionery
- Processed 'dry' foods
- Processed prepared meals

[50] CNIEL, 2015. L'économie laitière en chiffres – Edition 2015

- Sugar

The study found that the profile of food and drink waste across the clusters was highly varied (see Figure 19 in appendix 5), with key differences between clusters mainly producing reject (plant or animal origin) waste and those producing sludges derived from onsite secondary treatment processes:

- Wastes consisting mainly of rejects or food lost during the manufacturing processes were most common in five industry clusters: "meat, fish and poultry", "soft drinks + juices", "confectionery", "processed prepared meals", and "alcoholic drinks";
- Wastes consisting mainly of materials derived from onsite secondary treatment processes (sludges or digestates) were most common in 6 industry clusters: "grain/milling", "edible oils", "fresh fruit and vegetables", "processed dry foods", "dairy: milk & cream" and "dairy: cheese/ ice cream".
- Waste generated from fresh bakery and cakes manufacturing was evenly split between onsite sludges and rejects.

6.1.3 Definition of food waste in the sector

A clear understanding of how food waste in the sector is defined is needed before a quantification study is undertaken. The definition of food waste is closely linked to the destination of the produced food, inedible/edible parts, and the intention behind the production.

Destinations

Requirements on destinations to be considered when evaluating if a material stream is food waste are presented in the section 4.2.
A study carried out in the UK (Anthesis, 2014) has shown that typical off-site waste treatments include:

- Land spreading (covered in destination B4)
- Composting (destination B3) and anaerobic digestion (destination B5)
- Energy from waste (destination B7 co-generation)
- Landfill (destination B10)

Food and associated inedible parts going to any of these commonly observed destinations in the sector are considered food waste in the FUSIONS definitional framework. In addition, if food and associated inedible parts removed from the food supply chain at the processing and manufacturing stage go to any other destinations within destination B3 to B11, these flows will be considered food waste.

The food waste / non-food waste status for several materials flows commonly encountered in the food processing sector is clarified below. The status presented here is based on the fact that the final destination of the material is out of the human food chain but is not "animal feed" nor "biobased materials and biochemical processing" (i.e. two destinations not considered food waste under the FUSIONS definitional framework).

- Edible/non-edible materials coming from animals and generated at the processing and manufacturing stage are considered food waste since,
    - The animal is intended for food;
    - The animal has or had the potential to be eaten;
    - The animal has entered the food supply chain.

In particular, collagen, feathers, shells from shell fish are materials that are considered food waste since they have entered the food chain.

- Effluents from washing, cleaning, sorting, processing (may include small parts of processed food): the food waste / non-food waste status will depend on the composition of the effluent (see paragraph below about water in the food processing sector).
- Waste and residues from distillation of spirits: considered as food waste if the spirits is intended for food.
- Husks (e.g. of wheat or rice): considered as food waste (since they have entered the food supply chain).
- Co-products and by-products from edible oil extraction: considered as food waste (since they have entered the food supply chain).
- Leaves of consumable plants – (e.g. tomato or cabbage) removed during processing stage: considered as food waste since it is an edible part of food that has entered the food chain. Note that when these parts of plants are left on field under normal harvesting conditions (primary production stage), this is not considered food waste.
- Materials getting out of the main process chain because of quality issues for instance (e.g. broken biscuits) but still kept within the food supply chain: not considered food waste. Such materials may be:
    - marked down in price but ultimately sold and used as food;
    - re-worked or incorporated into other food products (e.g. as ingredients), even if not the most financially-rewarding purposes.
- Unsold food (and associated inedible parts) which is redistributed/donated by manufacturers to charities: not considered food waste (a percentage may have to be disposed of, and therefore be classed as food waste);

Note that in case of mechanical biological treatment (MBT), there is a drying phase in which the treated material loses water, followed by a sorting phase, giving rise to recyclable sub streams. Therefore, waste that is undergoing this process loses weight. In such case the food waste quantification should be based on input materials and not on output materials.

- Water used in the food supply chain, but not incorporated into a product, is not considered as a part of "food and inedible parts of food removed from the food supply chain" (e.g. water used to flush food down the drain during cleaning processes).
- Water intentionally removed during processing (e.g. water evaporating during cooking) is not considered as food waste (since it is not "intended to be eaten" and therefore not defined as "food").

Dealing with water used in processing and manufacturing sector

Water is a key processing medium in food processing plants. Water is used throughout the food production process, including food cleaning, sanitizing, peeling, cooking, and cooling. Water is also used mechanically as a conveyor medium to transport food materials throughout the process as well as for washing production equipment between operations.

Methodological principle from the FUSIONS definitional framework (see section 1.2.3 in appendix 1)

- Water *used in a process*, but not incorporated into a product, is not considered as food waste since it is not a part of "food and inedible parts of food removed from the food supply chain" (e.g. water used to flush food down the drain during cleaning processes)[51].
- Water *intentionally removed* from a product during processing (e.g. water evaporating during cooking) is not considered as food waste (since it is not "intended to be eaten" and therefore not defined as "food").

Dealing with effluents when quantifying food waste from the processing and manufacturing sector

The food processing and manufacturing sector commonly generates liquid wastes called effluents. Effluents are composed of water as well as various materials such as food (e.g. when cleaning the production chain), dirt (dirt removed during a carrot washing process), etc. The food waste / non-food waste status will depend on the composition of the effluent and its final destination: food material contained in an effluent going to sewer is considered as food waste. Guidance on the quantification of this food waste are provided in appendix 3, section 3.11.

6.2 Identify and review existing data relating to food waste from processing and manufacturing

This section takes the user of the Manual through a process for determining whether existing information related to processing and manufacturing is robust enough to use within the sectorial quantification.

The key outcomes of this section are a) to identify all relevant data sources and b) to determine whether any of them are of sufficient quality to be used by the MS.

Applicable general core requirements: CR9, 10, 11

6.2.1 Identify existing data

Identifying existing food waste estimates

OR 25 – Optional recommendation: Identifying existing food waste estimates should be done by reviewing public data sources and studies as well as getting in touch with e.g. food industry federation, dominant food and beverage companies to check whether any public or private food waste quantification initiatives/projects have already been launched.

In particular, the user of the Manual should gather waste percentages (%) from existing detailed and representative case studies for each of the major food and drink industry sub-sectors of the MS. Such waste percentages are calculated as ratio between food waste (in tonnes) and total manufactured food produced (in tonnes).

[51] In certain food processing industries, there is a risk to significantly overestimate the amount of food waste if water for cleaning is not removed from the food waste quantification.

6.2.2 Review identified data and estimates

As a complement to core requirements presented in section 4.4.3, it is of crucial importance for this sector that the user of the Manual check the representativeness of data.
The objective is to check whether the identified data (e.g. food waste percentages) relies on e.g. a number of factories that covers a sufficient production quantities of the main food and drink industry sub-sectors of the MS and are representative of the sector as a whole.

CR 32 – Core requirement: The user of the Manual shall assess the coverage and representativeness of the identified data (e.g. food waste percentages) based on the information gathered during the mapping of the sector.

OR 26 – Optional recommendation: When ongoing initiatives/projects have been identified but have limited representativeness, the user of the Manual should get in touch with the responsible of the project/initiative to discuss if the outcomes could be aligned to the Manual's requirements.

About food and drink manufacturing "clusters" (sub-sectors) representativeness

OR 27 – Optional recommendation: When reviewing identified food waste data and estimates, the user of the Manual should consider the main sub-sectors in the country: it may be acceptable to focus only on the major sub-sectors.

Core requirement if optional recommendation is enacted:
When certain sub-sectors have not been considered, justifications and explanations for such choice shall be provided.

6.3 Select approach for sectorial food waste quantification

As presented in section 4.4.4, there are three main types of sources:

- Existing estimates: For MSs where, for instance, there are relevant food waste percentages for each or some of the major food and drink industry sub-sectors.
- New estimates based on existing raw data: For MSs where, for instance, existing records can be exploited to derive food waste percentages for each or some of the major food and drink industry sub-sectors.
- New estimates based on new measurements: For MSs where, for instance, there are neither existing relevant food waste percentages nor relevant records from percentages can be derived, for each or some of the major food and drink industry sub-sectors;

The hierarchy of which information to use is given in the decision tree in Figure 5.

6.4 Using existing estimates or raw data

Applicable general core requirements: CR12 and 13

Advice on how to use existing estimates is given in section 4.4.5.1.

It is likely that major food companies have already implemented a methodology (such as Six Sigma[52]) for quantifying and reducing different kinds of wastes (including food waste) and their associated costs. Therefore, factories might already have information in the form of food waste percentages (for a given process or at factory level) or if not, food waste percentage might be derivable from existing data (e.g. converting financial records back in to weights and comparing these to the amount of food produced).
It can also be noted that a number of food processing companies use the services of waste collection companies from which data on collected and treated quantities of waste may be available.

The key issue in this case will be to ensure that the food waste percentages already available or derived from already available data are aligned with the requirements of this Manual in terms of scope, food waste definitions, etc.

Based on the mapping of the sector and the review of existing data, the user of the Manual should have a clear view of what type of data to ask (i.e. which representative products and process) and to whom (i.e. which companies). The user of the Manual with then have to get in touch with targeted companies to collect the key existing data on food waste percentages. Preserving business confidentiality should be an important concern for MS authorities in this process, the best approach being to use aggregated and anonymised data.

OR 28 – Optional recommendation:
Once data on food waste percentages for each of the major representative sub-sectors has been collected by the user of the Manual, these percentages should then be multiplied with existing food productions statistics at national level for each sub-sector to obtain food waste amounts for the whole sector in the MS.

6.5 Undertaking a study involving new measurements

Recommended quantification method

OR 29 – Optional recommendation: The method presented in this section is recommended by the authors of this Manual and should be used by MSs when undertaking a new study involving new measurements.

Further details on quantification methodologies are provided in appendix 3.

The recommended approach is a combination (i.e. multiplication) of:

- Food wastage percentages representatives of each food industry sub-sector. These percentages will be collected through sampling;
- European production statistics.

Performing new measurements of food waste percentages

In order to obtain food wastage percentages, the recommended approach is weighing in combination with process improvement methodologies (such as Six Sigma which aims at

[52] The purpose of both the lean and the six sigma methods is to reduce variations at the same time as increasing profits, decreasing costs, eliminating defects and waste while keeping quality considerations in mind (Kovach et al., 2011).

reducing waste and thus implies some sort of quantification of these waste). The method can be applied in all types of food processing industries.

The recommended company-level approach for quantification of food waste percentages can be concluded by:
1. Mapping the process
2. Weighing "food waste" in the process where it occurs (=collecting primary data)
3. Perform measurements frequently enough

Map the process
OR 30 – Optional recommendation: The type and sequence of activities performed during processing will vary greatly across the various food industries (bakery, fish products, etc.). The user of the Manual should map the specific process (the series of activities in which the "food waste" occurs or may occur) for the main food industries[53] in order to know which activities occur within a specific food processing industry.
A process, in the context of a food processing industry, may be e.g. the whole production line from the mixing of raw materials to the end product; part of a production line or single activities such as filling up containers or packaging. Understanding the process is necessary for understanding where waste can occur.
The user of the Manual should ensure that the mapping of the process is detailed enough so that all activities which may generate waste can be identified.

Weighing the amount of wasted food
It is preferable to quantify the amount of wasted food by measuring the amount of wasted food where it occurs, in other words by collecting primary data. The amount of wasted food may vary over time as well as between food processing companies; within companies (e.g. between different production lines) and between products, so the measurements need to be specific to give a true picture of the amount of wasted food amounts occurring in a certain food processing industry.

Perform measurements frequently enough
It is also important to measure the amount of wasted food frequently enough, and during representative periods of production, to illustrate the variations in the amount of wasted food levels over time. When following up mean values for weeks/months or even years, the variations in waste levels may not be visible and the causes behind the waste are more difficult to identify. Measuring the amount of wasted food should preferably not be a single (isolated) project; the work should rather be an on-going, regular, part of the daily work.

Conversion factors
Conversion factors could be used for quantifying edible and inedible parts separately, with different conversion factors for different product groups and different levels of processing.

Combining food waste percentages with production statistics

A method using EU PRODCOM data[54] is suggested. The method is foremost suitable for producing "food waste" statistics for the food processing industry for the whole sector at MS level.

[53] i.e. Oils and fats; Processed fruit and vegetables; Bakery and farinaceous products; Dairy products; Drinks; Meat products; Grain mill and starch products; Fish products, etc.
[54] Eurostat (2010). Manufactured goods (PRODCOM). Available online at http://epp.eurostat.ec.europa.eu/portal/page/portal/prodcom/introduction

The EU PRODCOM system classifies products according to an eight-digit code: the first four digits are the classification of the producing enterprise given by the Statistical Classification of Economic Activities in the European Community (NACE) (Eurostat, 2008). Most product codes correspond to one or more Combined Nomenclature (CN) codes, which is the system used for customs and taxation.

The EU PRODCOM database includes data on:

- The physical volume of production sold during the survey period (used for the recommended macro level approach)
- The value of production sold during the survey period
- For some products, the volume of total production during the survey period

The table hereafter shows the various food product categories classified by the NACE Rev.2 3-digit code.

Table 6 – Food product categories by 3 digit NACE code (Rev. 2).

NACE code (3 digits)	Description
10.1	Processing and preserving of meat and production of meat products
10.2	Processing and preserving of fish, crustaceans and molluscs
10.3	Processing and preserving of fruit and vegetables
10.4	Manufacture of vegetable and animal oils and fats
10.5	Manufacture of dairy products
10.6	Manufacture of grain mill products, starches and starch products
10.7	Manufacture of bakery and farinaceous products
10.8	Manufacture of other food products
10.9	Manufacture of prepared animal feeds
11.0	Manufacture of beverages

It is suggested to use the more specific 4 digit code if possible (i.e. circa 30 codes – see appendix 5.3). However, if resources do not allow, the 3 digit code could suffice although there will be undoubtedly greater variation in the quantities of wastes arising from the processes listed under the more generic 3 digit code. An intermediary option would be a prioritisation of the most relevant 4 digit codes. Four digit codes to focus on could be identified by determining the sub-sectors that are likely to make up the most food waste in a given MS.

Product group specific "food waste" percentages (developed and improved over time with detailed and representative case studies) would be applied to the volumes of manufactured food to quantify the amount of wasted food having occurred to produce the volumes of sold manufactured food. The waste percentages would be determined by mapping and evaluating food production systems in collaboration with industry professionals (preferably using the suggested micro level methodological approach for

quantifying the amount of wasted food). The waste percentages should define edible and inedible wastes and co-products separately.[55]

The following equation quantifies the amount of wasted food (tonne):

$$Food\ waste\ (tonne) = Total\ sold\ manufactured\ goods\ (tonnes) \times \frac{Waste\ percentage\ (\%)}{100\% - Waste\ percentage\ (\%)}$$

Allowance for the flows of products and co-products from one food product group to another should be made to ensure the avoidance of double counting before consolidating the sub-sector mass-balances into an overall mass-balance for the EU food and drink processing industry.

[55] Examples of product-group specific "food waste" percentages at processing and manufacturing stage are provided in the Annex 1 of the SIK report No. 857 – The methodology of the FAO study: "Global Food Losses and Food Waste - extent, causes and prevention"- FAO, 2011.

7 Recommended approach for Wholesale, Retail and Markets

The primary objective of this chapter is to guide the reader through the process of determining food waste quantities (expressed in weight) for three sub-sectors, namely wholesale, retail and markets (WRM) in an EU Member State. The major steps of this process are found in Figure 4. In this section, the term "sector" refers to wholesale, retail and markets taken as a whole.

7.1 Scope and structure of the sector

This section helps the user of the Manual to have a better understanding of what the terms "wholesale, retail and markets" cover.

Applicable general core requirements: CR1, 2, 3, 4, 5.

7.1.1 Definition of wholesale, retail and markets

Applicable general core requirement: CR6

Details concerning the organisation of each sector are provided below.

7.1.1.1 Wholesale

Presentation

Wholesalers are business-to-business operations that buy and sell large quantities of goods. In particular, grocery wholesalers may be categorised into four different types, distinguished by the key customer groups they serve and the platform from which they serve them:

- **Specialist wholesale markets:** specialist markets that are of localised importance in major cities, supplying certain categories of product only to independent grocery retailers (including street markets) and caterers.
- **Cash and carry wholesalers:** supply a wide range of food and grocery categories with the majority of sales made through self-service depots. Their primary customers are independent grocery retailers and caterers, but may also have significant secondary customer bases in catering and general business users.
- **Delivered grocery wholesalers:** these operators supply product solely by delivery service, to customers in the grocery retail sector. These customers are primarily independent and convenience grocery retailers which may also include multi-site operators.
- **Delivered food service wholesalers:** these delivered operators service a wide range of businesses in the food service and hospitality sector including cafes, restaurants, quick service restaurants, staff canteens, schools, prisons and hospitals. In addition to "broadline" wholesalers, the segment also includes many product specialists, with a limited category focus in areas such as meat and fresh produce.

Note however that this typology[56] is provided for indicative purpose only, and that MSs may have certain structural differences in what is considered wholesale or not. In particular in certain MS the wholesale and retail sectors are often very much integrated with the same ownership/corporate structure, and it might in some cases be difficult to set a clear line between the two stages which will have to be assessed as a whole.

CR 33 – Core requirement: The user of the Manual shall regard the following NACE codes as the parts of the food supply chain corresponding to wholesale:

- 46.17 – Agents involved in the sale of food, beverages and tobacco
- 46.2 – Wholesale of agricultural raw materials and live animals
- 46.3 – Wholesale of food, beverages and tobacco

OR 31 – Optional recommendation: The user of the Manual should consider if there are certain structural specificities in its MS regarding the organisation of the wholesale sector and review the possible adaptions needed to fit to the scope specified in the Manual – e.g. certain activities may not be considered as wholesale in the MS but are considered as wholesale in the Manual or vice-versa. In particular, fruits and vegetables auction markets that are well developed in certain countries (e.g. Belgium) should be considered in the wholesale, retail and market sector.

Boundaries – Food supply chain steps to be considered for wholesale

CR 34 – Core requirement: The user of the Manual shall consider the following stages for wholesale: transport process from processing to wholesale, the commissioning process, the storage of products and the distribution to client.
Where a wholesaler is involved in the chain, the **starting point** shall be at the gate of processing and manufacturing[57]. The **end point** shall be at the gate into the end user (e.g. retail, food service or household).

Food waste during transportation between the location of (final) processing and wholesale/retail site is accounted for in the wholesale and retail sector. If products are refused at the gate of the retail site thus generating food waste, the *final ownership* of the material will define the stage in which the food waste shall be accounted for. For instance, if the retailer/wholesaler gets refunded/does not pay refused materials, then the waste shall be accounted for in the processing stage. On the other hand, if the refused material is paid by the retailer/wholesaler, then the waste shall be accounted for in the wholesale/retail stage.

7.1.1.2 Retailers

Presentation

A retailer is an operator that sells goods to consumers, as opposed to a wholesaler, who normally sell goods to another business.

Schematically, the retail sector can be organised as follows:

- Modern grocery retail
- Other forms of retail

[56] Typology taken from WRAP, 2013. Estimates of waste in the food and drink supply chain
[57] The food can also go straight from processing into the retailers' supply chain (no wholesale stage).

This typology is further described below and based on a study of EY, Arcadia and Cambridge Econometrics (2014)[58].

Modern grocery retail

The definition of modern retail adopted here takes into account size (sales area) and shop type, and thus indirectly assortment and different organizational models. Thus, modern grocery retail is defined as including

- Hypermarkets (>= 2 500m²);
- Supermarkets (400 - 2 499m²); and
- Discount shops (all sales area sizes).

Other forms of retails

This category includes:

- independent and traditional shops
- "new modern retail": e-commerce, drive-through markets, frozen food shops, organic food shops, fresh product shops, and very small supermarkets (<400m²) such as convenience stores.

Note that the "new modern retail" formats only represents a small share of edible grocery sales in EU – in 2012, grocery e-commerce represents 1.2%, frozen food stores 0.7%, health food stores 0.1% and convenience stores 4.5% (slightly up from 3.6% in 2004) - for a combined total of 6.5% (EY, Arcadia and Cambridge Econometrics, 2014).

CR 35 – Core requirement: The user of the Manual shall regard the following NACE codes as the parts of the food supply chain corresponding to food retailing activities:

- 47.1 Retail sale in non-specialised stores
- 47.2 Retail sale of food, beverages and tobacco in specialised stores
- 47.9 Retail trade not in stores, stalls or markets.

OR 32 – Optional recommendation: The user of the Manual should consider if there are certain structural specificities in its MS regarding the organisation of the retail sector and review the possible adaptions needed to fit to the scope specified in the Manual – e.g. certain activities may not be considered as retail in the MS but are considered as retail in the Manual or vice-versa.

Boundaries – Food supply chain steps to be considered for retail

CR 36 – Core requirement: The user of the Manual shall consider the following stages for modern retail as well as independent and traditional retailers:

- **Modern grocery retail** – The process starts with the arrival of (food) products at the retailer's distribution centre. It includes the commissioning, the storage at the retailer's distribution centre, the handling and transport processes to the retailer's outlets, the (short-time) storage at the outlets and the display at the shelf. The process ends with the act of purchase to end consumer.

  The **starting point** shall be at the input of products at the gate of the retail centre of distribution. The **end point** shall be at act of purchase to end consumer.

[58] EY, Arcadia and Cambridge Econometrics for the European Commission, 2014. The economic impact of choice and innovation in the EU food sector final report

- **Independent and traditional retailers** – In case of independent and traditional retailers (e.g. small scale retailers such as freelance retailer with one outlet) the process starts with the act of purchase at the wholesaler and includes the transport, the (short-time) storage, the display at the market and ends also with the act of purchase by the final consumer. Due to small scale of business, it shall be assumed that there is no distribution centre.

  The **starting point** shall be purchase at wholesaler by the retailer. The **end point** shall be at act of purchase and delivery to end consumer.

OR 33 – Optional recommendation: "New modern retail" should be considered, if possible. It is not a core requirement to consider "New modern retail" given its relatively limited market share at EU level. When reviewing the steps to be considered for "New modern retail", it should be kept in mind that small shops (such as convenience stores) belonging to a big retail company are likely to have a distribution centre, as opposed to freelance retailer with one outlet for which it shall be assumed that there is no distribution centre.

7.1.1.3 Markets

Presentation

This sub-sector includes street markets and covered markets as well as "Farmers' markets" – i.e. physical retail market featuring foods sold directly by farmers to consumers. "Specialist wholesale markets" (e.g. Rungis in Paris, New Covent Garden Market in London) are included in the wholesale sub-sector.

Boundaries – Life cycle stages for market

CR 37 – Core requirement: The user of the Manual shall consider similar starting point and end point for markets as for independent and traditional retailers, namely the **starting point** shall be purchase at wholesaler by the market retailer and the **end point** shall be at act of purchase to end consumer.

7.1.1.4 Other stakeholders

CR 38 – Core requirement:
Note that in certain cases, third-party logistics companies with their own warehouses or distribution centre may be involved in the food chain between manufacture and retail. If applicable and representative of a significant share of the material flows in the food supply chain of the MS, food waste occurring in such third-party companies shall be accounted in the "Wholesale, Retail and Markets" sector.

7.1.2 Mapping of wholesale, retail and market sector

Applicable general core requirement: CR7

A good understanding of the overall structure of the sector is essential for sampling and scaling (see section 4.4.5.5). It can include for instance:

- Market shares of "Modern grocery retail" vs. "other forms of retails + markets"
- If "Modern grocery retail" is predominant:
  - an analysis of the market shares of the key players;
  - an analysis of the shares by type of stores (hypermarkets, supermarkets, etc.) based on sales volumes and/or number of stores;

- Regional structure of the retail sector, with shares of stores and sales volumes in urban and rural areas.

- Other structural factors in the sector that could influence the level of food waste, such as:
  - Proportion of retail that uses wholesale;
  - Proportion of retail that uses regional distribution centres.

About market shares of "Modern grocery retail" vs. "other forms of retails + markets"

Modern retail constitutes a large portion of the grocery retail market in most of the EU 28 markets: greater than 70% in 12 MS, and greater than 50% in 19 MSs (see Figure 20 in appendix 6). Conversely, traditional retail still makes up a majority of the edible grocery market in many newer MS, with Romania and Bulgaria topping the list of traditional edible grocery retail market share (20% to 30% of modern retail in 2011).

About retail industry concentration: market shares of dominant players

It must be kept in mind that Top-5 retailers market shares at national level (not necessarily the same 5 in each MS) exceeds 60% in 13 MS (e.g. Netherlands, Denmark, France, Germany, etc.). This implies that an option for these countries would be to focus in priority the food waste quantification effort on those major retailers and then scale up the results at national level.

About types of stores

For instance in France in 2012:

- 35.5% of food products were sold in hypermarkets
- 27.6% of food products were sold in supermarkets

It should be kept in mind that hypermarkets and supermarkets types of stores can be further divided in sub-categories of size (Figure 22 and Figure 23 and in appendix 6). This implies that an option for France, would be to focus on these two types of stores within the Top-5 retailers.

7.1.3 Definition of food waste in the sector

Destinations

General requirements on final destinations to be considered when evaluating if a material stream is food waste are presented in the section 4.2.

The food waste / not food waste status of materials flows commonly encountered in the wholesale, retail and market sector are listed below.

Common destinations for food removed from the chain in this sector include landfill, industrial composting and anaerobic digestion, all of which are considered food waste destinations.

The following flow is considered removed from the food supply chain but the final destination is not considered food waste in the FUSIONS definitional framework:

- Unsold food (and associated inedible parts) used for animal feed

The following two flows are still part of the food supply chain and the food may ultimately be consumed (not considered food waste) or go to destinations that are considered food waste (not consumed and go to e.g. landfill, anaerobic digestion, etc.). It is these final destinations that are of interest for the quantification:

- Unsold food (and associated inedible parts) which is redistributed/donated by retailers to charities (a percentage may have to be disposed of, and therefore be classed as food waste);
- Unsold food (and associated inedible parts) sent back by retailers to manufacturing sector (a percentage may have to be disposed of, and therefore be classed as food waste).

7.2 Identify and review existing data relating to food waste from wholesale, retail and markets

This section takes the user of the Manual through a process for determining whether existing information related to wholesale, retail and markets is robust enough to use within the sectorial quantification.

The key outcomes of this section are a) to identify all relevant data sources and b) to determine whether any of them are of sufficient quality to be used by the MS.

Applicable general core requirements: CR9, 10, 11.

7.2.1 Identify existing data

Identifying existing food waste estimates

OR 34 – Optional recommendation: Identifying existing food waste estimates should be done by reviewing public data sources and studies as well as getting in touch with e.g. retail industry federation, local authorities from major cities, dominant retailers to check whether any public or private food waste quantification initiatives/projects have already been launched.

Identifying records

OR 35 – Optional recommendation: as a first step, identifying records should be done by reviewing public data sources (e.g. public waste collection statistics). Then, it is suggested to get in touch with key stakeholders of the sector to assess whether they would be willing to provide records. Records, in this context, may include weight of waste streams that include food waste (especially useful if the food waste has been separated from other waste fractions), input to treatment facilities that the stakeholders might own (e.g. anaerobic digestion plants), and records of food redistributed / returned / sent to animal feed for a full picture (but not contributing to the food waste estimate).
Key stakeholders to be contacted will depend on the stage of the food supply chain being considered (see below):

- Wholesale
    - **Wholesalers**: for commissioning and storage
    - **Logistic companies**: for transport from processing to wholesale and from wholesale to the client

- **Producers/processors**: for transports from processing to wholesale, if producers/processors have their own truck fleet for delivery directly to their clients (wholesalers)

- Retail
  - **Distribution centres:** for commissioning and storage
  - **Producer/processor:** for products refused at commissioning
  - **Stores:** for (short-time) storage at the outlets and display on the shelf.

7.2.2 Review identified data and estimates

As a complement to core requirements presented in section 4.4.3, it is of crucial importance for this sector that the user of the Manual check the representativeness of data according to structure of the sector (distribution of companies and stores, sales volumes, etc.).
The objective is to check whether the identified data (food waste estimates or raw data) rely on e.g. a sufficient number of stores representative of each main type (hypermarkets, supermarkets, etc.) and representative of the main players in the sector.

CR 39 – Core requirement: The assessment of representativeness shall be based on the information gathered during the mapping of the sector. This means that the method used for obtaining an estimate takes into account the respective market shares of the different types of wholesalers, retailers and markets and their respective levels of food waste.

OR 36 – Optional recommendation: When ongoing initiatives/projects have been identified but have limited representativeness, the user of the Manual should get in touch with the person/organization responsible for the project/initiative to discuss if the results could be aligned to the Manual's requirements (e.g. by weighting the raw data so that it is representative).

OR 37 – Optional recommendation:
Based on the extensive feedback from UK on food waste quantification in appears that most retailers do not have separate data on food waste, food waste being included in a "mixed waste" stream also containing packaging for instance. The user of the Manual should pay particular attention when reviewing food waste data from this sector on the inclusion/exclusion of packaging weights since it is necessary, in the context of this Manual, to exclude the weight of any associated packaging (i.e. the primary/secondary packaging that still contains the product).

About retail channels representativeness

OR 38 – Optional recommendation: When reviewing identified food waste data and estimates, the user of the Manual should consider three main possible channels: "Modern retail", "Markets", and "independent and traditional shops" (within the broader category "other forms of retail"[59]). It may also be acceptable to focus only on the major channel if it is largely dominant. Data from these three channels (or from the only dominant channel), will be scaled up to the whole sector.

Core requirement if optional recommendation is enacted:
When certain channels have not been considered, justifications and explanations for such choice shall be provided.

[59] This category "other forms of retail" also includes "new modern retail", which as to date as a very limited market share in EU and thus may be neglected.

7.3 Select approach for sectorial for food waste quantification

There are a number of potential methods for quantifying food waste within wholesale, retail and market sector. This section outlines the possible options and gives guidance on when each is suitable to apply.

For any quantification of food waste in the wholesale, retail and market sector, there are three important considerations:

- Whether existing data or estimates exist and/or whether new measurements are required;
- What method to use (or, in the case of existing data and estimates, has been used) to measure the amount of food waste generated;
- For existing estimates, how the existing data have been scaled to provide a national estimate.

The consideration of whether to use existing data or to initiate new measurements is discussed in section 4.4.4. The main determinant will be whether raw data or estimates exist that are suitable. This includes whether these raw data / estimated have used measurement methods that are sufficiently accurate, are representative for the applied MS/sector/business type (adjusted for seasonal variations, year of measurement etc.), have used a definition of food waste that aligns well with the FUSIONS definitional framework, covered the major disposal routes where food waste is found, and (in the case of estimates) were scaled in an appropriate way to provide a national picture.

The wholesale, retail and market sector is composed of a small number of sub-sectors and, to build up a complete picture for the whole sector, a number of individual studies may be required. In some MSs, quantification for some sub-sectors will use existing information and others will use new measurement.

Where it has been decided to use existing estimates or raw data, the main considerations can be found in section 7.4. Where new measurements need initiating, this is covered in section 7.5.

7.4 Using existing estimates or raw data

Applicable general core requirements: CR12 and 13

There are a number of situations in which existing estimates or raw data could be used to estimate food waste in the wholesale, retail and market sector. These include:

- Individual companies measure their food waste and this information is either reported or could be made available to develop a national estimate;
- Individual sites measure their food waste and this information is reported or could be made available;
- A group of companies (e.g. members of a trade body or signatories to a voluntary agreement) measure their food waste and this information is either reported or could be made available, again to develop a national estimate;

- A previous study exists that quantified food waste, either on a company or site basis. For example, surveys of commercial and industrial waste may include data on food waste from the wholesale, retail and market sector;

General advice on how to use existing estimates is given in section 4.4.5.1 and raw data in section 4.4.5.2.

There are a number of key considerations for use of existing information:

Measurement methods: the method used to measure the amount of food waste should be sufficiently accurate. In keeping with the methods recommended for measurement in section 7.5, the following are particularly strong methods for the wholesale and retail sector: scanning / counting of food waste items, direct weighing and waste compositional analysis. In some circumstances, mass balance may also be sufficiently accurate. If scanning is used on an economic basis, it is necessary to develop exchange factors between economic value and mass of products, to make food waste statistics available on a mass basis.

Scaling: Adjusting the measurements to provide a national picture (whether in existing estimates or to obtain a national estimate from raw data) should be appropriate given the data and the sector. For this sector, a scaling should usually be undertaken for each sub-sector (wholesale, markets and retail) separately.

Scaling factors should be closely related to the amount (weight) of food entering the operation or the amount (weight) of food sold. These allow the percentage of food "processed" that becomes waste to be calculated. Scaling factors relating to cost/market size at national level (i.e. overall turnover) should usually be used with caution in cases when there is a large range of variation within a single sub-sector. This issue is less important when the degree of scaling is small – e.g. there is food waste data for the majority of a sector or sub-sector (e.g. >80%); in this case, the exact details of the scaling are less important in order to obtain an accurate estimate as food waste from only a small part of the sector is unknown.

More general guidance on the above is given in section 4.4.3.

In some situations, information will be available only for a group of companies (e.g. from a trade body or voluntary agreement). If this group of companies covers a large proportion of the sector or sub-sector it represents, then the food waste could be scaled to represent the whole sector or sub-sector using market share (ideally by weight, but this is an example where turnover by value could be used). However, if the group of companies only covers a smaller proportion of the sector or sub-sector, then more care needs to be taken when scaling up results. In addition to using an appropriate scaling factor (see above), consideration should also be given to whether those companies supplying data are representative of the wider sector. In some situations, the fact that they are members of a trade body or signed up to a voluntary agreement may mean that they have lower levels of food waste compared to the rest if the (sub-)sector. If this is the case, some additional measurements relating to companies outside of this specific group would be useful to obtain an unbiased estimate.

OR 39 – Optional recommendation: The user of the Manual should use as a preferred approach for scaling the national turnover (income from the sales of goods) of the different sub-sectors.
If no data are available on the national turnover of the different sub-sectors, an alternative approach could be to use the number of full-time employees.

7.5 Undertaking a study involving new measurements

This section outlines the key methods for measuring food waste in the wholesale, retail and market sector. These include:

- Methods based on direct weighing (section 7.5.1)
- Methods based on counting / scanning (section 7.5.2)
- Mass balance (section 7.5.3)

As mentioned in section 4.4.5.6, packaging must be excluded from the food-waste estimates. This is especially relevant for the present sector in which it is likely that most of the food discarded will be packaged.

In practice, in many cases food-waste items removed from the food supply chain will still be in its packaging (e.g. yoghurt in its container) or data relating to food waste will include the weight of the packaging. The FLW Standard provides several approaches on how to exclude the weight of packaging from the amount of food waste.

Recommended quantification methods

OR 40 – Optional recommendation: Methods presented in this section are recommended by the authors of this Manual and should be used by MSs when undertaking a new study involving new measurements – for each method, refer to the "when to use" paragraph.

7.5.1 Methods based on direct weighing

Weighing is a well-established approach to measuring the weight of an object and involves using a weighing device (e.g., a set of scales) to quantify occurrences of food waste. An advantage of using weighing-based methods is that the use of weighing overcomes many of the under-reporting problems of methods such as surveys and diaries.

There are a few variants for using direct weighing within the wholesale, retail and market sector. These are:

Weighing waste streams only containing food waste

This involves weighing of food waste sorted for, for instance, industrial composting or anaerobic digestion. It requires access to the waste stream to undertake the weighing; this requires liaising with the site / premises generating the waste and the waste management company[60]. More details can be found in appendix section 3.2.

It is important that the waste collected only comes from the sites / retail outlets that are being sampled. For instance, for smaller operations, waste from a number of retailers may be placed in a single receptacle for joint collection. To only measure the waste from a single outlet, this may mean weighing the waste before it leaves that outlet.

[60] In many cases, waste management companies may already weigh the waste and consideration should be given to obtaining this weight data rather than repeat existing measurements.

The food waste may also be imperfectly sorted. There may be non-food in a separated food waste stream (i.e. contamination) and there may also be food waste in a mixed waste stream (e.g. in the residual waste stream). Therefore, a small-scale study may be required to determine the typical level of contamination, allowing correction of separate food waste streams. Where food is likely to be in a mixed waste stream, waste compositional analysis (see below) can be used on that mixed waste stream.

It is also useful to know over what time period the measured food waste has been generated. For instance, if the measurement of food waste is taken every time the waste is collected, the frequency of collections will determine the time period in which the weighed food waste was generated. Consideration should be given to how long a time period should be sampled for each wholesale, retail and market site (e.g. how many collection cycles) to ensure that the information collected is robust. This will depend on the sample size, variability between sites and how it is being scaled to obtain a nation estimate.

Where collection is infrequent, there is the potential for evaporation to reduce the weight of waste. This is a larger issue in hotter countries and where the containment of the food waste is more open. If resources allow, a study could be performed to understand the degree to which this occurs and correct for it.

When to use: Direct weighing (without sorting) can only be used for sorted waste streams (i.e. only containing food waste). Access to the waste stream is required, often before it is combined with waste from other premises or companies.

Waste compositional analysis

Waste composition analysis (WCA) is a method used to physically separate, weigh and categorise food waste. This method is applied to waste streams that include other material which is not food waste (e.g. packaging, garden waste, other solid waste items). For the wholesale, retail and market sector, this is usually a residual (general) waste stream.

WCA may also be used to understand the different materials that make up food waste (e.g. types of food categories, or amount of food waste that is food versus associated inedible parts).

WCA is best applied to waste that has not been compacted. If the waste has been compacted or excessively mixed, then the food may be difficult to identify and / or separate from non-food items.

WCA is also best applied to solid waste. Liquid and semi-solid items (e.g. sauces) are difficult to sort manually. These could be recorded using diaries or smart bins (see below).

During waste compositional analysis, it is good practice to have a sort supervisor who checks that this is the case.

When sorting the waste, it is important to ensure that – wherever practically possible – food waste is separated from packaging and the food waste weighed separately. In a small number of circumstances, this may not be practical (e.g. a small amount of jam left in a pot). In such circumstances, an approximate estimate of the weight of the food waste can be used.

When to use: waste compositional analysis can be used for mixed waste streams that can be accessed. It is difficult to use where food has been compacted or otherwise excessively mixed such that sorting is difficult. It is easier to apply to solid food items, rather than liquids or semi-solids.

7.5.2 Methods based on counting / scanning

Counting involves assessing the number of items that make up food waste and using the result to determine the weight. The items may be a single product (e.g. a banana or a can of soup) or a number of products in various types of containers (e.g. a bag of grain or a pallet of product). More details can be found in appendix section 4.3.

This is method can be used in the wholesale, retail and market sector where operators would like to record the waste that is being generated. This would involve scanning items as they are being wasted (e.g. taken for disposal) and this information being recorded electronically as part of a stock-keeping system.

Given this, it is of most use in the wholesale, retail and market sector when the food is packaged (and therefore has a barcode or other scanable device). It is less suitable when food is not packaged, labelled or otherwise in a state to be scanned. In these situations, methods based on manual counting or weighing (section 7.5.1) are preferable.

Where scanning is used, the information (data counting the number and type of items becoming waste) usually needs converting to obtain the weight wasted. This can be achieved by applying the weight of food per item for each type of item wasted. This information could be within a database or other stock-management system, or could be applied "manually" if such a database is not available.

In keeping with the FUSIONS definitional framework, the weight of an item used should exclude the weight of packaging or any other non-food element (e.g. paperwork attached to the packaging / food). It is also important to ensure that all relevant disposal routes in the FUSIONS definition framework are covered. Related to this, it is possible for biases to be introduced if scanning of wasted items is not complete. For example, operators may only scan a proportion of the items being wasted, missing some items.

If a system for scanning food waste does not exist, the cost of developing one will usually be relatively large for an individual company. Therefore, this method may only be available for larger companies where electronic stock-keeping already exists and can be adapted to include food waste recording (if it doesn't already).

The information generated may be considered sensitive to the company or organisation that generates it. Therefore, consideration should be given to how to use the data within a NFWQS so that it can be used effectively without disclosing any sensitive aspects of the data.

When to use: This method can only be used if there is a system that can record food as it becomes wasted via scanning or similar devices for counting the number of items wasted. It is only appropriate for packaged food items. Once the recording of food wasted is aligned with the definitional framework, it is often an accurate and cost-effective way of quantifying food waste.

7.5.3 Mass balance

An organisation can use a mass-balance method to infer food waste by measuring inputs (in the case of the wholesale, retail and market sector, incoming food products) and outputs (food purchases). In addition, changes in levels of stock and changes to the weight of food during processing (e.g. evaporation of water during cooking) need to be taken into account. More details can be found in appendix section 3.8.

Mass balance can be used to quantify food waste where direct measurement of the waste – which is usually more accurate – is not possible.

Depending on availability of data, mass balance can be applied to the whole wholesale, retail and market sector or to individual sites. For a sector-wide mass balance, this would require national data on the inputs and outputs to the sector (e.g. from statistics collected by the Government or a trade body). For set of individual sites, the input and output data could come from existing records.

When applied on a store or company level, mass-balance methods are similar to those described in section 7.5.2 (scanning-based methods) in that both can use information from stock-keeping systems. In the scanning-based methods, the food waste is scanned directly; in the mass-balance methods, food waste is inferred from the difference between incoming and outgoing food products.

Whichever method is used, the accuracy of the data is important to obtain a robust estimate of food waste. Particular issues include:

- Conversion of data using one unit (e.g. cost data, volume, number of items) to weight
- Changes in weight during processing – e.g. the amount of water evaporating during cooking may not be known
- Propagation of uncertainty within the mass-balance calculations (see below)

Subtraction is at the core of a mass balance method and this can increase the uncertainties associated with the resultant estimate of food waste, specifically when the food waste is expressed as a percentage. This is demonstrated by the following example.

In a mass-balance calculation, an estimate of 90 tonnes (±10 tonnes) for the outputs is subtracted from 100 tonnes (±10 tonnes) for the inputs. In this simple example, there is no change in level of stock or in the weight of food during processing. The resulting estimate of food waste would be 10 tonnes (±14 tonnes)[61], assuming the only uncertainty emanates from that associated with the inputs and outputs. The error, expressed as a percentage in the final result, would be (±140%), which is much greater than in the two original quantities (±11% and ±10%). This is often the case when one quantity is subtracted from another.

In some cases, the level of uncertainty due to the underlying data used and the propagation of uncertainties within the mass-balance calculations will render the results from a mass-balance method insufficiently accurate for the needs of the food waste quantification study. In such cases, other methods should be considered.

When to use: Mass balance is a useful method to use when direct measurement of food waste is not possible. It requires accurate data for inputs and outputs and good

[61] For two values being summed, the uncertainties of the total is approximately equal to the square root of the sum of the squares of the uncertainty of each (e.g. = √[(uncertainty 1)^2 + (uncertainty 2)^2]

knowledge of weight changes during processing. However, the nature of the calculations means that the uncertainties associated with estimates can become large, which may render this method insufficiently accurate. For instance, other losses (than food waste) between receipt and sale could be larger than what would be regarded just as food waste, for example shoplifting can be significant.

7.5.4 Other considerations

Sample design

When undertaking a NFWQS where new measurements are being made, it is not practically possible to sample all wholesale, retail and markets sites / companies in a MS, so a sample of sites / companies should be drawn that is as representative of all sites / companies in the MS as possible.

To ensure that the sample is representative, factors should be identified which may influence the amount of food waste generated (when expressed in the units used for scaling, e.g. per tonne of fold processed). These may include:

- Sub-sector within the wholesale, retail and market sector
- Nature of the distribution network (e.g. presence or absence of regional distribution centres)
- Size of the outlets
- Types of food sold in outlet (especially important for specialist shops such as butchers, bakers, etc.)

Where factors are identified as influencing the amount of food waste, it is important either to sample in proportion to their prevalence in the population or to weight the data when producing the results to achieve representativeness.

Ideally, samples should be taken throughout the year to address issues of seasonality. However, this may not always be possible due to budget and resource constraints (see below for what to do where it is not possible).

Measurement details

A clear protocol of what is considered food waste should be drawn up to facilitate accurate measurement. This protocol should be adhered to if waste is being sorted or where decisions are being made about what is or is not food waste.

Weighting or stratifying raw data

Before scaling the results, it is important to check whether the sample of wholesale, retail and markets sites for which food waste was measured was representative of all wholesale, retail and markets sites in the MS. If it was not (e.g. due to drop out of sites not agreeing to take part in the study), then weighting factors should be applied to ensure that the final result is based on a representative sample. (Stratification of the sample should lead to the same result as weighting.)

Seasonality

For all methods described in this section, seasonality should be considered. The amount of food waste generated within the wholesale, retail and market sector can vary throughout the year, with peaks associated with high demand. This could be related to holidays and festivals, as well as the changes in weather throughout the year.

Seasonal variation can be accounted for in national estimates by one of the following (in order of preference):

- Gathering data throughout the year in a representative manner
- Gathering data from part of the year and adjusting the results to take account of seasonal variation. Note: this requires the level of seasonal variation in food waste levels to be known (e.g. from a previous study).
- Gathering data from part of the year and adjust by modelling using a proxy for food waste – e.g. assuming that waste levels are in proportion to the amount of food sold throughout the year.

In addition to seasonality, there may be variation in food waste between years. In the case of the food sector, large differences in visitors to a country (e.g. due to one-off events such as the Olympics) could influence the results. If this happens in a year when food waste measurement is planned, it will mean that the level of food waste is higher than for adjacent years. The level of food waste should still be measured as accurately as possible, but such events should be noted in the narrative accompanying the results. If possible, the degree to which they have influenced results should be estimated.

8 Recommended approach for Food Service

The primary objective of this chapter is to guide the reader through the process of determining food waste quantities (expressed in weight) in the food service sector. The major steps of this process are found in Figure 4.

8.1 Scope and structure of the sector

The food service sector comprises of the businesses and people engaged in preparing meals and drinks for consumption outside of the home (of the people buying it). It is a very diverse sector and stakeholders have significantly different characteristics, which makes it a challenge to avoid a highly differentiated approach for food waste measurement. Moreover definitions of food service sub-sectors are not standardised and show much overlap from one sub-sector to the other, which makes it complex to compare between MSs.

Applicable general core requirements: CR1, 2, 3, 4, 5.

8.1.1 Definitions of food service sector

Applicable general core requirement: CR6

Presentation

To illustrate the variation, three classifications of the food service sector are presented in the table below:

- FSIN: Food Service Institute Netherlands
- WRAP: Waste and Resources Action Programme
- NACE: Nomenclature statistique des activités économiques dans la Communauté européenne (EU classification of economic activities)

Table 7 – Food service classification from various sources

FSIN		WRAP	NACE	NACE code
Horeca[62]	Drinks	Pubs	R&B[63]	56.1
	Restaurants	Restaurants	R&B	56.1
	Hotels	Hotels	Hotels	55.1
	Leisure	Leisure	-	-
On the go	Travel		R&B	56.1
	Gas station		R&B	56.1

[62] HOtel, REstaurant, CAfe

[63] Restaurants and mobile food service activities

FSIN		WRAP	NACE	NACE code
Catering	Inflight		EC & FA[64]	56.2
	Fast Service	Quick Service Restaurants	R&B	56.1
	Office	Staff catering	EC & FA	56.2
	Institutional	Healthcare	Hospital Act	86.1
		Services	-	-
	Education	Education	EC & FA	56.2

The choice for a sector segmentation is motivated by the different characteristics that imply some variation in the approach. The applied methodology and/or representativeness for a particular sub-sector may impose certain options for methods and to what extent the data can be used for scaling up. Obviously within the NACE code 56.1 the amount of waste will vary a lot between, for instance, pubs on the one hand and restaurants on the other hand. Consequently, a differentiated approach by sub-sectors is needed within NACE code 56.1.

CR 40 – Core requirement: Based on these considerations, the food service sector is divided into the sub-sectors presented in Table 8. The user of the Manual shall consider these sub-sectors as the parts of the food supply chain corresponding to food service.

Table 8 – Sub-sector segmentation of food service sector

Sub-sector	Definition	Examples
Pubs	Outlets that focus on providing alcoholic drinks. Food sales are less than 50% of turnover	Pubs (tenanted, managed branded, managed unbranded).
Restaurants	Outlets that have table service.	Italian, Chinese, Indian, French restaurants.
Hotels	Outlets that provide overnight accommodation. Food accounts for less than 50% of turnover.	Hotels, bed & breakfasts, youth hostels, caravan parks.
Leisure	Outlets located in places where leisure services are the prime focus of activity. Outlets in this sector may provide restaurant, quick service or pub style catering.	Museums/galleries, theatres, cinemas, sports clubs, events and mobile caterers, visitor attractions.
Travel	Outlets on locations where people are on the move except air travel.	Gas station, railway and airport kiosks
Inflight catering	Food service in airplanes	
QSR	Outlets that may have take-away or eat-in, or both.	Fast food, cafes, take-aways, fish & chip shops, sandwich bars.
Staff catering	Feeding employees at the place of work	Run in-house, contracted staff restaurants.
Healthcare	Outlets whose main focus is providing healthcare (including short- and long-stay care).	Private & National Health Service hospitals, care & nursing homes.
Education	Outlets that are primarily concerned with educating children or adults (or both).	Nursery, primary, secondary schools; further

[64] Event catering and other food service activities

Sub-sector	Definition	Examples
		& higher education establishments.
Services	Outlets that provide a publicly-funded service and which are not healthcare or educational establishments	Prisons, armed forces, police & fire service catering, other publically funded organisations

These sub-sectors and definitions are taken from WRAP[65], except for travel and inflight catering. People on the move like in shops in filling stations and railway stations take the food and go in many cases, and hence if this food is wasted by the customer, it cannot usually be measured at the location of the sale. In-flight catering differs from other sectors to a certain extent: people are usually offered food at fixed times within the flight and the number of options may be limited (often to two). Therefore, the choice of when and which foods to serve is decided upon by the airplane company, which will affect the amount of food waste. Moreover, food leftover from a flight has not usually been chilled and has to be thrown away.

Boundaries – Food supply chain steps to be considered for food service

CR 41 – Core requirement: The user of the Manual shall consider the following aspects for the starting point and end point of steps to be considered as food service.

Starting point
Ownership of the food is the starting point. In practice, for almost all sub-sectors the starting point is the entrance at the premises, since in most cases a logistic service provider is delivering the food and drinks there and ownership of the product changes. Only in cases of big chains are logistics organised from their own distribution centres and the starting point is there.

End point
As opposed to wholesale retail and market sector, the end point of the "food service" sector is not the act of purchase by the end-consumer. The end point is when the food provided by the food service business is actually put in a bin.
Food waste may be generated during preparation and/or storage by the food service business as well as during the consumption stage (after the sale/serving of food).

The proposed general rule is that the sector where the food waste is placed in a bin is accountable for it. So food thrown away (plate leftovers or food waste occurring during preparation) in a restaurant (by the restaurant staff or the consumer themselves in e.g. fast food restaurants) is accounted for in the food service sector. Take-away food leftovers thrown in the bin at home are considered to be household waste.
Moreover, aside from home, take away food maybe thrown away anywhere (train, bin in the streets, etc.) this waste is considered food service waste. The argument is that it is the food service that "owns" the problem and needs to find "a way to serve the food" giving less waste.

[65] WRAP, 2013. Overview of Waste in the UK Hospitality and Food Service Sector

8.1.2 Mapping of the food service sector

Applicable general core requirement: CR7

A good understanding of the overall structure of the sector is essential for sampling and scaling (see section 4.4.5.5).

Indeed, how the sub-sectors are organised determines two important aspects of the measurements.
Firstly, the *sampling size* for the measurements is dependent on the fragmentation of the sub-sector and the variability from one sampling unit to another. For instance, pubs are small business entities and there are many of them, thus a relatively large sample may be required is significant variability is observed from one pub to another. On the other hand, for inflight catering the number of companies involved is relatively limited. Waste measurements carried out on flights of one major company is likely to be representative for other companies, and hence the sample size can be much smaller[66].
Secondly, for the analysis of the measurements *market size and shares* need to be identified for upscaling.

OR 41 – Optional recommendations:
Market information on food service as mentioned in the core requirement above is as fragmented as the sector itself. The main reason is the sub-sector segmentation varies by country. Hence corresponding associations, where often sub-sector overviews are available, are organised differently and sometimes absent because of the small size of the sub-sector.
To retrieve the relevant information, each MS should summarise the sources for market data on these sub-sectors.
On a European level, data are collected as well. These sources can be used for comparison of the waste measurements and put them in the right perspective. Some examples are:

Contract Caterer Monitor Netherlands (GIRA SIC)
The monitor includes turnovers and market shares of contract caterers in the Netherlands, split by sectors (B&I, education, healthcare, welfare and others) and individual players (Sodexo, Compass, Albron, others).
Reports for northern, western and southern European countries are also available: http://www.girafoodservice.com/en/databases/group-catering-companies-eurocaterer.php

High pressure cooking: European foodservice market matures, while value chain dynamics just start (CapGemini Ernst & Young, 2004)
The report includes the market share of the top 100 European food service companies versus the rest, market share per sub segment of the top 100 (contract catering, quick service, full service, hotels, travel, in-store restaurants, pubs), also per main company for Europe in 2001.
Top 5s for QSR and restaurants in terms of turnover in Europe in 2001 are also included.
The various sub segments are described in more detail, including (an estimate of) revenue on a European level.

[66] Note that for most flights within Europe, the frequency of back and forth flying is once or more than once a day. In most cases the waste, including food waste is taken from the plane at the home base, and companies have insight in the amounts of waste. The link to the flight statistics would enable an estimate that can be used for upscaling. For long distance flights this is not the case since the food waste is removed from the plane outside EU. These volumes do not contribute to EU food waste.

The European foodservice market: main players, structures, dynamics and trends (Backman, 2006)
The presentation includes value of sales for contract catering, quick service restaurants, pubs, travel, restaurants, hotels and others taken from Horizons/FSE and ME, presumably in Europe in 2004.

These kind of data are necessary to support the experimental design per sub-sector in a MS.

8.1.3 Definition of food waste in the sector

A clear understanding of how food waste in the food service sector is defined is needed before a quantification study is undertaken. The definition of food waste is closely linked to the destination of the produced food. Indeed, any food coming from food service premises (as defined above) that goes to a destination classified as food waste (see chapter 3) is defined as food waste.

In the food service sector the potential food waste flows in general can be split up in four categories:

a) Products removed from the inventory including food damaged during transportation and food thrown away from storage (e.g. food exceeding a use-by date or loss of quality);
b) Product waste during food preparation at the food service location;
c) Products prepared front and back office (and possibly exposed (catering) or transported (patients in a hospital)) for ready-to-eat human consumption but not consumed (because e.g. not purchased by any consumer);
d) Plate leftovers.

Destinations

Food waste may be collected through several streams: municipal collected residual waste, municipal collected food waste, collections organised directly with waste management companies, etc. Common final destinations include landfill, anaerobic digestion, incineration with or without energy recovery, etc.

The destinations of the flows a) to d) is very much depending on size and type, however can be categorised as well:

i. If food service locations are small enterprises (e.g. local snackbar, small kiosk) these flows are relatively small and will be collected by local authorities or municipalities as if they are citizens of the community. Note that the destination of these flows is very much depending on the local policy of the authorities (e.g. priority to environmentally friendly waste treatments or priority to cost effectiveness).
ii. If the food service location is a large entity/company (hospital, school, leisure) they have to organise their waste flow according to national legislation. In many cases this implies that these entities make bilateral contracts with waste treatment companies. Depending on the company's policy it ends up composed, fermented and sometimes as animal feed.
iii. In many cases the food service location is part of a premises owned by someone else, for example, catering locations at offices, restaurants in railway stations or malls, etc. In these cases very often the flows mentioned a) – d) become a part of the flows as organised by the owner of the premises, which makes it difficult[67]

[67] For example, the waste could be intercepted / quantified before it leaves (or as it leaves) the individual premises – i.e. before it gets mixed with other waste.

to track down the amount of waste from each premises. This challenge can be met by additional measurement only.

A specificity of this sector is that the amount of food (including drinks) waste going to the sewer is likely to be relatively higher than in other sector. This can be direct disposal of drinks and other liquids; or as it is often seen after treatment by macerators/disposal units. Quantifying waste going to this destination is particularly challenging. It is recalled in this section that if these destinations could not be quantified, this should be specified in the NFWQS.

8.2 Identify and review existing data relating to food waste from food service

Applicable general core requirements: CR9, 10, 11.

8.2.1 Identify existing data

OR 42 – Optional recommendation:
Identifying and reviewing existing data should be done based on public data sources (e.g. waste collection statistics) or by asking food service companies to provided information on food waste they may already have. The available data should be accompanied with information on the measurement methods that were used, in order to get insight in comparability and reliability. Moreover, these companies can be asked to contribute to food waste measurement data on a regular basis, say annually.

8.2.2 Review identified data and estimates

As a complement to core requirements presented in section 4.4.3, it is of crucial importance for this sector that the user of the Manual check the representativeness of data according to structure of the sector (sub-sector segmentation of food service sector: sales volumes/number of meals per segments, etc.).
The objective is to check whether the identified data (food waste estimates or raw data) rely on e.g. a sufficient number of food service location representative of each main segments (hotels, restaurants, etc.) and representative of the main players in the sector.

CR 42 – Core requirement: The assessment of representativeness shall be based on the information gathered during the mapping of the sector. This means that the method used for obtaining an estimate takes into account the respective market shares of the different types of segments within the sector and their respective levels of food waste.

OR 43 – Optional recommendation: When ongoing initiatives/projects have been identified but have limited representativeness, the user of the Manual should get in touch with the person/organization responsible for the project/initiative to discuss if the results could be aligned to the Manual's requirements (e.g. by weighting the raw data so that it is representative).

About food services segments (sub-sectors) representativeness

OR 44 – Optional recommendation: When reviewing identified food waste data and estimates, the user of the Manual should consider the main sub-sectors: it may be acceptable to focus only on the major sub-sectors.

Core requirement if optional recommendation is enacted:
When certain sub-sectors have not been considered, justifications and explanations for such choice shall be provided.

8.3 Select approach for sectorial food waste quantification

There are a number of potential methods for quantifying food waste within the food service sector. This section outlines the possible options and gives guidance on when each is suitable to apply.

For any quantification of food service food waste, there are three important considerations:

- Whether existing data or estimates exist or whether new measurements are required
- What method to use (or, in the case of existing data and estimates, has been used) to measure the amount of food waste generated
- For existing estimates, how the existing data have been scaled to provide a national estimate

The consideration of whether to use existing data or to initiate new measurements is discussed in section 4.4.4. The main determinant will be whether raw data or estimates exist that are suitable, i.e. they used measurement methods that are sufficiently accurate, used a definition of food waste that aligns well with the FUSIONS definitional framework, covered the major disposal routes where food waste is found, and (in the case of estimates) were scaled in an appropriate way to provide a national picture.

The food service sector is composed of many diverse sub-sectors and, to build up a complete picture for the whole sector, many individual studies may be required. It is therefore likely that some sub-sectors will use existing information whilst other sub-sectors require new measurement to be undertaken.

Where it has been decided to use existing estimates or raw data, the main considerations can be found in section 8.4. Where new measurements need initiating, this is covered in section 8.5.

8.4 Using existing estimates or raw data

Applicable general core requirements: CR12 and 13

There are a number of situations in which existing estimates or raw data could be used to estimate food waste in the food service sector. These include:

- Individual companies measure their food waste and this information is either reported or could be made available to develop a national estimate;

- Individual sites measure their food waste and this information is reported or could be made available;
- A group of companies (e.g. members of a trade body or signatories to a voluntary agreement) measure their food waste and this information is either reported or could be made available, again to develop a national estimate;
- A previous study exists that quantified food waste, either on a company or site basis. For example, surveys of commercial and industrial waste may include data on food waste from the food service sector.

General advice on how to use existing estimates is given in section 4.4.5.1 and raw data in section 4.4.5.2.

There are a number of key considerations for use of existing information:

Measurement methods: the method used to measure the amount of food waste should be sufficiently accurate. In keeping with the methods recommended for measurement in section 8.5, the following are particularly strong methods for the food waste sector: scanning / counting of food waste items (for transportation and storage stages within the sector), direct weighing and waste compositional analysis. In some circumstances, use of diaries or mass balance may also be sufficiently accurate.

Scaling from the measurements to provide a national picture (whether in existing estimates or to obtain a national estimate from raw data) should be appropriate given the data and the sector. For the food service sector, a scaling should usually be undertaken for each sub-sector separately – i.e. not using data from restaurants to estimate the total amount of food waste from hospitals.

Scaling factors should be closely related to the amount of food served, e.g. amount (weight) of food entering food service site or amount (weight) of food served or sold. These allow the percentage of food "processed" that becomes waste to be calculated. Number of meals served can also be used where weight data are not available, although care needs to be taken that "a meal" is clearly defined. For health care sub-sector specifically, the bed days can be used as a scaling factor.

Scaling factors should usually be used with caution in cases when there is a large range of variation within a single sub-sector (e.g. the cost per kilogramme of food sold in a restaurant can vary over a wide range). This issue is less important when the degree of scaling is small – e.g. there is food waste data for the majority of a sector or sub-sector (e.g. >80%); in this case, the exact details of the scaling are less important in order to obtain an accurate estimate as only 20% of the data is unknown.

More general guidance on the above is given in section 4.4.3.

In some situations, information will be available only for a group of companies (e.g. from a trade body or voluntary agreement). If this group of companies covers a large proportion of the sector or sub-sector it represents, then the food waste could be scaled to whole sector or sub-sector using market share (ideally by weight, but this is an example where turnover by value could be used). However, if the group of companies covers a smaller proportion of the sector or sub-sector, then more care needs to be taken in scaling up results. In addition to using an appropriate scaling factor (see above), consideration should also be given to whether those companies supplying data are representative of the wider sector. In some situations, the fact that they are members of a trade body or signed up to a voluntary agreement may mean that they have lower levels of food waste. If this is the case, then some additional measurements relating to

companies outside of this membership / signatory members would be useful to obtain an unbiased estimate.

OR 45 – Optional recommendation: Where scaling factors are required to obtain a national estimate of food waste, the user of the Manual should use appropriate scale up factors for each representative sub-sector in the food service sector.

8.5 Undertaking a study involving new measurements

This section outlines the key methods for measuring food waste in the food service sector. These include:

- Methods based on direct weighing (section 8.5.1);
- Methods based on counting / scanning (section 8.5.2);
- Diary-based methods (section 8.5.3).

Recommended quantification methods

OR 46 – Optional recommendation: Methods presented in this section are recommended by the authors of this Manual and should be used by MSs when undertaking a new study involving new measurements – for each method, refer to the "when to use" paragraph.

8.5.1 Methods based on direct weighing

Weighing is a well-established approach to measuring the weight of an object and involves using a weighing device (e.g., a set of scales) to quantify instances of food waste. An advantage of using weighing-based methods is that the use of weighing overcomes many of the under-reporting problems of methods such as surveys and diaries.

There are a few variants for using direct weighing within the food service sector. These are:

Weighing waste streams only containing food waste

This involves weighing of food waste sorted for, for instance, industrial composting or anaerobic digestion. It requires access to the waste stream to undertake the weighing; this requires liaising with the site / premises generating the waste and the waste management company[68]. More details can be found in appendix section 3.2.

It is important that the waste collected only comes from the food service sites / premises that are being sampled. For instance, in a shopping mall where there are lots of food service outlets, it is important to analyse the waste from only those that are the target for sampling. This may mean weighing the waste before it has been combined with food waste from other nearby food service outlets. This may entail weighing the waste as it leaves the outlet.

[68] In many cases, waste management companies may already weigh the waste and consideration should be given to obtaining this weight data rather than repeat existing measurements.

The food waste may also be imperfectly sorted. There may be non-food in a separated food waste stream (i.e. contamination) and there may also be food waste in a mixed waste stream (e.g. in the residual waste stream). Therefore, a small-scale study may be required to determine the typical level of contamination, allowing correction of separate food waste streams. Where food is likely to be in a mixed waste stream, waste compositional analysis (see below) can be used on that mixed waste stream.

It is also important to know over what time period the measured food waste has been generated. For instance, if the measurement of food waste is taken every time the waste is collected, the frequency of collections will determine the time period in which the weighed food waste was generated. Consideration should be given to how long a time period should be sampled for each food service site / premises (e.g. how many collection cycles) to ensure that the information collected is robust. This will depend on the sample size, variability between sites and how it is being scaled to obtain a nation estimate.

Where collection is infrequent, there is the potential for evaporation to reduce the weight of waste. This is a larger issue in hotter countries and where the containment of the food waste is more open. If resources allow, a study could be performed to understand the degree to which this occurs and correct for it.

When to use: Direct weighing (without sorting) can only be used for sorted waste streams (i.e. only containing food waste). Access to the waste stream is required, often before it is combined with waste from other premises or companies.

Waste compositional analysis

Waste composition analysis (WCA) is a method used to physically separate, weigh and categorise food waste. This method is applied to waste streams that include other material which is not food waste (e.g. packaging, garden waste, other solid waste items). For the food service sector, this is usually a residual (general) waste stream, but could also include mixed food and garden waste in some settings.

WCA may also be used to understand the different materials that make up food waste (e.g. types of food categories, or amount of food waste that is food versus associated inedible parts).

WCA is best applied to waste that has not been compacted. If the waste has been compacted or excessively mixed, then the food may be difficult to identify and / or separate from non-food items.

WCA is also best applied to solid waste. Liquid and semi-solid items (e.g. sauces) are difficult to sort manually. These could be recorded using diaries or smart bins (see below).

During waste compositional analysis, it is good practice to have a sort supervisor who checks that this is the case.

When sorting the waste, it is important to ensure that – wherever practically possible – food waste is separated from packaging and the food waste weighed separately. In a small number of circumstances, this may not be practical (e.g. a small amount of jam left in a pot). In such circumstances, an approximate estimate of the weight of the food waste can be used.

When to use: Waste compositional analysis can be used for mixed waste streams that can be accessed. It is difficult to use where food has been compacted or otherwise

excessively mixed such that sorting is difficult. It is easier to apply to solid food items, rather than liquids or semi-solids.

Smart Bins

Smart bins are devices that can weigh individual instances of food waste and record totals over a given period of time. These devices usually have an electronic interface which allows the user to enter details about the waste (e.g. what type of food it is).

These have been deployed in the food service sector as a devise to record the amounts and types of food waste as a first step to preventing that waste[69].

Although smart bins are a form of direct weighing, because the weighing is usually performed by the people who are generating that waste, there is the opportunity for the measurement to influence the amount of waste generated. For instance, in anticipation of weighing the waste, those working within the food service sector may be more careful when preparing foods, leading to less waste. This is a similar effect to that observed with food waste diaries.

Given this, methods where the measurement method uses smart bins are less preferable to the other direct weighing methods. If smart-bin-based methods are used, these should be supplemented with information to determine the degree of behaviour change that has occurred and, where necessary, to correct for this effect when generating national estimates.

When to use: Quantification based on measurements from smart bins should be used when other direct-weighing methods are not suitable – e.g. where there is no access to the waste stream for direct weighing or for waste that would otherwise go down the sewer.

8.5.2 Methods based on counting / scanning

Counting involves assessing the number of items that make up food waste and using the result to determine the weight. The items may be a single product (e.g. a banana or a can of soup) or a number of products in various types of containers (e.g. a bag of grain or a pallet of product). More details can be found in appendix section 3.3.

This is method can be used in the food service sector where operators would like to record the waste that is being generated. This would involve scanning items as they are being wasted (e.g. taken for disposal) and this information being recorded electronically as part of a stock-keeping system.

Given this, it is of most use in the food service sector in the early stages of food's journey within the sector: during the acquisition, transport and storage of food. This is when the food is usually packaged (and therefore has a barcode or other scanable device). It is less suitable during the preparation and consumption stages of the food service sector when food is not usually packaged, labelled or otherwise in a state to be scanned. In these situations, methods based on weighing (section 8.5.1) are preferable.

Where scanning is used, the information (usually data counting the number and type of items becoming waste) usually needs converting to obtain the weight wasted. This can

[69] See for instance the presentation of the case study conducted by WRAP and Sodexo in UK and Ireland: http://www.wrap.org.uk/sites/files/wrap/Sodexo%20smart%20and%20manual%20monitoring%20Case%20Study.pdf

be achieved by applying the weight of food per item for each type of item wasted. This information could be within a database or other stock-management system, or could be applied "manually" if such a database is not available.

In keeping with the FUSIONS definitional framework, the weight of an item used should exclude the weight of packaging or any other non-food element (e.g. paperwork attached to the packaging / food). It is also important to ensure that all relevant disposal routes in the FUSIONS definition framework are covered. Related to this, it is possible for biases to be introduced if scanning of wasted items is not complete. For example, operators may only scan a proportion of the items being wasted, missing some items.

If a system for scanning food waste does not exist, the cost of developing one will usually be relatively large for an individual company. Therefore, this method may only be available for larger companies where electronic stock-keeping already exists and can be adapted to include food waste recording (if it doesn't already).

The information generated may be considered sensitive to the company or organisation that generates it. Therefore, consideration should be given to how to use the data within a NFWQS so that it can be used effectively without disclosing any sensitive aspects of the data.

When to use: This method can only be used if there is a system that can record food as it becomes wasted via scanning or similar devices for counting the number of items wasted. It is only appropriate for the early stages of food's journey through the food service sector. Once the recording of food wasted is aligned with the definitional framework, it is often an accurate and cost-effective way of quantifying food waste.

8.5.3 Diary-based methods

Diary-based methods involve an individual or group of individuals keeping a record or log of the food that they throw away. It is best suited for quantification where an entity does not have direct access to the food waste. It also can provide insights about why the food is thrown away, the types of food and other information that can be recorded in the diary. It is a widely used technique in social and market research to capture information about behaviours as they are carried out. More details can be found in appendix section 3.6.

In many food service settings, diarists can weigh the amount of food waste using weighing scales available to them. This increases the accuracy of diary based methods (compared to diary methods that use approximate measures for estimation of the amount of waste).

There are however some significant disadvantages to the diary method, some of which can be overcome with good design and strong analysis. Food-waste data collected through a diary method is likely to be less accurate than food-waste data collected using weight-based methods such as direct weighing or waste compositional analysis. For a number of reasons food-waste tends to be under-reported by diarists:

- **Social desirability bias** – where diarists complete the diary in the way perceived by them to be desirable to others, under-recoding the amounts of food waste because wasting food is not a desirable practice
- **Behavioural reactivity** – where diarists react to the fact they discard more food than expected by changing their behaviours in the middle of the diary collection process

- **Missed instances of food waste** – this particularly applies where units have more than one occupant and some instances of food waste is not captured by the diarist

Diarists are liable to drop out of the process, particularly if the demands placed on them are high. Commitment which may have been high at the start of the process can easily wane, leading to smaller sample sizes than expected and increased uncertainty in the results.

When to use: Diaries are a useful method for capturing food waste data when there is limited access to the waste or the food waste is going to a disposal route that is hard to capture information about (e.g. down the sewer). However, they are subject to biases, which usually lead to underestimates of food waste. For this reason they are less preferable than methods based on direct weighing (section 8.5.1) or scanning (section 8.5.2).

8.5.4 Other considerations

Sample design

When undertaking a NFWQS where new measurements are being made, it is not practically possible to sample all food service premises / sites in a MS, so a sample of premises / sites should be drawn that is as representative of all premises / sites in the MS as possible.

To ensure that the sample is representative, factors should be identified which may influence the amount of food waste generated (when expressed in the units used for scaling, e.g. per tonne of fold processed). These may include:

- Sub-sector within the food service sector
- How the food is served (e.g. buffet, counter service, table / bed service)
- Range of foods offered (e.g. a limited number of menu options or a wide range)
- Catering arrangements (e.g. preparation on site, preparation off site with reheating on site)
- Size of operation

Where factors are identified as influencing the amount of food waste, it is important either to sample in proportion to their prevalence in the population or to weight the data when producing the results to achieve representativeness.

Ideally, samples should be taken throughout the year to address issues of seasonality. However, this may not always be possible due to budget and resource constraints (see below for what to do where it is not possible).

Measurement details

A clear protocol of what is considered food waste should be drawn up to facilitate accurate measurement. This protocol should be adhered to if waste is being sorted or where decisions are being made about what is or is not food waste.

Weighting or stratifying raw data

Before scaling the results, it is important to check whether the sample of food service sites / premises for which food waste was measured was representative of all food service sites / premises in the MS. If it was not (e.g. due to drop out of sites / premises

not agreeing to take part in the study), then weighting factors should be applied to ensure that the final result is based on a representative sample. (Stratification of the sample should lead to the same result as weighting.)

Seasonality

For all methods described in this section, seasonality should be considered. The amount of food waste generated within the food service sector can vary throughout the year, with peaks associated with high demand. This could be related to holidays and festivals, as well as the changes in weather throughout the year.

Seasonal variation can be accounted for in national estimates by one of the following (in order of preference):

- Gathering data throughout the year in a representative manner
- Gathering data from part of the year and adjusting the results to take account of seasonal variation. Note: this requires the level of seasonal variation in food waste levels to be known (e.g. from a previous study).
- Gathering data from part of the year and adjust by modelling using a proxy for food waste – e.g. assuming that waste levels are in proportion to the amount of food sold throughout the year.

In addition to seasonality, there may be variation in food waste between years. In the case of the food sector, large differences in visitors to a country (e.g. due to one-off events such as the Olympics) could influence the results. If this happens in a year when food waste measurement is planned, it will mean that the level of food waste is higher than for adjacent years. The level of food waste should still be measured as accurately as possible, but such events should be noted in the narrative accompanying the results. If possible, the degree to which they have influenced results should be estimated.

9 Recommended approach for Households

The primary objective of this chapter is to guide the reader through the process of determining household food waste (HHFW) quantities (expressed in weight) in an EU Member State. The major steps of this process are found in Figure 4.

9.1 Scope and structure of the sector

This section helps the user of the Manual to define households, collect data on the "sector" and determine what waste streams and destinations of food are covered by the term household food waste.

The key outcome of this activity is to have a definition of a household and what constitutes household food waste that is clear, consistent with the FUSIONS framework definition and can be put into operation in a NFWQS (i.e. it is practical).

Applicable general core requirements: CR1, 2, 3, 4, 5.

9.1.1 Definition of household

Applicable general core requirement: CR6

There may be slightly different definitions of households amongst the MSs – for instance, those used in the census of the population or other key surveys. It is important to align the definition closely to these to ensure that other data relating to households can be used in the analysis of food waste data.

For instance:

- for the UK's most recent census in 2011[70], the definition of household was:
  - one person living alone; or
  - a group of people (not necessarily related) living at the same address who share cooking facilities and share a living room or sitting room or dining area.

    There was further advice on how to treat sheltered accommodation and caravans.
- For the French Institute for Statistics and Economic Studies (INSEE), the definition is relatively similar[71]:

[70] Final Population Definitions for the 2011 Census (2011 Census Programme): http://www.ons.gov.uk/ons/guide-method/census/2011/the-2011-census/2011-census-questionnaire-content/final-population-definitions-for-the-2011-census.pdf

[71] INSEE definition of household (in the sense of census surveys): http://www.insee.fr/en/methodes/default.asp?page=definitions/menage-recensement.htm

- A household (or "ordinary household") in the sense of the census survey describes all the persons sharing the same main residence, without these persons necessarily being blood-related.
- A household can be constituted by a single person. There is equality between the number of households and the number of main residence.

  Note that persons living in mobile dwellings, mariners, the homeless and persons living in collective dwellings (workers' hostels, retirement homes, university halls of residence, prisons...) are considered as living outside a household

OR 47 – Optional recommendations:
Therefore, measurement of household food waste should include that generated within houses and flats. This includes food brought into households (but not eaten) from retail and markets, as well as that direct from wholesale. It also includes foraged foods (e.g. mushrooms and berries) and those given as gifts or donations that have entered the households. In addition, food grown in a garden or on an allotment should be included where it is brought into the home.

Estimates of household food waste should exclude care homes, prisons, hotels and guest houses, which are all covered by the food service sector. Food waste within litter is also covered under the food service sector, because most litter will be linked to consumption outside the home.

Care should be taken to ensure that food waste from caravans and caravan parks is not double counted, as sometimes this is covered by the definition of households and sometimes by non-household consumption sector. As this is likely to be a small contribution to total food waste of either sector, it is not too important which sector this is covered in, but it should be clearly reported in the NFWR where it has been included.

9.1.2 Mapping of household sector

Applicable general core requirement: CR7

It is useful to scope out the characteristics of households in the country by collating existing information. This can help with deciding what is and is not defined as household food waste.

CR 43 – Core requirement: The following information shall be collected prior to undertaking a quantification study for household food waste:

- Total number of households in the MS; there may be multiple (different) estimates for an individual MS and efforts shall be made for understanding why there are differences (e.g. differences in definition of what a household is or the methods for counting households). This can help with defining a household for the NFWQS.
- Distribution of number of people in the household; food waste is closely linked to the number of people in the household.

All this information can help to ensure that, where sampling takes place, the sample is representative of the population of households within the MS. It can also help if stratification is required in the sampling (see section 4.4.5.5).

OR 48 – Optional recommendation: In addition to the above core requirements, MS may also find information on the following useful:

- Types of property; e.g. houses, flats. This may impact on how waste is collected from these households and the amounts.
- Household "structure"; it can be useful to know how many households contain children, how many contain people from more than family, etc.

It is also useful to understand how much food enters households in the MS. This information can be obtained from surveys about food brought into the home that are commonly compiled by the Governments of many MSs. Alternatively, data can often be sourced from companies compiling retail sales information. It is useful if this information can be obtained for the weight of food purchases, so that it can be directly compared to the weight of food waste produced. This information can be used to sense check estimates of household waste.

If food sales information is available by month or season, it can also be useful in understanding seasonal trends in purchasing, which may underpin the design of quantification studies.

9.1.3 Definition of food waste in the sector

Destinations – What waste destinations to cover in a NFWQS?

CR 44 – Core requirement: Once the definition of a household is determined and the household sector has been scoped out, the destinations to be included in a NFWQS shall be determined.

The following list of destinations should be considered as a list of potential destinations to quantify. However, as discussed below, not all of these need necessarily be quantified.

- Waste streams collected by (or on behalf of) local authorities or municipalities. These will depend on the exact collections found in the MS and may include:
  - "Mixed" (or residual) waste collected from the kerbside
  - "Mixed" (or residual) waste collected from other sources (e.g. household waste recycling centres)
  - Collections targeting food waste (e.g. separate food waste collections or mixed garden and food waste collections)
  - Contamination of other waste streams (e.g. dry recycling[72])
- Sewer waste, mainly via the kitchen sink and dishwashers
- Home composting

For consistency with the definitional framework, food fed to animals (e.g. family pets, wild birds, chickens or pigs kept in the garden) is not defined as food waste and shall not be included as in food waste quantification.

CR 45 – Core requirement: The major food-containing waste streams collected by or on behalf of) local authorities or municipalities shall be included in the NFWQS. This is likely to include "mixed" (or residual) waste collected from the kerbside and collections targeting food waste (e.g. separate food waste collections or mixed garden and food waste collections).

[72] Dry materials such as paper, card, cans, plastic bottles, mixed plastic, glass, etc.

These waste streams have been included as a core requirement as they represent the majority of household food waste in all EU countries where sufficient information is available[73]. There are also existing data sources available for this waste due to reporting under European waste regulations, thereby making quantification studies more affordable as they can build on existing data.

OR 49 – Optional recommendation: Other destinations should be included in the NFWQS, such as:

- "Mixed" (or residual) waste collected from other sources (e.g. household waste recycling centres)
- Contamination of other waste streams (e.g. dry recycling)
- Sewer waste, mainly via the kitchen sink and dishwashers
- Home composting

These destinations have been included as an optional recommendation as they represent the minority of household food waste in all EU countries where sufficient data are available[74]. It is desirable for countries to include these destinations so that they have a complete picture of household food waste.

In the context of a possible food waste reduction target, it would be advisable to try to measure these streams in the baseline and final year of the target if at all possible. However, given the amount of food waste associated with these destinations, the cost of obtaining data and the accuracy of this data, it may not always be cost-effective to include these streams.

For the first two optional waste streams, which are both collected by (or on behalf of) local authorities or municipalities, information may not be available and they are often very small in the quantities collected. For the latter two – sewer waste and home composting – it is hard to measure these waste streams accurately. The main measurement methods used to date are kitchen diaries or questionnaires, both of which lead to bias in the results.

Materials – What material to include?

CR 46 – Core requirement: Studies quantifying household food waste shall include material that confirms to the definition of food waste in the FUSIONS definitional framework. A long list of examples of what to include is given in appendix 8[75].

It is worth noting that the following materials are included (as inedible parts):

- Used teabags and tea leaves
- Used coffee grounds and pods
- Chewing gum

In addition, the following shall be excluded:

- Medicines
- Pet food

[73] FUSIONS, 2016. Food waste data set for EU-28 – WP & Task number: WP 1 task 1.6 – Deliverable Number: D1.8
[74] FUSIONS, 2016. Food waste data set for EU-28 – WP & Task number: WP 1 task 1.6 – Deliverable Number: D1.8
[75] There are some items that are regularly eaten in some cultures but not in others (and therefore may be considered as inedible parts). The presence of a list should be seen as a draft, with changes made following input from stakeholders across the EU. It should not be seen as an attempt to impose cultural values from one part of the EU on another.

9.2 Identify and review existing data relating to food waste from households

This section takes the user of the Manual through a process for determining whether existing information related to households is robust enough to use within the sectorial quantification.

The key outcomes of this section are a) to identify all relevant data sources and b) to determine whether any of them are of sufficient quality to be used by the MS in the quantification household food waste.

Applicable general core requirements: CR9, 10, 11.

9.2.1 Identify existing data

Existing information could take the form of:

- **Existing estimates** of household food waste (or a subset, e.g. for one destination). If these are of sufficient quality, they can be used directly. Sometimes estimates can be improved through a process of adjustment. For instances, if the sample of households included in a study only included houses and omitted flats, then other information (e.g. the average number of people living in a flat relative to the average house) could be used to adjust the results to obtain a national estimate.
- **Raw data:** it can, for instance, take the form of records for the amount of waste from individual households, which requires scaling to obtain a national estimate.

For the destinations which form part of the core requirements for household food waste (see section 9.1.3), there are some specific data that may be available in many MSs:

- Total quantity of waste in key waste streams (e.g. mixed ("residual") waste). This information should form part of reporting of waste statistics to Eurostat as part of the EU waste regulations. Therefore, the ministry or agency responsible for this reporting should hold this information.
- Existing waste compositional analyses[76] of key waste streams, which may include the proportion of these waste streams which are food. These may have been undertaken by individual local authorities / municipalities or a central governmental department or one of its agencies. It is likely that the data relating to these can be obtained from such organisations; in other situations, those undertaking the waste compositional analyses (e.g. waste management companies, specialised waste consultancies) may need to be contacted.

Moreover, waste management companies may also be a source of information on household food waste.

[76] Waste compositional analyses are studies that involve sorting waste into different materials and weighing the amount of each material. They are also called waste characterisation studies or sometimes waste audits. More details of these can be found in appendix 1.

9.2.2 Review identified data and estimates

About quantification methods

CR 47 – Core requirement: Before using existing data, the user of the Manual shall consider whether the data are reliable enough to be used. In the case of households, particular attention shall be paid about the **quantification methods** that were used for measuring food waste (e.g. sorted by hand and then weighed) and how the measurements were collected (e.g. in a diary, from a recall survey, electronically recorded).

Activities related to core requirement:
Some measurement methods introduce a substantial bias into any estimate. For instance, diaries used to record food waste in the home have been found to underestimate waste levels when compared to waste compositional analysis[77]. Therefore, data from more accurate measurement methods should be used in preference of data from less accurate methods. If data from kitchen diaries is used, attempts should be made to minimise the bias introduced into the results. The user of the Manual should consult someone with expertise in food waste measurement if they do not have this expertise themselves.

About sampling procedures

CR 48 – Core requirement: In case sampling procedures have been used, the user of the Manual shall review how sampling was undertaken.

Activities related to core requirement:
There is the potential for considerable bias to be introduced through inappropriate sampling of households. For instance, if a large number of households are approached to take part in a study and a small proportion volunteer to be involved, there could be a large degree of self-selection bias in the sample – those volunteering may not be representative of the whole population. Preference should be given to studies where probability sampling (also known as random sampling) has been undertaken or, if quota sampling has been used, studies that put safeguards in place to minimise the effect of how the quotas are filled. Studies based on convenience sampling should be avoided. The user of the Manual should consult someone with expertise in sampling if they do not have this expertise themselves.

About scaling factors

CR 49 – Core requirement: In case the data have been scaled from a sample to obtain an estimate for the population (i.e. at national level), the user of the Manual shall review the factor used to scale the data and, if applicable, any stratification or weighting procedures used.

Activities related to core requirement:
In general, a scaling factor should have a relatively strong correlation with food waste levels. Here are some specific recommendations for households:

- Scaling the data using number of households or number of people both give good results (usually weighting or stratifying by number of occupants in the household – see next point).

[77] Høj S.B., 2011. Metrics and measurement methods for the monitoring and evaluation of household food waste prevention interventions, M.Bus thesis, University of South Australia, Adelaide.

- Weighting or stratifying by the number of occupants in a household is recommended as, whether measured per person or per household, the level of waste varies with number of occupants.

About overall uncertainty around estimates

CR 50 – Core requirement: In case estimates have been produced, the user of the Manual shall understand the degree of uncertainty around those estimates.

Possible sources of error:

Common sources of errors for estimates for the household sector include:

- Sampling error relating to only measuring waste from a sample of households from the population;
- Bias in the sample – due to how the sample is drawn (e.g. if types of housing, such as flats, have had to be omitted) or low response rate.
- Bias from the method for measuring food waste (e.g. kitchen diaries)
- Municipal waste generally includes waste from households and from businesses producing waste similar to households. For data or estimates based on municipal waste statistics, it is important to ensure that estimates only cover households and that the waste relating to businesses has been removed. In some EU countries, the reporting of municipal waste statistics makes this distinction between household and business waste. In other countries, adjustment to the data will need to be made.

9.3 Select approach for sectorial food waste quantification

This section guides the Manual reader through the process of deciding what information to use for quantifying HHFW. The key outcome of this section is to obtain a clear plan of where information will be coming from for the sectorial quantification.

As presented in section 4.4.4, there are three main types of source:

- Existing estimates
- A new estimate based on existing raw data
- A new estimate based on new measurement

The hierarchy of which information to use is given in the decision tree in Figure 5.

Following the decision tree in Figure 5, if existing estimates of HHFW are "sufficiently accurate" then they should be used. However, it can be difficult to determine whether a study is "sufficiently accurate". For instance, if an existing estimate misses out some important destinations of waste (e.g. it covers mixed ("residual") waste collected by local authorities, but omits separately collected food waste), then this could be supplemented by additional information on the missing waste destinations, thereby making the existing estimate sufficiently good on this metric. Advice on how to use existing estimates is given in section 9.4.

If existing estimates are not deemed accurate enough, raw data should be considered to see if it can be used to quantify HHFW. Again, the scope of this raw data and how it was

measured needs to be "sufficiently accurate". Advice on how to use raw data is given in section 9.5.

If neither existing estimates nor raw data are sufficiently accurate, then a new study will be required involving measurement of HHFW. Advice on how to undertake or commission a new study is given in section 9.6.

9.4 Using existing estimates

Applicable general core requirements: CR12 and 13

CR 51 – Core requirement: When using existing estimates of household food waste, the reference for this estimate shall be clearly stated, alongside any adjustment of the estimate that has taken place.

As discussed above, in some cases it is necessary to adjust existing estimate so that they are more applicable to information required. This may involve updating an estimate to take into account a change in population, or an adjustment to correct a bias. For instance, if only houses were sampled (and flats omitted), then an adjustment will probably be required to account for differences in the average number of people living in each.

Where adjustments have been made, the process for this adjustment shall be transparent. The food waste estimate before and after the adjustment shall be stated. Any additional data used shall be clearly referenced.

OR 50 – Optional recommendation: In particular, as regards scaling factors, the user of the Manual should use as a preferred approach the population as a scale up factor.

9.5 Using existing raw data

This section covers the use of existing raw data for estimating HHFW.

It presents a common method for estimating HHFW from existing data which is a "synthesis" of local authority / municipal data. The method requires two types of existing data to be available:

- **Total quantity of waste in key waste streams** – e.g. mixed ("residual") waste. This information should form part of reporting of waste statistics to Eurostat as part of the EU waste regulations. Therefore, the ministry or agency responsible for this reporting normally holds this information.
- **Existing waste compositional analyses of key waste streams**, which may include the proportion of these waste streams which are food. These may have been undertaken by individual local authorities / municipalities or a central governmental department or one of its agencies. Sometime, the data relating to these can be obtained from these organisations; in other situations, those undertaking the waste compositional analyses (e.g. waste management companies, specialised waste consultancies) may need to be contacted.

The method entails applying the information from the waste compositional analyses to the relevant waste stream. The usual way of doing this is to multiple the percentage or proportion of food waste in a given waste stream by the total amount of waste in the relevant waste stream. This obtains the total amount of food in that waste stream.

It is usual to apply this method to the mixed waste streams that contain substantial amounts of waste:

- Mixed residual waste
- Mixed food and garden waste

In addition to this, an estimate of food waste in separate collections (if present) should be added to the estimate to meet the core requirements of the Manual (i.e. covering all major waste streams containing food waste coming from households).

There are a number of details that can influence the results:

- Municipal waste generally includes waste from households and for businesses producing waste similar to households. For a synthesis study, it is important to ensure that the result is only for waste from households, and that the waste relating to businesses has been removed. In some EU countries, the raw data from reporting of municipal waste statistics makes this distinction between household and business waste. In other countries, adjustment to the data will need to be made.
- The proportion of food waste in the mixed ("residual") waste stream is affected by whether there are collections that target food waste (either separately or mixed with garden waste). If these collections exist, this diverts food waste away from residual waste, lowering the proportion of food waste. Therefore, when conducting a "synthesis" study, it is important to check whether the local authorities / municipalities supplying waste compositional data are representative of the collections targeting food waste for the whole MS. If they are not, then stratification of the sample (or weighting the data) should be undertaken to ensure that the collection systems of the MS are well represented in the analysis.
- In addition to collections schemes, there are other factors that could potentially influence the proportion of food waste in any given stream. These could include socio-demographic factors (such as size of household, income and deprivation), frequency of collection for a waste stream and ability to compost food at home (which may correlate with type of housing and presence of a garden). If there is sufficient information to check whether these factors correlate with the proportion of food waste in the waste stream, this should be done and, if there is an effect, stratification or weighting should be undertaken to minimise the impact on the results.

Where information is used from waste compositional analyses undertaken by other organisations, it is important to understand what is included in the "food" category. It should **include** all food and drink waste (not just edible material) and should **exclude** packaging. For the latter point, attention should be paid to how food waste found in its packaging is sorted and categorised. If the original measurements differ from this definition, steps should be taken to adjust the existing data. Attempts should also be made to influence future data collection to align the data collection with the FUSIONS definitional framework.

An example of synthesis studies is *Synthesis of Food Waste Compositional Data 2012* [78].

[78] http://www.wrap.org.uk/sites/files/wrap/hhfdw-synthesis-food-waste-composition-data.pdf

9.6 Undertaking a study involving new measurements

Recommended quantification methods

OR 51 – Optional recommendation: Methods presented in this section are recommended by the authors of this Manual and should be used by MS when undertaking a new study involving new measurements.

This section covers the methods that involve new measurements of household food waste. The first section covers methods for waste streams collected by (or on behalf of) local authorities or municipalities (a core requirement of the Manual). The second section covers other destinations for food waste, namely sewer and home composting (an optional recommendation of the Manual).

In both cases, new measurement studies can be tailored to obtain more data than what is specified in the core requirements of this Manual (i.e. the total amount of HHFW going to the relevant destinations). For example, the types of food wasted and whether they were edible or inedible material can be included in the studies outlined in this section. This allows more granular data that can form the basis for calculation of the carbon and water footprints of HHFW, the cost to households of HHFW, and many other pieces of information that can support decision making and communication. Kitchen diaries can help establish why food is wasted in the home; waste compositional analysis can record detailed information: for example, information on whether food is in packaging and information from that packaging.

9.6.1 Local authority / municipal waste streams

This section covers measurement of waste within waste streams collected by (or on behalf of) local authorities or municipalities. The method is similar to that described under section 9.5, except that – instead of using existing data from waste compositional analyses – the MS undertakes or commissions these waste compositional analyses themselves.

The basic method of waste compositional analysis is described in appendix 3. This method has the advantage that the waste compositional analyses actually measure the HHFW directly, rather than relying on information from kitchen diaries or questionnaire surveys, which are less accurate.

When applying waste compositional analysis to HHFW, there are some key points to ensure that the results are as accurate as possible:

- Sample design;
- Measurement details;
- Weighting or stratifying raw data;
- Scaling results; and
- Adjustment for seasonality.

Sample design: It is not practically possible to sample all households in a MS, so a sample of households should be drawn that is as representative of all households in the MS as possible. Due to the costs associated with travel and sites to sort the waste, it is usual to use cluster (or area) sampling. This involves creating a representative sample via a two- (or multi-) stage sampling process.

The first step is to obtain a representative set of areas (e.g. local authorities or municipalities) that are representative of all areas for a set of relevant criteria. These criteria could include deprivation, average household size and the characteristics of the waste collection scheme, such as provision of collections targeting food waste.

The second step involves selecting samples of households in these areas, ensuring that the households within all the chosen areas are representative of all households in the MS for a set of relevant criteria. These criteria could include: number of people in the household, income level, presence of children.

Ideally, samples should be taken throughout the year to address issues of seasonality. However, this may not always be possible due to budget and resource constraints (see below for what to do where it is not possible).

Measurement details: a clear protocol of what is considered food waste should be drawn up to facilitate accurate measurement. This protocol should be adhered to by all those doing the sorting – it is good practice to have a sort supervisor who checks that this is the case.

When sorting the waste, it is important to ensure that – wherever practically possible – food waste is separated from packaging and the food waste weighed separately. In a small number of circumstances, this may not be practical (e.g. a small amount of jam left in a pot). In such circumstances, an approximate estimate of the weight of the food waste can be used.

Weighting or stratifying raw data: before scaling the results, it is important to check whether the sample of households for which HHFW was measured was representative of all households in the MS. If it was not (e.g. due to households not agreeing to take part in the study or not presenting waste on the collection day), then weighting factors should be applied to ensure that the final result is based on a representative sample (stratification of the sample should lead to the same result as weighting).

Scaling results: there are a number of ways of scaling the results to achieve a result for all households in the MS, for instance:

- **If a total weight for a waste stream is known.** In this situation, the percentage of each waste stream that is food waste should be determined for the sample. This percentage can then be applied to the total weight for the waste stream in question.
- **If a total weight for the waste stream is not known**. In this case, the average amount of food waste per household or per person should be determined. This can then be multiplied by the number of households or people in the MS.

The first method is preferable as it has the advantage that it addresses problems of how to account for households that do not set out waste.

Adjustment for seasonality: If sampling has not been possible throughout the year, then seasonality can be accounted for by adjusting the results. In a UK study, it was

found that this was not particularly important for the total amount of food waste (which was similar throughout the year), but was important in determining what types of food were wasted, as these do vary throughout the year. The method for this adjustment involves determining the amount of sales of a given type of food in the sampling period and calculating how this compares to the amount of sales that would have occurred if sales had been evenly distributed throughout the year. This leads to an adjustment factor that is applied to individual types of food in the waste stream[79].

9.6.2 Other destinations (sewer, home composting)

For obtaining information of HHFW that goes down the sewer or is home composted, it is particularly difficult to directly measure this waste. For example, HHFW going down the sewer is difficult to separate from other material going down the sewer (e.g. washing up water).

Kitchen diaries have been successfully used to quantify these waste streams in a number of countries (UK, Sweden, etc.). These diaries allow obtaining information from a sample of households who record HHFW at the point of disposal. Full details of the method can be found in appendix 3.

Sample design: It is not practically possible to sample all households in a MS, so a sample of households should be drawn that is as representative of all households in the MS as possible. Given that the amount of HHFW generated is a key metric, the sample should be representative on the number of people in the household. For studies focusing on home composting, there are two possible approaches:

1. The households studied should be representative with respect to the presence or absence of home composting, or
2. Only households that home compost should be sampled and then the results scaled to all households in the MS that home compost.

It is usually possible to undertake a kitchen diary study "remotely", that is to say without visiting every home (e.g. the kitchen diary "pack" can be sent to households and other correspondents via e-mail, letter or SMS messages, as appropriate to the study. Therefore, this opens the possibility of sampling any household within a MS, potentially allowing representative (or probability) sampling to be undertaken.

Ideally, samples should be taken throughout the year to address issues of seasonality. However, this may not always be possible due to budget and resource constraints (see below for what to do in this situation).

Measurement details: There are a number of ways of asking households to record the amount of each item of food waste. In some studies, calibrated kitchen scales are provided to all households and all items should be weighed. However, depending on the sample size, this can be an expensive approach. Alternatively, households can be asked to use their own scales (if they have them, with provision of scales only to households without them). This would mean that not all scales will be calibrated, introducing an uncertainty into the results.

Other approaches ask households to estimate the amount using a range of units – e.g. two apples, one slice of toast and a small handful of peas. This has the advantage that the

[79] See methodology presented in chapter 11 of the WRAP (2012) study *Household Food and Drink Waste in the UK 2012* methodology

measurement is very quick (thus minimising non-recording of waste items). However, the accuracy of the measurement will be lower as these non-standard units will need to be converted to weight. The process of converting information from non-standard units to weight should be done by the researchers undertaking the study; this can be a time consuming process.

The exact method for measurement should be determined by the circumstances of the MS – the budget, coverage of scales in households and available resource to convert non-standard units to weight.

Participants in diary research should be encouraged to record all relevant HHFW. For sewer waste, this should include all inlets to the sewer, including the kitchen sink, and sink-based waste disposal unit (e.g. a macerator), the dishwasher, and, less importantly, toilets and any outside drains.

Examples of pages from kitchen diaries can be found in section x.

Weighting or stratifying raw data: before scaling the results, it is important to check whether the sample of households that completed the kitchen diary research was representative of all households in the MS. If it was not (e.g. due to households not completing the diary), then weighting factors should be applied to ensure that the final result is based on a representative sample. (Stratification of the sample should lead to the same result as weighting).

Scaling results: the total amount of HHFW going down the sewer or home composted is not usually known from other sources. Therefore, the weighted average amount of food waste per household or per person should be determined. This can then be multiplied by the number of households or people in the MS.

Adjustment for seasonality: If sampling has not been possible throughout the year, then seasonality can be accounted for by adjusting the results. A method for this is described in 9.6.1 that is suitable to be applied to kitchen diaries.

Dealing with water added in the home: for sewer waste, the amount of HHFW can be affected greatly by how water added to products in the home is reported. In some studies, the information supplied in the diaries has been used to estimate how much water has been added in the home and this has been reported separately from the amount of HHFW (excluding this added water). For instance, if fruit juice is served diluted, an estimate is made of how much water was added and this is subtracted from the estimate of HHFW (and reported separately). It is recommended that this approach is taken by MSs.

Issues associated with kitchen diaries: It should be remembered that kitchen diaries are a self-reported measure of food waste and are therefore not as accurate as a third party measuring the HHFW. Issues with kitchen diaries include householders forgetting to record all HHFW, choosing not to record all food waste (e.g. due to social desirability bias) or the key diary keeper not being aware of all food waste generated in the household. These biases can be minimised by regular reminders to those participating in a kitchen diary study to record all waste (e.g. via a telephone call or text message), emphasising the importance of accurate diary keeping, stressing the fact that households are not being judged and encouraging all people in the household to be involved with the diary keeping.

Even with these measures, changes to the way the diary keeping is undertaken have the potential to affect the measurement[80]. Therefore, where MSs are using these methods to

[80] As discussed in section 2.3 of *Methods report: http://www.wrap.org.uk/sites/files/wrap/Methods%20Annex%20Report%20v2.pdf*

quantify food waste, they should try to replicate the method used each time they undertake a study to increase the comparability of the estimates produced.

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1 Appendix – Complementary information on FUSIONS definitional framework

1.1 The FUSIONS framework

The FUSIONS theoretical framework of resource flows leaving the food supply chain is provided in Figure 8 and is described in detail in the subsequent sections of this chapter.

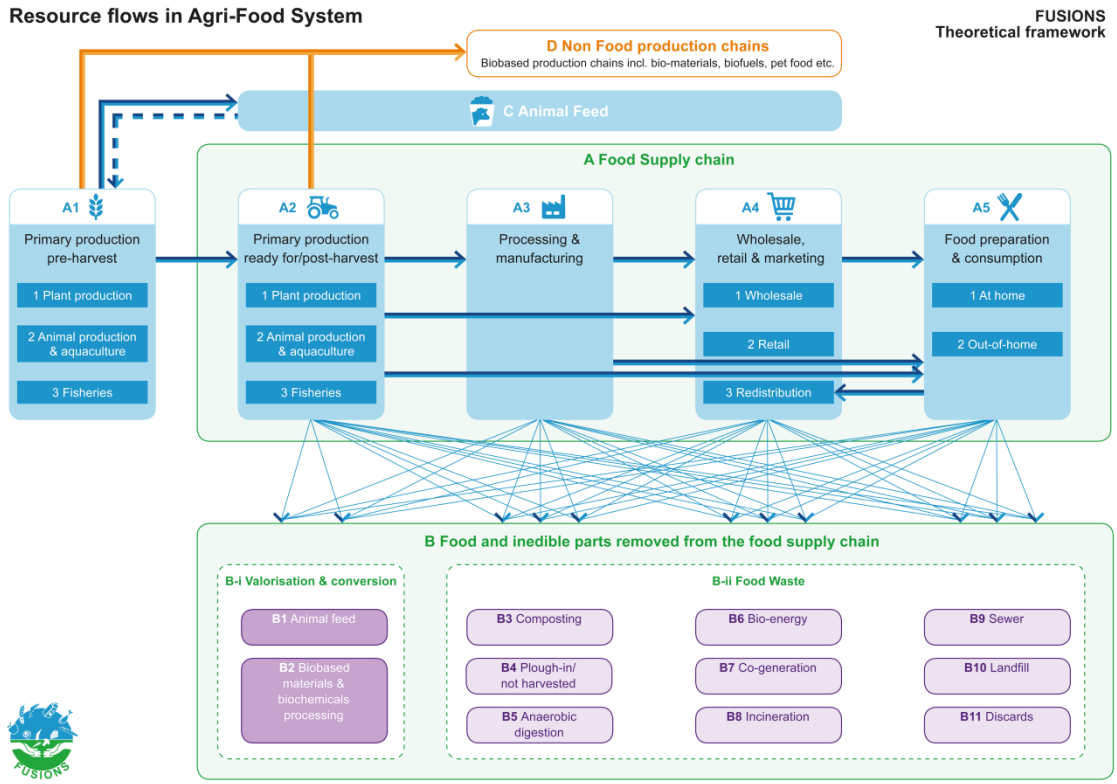


Figure 8 – The FUSIONS theoretical framework

Explanation:
The Food supply chain is described by boxes A2 to A5. Note that material leaves stage A1 and enters stage A2 when the crop is ready for harvest or animal is ready for slaughter[81]*. "Food and inedible parts of food removed from the food supply chain" (B) is classified based on whether it is to be valorised or converted or disposed. Box (B) covers all flows leaving the food supply chain which are classified as either food (edible parts) or inedible parts of food.*
Section B-ii shows the FUSIONS proposal for "food waste" being applied in this document. ***It is defined by the final destination of all food, and inedible parts of food, removed from the food supply chain****. Any food or inedible parts of food directed for the destinations B3-B11 are termed food waste because*

[81] See section 1.2.2 in the present appendix 1 for a list of specific starting points of the food supply chain according to the FUSIONS theoretical framework.

they are not putting food to its most productive use. Any food or inedible parts of food sent to animal feed, bio-based material/chemistry processing (B1-B2) are termed "valorisation and conversion" and are distinct from "food waste".

The food supply chain is the connected series of activities used to produce, process, distribute and consume food. The food supply chain starts when the raw materials for food are ready to enter the economic and technical system for food production or home-grown consumption (A2). It ends when the food is consumed (A5) or "removed" (Section B) from the food supply chain.
"Food and inedible parts of food removed from the food supply chain" (B) refers to the resources leaving the food supply chain regardless their cause. The destinations are B-i (valorisation and conversion) and B-ii (food waste). "Food waste" (B-ii) refers to the fraction of "food and inedible parts of food removed from the food supply chain" to be recovered or disposed (including - composted, crops ploughed in/not harvested, anaerobic digestion, bio-energy production, co-generation, incineration, disposal to sewer, landfill or fish discarded to sea).
Redistribution, the act of donating food surplus to charity, is often considered alongside other destinations in Section B. However, FUSIONS considers redistribution as a part of the food supply chain since the redistributed food is intended for consumption, although the logistics and distribution activities are different from that originally planned. The flow from A5 to A4 holds the surplus food intended for redistribution. It may go on to be wasted and it is this resource flow that is of interest, hence it feeds into Section B in the same way as all other resource flows.

The FUSIONS theoretical framework provided in in Figure 8 allows codification of any flow, edible or inedible, leaving the food supply chain.

The total (edible and inedible) resource flow leaving the food supply chain is what today is considered *practically* possible to measure and monitor on an EU28 level. Nevertheless, a separation of edible and inedible parts of the resource flows leaving the food supply chain(B) is encouraged where possible for enhancing the implementation of effective food waste prevention strategies along with resource efficient managements strategies of the resource flows (B).

1.2 Definitions

1.2.1 Food

The definition of food comply with official documents (such as existing legislation) using present definitions of "food"; presented in the EU regulation No 178-2002 on general principles and requirements of food law[82] as well as the FAO/WHO Codex Alimentarus Commission on food safety (ALINORM 04/27/33A) Article 3[83]. The FUSIONS definition of "food" is given in Table 9.

[82] EU Regulation No 178-2002: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2002:031:0001:0024:EN:PDF

[83] FAO/WHO Codex 04/27/33A: http://www.codexalimentarius.org/input/download/report/618/al0433ae.pdf#page=46

Table 9 – The FUSIONS definitions of "food"

Food	Food means any substance or product, whether processed, partially processed or unprocessed, intended to be, or reasonably expected to be eaten by humans. "Food" includes drink, chewing gum and any substance, including water, intentionally incorporated into food during its manufacture, preparation or treatment.

It is often interpreted as excluding inedible parts of food; therefore, these have been separately brought out, and included in the framework.

"Intended to be, or reasonably expected to be":
"*Intended to be, or reasonably expected to be*", in the FUSIONS definition of food, refers to the intention of the current user acquiring the substance or product (to be further produced, processed, distributed or consumed). This means that once defined as "food", substances and products may, as they proceed along the food supply chain, divert to other supply chains and thereby stop being defined as food. This also means that culture can affect how substances and products are defined with regards to whether they are "intended to be or reasonably expected to be eaten by humans".

1.2.2 Food supply chain

The "food supply chain" produces, processes, distributes and consumes "food". The FUSIONS definition of "Food supply chain" is given in Table 10.

Table 10 – The FUSIONS definition of "food supply chain"

Food supply chain (A)	The food supply chain is the connected series of activities used to produce, process, distribute and consume food.

Specific starting points of the food supply chain according to the FUSIONS theoretical framework are:

- When crops are mature for harvest
- When fruit and berries are mature for harvest
- The harvesting of wild crops, fruit and berries
- When animals are ready for slaughter (live-weight)
- When wild animals are caught or killed (live-weight)
- The drawing of milk from animals
- When eggs are laid by the bird
- The catching of wild fish in the net/on the hook
- When fish from aqua-cultural is mature in the pond

When the specific starting points of the food supply chain, mentioned above, are not applicable, the starting point of the food supply chain is determined by when the raw materials for food enter the economic or technical system for food production or home-grown consumption.

The end point of the food supply chain is defined by when food is a) eaten or consumed or b) otherwise removed from the food supply chain. Consumed refers to the main purpose of the food item other than eaten; e.g. chewed (for gum) or used (for tea leafs, cooking oil[84]).

Only substances or products defined as "food" and "inedible parts of food" can be part of the food supply chain. Certain raw materials can enter several different value chains, e.g. wheat which can enter the "food supply chain" (bread production); the "feed supply chain" (animal feed) or the "energy supply chain" (bio-energy). The scope of FUSIONS however only include "food" and "inedible part of food" (and thereby only the "food supply chain"), determined by whether or not a substance or product is "intended to be, or reasonably expected to be eaten by humans", which is determined by the person/company currently handling the raw material.

1.2.3 Food and inedible parts of food removed from the food supply chain

According to the EU Food law it is the "intention or reasonable expectations" of the current user that determines whether a fraction of food is a part of the "food supply chain", meaning that only the fraction intended to enter the food supply chain can leave it. Fractions of food and inedible parts of food diverted from the food supply chain before its end point are referred to as *"food and inedible parts of food removed from the food supply chain"* and is attributed to a set of specific boundary conditions:

Specifically for "food" including water:

- If water is incorporated into food and this food is removed from the food supply chain, then the incorporated water is considered as a part of "food and inedible parts of food removed from the food supply chain" e.g. water added to fruit juice or water incorporated into rice during cooking.
- Water used in the food supply chain, but not incorporated into a product, is not considered as a part of "food and inedible parts of food removed from the food supply chain" (e.g. water used to flush food down the drain during cleaning processes).
- Water intentionally removed during processing (e.g. water evaporating during cooking) is not considered as food waste (since it is not "intended to be eaten" and therefore not defined as "food").
- Water that is unintentionally removed (e.g. evaporation during storage) the water is considered food waste since it was "intended to be eaten by humans".

"Removed from the food supply chain" includes food and inedible parts of food which are:

- Used for animal feed production or fed to animals by the public. Note that this stream is still a part of the agri-food system but not a part of the food supply chain as defined by FUSIONS (Figure 8) – Destination B1
- Biobased material / biochemical processing: this typically includes:
    - For biomaterials – biobased plastics such as polylactic acid (PLA);

[84] Left over cooking oil is considered as food waste if not used as feed or further processing. Cooking oil is seen as an ingredient since it is integrated into the food during cooking. Ideally the process should be designed so that a minimum of cooking oil is wasted. The same is valid for other process aids that are intended to be integrated into the food product as a part of the processing of the final product.

- For biochemicals – Extraction of molecules that will be used in chemistry applications such as production of high-end organic chemicals.

- Composted (at home or industrially) – Destination B3
- Ploughed back into ground or not harvested – Destination B4
- Anaerobically digested – i.e. production of biogas (containing methane) from fermentation processes – Destination B5
- Used for bio-energy – i.e. production of energy using resources other than biogas/methane, including biofuels (e.g. bioethanol or biodiesel) – Destination B6
- Used for co-generation – i.e. combined heat and power generation from incineration – Destination B7
- Incinerated without energy recovery – Destination B8
- Flushed down the sewer or to a controlled water course – Destination B9
- Sent to landfill[85], land-spread – Destination B10
- Discarded at sea – Destination B11

"Removed from the food supply chain" *does not* include food and inedible parts of food which are:

- redistributed (e.g. by charities)
- marked down in price but ultimately sold (e.g. by a retailer)
- not used for the most financially-rewarding purposes, but still kept within the food supply chain, sometimes re-worked
- incorporated into other food products (e.g. the fibre from vegetables used as a bulking agent within other food products)

"Food and inedible parts of food removed from the food supply chain" are further defined into two sub-fractions according to Table 11, "food" and "inedible parts of food".

Table 11 – FUSIONS' definitions of "food" and "inedible parts of food"; the sub-fractions of "Food and inedible parts of food removed from the food supply chain"

Food	Edible food that has or had the potential to be eaten removed from the food supply chain
Inedible parts of food	Associated inedible parts of food removed from the food supply chain

Food:
"Food and inedible parts of food removed from the food supply chain" can include a small or a large share of edible food products and substances, resulting from a production system with high or low efficiency. This food fraction is often of special interest when addressing food waste prevention.
"Food" for one person may not be "food" for another person, e.g. offal. In its definitional framework, FUSIONS does not introduce a third category - "potentially/technically" edible (e.g. as used by WRAP in the UK[86]). Instead, a resource is either "(edible) food" or "inedible parts of food". Determination of edible and inedible fractions is further considered in the paragraph on "material type" in section 4.2 as well as in appendix 7.

[85] A landfill site is an area of land or an excavated site that is specifically designed and built to receive wastes.
[86] http://www.wrap.org.uk/content/household-food-and-drink-waste-uk-2012

Note that in appendix 7, "technically" edible items are listed to illustrate possible cultural differences, but are considered edible from a FUSIONS definition perspective.

Inedible parts of food:
The inedible parts of food removed from the food supply chain may be re-used in other value chains, recycled or used for energy recovery etc. Thus, the resource efficiency of the food system as a whole depends on resource efficient waste management of both inedible and edible parts of food.

"Has or had":
The definition of "edible food" recognizes that food which is no longer considered edible (since e.g. it is moulded, rotten or the date label has expired), but which has *had* the potential to be eaten, is to be considered as "edible food"; even though it is not edible at the point of disposal.

Removed:
The term "removed from" encompasses other terminology such as "lost to" or "diverted from". It assumes that any food being produced for human consumption, but which leaves the food supply chain, is "removed from" it regardless of the cause, point in the food supply chain or method by which it is removed.

"Valorisation & conversion" and "food waste":
"Food and inedible parts removed from the food supply chain" can be utilised either for "valorisation and conversion" (B-i in in Figure 8) or become "food waste" (B-ii in Figure 8). Depending on the destination, the fractions of "food and inedible parts removed from the food supply chain" are defined in Table 12.

Table 12 – FUSIONS' definitions of the fractions of "food and inedible parts of food removed from the food supply chain"

Valorisation and conversion (B-i)	Fractions of "food and inedible parts of food removed from the food supply chain" to be re-used or recycled (animal feed , biobased materials and biochemical processing)
Food waste (B-ii)	Fractions of "food and inedible parts of food removed from the food supply chain" to be recovered or disposed (including - composted, crops ploughed in/not harvested, anaerobic digestion, bioenergy production, co-generation, incineration, disposal to sewer, landfill or discarded to sea)

2 Appendix – Other initiatives on food waste quantification

2.1 The Food Loss & Waste Protocol

The Food Loss & Waste Protocol was launched in 2013 and is being developed by a wide representation of stakeholders. This includes a Steering Committee that consists of two UN agencies (FAO and UNEP), two global private sector associations (CGF and WBCSD), two bodies with technical expertise on measuring food loss and waste (FUSIONS and WRAP), and WRI as a leading global research organization, which serves as Secretariat.

The *FLW Protocol Accounting and Reporting Standard (FLW Standard)*, the first output of the FLW Protocol, targets to be globally applicable and is designed to harmonize and standardize how quantitative food loss and food waste data are accounted for and reported by providing a set of accounting and reporting requirements and applicable definitions. It can be used by both countries and companies to measure any food loss or waste within the food supply chain. It does not impose a definition of food loss or waste on the users of the *FLW Standard*. Indeed, it does not declare which specific processes or activities are "loss and waste" but instead, it provides categories of what might be possible "destinations" or pathways for food loss and food waste.

The standard contains information on all aspects of the quantification process, including preparing to quantify, important concepts and definitions, and guidance on methods. An appendix covering conversion and data management is also included. The standard takes the reader through a series of steps to quantify the food waste within the chosen scope – what methods to use in different circumstances and detailed advice on deploying these methods accurately and effectively. The major steps in the process are summarised in Figure 9.

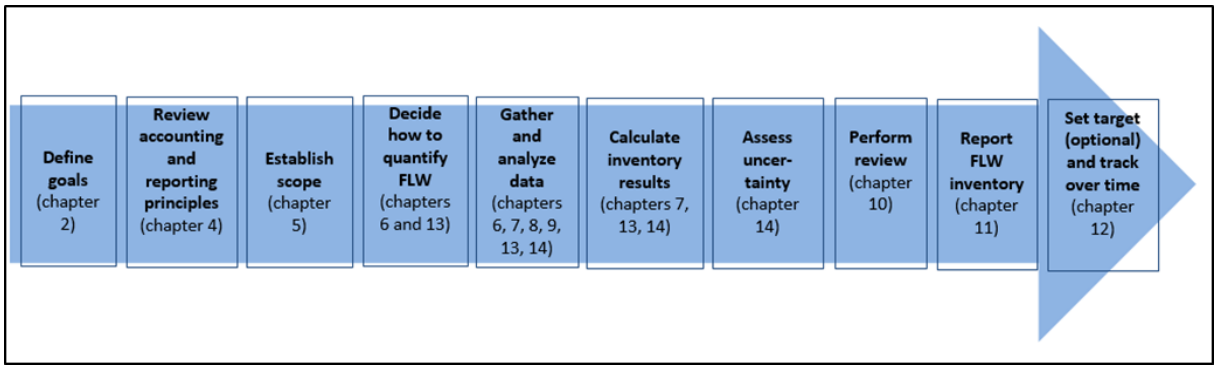


Figure 9 – Overview of steps in food waste accounting and reporting (from the *FLW Standard*, WRI)

The first full draft of the *FLW Standard* was published online in March 2015 and is currently being pilot-tested in several projects. For a quantification of food waste, it provides a means to ensure consistency and transparency when reporting about the scope and methods used.

Future actions:

Feedback from external reviewers and pilot testers will be incorporated with Version 1.0 of the FLW Standard to be published in early 2016.

Link with the Food Waste Quantification Manual

In the context of a national food waste quantification study, the user of the Manual may also use the FLW Standard. In order to facilitate the use of both documents a table of correspondence between the Manual and the FLW Standard for the names of the destinations for food and inedible parts removed from the food supply chain is provided below (Table 13 – Destinations for food and inedible parts removed from the food supply chain – Table of correspondence between the Manual and the FLW Standard destinations Table 13).

Table 13 – Destinations for food and inedible parts removed from the food supply chain – Table of correspondence between the Manual and the FLW Standard destinations

FUSIONS destination	FLW Standard destinations (non-final / subject to change)
B1 – Animal feed	Similar name / Similar scope
B2 – Biobased materials and biochemical processing	Similar name Scope: similar but also includes production of biodiesel
B3 – Composting	Name: "Composting / aerobic process" Scope: Similar
B4 – Plough in / not harvested	Name: "Not harvested / ploughed in" Scope: Does not include land application (separate destination)
B5 – Anaerobic digestion	Name: "Codigestion / anaerobic digestion" Scope: B5+B6
B6 – Bio-energy	Name: "Codigestion / anaerobic digestion" Scope: B5+B6 (except production of biodiesel included in "Biobased materials and biochemical processing" (see row2).
B7 – Co-generation	See below
B8 – Incineration	Destination "Controlled combustion" – i.e. sending material in a facility that is specifically designed for combustion in a controlled manner with and without energy recovery. "Open burn" is classified under another destination.
B9 – Sewer	Name: "Sewer / wastewater treatment plant" Similar scope
B10 – Landfill	Similar name / Similar scope
B11 – Discards	Name: "Refuse/discards/litter" Scope: fish discards but also includes open dumps (e.g., uncovered, unlined), open burn (i.e., not in a controlled facility) as well as the portion of harvested crops eaten by pests.

2.2 FAO's Global Data on Food Losses and the Global Food Loss Index (GFLI)

For many years, FAO has been disseminating annual estimates of food losses for the countries in the whole world, broken down by primary agricultural products. These estimates are compiled as part of the Food Balance Sheets (FBS), an accounting framework for recording the different types of supply and utilization of the various types of food products[87].

The definition of food losses employed by FAO follows from the concepts of the FBS (FAO, 2001). Accordingly, it encompasses the amounts lost at all stages of the supply chain "between the level at which production is recorded and the household" (*ibd.*, p. 10). Therefore, post-harvest losses occurring during the treatment on farm, during storage, transport and distribution are included, whereas pre-harvest losses and losses within the household are excluded. Food losses are measured in the FBS in terms of weight units of the primary equivalents of the respective product. A distinction between edible and inedible materials cannot be made, as the products are represented as homogenous goods in their "as-purchased" form (*ibd.*, p. 15).

FAO is currently developing a **Global Food Loss Index (GFLI)** to monitor countries' success in reducing food losses along production and supply chains that contributes to the Sustainable Development Goal 12.3 proposed for the United Nations Post-2015 Agenda. The compilation of the GFLI shall be based on the food-losses estimates recorded in the FBS, while the quality of these figures is currently being improved by broadening and enhancing the primary database and developing further the applied estimation methods.

Global Food Loss Index (GFLI)

The GFLI, being developed by the Statistics Division of FAO, aims to measure national trends in food losses along production and supply chains. Among the different steps of the food supply chain, the GFLI covers losses occurred on farm, during transport, in storage, and during processing. At the moment, losses in retail and household are not covered. Currently, GFLI uses dietary energy supply, expressed in kilocalories (kcal), as the reference unit of measure.

What it does on the quantification and assessment of PHL:

The GFLI will be obtained as a result of aggregation of data on food losses, broken down by primary agricultural products. These data will be collected on the basis of representative surveys (primary data) or, in cases of data gaps, estimated by applying econometric techniques and using information from case studies. They will be aligned with data on agricultural production, foreign trade and the various types of utilization of agricultural products, on the basis of Food Balance Sheets.

The GFLI can be compiled annually for all the countries for which Food Balance Sheets are available.

The graph below shows how GFLI is built.

[87] http://faostat3.fao.org/

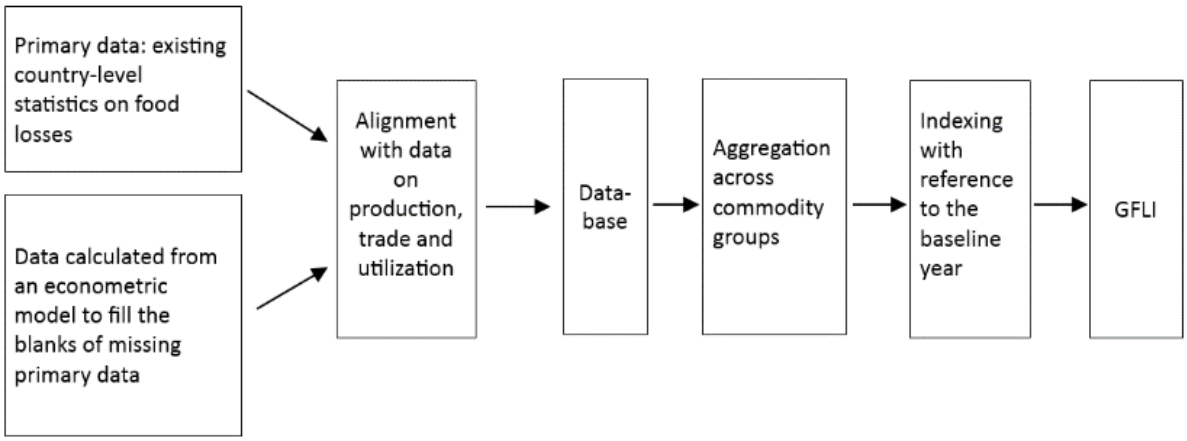


Figure 10 – Schematic depiction of the calculation method of the GFLI

Future actions:

GFLI is being constantly maintained and improved. Reliable country level statistics on food losses are the base of GFLI, but the availability of such data varies greatly among regions, and in general is far from sufficient presently. If provided with adequate amount of data, GFLI has the potential fill the gap for a wide range of commodities and regions.

The accuracy of the GFLI is being constantly maintained and improved, mainly by means of the following activities:

- increasing the availability of primary data;
- increasing the quality of the primary data;
- developing further the estimation model.

A review of the econometric model used to estimate missing data is taking place.

Furthermore, FAO is evaluating the need for adjustments in the underlying measurement concepts by taking into account the Food Losses and Waste Protocol and Standard (FLW Standard) and the definitions proposed by the Global Initiative on Food Loss and Waste Reduction (SAVE FOOD[88]), APHLIS[89], EU project FUSIONS and other initiatives at international level.

2.3 Eurostat "Food waste plug-in" approach

Eurostat launched a food waste plug-in in 2013 to be reported together with the standard reporting of the year 2014. The food waste plug-in builds on what is already reported to Eurostat, namely waste codes (EWC-Stat codes[90]) and branches (according to NACE-division). What is unique with the food waste plug-in is that it is asking for data on waste

[88] Save Food Initiative. www.save-food.org

[89] African Postharvest Losses Information System. www.aphlis.net/

[90] EWC-Stat is a material-based aggregate of the LoW (List of Waste) codes in the Waste Framework directive. The complete list can be found in the Waste Statistics Regulation at:
http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1435147770984&uri=CELEX:32002R2150

categories in Low-codes from the branches that might contain (or are likely to contain) food waste. Also data on treatment of this waste is to be reported.

See Table 14 for the reported data on generation of food waste: the red line being the EWC-Stat code and the lines under are the corresponding LoW-codes), note that this is just a part of the table:

Table 14 – Example of reported data on generation of food waste

EWC-Stat 4 categories and breakdown into LoW items ⇩		NACE Rev. 2 activities and households ⇨ (Red items are used already in the WStatR data collection, but without the LoW breakdown in waste.)	C10-C12 aggregate			Wholesale trade, except of motor vehicles and motorcycles			Retail trade, except of motor vehicles and motorcycles		
			C10-12			46			47		
			value	flag	conf	value	flag	conf	value	flag	conf
09.1 Animal and mixed food waste			230245								
of which	02 01 02	animal-tissue waste	3157	E							
	02 02 01	sludges from washing and cleaning	3308	E							
	02 02 02	animal-tissue waste	123493	E							
	02 02 03	materials unsuitable for consumption or processing	43073	E							
	02 03 02	wastes from preserving agents	0	E							
	02 05 01	materials unsuitable for consumption or processing	57033	E							
	02 06 02	wastes from preserving agents	0	E							
	19 08 09	grease and oil mixture from oil/water separation	0	E							
	20 01 08	biodegradable kitchen and canteen waste	179	E					12 774	E	
	20 01 25	edible oil and fat	0	E							
09.2 Vegetal wastes			472607	E							
of which	02 01 01	sludges from washing and cleaning	0	E							
	02 01 03	plant-tissue waste	3690	E							
	02 01 07	wastes from forestry	0	E							

The LoW-codes used also contain waste material other than food waste. Therefore, it is hard to obtain an estimate of solely for food waste from the data supplied for the plug-in. In definitive, the data reported does not give the full picture of food waste arisings in EU.

For example:
Food waste data are calculated as "food waste" according to the FUSIONS-definition and reported as food waste within one country. For the plug-in and the regular WStatR-reporting these figures are filled in the tables under the waste code where it belongs.
1. For the regular reporting it is then mixed with other wastes having the same EWC-stat-code. That means it is not reversible.
2. For the plug-in even though divided into LoW-codes, there will still be other wastes reported along with the food waste such as in the case of the food waste from households which will be reported together with other "mixed municipal waste". So food waste is still being mixed with other wastes and this amalgamation is not reversible.

One solution to this might be to change the instructions and ask for the food waste part of each LoW-code.

3 Appendix – Presentation of methods for quantifying food waste

This section is adapted from the Food Loss & Waste Standard. Please refer to the Protocol for additional operational details on the implementation of these methods.

3.1 Records

Records are information that is often routinely collected (e.g. waste transfer receipts or warehouse record books) that can be used to quantify the amount of food waste. They are typically created for a purpose other than tracking food waste (e.g. for financial management, inventory management, legal compliance or process management).

Using records to generate the data for a food waste quantification study most often costs less than undertaking a new study to measure or approximate food waste. Where records are based on actual measurements, the data may also be more accurate than data collected through a new study that relies on a number of calculations and assumptions.

One disadvantage when using existing data from records is that it may not be clear what method has been used to generate the information contained in the records. An organisation should understand how the records have been created since some methods result in more accurate quantification (e.g. if the records are based on weighing then they are likely to be very accurate, whereas if they are based on an approximation of volume they may be less accurate).

3.2 Direct weighing

Weighing is a well-established approach to measuring the weight of an object and involves using a weighing device (e.g. a set of scales) to quantify instances of food waste. Weighing may be used as a stand-alone method or with other methods (e.g. waste composition analysis).

3.3 Counting

Counting involves assessing the number of items that make up food waste and using the result to determine the weight. The items may be a single product (e.g. a banana or a can of soup) or a number of products in various types of containers (e.g. a bag of grain or a pallet of product).

There are several approaches that incorporate counting as a means for calculating the amount of food waste: basic counting, a scanning-based approach, and using visual scales.

At the foundation of counting-based methods are several steps.

- Determine the unit being counted (e.g. individual item, container, bag, lorry),

- If the weight is not already known, weigh one – or a representative sample - of these units,
- Count the units, and
- Multiply the unit's weight (or average sample weight) by the count.

Basic Counting
Counting can be a straightforward way for an organisation to quantify food waste where the weight of the items being counted is known. An example might be a retailer for whom tomatoes in cans have become food waste. If the net weight (i.e., excluding the can) of each can is 450g and there are 100 cans, it can simply multiply the numbers (450 g times 100 cans) together and report 45kg as food waste.

If the weight of an item is not known in advance or varies, an organisation can derive an average weight by weighing a representative sample of items.

Scanning
A scanning approach makes use of scanning technology linked to printed or digital bar codes to count and record instances of food waste. An organisation that uses a scanning approach will undertake the following steps. Where these are automated, an organisation can use appropriate scanning technology and software.

1. Scan the bar codes of individual items, cases, or pallets of product that are considered food waste. This is frequently done using a mobile scanning device connected to a database. In some cases, an organisation may be able to extract data manually from the inventory database.
2. Convert the number of units scanned into a weight using data linked to the bar code. The bar code links to underlying data associated with a product. Scanning technology typically links the data electronically though it would also be possible to manually look up bar code numbers in the underlying database.

If desired, an organisation can roll up the data from the individual product level (e.g., tilapia) to the broader food category (e.g., seafood). Moreover, the information may then be combined with data on annual turnover for each product group to understand the economic implications.

Visual scales
In agricultural contexts, picture cards and visual scales are useful aids in evaluating the condition of perishable as well as durable crops. They are a relatively quick and low-cost method of evaluating and quantifying food waste, most typically to assess damage by pests to stored crops.

3.4 Assessing volume

Assessing volume is the process of measuring or approximating the space taken up by food waste. For the requirements of the food waste quantification, the volume of food waste is subsequently converted into a weight. The method is ideal for liquid food waste, but can also be applied to solid and semi-solid material, including solid food waste suspended in liquid.

An organisation may use devices such as calibrated containers to precisely measure the volume, or may use other techniques including water displacement or visual assessment. The international standard measurement unit of volume is cubic meter (m3).

3.5 Waste composition analysis

Waste composition analysis (WCA) is a method used to physically separate, weigh and categorise food waste. An organisation may use this method to separate food waste from a "waste" stream that includes other material which is not food waste (e.g. packaging, garden waste, other solid waste items). It may also be used to understand the different materials that make up food waste (e.g. types of food categories, or amount of food waste that is food versus associated inedible parts). A WCA may also be referred to as a "waste characterization study" or "waste sort."

A WCA provides an opportunity to collect very detailed information about food waste. The food waste could, for example, be sorted into specific food categories (e.g. apples, cake, and chicken). The information collected can also be linked to why food waste occurred. For example items still in their original packaging could be sorted separately and data recorded from the packaging (e.g. item's brand, type, flavour) along with whether it was found open or unopened, how much was eaten or how much of the pack was left.

3.6 Diaries

Diaries are a method in which an individual or group of individuals keeps a daily record or log of information. It is best suited for quantification of food waste where an organisation does not have direct access to the food waste and where insights are needed about behaviours linked to amounts and types of food. It is a widely used technique in social and market research to capture information about behaviours as they are carried out, and is well suited to habitual, routine behaviours carried out in a private setting.

Diaries can be used by any individual or organisation producing food waste (the "diarist") but most commonly they have been used to study food waste in households and commercial kitchens. The quantities are recorded before the food waste is "thrown away." If done well they can provide a rich description in real time not only of the types and amounts of food waste but also of the reasons why food waste occurs.

In the diary method, the measurement or approximation of food waste can be undertaken in several ways, with the diary instrument acting as the mechanism for data capture. Types of information that can be recorded in diaries are weights of food waste captured through direct weighing, volume-based measurements or approximations (e.g. using calibrated spoons, cups, jugs, or approximations such as) or counting of items (e.g. five apples). Sometimes measurement devises are provided to research participants (e.g. a set of weighing scales). Other times, vessels are provided for volumetric assessment (e.g. a bag or small container to collect food waste).

Diaries have been used to collect information on food waste in the UK, Sweden, Oregon (USA), and Seattle (USA), often as one part of a larger study that encompasses other methods.

3.7 Surveys

Surveys are a cost-effective way of gathering information from a large number of individuals or entities on attitudes, beliefs and self-reported behaviours. One of the defining characteristics of a survey is that questioning is structured, in other words the questions are specified in advance and written down. In the context of quantifying food waste, surveys fall into three distinct categories:

1. Surveys that ask respondents to provide prior measurements or approximations of food waste;
2. Surveys that ask for other factual information that enables the researcher to make an estimate of food waste (e.g. information about the number, size, fullness and frequency of collection of food waste containers that can be converted into a volume of food waste, or inputs to an inference-based method);
3. Surveys that ask respondents to provide their perceptions of the types and amounts of food waste through recall or visual approximation.

Surveys as described in category 3 ask respondents to provide their perceptions of the types and amounts of food waste. Relying on recall is prone to error and as such, the uncertainty associated with this data should be clearly explained. Since the accuracy of the figures will be lower than other methods, an organisation should not use the data for more than a general understanding of food waste quantities.

Ideally, the quantification of food waste would be carried out through means other than the survey alone (e.g. weighing, diaries or waste compositional analysis) and then combined with the information collected through the survey. A survey can be especially be useful where an organisation is seeking to design effective interventions to reduce food waste and looking to gather insights about the attitudes, values and behaviours associated with specific amounts and types of food waste.

Surveys require questionnaires, and these can either be administered by an interviewer or they can be distributed for respondents to complete themselves. Where questionnaires are to be administered by an interviewer, the mode of administration will either be by telephone or as a face-to-face interview. Where surveys are to be distributed for completion by respondents the means of distribution will either be by post or electronic methods (e.g. on-line, email and app-based).

Survey data consists of cases (i.e. individual responses) and variables (i.e. attributes by which cases vary). Data from surveys is analysed using quantitative techniques such as frequency counts and cross- tabulations, the choice of which will depend on the nature of the variables.

Qualitative data can also be collected, often in response to "open" as opposed to "closed" questions, but in surveys this is often coded to transform it into quantitative data.

3.8 Mass Balance

An organisation can use a mass-balance method to infer food waste by measuring inputs (e.g. ingredients at a factory site) and outputs (e.g. products made) alongside changes in levels of stock and changes to the weight of food during processing (e.g. evaporation of water during cooking). This method can be applied at various stages in the food supply

chain. Using mass balance is one of three methods described in this Manual that are based on "inference by calculation". The others are using a model and using proxy data.

Mass-balance can be used to quantify food waste where reliable measurement or approximation is not possible. Mass balance may also be referred to as Material Flow Analysis or Substance Flow Analysis.

The table below provides several examples of what inputs, outputs and stock would be in a range of circumstances. Changes in stocks may be positive (i.e. an increase in storage) or negative (e.g. withdrawal). A negative change in a stock will include food waste but may also include other changes, such as stolen items, which increases the uncertainty associated with this method.

Different categories of inputs, outputs and stocks may be important. For example, an organisation might wish to separately itemise food by type, and record purchased outputs separately from donated outputs. At whatever level of detail the mass balance is carried out, it is essential that all parts of the equation are measured in the same units (e.g. kilograms).

Table 15 – Examples of inputs, outputs and stock

Supply chain stage / Sector	Inputs	Outputs	Stock
Processing site / factory	Ingredients	Final product	Levels of ingredients or final product within site
Retail store	Food products delivered to the store	Food bought by customers	Food on shelves and in storage
Household	Food purchases entering the home	Food consumed	Food held in the home
Whole economy	Food production and imports	Food exports and consumption	Food held within the country

3.9 Models

Models are a method used to infer the amount of food waste by calculation. A model is a simplified version of the real world, which uses mathematical terminology and a mathematical approach to estimate food waste based on the interaction of multiple factors that influence the generation of food waste. These factors may be causal and directly affect the amount of food waste generated (e.g. grain storage practices,) or may be contextual in that they are more indirect (e.g. weather conditions) and may amplify the effect of the causal factors. Using a model is one of three methods described in this standard that are based on "inference by calculation". The others are undertaking a mass balance and using proxy data.

There are a number of ways in which models can be used to estimate food waste. A wide range of modelling approaches may be used from across various disciplines including statistics, economics and operational research.

Models for food waste may draw on factors such as climatic, agricultural or other data from which a scientific analysis has demonstrated that food waste values can be calculated.

Models that rely on previously established relationships between measurable factors (e.g. weather conditions) require two kinds of information:

1. Information about the factors that can affect the level of food waste (e.g. timing of rain and timing of crop harvests). This information may be available from existing data sets, provided they are sufficiently reliable, or otherwise will need to be quantified.
2. Information about the nature of the relationship between these factors and food waste. The relationships between measurable factors and food waste are described by mathematical functions (e.g. formulas) within the model. These relationships may have already been established (e.g. reported in literature) or may need to be determined through a new study. This involves understanding, for example, how harvesting a crop that is wet from a recent rain may influence the likelihood of damage that results in food waste. Another example is the relationship between temperature during storage and insect damage. Higher temperatures result in faster life cycles among insects, which results in higher levels of damage by insects.

Another approach to modelling uses information on the relationship between the amounts of food waste generated and economic factors (e.g. output of a sector) to estimate levels of food waste within an economy.

Other modelling approaches simulate the system that generates food waste. For example, an estimate of food waste can be obtained by tracking food as it is bought, stored and consumed. Examples of this simulation approach include WRAP's The Milk Model.

3.10 Using proxy data

This method enables an estimate of food waste to be made using proxy data (i.e. food waste data that is outside the scope of the food waste quantification but which can be used as part of a calculation to infer quantities of food waste). An organisation may decide to use proxy data if measurement or approximation is not feasible (e.g. if it does not have direct access to the food waste, or a limited budget). Using proxy data is one of three methods described in this standard that are based on "inference by calculation." The others are undertaking a mass balance and using models.

The proxy data could be detailed (e.g. amounts of the food waste generated by individual sites or households) or high-level (e.g. total agricultural food waste in a country). The level of detail in the proxy data will affect the nature of the calculations performed to obtain an estimate of food waste, as described in this section (see section 13.11.5, Step 4).

Proxy data could include data that is older than the temporal scope of the quantification study, comes from a different geographical area or is from a sector other than that

defined in the scope. For example, if data on food waste exists for 2009 but the quantification study scope is 2013, the 2009 data could be used and scaled up to account for population changes since 2009. In this case, the 2009 data are the proxy data. As another example, if a MS wishes to carry out a NFWQS but has no data, food waste data from a neighbouring country could be used based on the assumption that the two countries are very similar. In this case, the data from the neighbouring country is the proxy data.

3.11 Quantifying food waste if water is added

This section provides guidance for an organisation seeking to quantify food waste where water has been added. Water may be added to meet requirements for diluting the food waste before disposal. Water may also be used to wash a storage area or equipment in a food processing facility to meet production and safety standards, which results in food waste becoming part of the liquid waste stream.

If the food waste is flushed through a pipe to the sewer or another destination, an organisation should explore whether there is existing data on "effluents" (i.e. the liquid discharged) that it could use to quantify the food waste. A "drying and weighing" approach may also be used to estimate the amount of food waste, if it is insoluble. This approach may be applied to a liquid waste stream before or after it flows through the pipes.

Using existing data on effluents

Existing data on effluents may be available where an environmental permit is required to discharge effluent to a sewer or watercourse. In these situations, it is common for limits to be set for Total Suspended Solids, Total Dissolved Solids, Total Organic Content, Chemical Oxygen Demand and Biological Oxygen Demand.

"Total Solids" can then potentially be calculated by adding the data on "Total Suspended Solids" and "Total Dissolved Solids." These limits may be periodically monitored by the organization responsible for the sewer or watercourse into which the effluent is discharged. In addition, many operations may also monitor / treat their own effluent to ensure that permit conditions are met, which may provide further data that could be used to calculate the amount of food waste.

Using existing data on effluents could reduce the cost of data collection and provide a time series against which to evaluate food waste. However, it requires an effective sampling regime to ensure that the results are not biased (e.g. by changes in production rates throughout the day).

Using a "drying and weighing" approach

A "drying and weighing" approach involves taking a sample of the food waste along with the added water and taking steps to separate, dry and weigh the suspended solids. It is a relatively "low-technology" way to determine the amount of food waste suspended in a liquid.

The primary advantage of this approach is that it can provide a reasonably accurate measurement of suspended solids that would otherwise be very difficult to measure.

However, any soluble food waste and intrinsic water content[91] will be evaporated off during the heating process. This approach also cannot distinguish suspended solids that are not food waste (e.g. grit or soil) from what is food waste.

"Drying and weighing" can be undertaken regardless of the concentration of solids in a liquid. If this approach is applied to effluent discharge, it does require an understanding of the rate of discharge in order to quantify the amount of suspended solids relative to a given quantity of processing or over a given period of time.

Implementing this approach involves taking samples of known quantities of the liquid that contains the suspended food waste solids, filtering them, and then heating the suspended material to evaporate the water. The "dried" material that remains at the end of the process is then weighed. The average level of this material is then multiplied by the total volume of liquid to calculate the total amount of solid material in the liquid over a given period of time.

When calculating the amount of food waste it is important to take into account the intrinsic water content removed during the drying process. As an example, if over the course of a year, sample weightings indicate that 100 tonnes of suspended solids is in the liquid waste stream and the finished item is 50 percent water and 50 percent dry matter, then the equivalent of approximately 200 tonnes of food waste has been produced over that period of time (i.e. 100 tonnes divided by 50 percent).

An organisation may also adjust for a known level of solubility for the items included (e.g. if half of the items were soluble and half insoluble, the organisation would double the estimate calculated from the suspended solids alone). This adjustment may be difficult to apply if there are a range of items with a different solubility and water content.

A laboratory is required in which to conduct the heating and weighing. This may add cost to the process, and also means that only relatively small samples can be processed, which may lead to inaccuracies in the results if the sample is unrepresentative, or may require many samples being processed.

[91] Water is a part of most food items. The proportion of water in an item's weight is the intrinsic water content.

4 Appendix – Primary Production

4.1 Quantification example

This appendix suggests a simplified approach for quantifying food waste in primary production:

The primary production aimed at human consumption can be divided into:

1. Fruits, berries and vegetables
2. Cereals
3. Meat
4. Fish
5. Animal products
6. Others

Approach for meat, fish and animal products

For meat it is often possible to use statistical data for transport mortality and rejected animals in slaughterhouses. Data on fish wastage during catch, transport and pre-processing can be found using questionnaires to fishermen, transport companies and processors. For fish farming, the same situation as for meat seems to apply. National statistics are often available for e.g. transport from the pens to slaughter house. For animal products (e.g. milk, eggs) the system starts when the products leaves the body of the animals. The number of companies buying the products are usually much lower than the number of primary producers. Thus, data collection is made easier. On-farm wastage can be measured by e.g. questionnaires and surveys.
Plant based products wastage is probably most difficult to quantify, since variability is higher, number of products larger and number of producers large.

Approach for fruits, berries and vegetables.

The first step could be to find national production figures. Choose products that make up 80% of the national production in production quantity (Tonnes). Examine the remaining 20% to find the production of products that are known to have a high wastage such as leafy vegetables. Consider including also these products.

The second step could be to make a sampling strategy based on production technology, size distribution and other factors that might have an impact on wastage figures. It is a good idea to consult experts and scientific literature at this stage to find out how what factors are important in order to find out which sections should be investigated separately – e.g. is it necessary to make a separate sample of organic production?

The third step is to review existing quantifications and existing raw data.

The fourth step is to set up a sampling strategy, given the constraints in time and resources, that give scientifically valid results or if not possible, as much of the population as possible.

The next step could be to send questionnaires or invitation to an online survey. Preferably data should be collected in cooperation with other data collection, e.g. for

national statistics or as a part of the subsidy application procedure. For harvest waste set factors can be used.

Approach for cereals

Cereals are dominated by a few products, hence few products have to be investigated. Harvest waste is difficult to measure given the small size of the grain. Set factors may be used. Otherwise the same approach as for fruits, vegetables and berries may be used.

4.2 Illustrative data for sector mapping

Table 16 – Size of farms in terms of economic output in EU-28.

		Size of holding in terms of standard output in euros										
	Total	0	< 2 000	2 000 – 3 999	4 000 – 7 999	8 000 – 14 999	15 000 – 24 999	25 000 – 49 999	50 000 – 99 999	100 000 – 249 999	250 000 – 499 999	≥ 500 000
EU-28	12 247 990	240 710	5 220 970	1 939 160	1 528 830	981 790	602 070	627 140	466 510	411 810	148 600	80 570
Share of EU-28	100.0%	2.0%	42.6%	15.8%	12.5%	8.0%	4.9%	5.1%	3.8%	3.4%	1.2%	0.7%
BE	42 850	160	1 340	1 580	2 590	3 230	2 940	4 530	5 750	11 470	6 330	2 930
BG	370 490	980	254 130	59 480	26 290	12 510	6 060	4 750	2 570	1 990	1 010	730
CZ	22 860	130	1 350	2 460	4 110	3 500	2 390	2 800	2 030	1 670	760	1 670
DK	42 100	1 210	820	1 140	3 780	5 830	5 280	6 290	4 680	4 490	3 440	5 160
DE	299 130	470	1 120	6 560	26 460	37 170	30 850	42 320	49 310	63 970	27 640	13 280
EE	19 610	3 520	5 080	2 940	2 750	1 750	1 020	940	720	500	170	230
IE	139 890	60	17 860	16 810	25 150	26 030	17 570	15 160	11 160	8 660	1 040	400
EL	723 010	5 310	235 680	140 840	134 970	95 590	53 340	39 280	13 500	3 760	540	200
ES	989 800	17 380	211 250	163 210	163 070	125 130	82 430	93 750	68 070	43 160	13 850	8 510
FR	516 100	2 110	41 740	32 470	41 760	42 280	38 390	66 560	90 440	113 890	35 600	10 870
HR	233 280	350	89 130	51 540	41 540	24 430	11 880	8 800	3 860	1 380	200	160
IT	1 620 880	23 800	494 590	263 770	236 340	177 020	119 510	128 590	88 660	59 440	17 410	11 770
CY	38 860	300	21 860	6 170	4 210	2 340	1 230	1 180	810	500	150	110
LV	83 390	7 660	39 240	14 560	10 130	4 910	2 640	2 120	1 070	700	220	150
LT	199 910	3 190	96 760	46 540	27 140	12 220	5 700	4 580	2 180	1 110	270	240
LU	2 200	:	20	110	140	180	150	270	330	740	230	40
HU	576 810	19 900	358 690	91 000	46 460	25 350	13 000	10 520	5 920	3 590	1 080	1 330
MT	12 530	3 120	5 130	1 210	1 200	740	410	350	180	140	50	10
NL	72 320	120	60	1 880	6 670	6 480	4 890	6 360	6 920	16 970	13 370	8 600
AT	150 170	250	20 800	13 640	20 320	20 550	16 940	24 080	19 220	11 620	2 280	460
PL	1 506 620	42 520	442 880	290 340	274 240	195 020	112 890	94 620	35 710	12 830	3 390	2 180
PT	305 270	2 710	116 540	71 840	48 550	24 970	12 760	11 470	8 020	5 940	1 600	860
RO	3 859 040	99 840	2 716 620	602 470	313 000	78 460	22 240	13 370	6 450	4 120	1 450	1 010
SI	74 650	0	15 690	17 650	18 120	10 650	5 000	4 460	2 170	780	80	40
SK	24 460	320	7 520	6 710	3 940	1 710	890	860	670	660	370	810
FI	63 870	1 210	3 160	6 320	10 560	10 510	7 100	8 140	8 270	6 860	1 330	420
SE	71 090	2 200	5 710	9 990	13 190	10 960	7 080	7 450	5 540	5 570	2 260	1 150
UK	186 800	1 890	16 200	15 930	22 150	22 270	17 490	23 540	22 300	25 300	12 480	7 250
IS	2 590	0	10	30	90	220	330	560	590	620	110	30
NO	46 620	40	190	920	4 280	7 740	7 460	8 730	8 010	7 170	1 650	440
CH	59 070	20	780	1 230	2 650	4 410	5 540	10 600	16 090	14 000	2 900	860
ME	48 870	1 250	30 180	9 640	5 350	1 830	430	140	40	10	0	0

Source: Eurostat (online data code: ef_kvecsleg)

Table 17 – Size of farms in term of livestock units, in EU 28

	Total	Cattle	Sheep	Goats	Pigs	Poultry	Others
EU-28	135 212	64 045	9 599	1 231	37 076	20 332	2 929
Share of EU-28	100.0%	47.4%	7.1%	0.9%	27.4%	15.0%	2.2%
BE	3 798.7	1 831.1	12.1	3.2	1 578.6	340.6	33.2
BG	1 149.5	473.9	141.5	38.9	177.4	224.8	93.0
CZ	1 722.5	960.8	18.4	1.7	457.2	264.1	20.3
DK	4 919.4	1 134.0	16.0	1.3	3 516.0	204.3	47.8
DE	17 792.6	9 060.1	208.9	15.0	6 389.9	1 749.3	369.4
EE	306.3	182.1	8.7	0.4	89.1	20.6	5.5
IE	5 787.4	4 743.3	474.5	1.1	379.4	104.3	84.8
EL	2 406.5	465.6	915.7	421.3	243.7	332.8	27.4
ES	14 830.9	4 164.5	1 657.4	236.4	6 154.7	2 341.9	276.1
FR	22 674.2	13 861.2	747.5	143.3	3 225.7	4 332.3	364.2
HR	1 020.2	373.1	88.6	11.2	381.4	150.8	15.0
IT	9 911.5	4 363.1	678.2	86.2	2 455.1	2 136.0	192.9
CY	200.8	39.2	26.8	24.2	76.6	32.5	1.5
LV	474.6	298.1	8.4	1.3	96.6	61.4	8.9
LT	900.1	576.5	6.5	1.7	201.1	90.7	23.6
LU	167.7	143.2	0.9	0.5	18.2	1.2	3.7
HU	2 483.8	525.4	120.4	9.2	793.2	976.1	59.4
MT	41.7	11.8	1.2	0.4	17.5	9.2	1.6
NL	6 711.5	2 776.6	113.0	35.3	2 496.4	1 175.4	114.8
AT	2 517.2	1 434.0	39.8	8.1	792.1	178.5	64.8
PL	10 377.2	4 406.2	26.1	10.7	3 656.9	2 061.7	215.6
PT	2 206.0	1 029.9	222.0	42.1	458.8	403.1	50.2
RO	5 444.2	1 667.2	841.2	124.1	1 372.4	962.6	476.7
SI	518.5	331.7	13.8	3.5	92.3	58.7	18.5
SK	668.3	343.4	39.5	1.1	143.6	135.2	5.6
FI	1 121.1	656.1	12.6	0.5	328.4	98.2	25.3
SE	1 751.9	1 074.7	56.5	0.0	370.1	156.9	93.6
UK	13 308.4	7 118.3	3 102.8	9.0	1 113.1	1 729.4	235.9
IS	161.0	55.6	46.3	0.1	9.4	5.7	43.8
NO	1 229.3	603.0	230.8	6.8	195.1	164.2	29.4
CH	1 793.8	1 164.0	43.4	8.7	420.9	88.8	68.0
ME	118.4	67.8	22.9	3.6	12.7	8.0	3.5

Source: Eurostat, Farm structure survey

Table 18 – Type of labour employed on farms, EU 28

	Family labour force	Regular non-family labour force	Family labour force	Regular non-family labour force	Non-family, non-regular labour force	Labour force directly employed by the holding
	(1 000 persons)		(1 000 annual work units)			
EU-28	23 503.5	1 970.7	7 735.9	1 447.1	762.8	9 945.8
BE	66.5	14.4	46.2	11.3	4.1	61.6
BG	681.5	57.4	336.8	52.3	17.4	406.5
CZ	43.0	89.8	24.0	80.6	3.4	108.0
DK	56.9	23.2	30.0	20.8	1.5	52.3
DE	577.4	172.4	348.6	141.0	55.8	545.5
EE	39.4	12.9	13.3	11.2	0.6	25.1
IE	255.6	16.4	152.6	9.8	3.0	165.4
EL	1 186.5	26.2	354.4	18.3	56.8	429.5
ES	1 951.8	275.3	563.7	157.2	168.1	889.0
FR	568.4	446.4	340.7	351.8	87.2	779.7
HR	499.4	14.3	167.6	11.7	5.2	184.5
IT	3 229.6	163.2	758.4	84.1	111.3	953.8
CY	77.7	4.3	12.9	3.8	1.9	18.6
LV	163.6	17.4	71.4	13.3	0.5	85.2
LT	338.2	27.9	119.9	24.0	3.0	146.8
LU	4.1	0.9	2.8	0.8	0.2	3.7
HU	1 052.8	90.7	325.1	77.9	20.5	423.5
MT	17.6	0.9	4.4	0.4	0.0	4.9
NL	147.9	63.7	95.6	45.9	20.3	161.7
AT	319.2	27.1	97.8	13.4	3.1	114.3
PL	3 716.1	86.5	1 795.6	73.8	27.8	1 897.2
PT	657.8	50.3	294.4	41.4	27.6	363.4
RO	7 051.3	105.6	1 428.7	72.3	109.3	1 610.3
SI	205.2	3.3	68.7	2.8	5.1	76.7
SK	46.1	44.9	15.8	38.4	1.9	56.1
FI	111.2	14.1	47.7	7.7	4.3	59.7
SE	119.8	21.7	38.9	14.7	3.3	56.9
UK	319.1	99.6	180.3	66.4	19.6	266.3
IS	4.0	1.7	2.6	1.2	0.3	4.2
NO	107.9	17.4	36.9	6.5	3.0	46.4
CH	121.9	44.5	69.9	23.7	2.4	96.0
ME	98.2	0.8	46.4	0.7	0.8	47.9

Source: Eurostat (online data code: ef_olfftecs)

Figure 11 illustrates how big the different sectors are in terms of economic output for a certain region or country, in this case France.

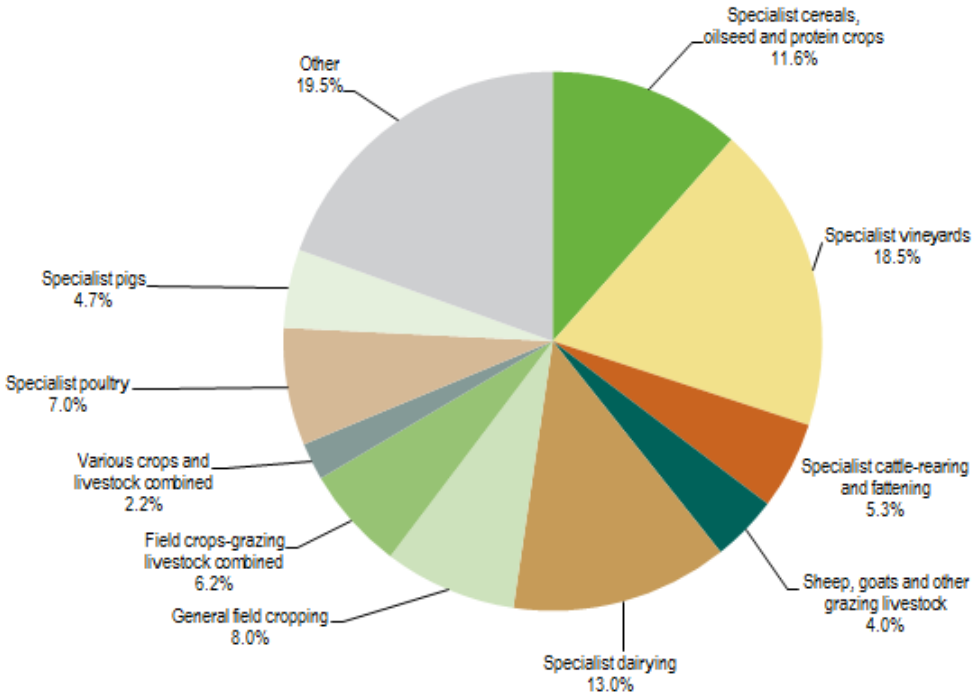


Figure 11 – Share of different agricultural products, by economic output, EU 28.

5 Appendix – Processing and Manufacturing

5.1 Illustrative data for sector mapping: EU Level data

Figure 12 – Turnover, value added, employees and companies in food and drink industry sub-sectors in EU (%)[92]

Table 19 – Breakdown of the composition of the "various food products" category from Figure 12 (%)[93]

	Turnover	Number of employees
Cocoa, chocolate and sugar confectionery	30	32
Tea and coffee	13	11
Prepared meals and dishes	10	16
Sugar	10	5
Others	37	37
Various food products	100	100

[92] FoodDrinkEurope, 2014. Data and Trends of the European Food and Drink Industry2013-2014

[93] This is a heterogeneous group which includes chocolate and confectionery products, sugar, coffee and tea as well as prepared meals and baby food.

	Employment ranking in manufacturing[2]	Turnover	Value Added	Number of employees	Number of companies
		€billion	€billion	1,000	
Austria	-	19.2	4.8*	63	3,740
Belgium	1	47.5	6.8	89	4,768
Bulgaria	2	4.7	0.8*	96*	5,667
Cyprus	1	1.5*	0.4*	13*	845
Czech Republic	4	10.9	2.4	103	9,207
Denmark	1	26.2	3	54	1,600*
Estonia	2	1.6	0.3*	13	456
Finland	3	11	2.6	33	1,693
France	1	160.9	23.6	495	13,500
Germany	4	169.3	33.5	555	5,970
Greece	-	11.2	1.4*	65	1,180
Hungary	2	8.7	1.9	95	4,971
Ireland	1	22*	6.9*	43*	689*
Italy	3	130	24	386	6,850
Latvia	1	1.6*	0.3*	25*	838
Lithuania	1	3.6*	0.6*	42*	1,327
Netherlands	1	66.6*	15	133	4,751
Poland	1	49.7*	9*	396*	14,330
Portugal	1	14.5	2.9	110	10,500
Romania	1	10.7	2.2	184	8,355
Slovakia	3	3.8	0.7	29	210
Slovenia	5	2	0.4	13	617
Spain	1	90.2	26.8	440	29,196
Sweden	5	19.5	4.6	55	3,600
United Kingdom	1	114.1	29.7	406	7,766

(1) Or by Eurostat
(2) Ranking of the food and drink industry in the manufacturing sector in terms of employment
* 2011 data

Figure 13 – Food and drink industry data as published by FoodDrinkEurope National Federations[1], 2012

5.2 Illustrative data for sector mapping: MS level data

Sweden example

All figures below adapted from Statistics Sweden.

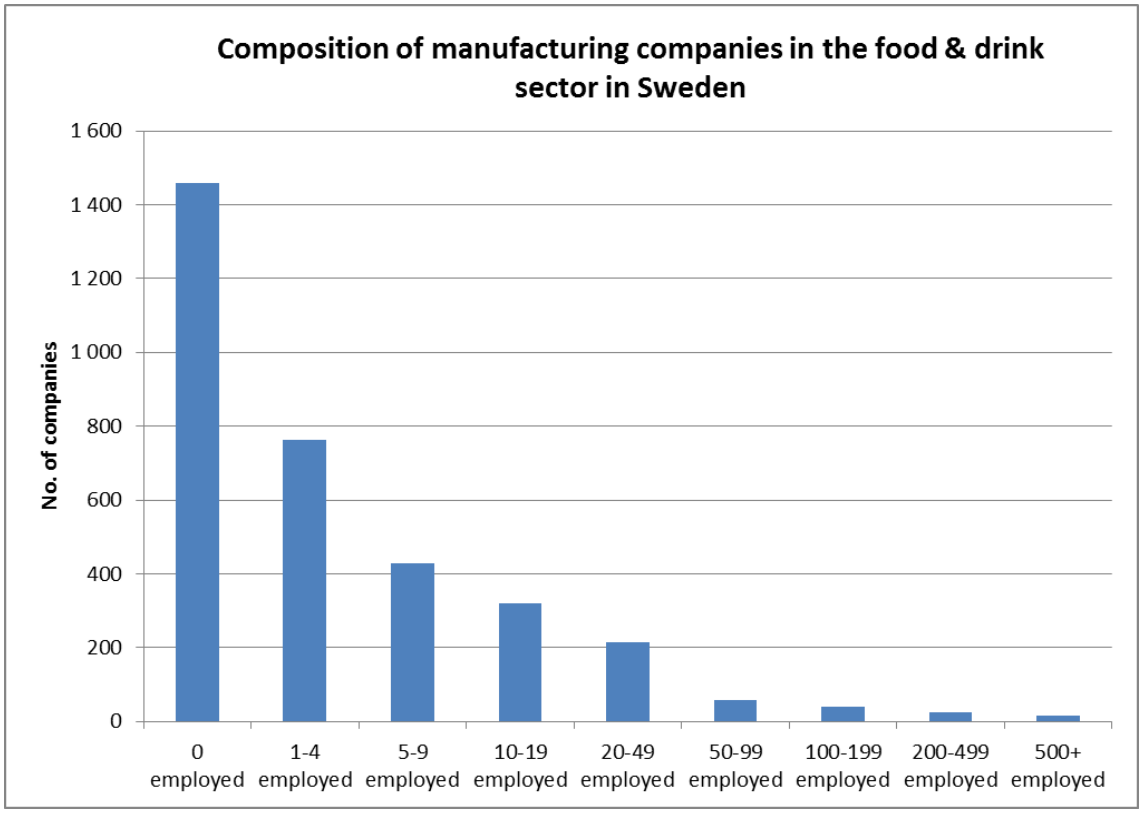


Figure 14 – Composition of manufacturing companies in the food & drink sector in Sweden showing the no. of food & drink producing companies with 0 up to 500+ employees

In Sweden, most food & drink producing companies have below 10 employees and very few companies have above 100 employees.

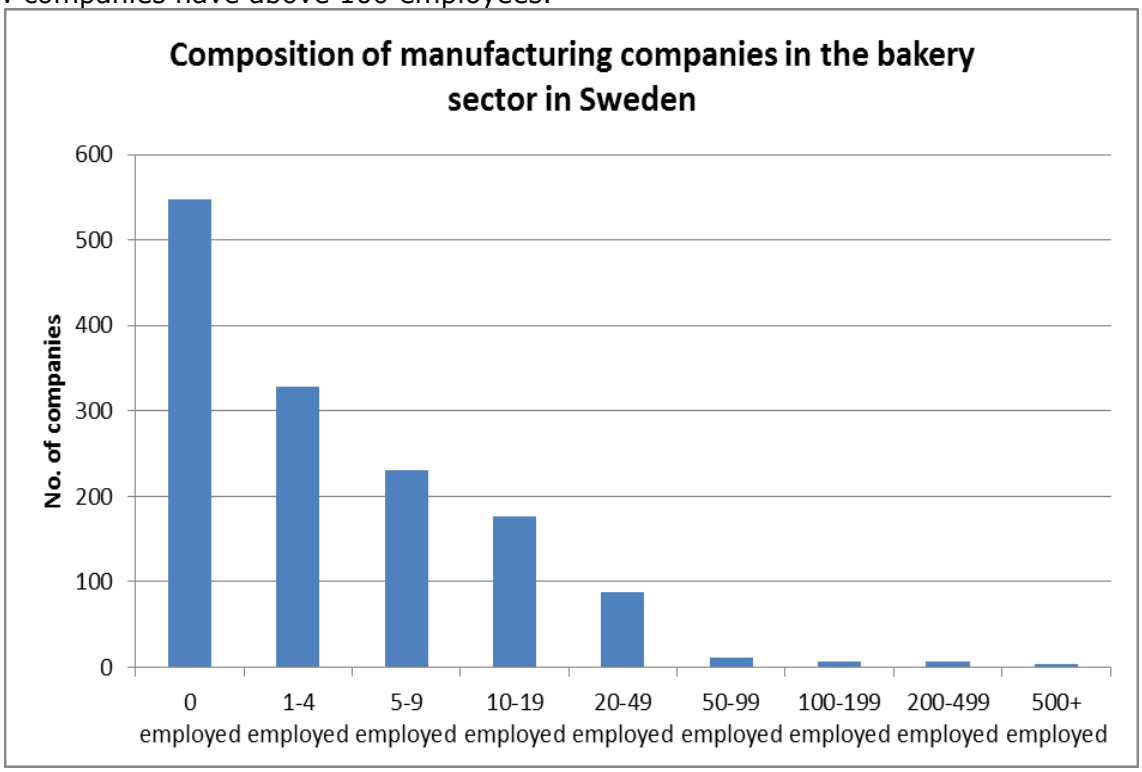


Figure 15 – Composition of manufacturing companies in the bakery sector in Sweden showing the no. of food & drink producing companies with 0 up to 500+ employees

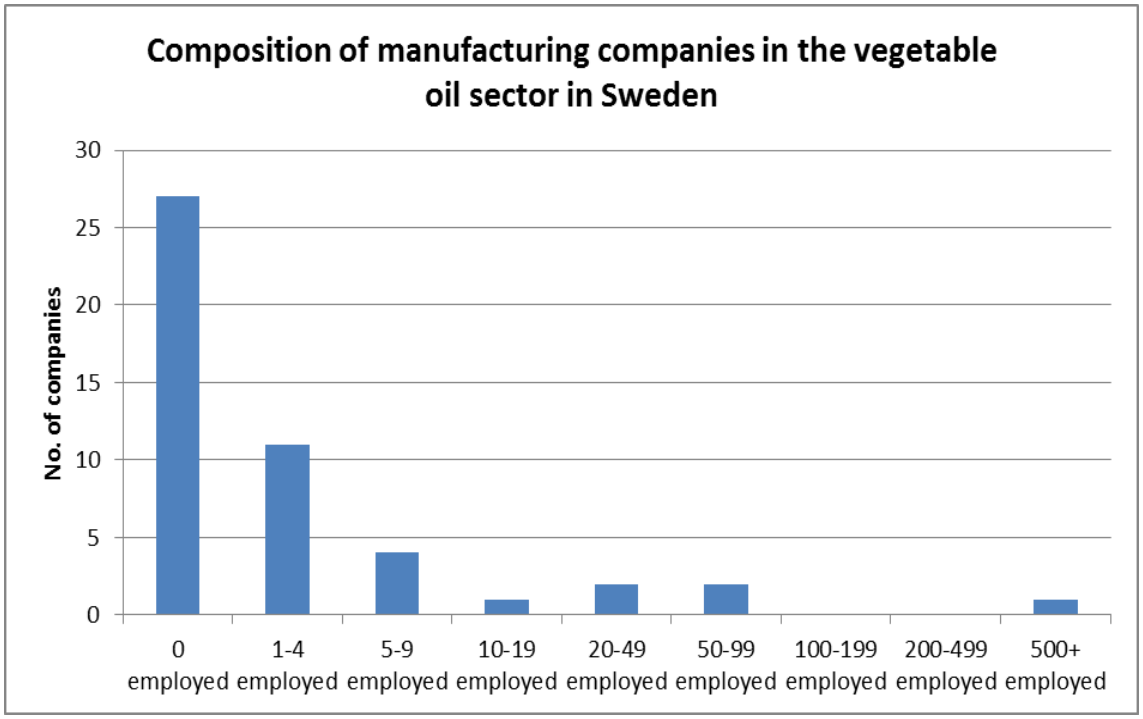


Figure 16 – Composition of manufacturing companies in the vegetable oil sector in Sweden showing the no. of food & drink producing companies with 0 up to 500+ employees

Figure 15 and Figure 16 shows that the difference in no. of companies between food & drink producing sectors can very large! Sweden has about 550 companies in the bakery industry while only about 27 companies in the vegetable oil industry.

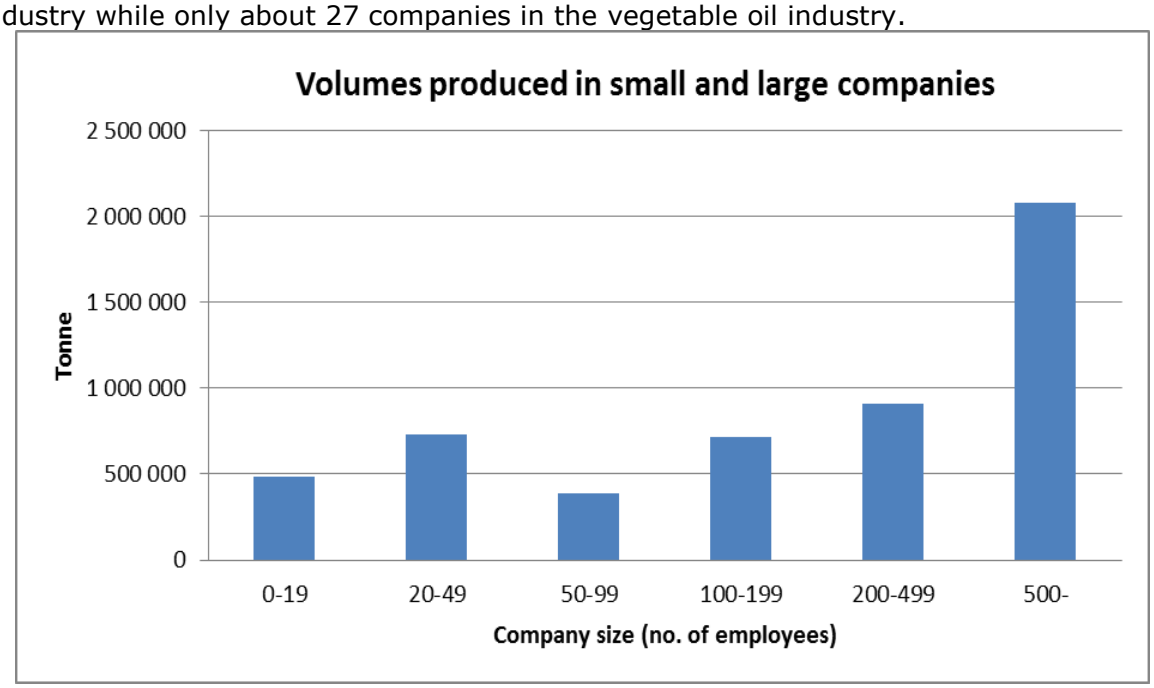


Figure 17 – Quantities produced in small and large companies, tonnes produced in companies with 0-19 employees; 20-49 employees up to 500+ employees

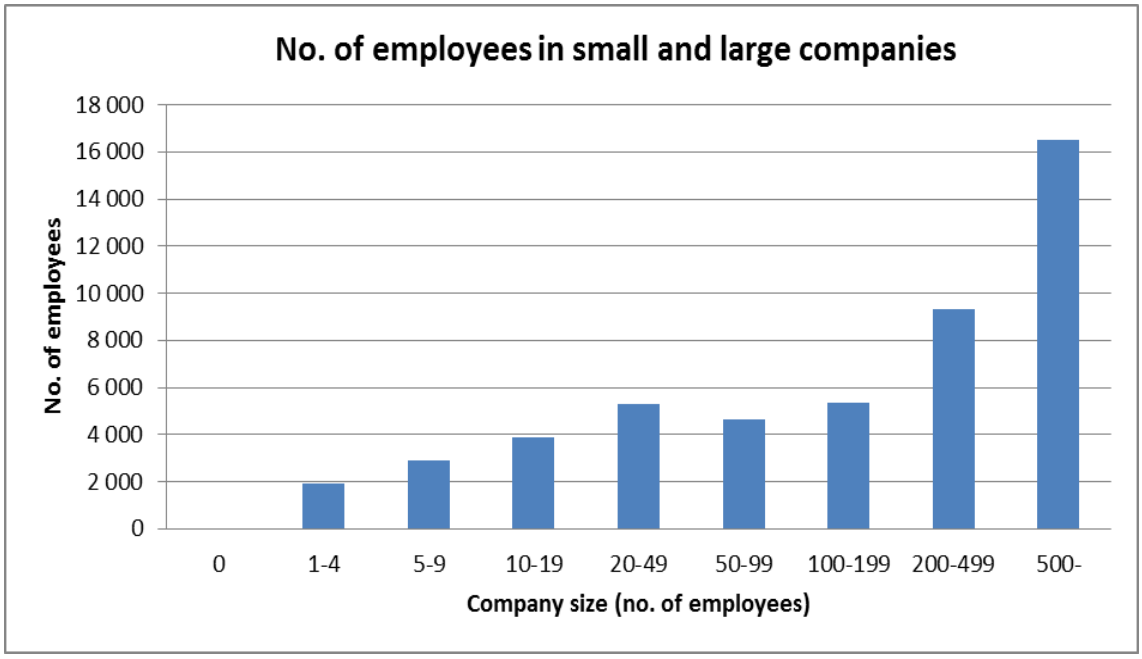


Figure 18 – Number of employees in small and large companies, the no. of employees in companies with 0 employees; 1-4 employees; 5-9 employees up to 500+ employees

Taken together, Figure 14, Figure 17 and Figure 18 show that very few companies (those with >100 employees) represent a very large share of total quantities produced and total no. of employees.

UK example

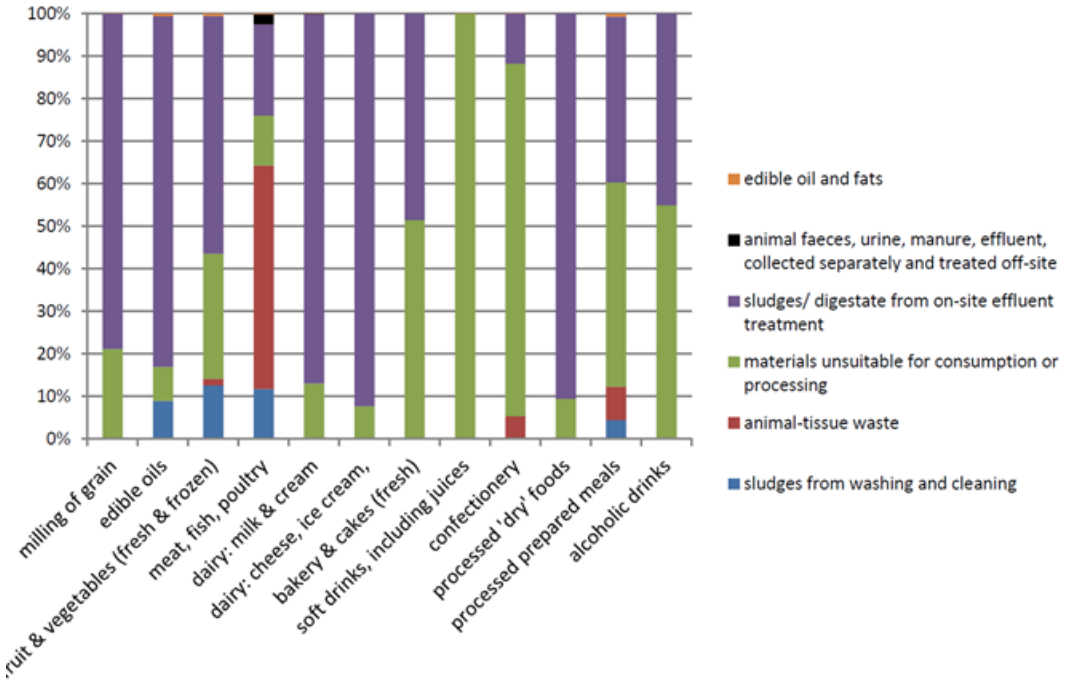


Figure 19 – Variation in food and drink waste types as % total food/drink waste across 12 industry clusters (Anthesis, 2014)

5.3 Food product categories by 4 digit NACE code (Rev. 2).

Table 20 – Food product categories by 4 digit NACE code (Rev. 2).

NACE code (4 digits)	Description
10.1	**Processing and preserving of meat and production of meat products**
10.1.1	Processing and preserving of meat
10.1.2	Processing and preserving of poultry meat
10.1.3	Production of meat and poultry meat products
10.2	**Processing and preserving of fish, crustaceans and molluscs**
10.3	**Processing and preserving of fruit and vegetables**
10.3.1	Processing and preserving of potatoes
10.3.2	Manufacture of fruit and vegetable juice
10.3.9	Other processing and preserving of fruit and vegetables
10.4	**Manufacture of vegetable and animal oils and fats**
10.4.1	Manufacture of oils and fats
10.4.2	Manufacture of margarine and similar edible fats
10.5	**Manufacture of dairy products**
10.5.1	Operation of dairies and cheese making
10.5.2	Manufacture of ice cream
10.6	**Manufacture of grain mill products, starches and starch products**
C10.6.1	Manufacture of grain mill products
C10.6.2	Manufacture of starches and starch products
10.7	**Manufacture of bakery and farinaceous products**
10.7.1	Manufacture of bread; manufacture of fresh pastry goods and cakes
10.7.2	Manufacture of rusks and biscuits; manufacture of preserved pastry goods and cakes
10.7.3	Manufacture of macaroni, noodles, couscous and similar farinaceous products
10.8	**Manufacture of other food products**

NACE code (4 digits)	Description
10.8.1	- Manufacture of sugar
10.8.2	Manufacture of cocoa, chocolate and sugar confectionery
10.8.3	Processing of tea and coffee
10.8.4	Manufacture of condiments and seasonings
10.8.5	Manufacture of prepared meals and dishes
10.8.6	Manufacture of homogenised food preparations and dietetic food
10.8.9	Manufacture of other food products n.e.c.
11.0	**Manufacture of beverages**
11.0.1	Distilling, rectifying and blending of spirits
11.0.2	Manufacture of wine from grape
11.0.3	Manufacture of cider and other fruit wines
11.0.4	Manufacture of other non-distilled fermented beverages
11.0.5	Manufacture of beer
11.0.6	Manufacture of malt
11.0.7	Manufacture of soft drinks; production of mineral waters and other bottled waters

6 Appendix – Wholesale, Retail and Markets

6.1 Illustrative data for sector mapping

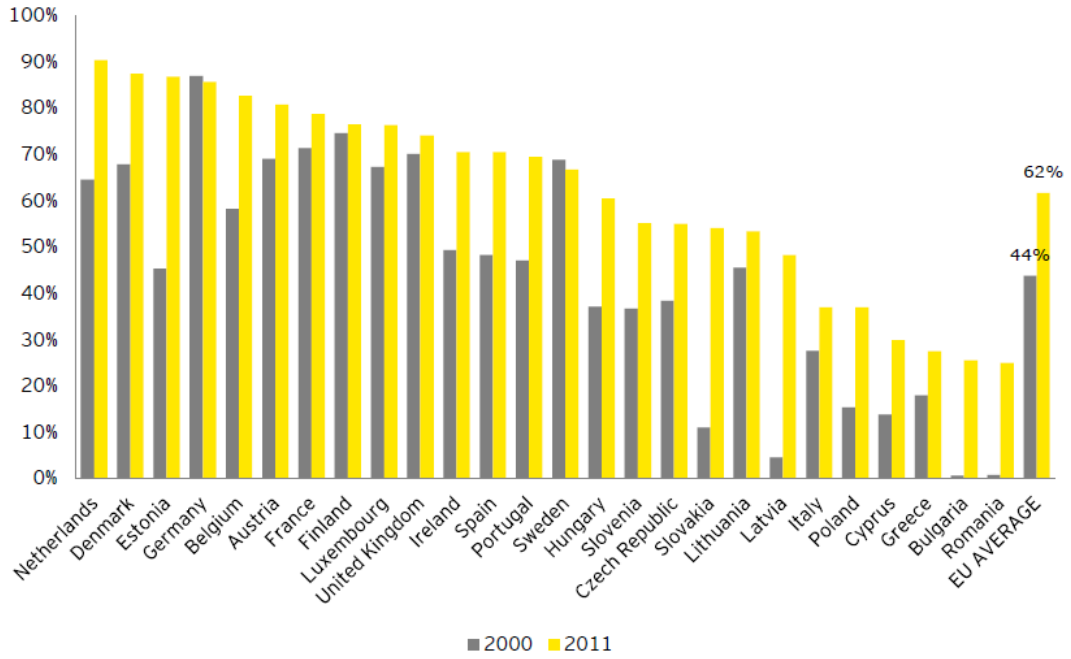


Figure 20 – Evolution of the market share of modern retail compared to total edible grocery market (2000 – 2011) (EY, Arcadia and Cambridge Econometrics, 2014)

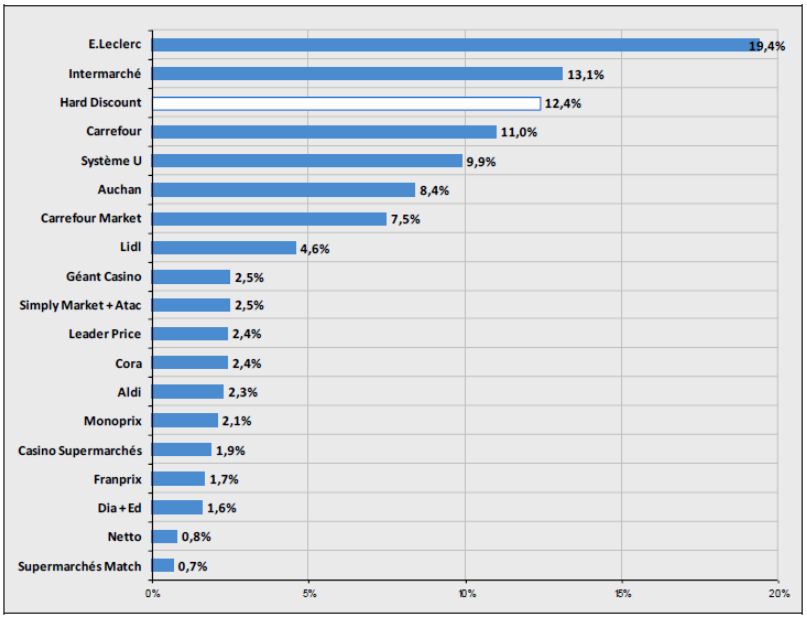
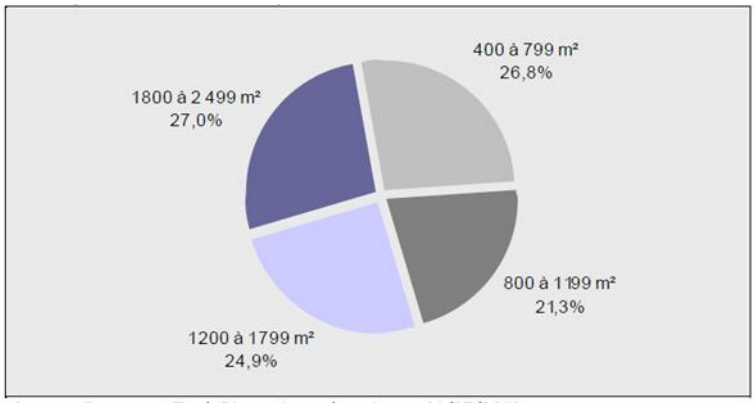
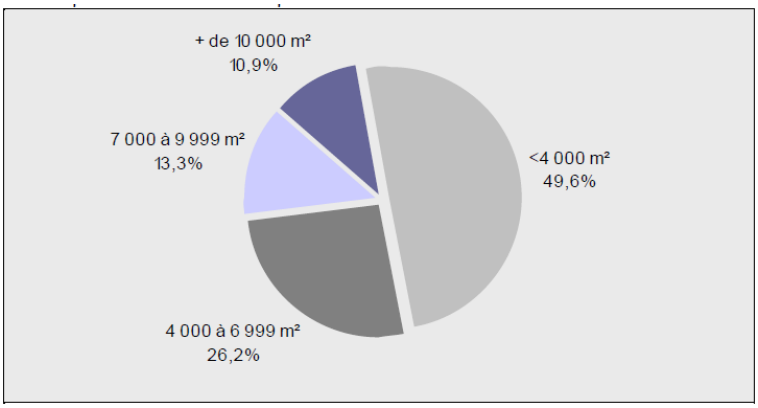


Figure 21 – Example: Market shares of the retail groups in France in 2013 (Source Kantar Worldpanel)



Source : Panorama TradeDimensions, données au 01/07/2013

Figure 22 – Repartition of supermarkets by surface categories in France (share in % of total number of stores) (Source Panorama TradeDimensions, 2013)



Source : Panorama TradeDimensions, données au 01/07/2013

Figure 23 – Repartition of hypermarkets by surface categories in France (share in % of total number of stores) (Source Panorama TradeDimensions, 2013)

7 Appendix – Edible and non-edible parts of food

The classification below gives a description of items that are considered edible and inedible. This classification was adapted from the classification used by WRAP for fieldwork with households (WRAP, 2012). Therefore, the list refers to products encountered in households but overall it is also appropriate for "food service" and "retail / markets / wholesale" sectors. Some materials / products maybe missing for sectors upstream in the supply chain.

Food type code	Food type	Sub-type	Edible	"Technically edible"[94]	Inedible	Comments
A01	Bakery	Cracker / crisp bread	All items	None	None	
A02	Bakery	Bread sticks	All items	None	None	
A03	Bakery	Dough	All items	None	None	
A04	Bakery	Dumpling	All items	None	None	
A05	Bakery	Morning goods	All items	None	None	
A06	Bakery	Pastry	All items	None	None	
A07	Bakery	Speciality bread	Whole loaves, whole slices (not end slices), whole rolls, baguettes, etc.	Crusts, end slices	None	
A08	Bakery	Standard bread	Whole loaves, whole slices (not end slices), whole rolls, baguettes, etc.	Crusts, end slices	None	
A10	Bakery	Yorkshire pudding and other batter	All items	None	None	
A11	Bakery	Other bakery	All items	None	None	
B01	Meat & fish	Pork / ham / bacon	Meat, flesh, pork products (e.g. sausages, faggots), sliced ham	Fat / skin, bacon rind, crackling	Bones	Carcasses need splitting into edible and inedible
B02	Meat & fish	Beef	Flesh, beef products (e.g. burgers), mince, corned beef, Bones (>40% meat)	Beef fat	Bones	Carcasses need splitting into edible and inedible

[94] Considered as edible in the FUSIONS definitional framework, but in practice food culture will have an influence.

Food type code	Food type	Sub-type	Edible	"Technically edible"[94]	Inedible	Comments
B05	Meat & fish	Fish and shellfish	Fish flesh, prawn flesh, crab stick, fish product (e.g. fish finger), prawns flesh, etc.	Fish skin	Fish bones, heads / guts, shells (mussels, prawns, etc.),	Whole items need splitting into edible and inedible
B07	Meat & fish	Lamb	Flesh, lamb products (e.g. burgers), mince	Fat	Bones	Carcasses (bones) need splitting into edible and inedible
B10	Meat & fish	Poultry (chicken / turkey / duck)	Meat, flesh, poultry products, sliced poultry	Fat / skin	Bones	Carcasses need splitting into edible and inedible
B11	Meat & fish	Meat and fish based sandwich spread	All items	None	None	All edible
B12	Meat & fish	Bone (unidentifiable / mixed)	None	None	All	All inedible
B13	Meat & fish	Other meat (unidentifiable / mixed meat / offal)	TBD	TBD	TBD	See other meat types as a guide
B15	Meat & fish	Game	Meat, flesh, game products	Fat / skin	Bones	Carcasses need splitting into edible and inedible
C01	Dairy & eggs	Milk	All items	None	None	All edible
C02	Dairy & eggs	Cheese	All other items	Semi-edible rinds	Inedible wax around cheese	Whole items need splitting into edible and inedible
C03	Dairy & eggs	Cream and crème fraiche	All items	None	None	All edible
C04	Dairy & eggs	Egg	Whole egg, raw or cooked eggs, pickled eggs	None	Shell	Whole items need splitting into edible and inedible
C05	Dairy & eggs	Yoghurt / yoghurt drink	All items	None	None	All edible
C06	Dairy & eggs	Other dairy	All items	None	None	All edible
D01	Staples	Breakfast cereal	All items	None	None	All edible
D02	Staples	Flour	All items	None	None	All edible
D03	Staples	Pasta	All items	None	None	All edible
D05	Staples	Rice	All items	None	None	All edible
D06	Staples	Other staple foods	All items	None	None	All edible
E01	Fresh fruit	Apple	Whole apples, flesh	Skin / peel (if separate)	Core, tops / stalks / ends	Whole items need splitting into edible and inedible
E02	Fresh fruit	Banana	Flesh, whole items	None	Skin	Whole items need splitting into edible and inedible

Food type code	Food type	Sub-type	Edible	"Technically edible"[94]	Inedible	Comments
E03	Fresh fruit	Kiwi	Flesh, whole items	None	skin, stones, tops / stalks / ends	Whole items need splitting into edible and inedible
E04	Fresh fruit	Melon	Whole melons, flesh	None	skin, stones, tops / stalks / ends	Whole items need splitting into edible and inedible
E05	Fresh fruit	Mixed fruit	TBD	TBD	TBD	See other fruit types as a guide
E06	Fresh fruit	Orange	Whole oranges, flesh	Skin / peel (if separate)	Tops / stalks / ends	Whole items need splitting into edible and inedible
E07	Fresh fruit	Pear	Whole pear, flesh	Skin / peel (if separate)	Core, tops / stalks / ends	Whole items need splitting into edible and inedible
E08	Fresh fruit	Pineapple	Whole pineapple, flesh	None	skin, stones, tops / stalks / ends	Whole items need splitting into edible and inedible
E10	Fresh fruit	Soft / berry fruit	Whole item, flesh	None	Tops / stalks / ends	Whole items need splitting into edible and inedible
E11	Fresh fruit	Stone fruit	Whole item, flesh	Plum peel, nectarine peel, peach peel	Stones, tops / stalks ends, mango skin, avocado skin	Whole items need splitting into edible and inedible
E12	Fresh fruit	Other citrus	Whole item, flesh	Skin / peel (if separate)	Tops / stalks / ends	Whole items need splitting into edible and inedible
E13	Fresh fruit	Other fruit	Flesh, whole items	None	Examples include shell / skin of coconut, papaya, passion fruit, lychee, pomegranate	Whole items need splitting into edible and inedible
F01	Processed fruit	Apple	All items	None	None	All edible
F02	Processed fruit	Banana	All items	None	None	All edible
F03	Processed fruit	Kiwi	All items	None	None	All edible
F04	Processed fruit	Melon	All items	None	None	All edible
F05	Processed fruit	Mixed fruit	All items	None	None	All edible
F06	Processed fruit	Orange	All items	None	None	All edible
F07	Processed fruit	Pear	All items	None	None	All edible
F08	Processed fruit	Pineapple	All items	None	None	All edible
F10	Processed fruit	Soft / berry fruit	All items	None	None	All edible
F11	Processed fruit	Stone fruit	All items	None	Date stones	Whole items need splitting into edible and inedible
F12	Processed fruit	Other citrus	All items	None	None	All edible

Food type code	Food type	Sub-type	Edible	"Technically edible"[94]	Inedible	Comments
F13	Processed fruit	Other fruit	All items	None	None	All edible
G01	Fresh vegetables & salad	Aubergine	Flesh, whole items	Peel / skin	Tops / stalks / ends	Whole items need splitting into edible and inedible
G02	Fresh vegetables & salad	Baked beans	None found in household waste	None found in household waste	None found in household waste	n/a
G03	Fresh vegetables & salad	Bean (all varieties)	Flesh, whole items	Peel / skin (rare)	Tops / stalks / ends, leaves	Whole items need splitting into edible and inedible
G04	Fresh vegetables & salad	Broccoli	Whole item, flesh	Tops / stalks / ends, leaves	None	All edible
G05	Fresh vegetables & salad	Cabbage	Whole item, flesh	Stalks	None	
G06	Fresh vegetables & salad	Carrot	Whole item, flesh	Peel / skin	Tops / stalks / ends	Whole items need splitting into edible and inedible
G07	Fresh vegetables & salad	Cauliflower	Whole item, flesh	Tops / stalks / ends, leaves	None	All edible
G08	Fresh vegetables & salad	Celery	Flesh, whole items	None	Tops / stalks / ends, Skin / peel (if separate), leaves	Whole items need splitting into edible and inedible
G09	Fresh vegetables & salad	Coleslaw and hummus	All items	None	None	All edible
G10	Fresh vegetables & salad	Courgette	Flesh, whole items	Peel / skin	Tops / stalks / ends, leaves	Whole items need splitting into edible and inedible
G11	Fresh vegetables & salad	Cucumber	Whole item, flesh	Peel / skin	Tops / stalks / ends	Whole items need splitting into edible and inedible
G12	Fresh vegetables & salad	Leafy salad	Leaves, whole, flesh	None	Tops / stalks / ends	Whole items need splitting into edible and inedible
G13	Fresh vegetables & salad	Leek	Flesh, whole items	None	Tops / stalks / ends, Skin / peel (if separate), leaves	Whole items need splitting into edible and inedible
G14	Fresh vegetables & salad	Lettuce	Leaves, whole, flesh	None	Tops / stalks / ends	Whole items need splitting into edible and inedible
G15	Fresh vegetables & salad	Mixed vegetables	TBD	TBD	TBD	See advice on mixed items
G16	Fresh vegetables & salad	Mushroom	Flesh, whole items	Skin / peel (if separate), tops / stalks / ends	None	All edible

Food type code	Food type	Sub-type	Edible	"Technically edible"[94]	Inedible	Comments
G17	Fresh vegetables & salad	Non-leafy salad	All items	None	None	All edible
G18	Fresh vegetables & salad	Onion	Whole item, flesh	None	Tops / stalks / ends, Peel / skin	Whole items need splitting into edible and inedible
G19	Fresh vegetables & salad	Pea (all varieties)	Whole items	None	Pea pods	Whole items need splitting into edible and inedible
G20	Fresh vegetables & salad	Pepper	Whole item, flesh	None	Tops / stalks / ends, Peel / skin	Whole items need splitting into edible and inedible - not sure that peel / skin should be unavoidable (but v. minor component)
G21	Fresh vegetables & salad	Potato	Flesh, whole items	Potato skins (if separate from the potato)	Sprouting parts of potatoes	All edible apart from sprouting parts
G22	Fresh vegetables & salad	Spinach	Whole items, leaves, 'flesh'	Trimmings	None	All edible
G23	Fresh vegetables & salad	Vegetable based sandwich spread	All	None	None	All edible
G24	Fresh vegetables & salad	Spring onion	Flesh, whole items	Leaves, peel / skin	Tops / stalks / ends	Whole items need splitting into edible and inedible
G25	Fresh vegetables & salad	Sprout	Flesh, whole items	None	Tops / stalks / ends, leaves, skin / peel	Whole items need splitting into edible and inedible
G26	Fresh vegetables & salad	Sweetcorn / corn on the cob	Flesh, whole items	None	Leaves, centre of cob	Whole items need splitting into edible and inedible
G27	Fresh vegetables & salad	Tomato	Whole item, flesh	Peel / skin	Tops / stalks / ends	Whole items (with stalks) need splitting into edible and inedible
G28	Fresh vegetables & salad	Other vegetables and salad	Flesh and whole items	Asparagus ends (trimmings)	Examples include rhubarb leaves, pumpkin skins and seeds, squash skins and seeds, plantain skin	Whole items need splitting into edible and inedible

Food type code	Food type	Sub-type	Edible	"Technically edible"[94]	Inedible	Comments
G29	Fresh vegetables & salad	Other root vegetables	Whole item, flesh	None	Skin / peel and stalks / ends for parsnips, turnips, sweet potatoes, beetroot, swede, radish	Whole items need splitting into edible and inedible
H01	Processes vegetables & salad	Aubergine	All items	None	None	All edible
H02	Processes vegetables & salad	Baked beans	All items	None	None	All edible
H03	Processes vegetables & salad	Bean (all varieties)	All items	None	None	All edible
H04	Processes vegetables & salad	Broccoli	Whole item, flesh	Tops / stalks / ends, leaves	None	All edible
H05	Processes vegetables & salad	Cabbage	Flesh, whole items	Outer leaves	None	All edible
H06	Processes vegetables & salad	Carrot	All items	None	None	All edible
H07	Processes vegetables & salad	Cauliflower	All items	None	None	All edible
H08	Processes vegetables & salad	Celery	All items	None	None	All edible
H09	Processes vegetables & salad	Coleslaw and hummus	All items	None	None	All edible
H10	Processes vegetables & salad	Courgette	All items	None	None	All edible
H11	Processes vegetables & salad	Cucumber	All items	None	None	All edible
H12	Processes vegetables & salad	Leafy salad	All items	None	None	All edible
H13	Processes vegetables & salad	Leek	All items	None	None	All edible
H14	Processes vegetables & salad	Lettuce	All items	None	None	All edible
H15	Processes vegetables & salad	Mixed vegetables	Nearly all items	None	None	All edible
H16	Processes vegetables & salad	Mushroom	All items	None	None	All edible
H17	Processes vegetables & salad	Non-leafy salad	All items	None	None	All edible
H18	Processes vegetables & salad	Onion	All items	None	None	All edible
H19	Processes vegetables & salad	Pea (all varieties)	All items	None	None	All edible

Food type code	Food type	Sub-type	Edible	"Technically edible"[94]	Inedible	Comments
H20	Processes vegetables & salad	Pepper	Whole item, flesh	Peel / skin	Tops / stalks / ends	Whole items need splitting into edible and inedible
H21	Processes vegetables & salad	Potato	All items	None	None	All edible
H22	Processes vegetables & salad	Spinach	All items	None	None	All edible
H23	Processes vegetables & salad	Vegetable based sandwich spread	All items	None	None	All edible
H24	Processes vegetables & salad	Spring onion	All items	None	None	All edible
H25	Processes vegetables & salad	Sprout	All items	None	None	All edible
H26	Processes vegetables & salad	Sweetcorn / corn on the cob	Flesh, whole items	None	Leaves, centre of cob	Whole items need splitting into edible and inedible
H27	Processes vegetables & salad	Tomato	All items	None	None	All edible
H28	Processes vegetables & salad	Other vegetables and salad	Nearly all items	None	None	All edible
H29	Processes vegetables & salad	Other root vegetables	Nearly all items	None	None	All edible
H30	Processes vegetables & salad	Coleslaw	All items	None	None	All edible
H31	Processes vegetables & salad	Hummus	All items	None	None	All edible
I01	Confectionery and snacks	Chocolate and sweets	All items	None	None	All edible
I02	Confectionery and snacks	Cereal bar	All items	None	None	All edible
I03	Confectionery and snacks	Savoury snacks	All other items	None	Nut shells	Whole items need splitting into edible and inedible
I04	Confectionery and snacks	Other confectionery and snacks	All items	None	None	All edible
I05	Confectionery and snacks	Sweet biscuits	All items	None	None	All edible
J01	Drinks	Coffee	Unused coffee products (granules, pods, beans)	None	Used coffee products (pods, grounds)	See tea
J02	Drinks	Fruit juice and smoothies	All items	None	None	All edible
J03	Drinks	Hot chocolate	All items	None	None	All edible

Food type code	Food type	Sub-type	Edible	"Technically edible"[94]	Inedible	Comments
J04	Drinks	Lager, beer and cider	All items	None	None	All edible
J05	Drinks	Milkshake and milk drink	All items	None	None	All edible
J06	Drinks	Carbonated soft drink	All items	None	None	All edible
J07	Drinks	Squash	All items	None	None	All edible
J08	Drinks	Tea waste	Unused tea bags	None	Used tea bags	Tricky, as only a small amount of material is extracted from tea when used, and water is absorbed
J09	Drinks	Bottled water	All items	None	None	All edible
J10	Drinks	Wine	All items	None	None	All edible
J11	Drinks	Other alcohol	All items	None	None	All edible
J12	Drinks	Other drink	All items	None	None	All edible
K01	Condiments, sauces, herbs & spices	Cook in sauce	All items	None	None	All edible
K02	Condiments, sauces, herbs & spices	Dip	All items	None	None	All edible
K03	Condiments, sauces, herbs & spices	Gravy	All items	None	None	All edible
K04	Condiments, sauces, herbs & spices	Herb / Spice	Most other items	Stalks of herbs	Examples include garlic peel, ginger peel, ends of garlic, ginger or chilli peppers	Whole items need splitting into edible and inedible
K05	Condiments, sauces, herbs & spices	Honey	All items	None	None	All edible
K06	Condiments, sauces, herbs & spices	Jam	All items	None	None	All edible
K07	Condiments, sauces, herbs & spices	Ketchup	All items	None	None	All edible
K08	Condiments, sauces, herbs & spices	Mayonnaise / salad cream	All items	None	None	All edible
K09	Condiments, sauces, herbs & spices	Olives	All items	None	Stones	Whole items need splitting into edible and inedible
K10	Condiments, sauces, herbs & spices	Pickle	All items	None	None	All edible
K11	Condiments, sauces, herbs & spices	Salt	All items	None	None	All edible
K12	Condiments, sauces, herbs & spices	Sugar	All items	None	None	All edible
K13	Condiments, sauces, herbs & spices	Sweet spread	All items	None	None	All edible

Food type code	Food type	Sub-type	Edible	"Technically edible"[94]	Inedible	Comments
K14	Condiments, sauces, herbs & spices	Other condiments etc.	All avoidable in waste comp 2012	None	None	All edible
L01	Oils and fats	Oil	Unused oil	Used cooking oil	None	All edible
L02	Oils and fats	Fat	Butter, marg, lard, dripping	'used' fat (for cooking, if known)	None	All edible
M01	Cakes and desserts	Cheesecake	All items	None	None	All edible
M02	Cakes and desserts	Chocolate pudding / dessert	All items	None	None	All edible
M03	Cakes and desserts	Cakes / gateau / doughnuts / pastries	All items	None	None	All edible
M04	Cakes and desserts	Fruit pie / strudel / crumble	All items	None	None	All edible
M05	Cakes and desserts	Ice Cream	All items	None	None	All edible
M06	Cakes and desserts	Jelly	All items	None	None	All edible
M07	Cakes and desserts	Milk pudding (custard etc.)	All items	None	None	All edible
M08	Cakes and desserts	Mousse	All items	None	None	All edible
M09	Cakes and desserts	Trifle	All items	None	None	All edible
M10	Cakes and desserts	Other desserts	All items	None	None	All edible
P01	Other	Baby food	All items	None	None	All edible
P02	Other	Baby milk	All items	None	None	All edible
P03	Other	Gunge	None	All	None	All edible
P08	Other	Drainings from canned food	None	All	None	All edible
Q01	Homemade and pre-prepared meals	Soup	All items	None	None	All edible
Q02	Homemade and pre-prepared meals	Composite meal	Everything else	Pie crust, pizza crust	None (or very little)	All edible
Q03	Homemade and pre-prepared meals	Sandwich	All other items	Sandwich crusts	None	All edible
Q04	Homemade and pre-prepared meals	Savoury products	All other items	Pastry (if separate)	None	All edible

8 Appendix – Sectorial secondary objectives: illustrative objectives for primary production

In addition to this primary objective, MS can have secondary objectives in relation to food waste quantification in the "primary production" sector. These secondary objectives can cover a range of topics such as:

- **Increasing profitability** – The economic situation of stakeholders in primary production both in the "green" (agriculture) and "blue" (aquaculture and fisheries) sectors is a matter of great concern. Subsidies in this sector account for a significant part of EU budget. Thus, quantifying food waste and acting to reduce it can be seen as one of the levers in order to ultimately increase profitability of primary productions sector.
- **Better utilisation of waste** – Waste in the primary production sector tend to be more scattered than in other industrial sectors due to the large number of units, thus leading to higher transportation costs. On the other hand, the waste fractions are, in general, relatively "pure" (i.e. not mixed with other materials). This situation creates both opportunities and challenges for waste utilisation.
- **Identifying reasons for waste and underlying structural causes** – Biological processes play an important role in waste generation in the primary production, whereas in other sectors industrial processes tend to have a relatively higher contribution. It is also important to look at underlying structural reasons, e.g. if farmers are obliged to deliver a certain amount of product, they may plan to produce more because of the risk of low yields due to bad weather, etc. These reasons are also barriers to waste reduction and it is important to be aware that they can be based on physical, economic, juridical, organisational and even cultural issues.
- **Reducing waste amounts** – plant cultivation or animal breeding are biological processes. Therefore, it is not realistic to completely control these systems and fully eliminate food waste. A certain share of food intended for human consumption will always be sorted out and used for other purposes, but it is in general possible to utilise this fraction in an improved way and thus reduce waste.
- **Comparison between regions or between product groups of interest** – Such comparisons can give clue to reasons for waste and possible reduction measures by revealing differences in waste amounts that is not so much related to the product but more to differences in agronomical practices, organisational issues, economy and cultural and social issues.

9 Appendix – List of core requirements and optional recommendations (general approach)

Table 21 – List of core requirements and optional recommendations (general approach)

CR/OR number	Section / Topic	Description
CR 1	4.2 / Timeframe	In any given NFWQS, users of the Manual shall compile food waste quantities on the base of one calendar year (from January 1 to December 31).
CR 2	4.2 / Material type	The user of the Manual shall at least quantify the total amount of food and associated inedible parts.
OR 1	4.2 / Material type	The user of the Manual should separately quantify the amount of i) food and ii) inedible parts and then report the combined total as well as separate results.
CR if OR1 is enacted	4.2 / Material type	Following the above recommendation has other implications. If the amount of food and inedible parts are quantified separately, then user of the Manual shall: • Describe what sources or frameworks were used to categorise a material as food or as associated inedible parts. This includes stating if any assumptions were used to define whether a material was "intended" for human consumption or not, and • If approximations were made to quantify separately the food or associated inedible parts, describe the approach used and, if applicable, all conversion factors, related sources, methods, and assumptions.
CR 3	4.2 / Destination	The user of the Manual shall follow the FUSIONS definition of food waste and therefore, food or inedible parts of food sent to destinations under B-ii (see in Figure 2, destinations B3 to B11) shall be accounted for in the NFWQS. However, food or inedible parts of food sent to "valorisation and conversion" (see in Figure 2, destination B-i, including B1 "animal feed" and/or B2 "biobased materials and biochemical processing") shall be excluded from the NFWQS.
Subsequent core requirement	4.2 / Destination	The user of the Manual shall: • Describe what sources or frameworks were used to categorise "food or inedible parts of food removed from the food supply chain" as belonging to destination "valorisation and conversion" (B-i) or to destination "become food waste" (B-ii). This includes stating if any assumptions were used to distinguish B-i and B-ii. • If estimates were used to distinguish B-i and B-ii, describe the approach used and, if applicable, all factors, related sources, methods, and assumptions.

CR/OR number	Section / Topic	Description
OR 2	4.2 / Destination	The user of the Manual should quantify food waste separately for each destination listed (destinations B3 to B11 within B-ii). In this context, it may help to also quantify destinations B1 and B2, despite them not being considered food waste, in order to have a full picture of material flows and perform overall coherence checks of amounts. In practice, shifting directly from a food waste quantification study in which all destinations within B-ii are quantified as a whole to a food waste quantification study in which all destinations are quantified separately may not be feasible. In this case, a MS should go through an intermediary step in which certain destinations could be combined (e.g. a consolidated destination "energy" including: B5 – Anaerobic digestion, B6 – Bio-energy, and B7 – Co-generation).
OR 3	4.2 / Destination	In addition to final destinations B1 to B11, the user of the Manual should also consider trying to quantify the amount of food going to redistribution as well as the flows between supply chains sectors (e.g. from retail sector back to manufacturing sector). This would help in having a complete view of the material flows within the food chain before food reaches its final destination.
Core requirement if certain destinations cannot be accounted for	4.2 / Destination	In practice, considering the current level of waste analysis in the EU, it will be extremely difficult to quantify food waste for all destinations listed (destinations B3 to B11 within B-ii). Note that destinations B3 to B11 are "possible" destinations of food waste, certain destinations being more common in certain countries. The user of the Manual shall analyse the specific situation in its MS and focus on the most relevant destinations. In addition, if certain destinations could not be accounted for (e.g. food waste from household sent to sewer), this shall be clearly specified in the NFWQS and mentioned as a limitation but this shall not prevent the MS from conducting the quantification.
CR 4	4.2 / Boundaries	The user of the Manual shall comply with the three boundaries dimensions – i.e. food category, food supply chain stage, and geography – presented in Table 2.
Subsequent core requirement	4.2 / Boundaries	The user of the Manual shall use the classifications presented in Table 2 in order to specify if any components (i.e. region, food category, etc.) of the boundary dimensions that could not be accounted for.
OR 4	4.3 / Prioritizing sectorial quantifications in the context of a rolling programme	In the context of a rolling programme, the MS should decide which sector should be quantified in priority. In addition, the MS should decide what would be the suitable updating frequency of the quantification for priority sectors versus non-priority sectors.
CR 5	4.4 / General approach for sectorial quantifications	All sectorial quantifications shall follow similar major steps (see Figure 4): 1. Review the scope and structure of the sector; 2. Set up a work plan; 3. Identify and review existing estimates and / or raw data relating to the sector; 4. Select approach for quantification – i.e. decide on which components of the sectorial food waste can be quantified with existing data and which require additional measurement; Undertake quantification using existing data and/or with new measurements.

CR/OR number	Section / Topic	Description
CR 6	4.4.1 / Definition of the sector	The user of the Manual shall comply with the definition of sectors provided in this Manual as far as possible and to justify and explain any deviations. Definitions are given in each sector-specific chapter.
Core requirement if certain components of the sector cannot be accounted for	4.4.1 / Definition of the sector	If for any reason, a sectorial quantification could not include a certain component of the sector, this shall be clearly specified in the NFWQS and mentioned as a limitation but this shall not prevent the MS from conducting the sectorial quantification.
CR 7	4.4.1 / Mapping of the sector	The user of the Manual shall carry out an initial study in order to have a general understanding of the sector's value chain. Ultimately, the objective shall be to have a typology of key players in the sector (based on their sizes or type of production, or other key characteristics of their operations) with information on their respective market shares, as well as elements (at least qualitative) on their food waste levels.
CR 8	4.4.2 / Set up a work plan	The user of the Manual shall set up a work plan in order to plan and organise all future activities and resources for quantifying food waste
CR 9	4.4.3 / Identify existing data	The user of the Manual shall a) identify all relevant information sources and b) determine whether any of them are suitable to be used in the NFWQS.
CR 10	4.4.3 / Identify existing data	For all sectorial quantifications, the user of the Manual should search the academic and grey literature for relevant data or studies. The user of the Manual should also approach ministries and agencies that work on food and waste statistics to see if there is anything that can be used for NFWQSs.
CR 11	4.4.3 / Review identified data	Prior to using existing estimates / raw data, the user of the Manual shall review the data and the study parameters carefully and shall fully understand how these data were obtained.
Subsequent core requirements:	4.4.3 / Review identified data	Factors to consider when determining whether to use existing raw data relate to scope (time frame, material types, destinations, boundaries) and reliability (quantification methods, sampling procedures).
OR 5	4.4.3 / Review identified data	In case there is insufficient information on existing data (e.g. in accompanying documentation), the collectors of the data or study authors / commissioners should be contacted to try to obtain all necessary details to conduct the review.
OR 6	4.4.4	Preserving business confidentiality should be an important concern for MS authorities in any data gathering exercises.
CR 12	4.4.5.1 / Undertake quantification using existing food waste estimates	The user of the Manual shall indicate in the National Food Waste Report (see section 4.6) how these estimates for food waste have been exploited.

CR/OR number	Section / Topic	Description
CR 13	4.4.5.2 / Undertake quantification using existing raw data	The user of the Manual shall indicate in the National Food Waste Report (see section 4.6) the source of the data. This could be either a reference to the original study that was used to obtain the data (if such a source exists) and/or explanations on the process for obtaining the raw data (if the data are not coming from a study or if it does but further adjustments were made). Then, the user of the Manual shall also detail the procedure to derive food waste estimates from the raw data. In particular, the user of the Manual shall detail (if relevant) the scaling procedure used (see section 4.4.5.5). Finally, the user shall describe the food waste "component" (i.e. any given sector / segment of a sector / waste stream / destination / etc.) on which the existing raw data are applied.
OR 7	4.4.5.4 / Methods based on inference by calculation	Using calculations based on data from outside the scope of the quantification study (e.g. from another country) should be kept to a minimum.
OR 8	4.4.5.5 / About sampling and scaling	The user of the Manual should follow the advice provided in the FLW Standard when using a sample-based approach for food waste quantification (be it for existing estimates, new estimates based on existing raw data, or new estimates based on new measurement).
CR 14	4.4.5.6 / About packaging	The user of the Manual shall exclude packaging from the food-waste estimates obtained within a NFWQS.
Subsequent core requirement:	4.4.5.6 / About packaging	If certain packaging could not be excluded from the food waste quantification: the user of the Manual shall specify which ones – i.e. which food categories, which sectors, and which type of packaging.
CR 15	4.5 / Role of the coordinating organisation	The coordinating organisation shall pay particular attention to any potential differences in terms of methodology between sectorial quantifications.
CR 16	4.5 / Providing specifications to other organisations involved in the sectorial quantifications	The coordinating organisation shall communicate with enough detail any relevant aspects of this Manual that other involved organisations may need in order to carry out their tasks.
CR 17	4.6.1 / Reporting principles	To the extent possible, the National Food Waste Report (NFWR) prepared by the MS shall be in accordance with the following principles (adapted from the FLW Protocol): Relevance, Completeness, Consistency, Transparency.
CR 18	4.6.1 / Reporting principles – Transparency	If a core requirement has not been followed, the deviation shall be clearly mentioned and justified in order to be transparent in the NFWR. Limitations shall be properly identified and explained rather than not reporting at all.
OR 9	4.6.3 / Recommendations on the information to be presented in the National Food Waste Report	A NFWR prepared by the user of the Manual should contain the basic information presented in Box 1.

CR/OR number	Section / Topic	Description
OR 52	4.6.4 / Additional advice for communicating results publicly on a voluntary basis	Regardless of the audience, the report disclosed publicly on a voluntary basis should be designed to clearly describe the goals of the NFWQS, context and rationale behind various accounting decisions, summarise the overall conclusions that can be drawn from the evaluation of food waste quantities, as well as the limitations of the quantification exercise. Particular attention should be paid to the food waste definition, proper explanations on what is considered food waste or not should be provided in any communication in order to avoiding misunderstanding and misuse of the food waste data provided in the report. Typically it should always be clearly mentioned whether the considered food waste amount is only for edible materials or includes bother edible and inedible materials.
CR 19	4.6.4 / Describing limitations of NFWQS results	In order to raise awareness with audiences that the quantification study's scope and other factors affect the results and to therefore be aware of any limitations, a MS shall include a relevant disclaimer.

Food Waste Quantification Manual

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